DOE/EA-1726

FINAL ENVIRONMENTAL ASSESSMENT

Environmental Assessment for Department of Energy Loan Guarantee to Kahuku Wind Power, LLC for Construction of the Kahuku Wind Power facility in Kahuku, Oʻahu, Hawaiʻi

U.S. Department of Energy
Loan Guarantee Program Office
Washington, DC 20585

May 2010

SUMMARY

Introduction

The U.S. Department of Energy (DOE) is proposing to issue a $117 million loan guarantee to Kahuku Wind Power, LLC to support construction of the proposed 30 megawatt (MW) Kahuku Wind Power facility in Kahuku, Oʻahu, Hawaiʻi.

DOE has prepared this Environmental Assessment (EA) to comply with the National Environmental Policy Act (NEPA) (42 USC 4321, et. seq.), Council on Environmental Quality regulations for implementing NEPA (40 CFR Parts 1500-1508), and DOE NEPA regulations (10 CFR Part 1021). The EA examines the potential environmental impacts associated with the proposed action and No Action Alternative and determines whether the proposed action has the potential for significant environmental impacts. The information contained in the EA will enable DOE to fully consider the potential environmental impacts of issuing a loan guarantee for the Kahuku Wind Power project.

Purpose and Need

The Energy Policy Act of 2005 (EPAct 2005) established a federal loan guarantee program for eligible energy projects in the U.S. that employ innovative energy technologies. Title XVII of the EPAct 2005 authorizes the Secretary of Energy to issue loan guarantees to eligible projects that "(1) avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases; and (2) employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued" (42 USC 16513). The two principal goals of the loan guarantee program are to encourage commercial use in the U.S. of new or significantly improved energy-related technologies and to achieve substantial environmental benefits. The purpose and need for agency action is to comply with DOE's mandate under EPAct 2005 by selecting eligible projects that meet the goals of the Act. DOE is using the NEPA process to assist in determining whether to issue a loan guarantee to Kahuku Wind Power LLC to support the proposed project.

The proposed Kahuku Wind Power facility would integrate installation of two new or significantly improved technologies compared to commercial technologies currently available in the U.S., the Xtreme Battery Energy Storage System (BESS) and the Clipper Liberty™ wind turbine generators (WTGs). It would also generate electricity from a renewable resource that would otherwise be generated from fossil based fuel, thereby reducing greenhouse gas emissions and other pollutants that are harmful to the environment and human health. The 30 MW of power potentially generated by the proposed facility would be able to eliminate the use of approximately 154,550 barrels of oil annually that would otherwise be used to produce conventional power in Hawaiʻi. Eliminating the consumption of this amount of oil would in turn reduce emissions of the following air pollutants:

- carbon dioxide (CO_2): 159 million lbs (72.4 million kg) annually and 3.2 billion lbs (1.4 billion kg) over the life of the project;
- sulfur dioxide (SO_2): 330 thousand lbs (149.8 thousand kg) annually and 6.6 million lbs (2.7 million kg) over the life of the project;
- nitrogen oxides (NO_X): 237 thousand lbs (107 thousand kg) annually and 4.7 million lbs (2.1 million kg) the life of the project; and
- mercury (Hg): 1.5 lbs (0.7 kg) annually and 30 lbs (13.6 kg) over the life of the project.

The proposed Kahuku Wind Power facility would contribute to the avoidance and reduction of air pollutants and anthropogenic emissions of greenhouse gases, as required by EPAct 2005.

Proposed Action and Alternatives

DOE's proposed action is to issue a $117 million loan guarantee to Kahuku Wind Power LLC to support construction of the Kahuku Wind Power facility. The proposed facility would consist of 12 Clipper Liberty^{TM} 2.5-MW WTGs, an operations and maintenance (O&M) building, one permanent unguyed meteorological (met) tower, seven microwave dishes, one on-site and up to two off-site microwave towers, an electrical substation, a BESS, and a network of unpaved service roadways. The proposed project area is approximately 578 ac (234 ha) in the Kahuku area on the northeastern portion of the Island of O‘ahu, within the State of Hawai‘i.

In addition to the proposed action of issuing the loan guarantee to Kahuku Wind Power LLC for the proposed facility, a No Action Alternative was also evaluated in the EA. Under the No Action Alternative, DOE would not issue the loan guarantee to Kahuku Wind Power LLC for the project. Without the DOE loan, it is unlikely that Kahuku Wind Power LLC would implement the project as currently planned. Thus, the No Action Alternative is that no wind power facility would be constructed at the project area.

The decision for DOE consideration presented in this EA is whether or not to approve the loan guarantee for the proposed Kahuku Wind Power facility. Prior to submitting its application, Kahuku Wind Power LLC considered alternative sites, including two on O‘ahu with reasonable potential for wind development, Ka‘ena Point to the west of Kahuku and Kahe Ridge to the south. Kahuku Wind Power LLC determined that the proposed site was the most viable location for the proposed project based on the existing needs for renewable energy in Hawai‘i, evaluation of wind resources on O‘ahu, and a thorough consideration of alternative sites in the area.

Summary of Resource Areas Examined

The EA evaluates the environmental effects that could result from implementing the proposed action and No Action Alternative. Table S.1 provides a summary of the potential environmental consequences that could result from implementing the proposed action and from the No Action Alternative.

Table S.1 Summary of Impacts by Resource

Resource Area	No Action Alternative	Proposed Action
Climate	There would be no change in existing conditions and no impacts to climate.	Construction Period: Construction of the facility would result in slight emissions of CO_2; however, these would be temporary and of relatively low level. Operational Period: The proposed WTGs do not have the potential to affect temperature, rainfall, humidity, or most other meteorological parameters. Operation of the facility would result in slight emissions of CO_2; however, these would be of relatively low level, and the proposed project would more than offset these emissions by decreasing fossil fuel consumption and emission of greenhouse gases.

Resource Area	No Action Alternative	Proposed Action
Topography	There would be no change in existing conditions and no impacts to topography.	<u>Construction Period</u>: Grading would cause minor alterations of local topography, but would not alter major topographic features. <u>Operational Period</u>: Minor grading would occur on the project area to prevent ponding, but would not alter major topographic features.
Geology, Soils, and Geologic Hazards	There would be no change in existing conditions and no impacts to soils and geology.	<u>Construction Period</u>: Grading for new roads, WTG pads, and other project components would disturb approximately 67 acres of soils and cause alteration of shallow consolidated bedrock near the surface in some areas. No significant geologic resources are known or expected to occur in the project area, so no geologic impacts are expected. Best Management Practices (BMPs) would be employed to prevent and minimize soil erosion during construction. <u>Operational Period</u>: BMPs (including revegetation) would be employed to prevent and minimize soil erosion during operation.
Water Resources	There would be no change in existing conditions and no impacts to water resources.	<u>Construction Period</u>: Potential impacts to water resources have been avoided by proper siting of the individual WTGs, associated facilities, and roadways. The project would result in only slight increases in impervious surfaces (~26 acres); therefore, it would not significantly increase the volume of stormwater runoff leaving the project area. No components of the project would adversely affect the quantity or quality of water available in basal groundwater. BMPs and general construction management techniques would be implemented to minimize any potential impacts to receiving waters in the area. <u>Operational Period</u>: Same as above.
Air Quality	There would be no change in existing conditions and no impacts to air quality.	<u>Construction Period</u>: Construction of the proposed project would result in emission of low levels of air pollutants during earthmoving operations from vehicles traveling project roadways and vehicles traveling to and from the project area. Because these would be temporary and of relatively low level, impacts to air quality are expected to be minimal. <u>Operational Period</u>: Once operational, the proposed project would result in minor emissions of air pollutants due to staff and vendor vehicle trips, periodic use of cranes, and operation of the electrical substation and BESS equipment. These emissions would be very low and would not result in adverse long-term impacts to air quality. The project would indirectly benefit air quality by reducing air pollutants produced during fossil fuel consumption that would otherwise be used to produce conventional power.

Resource Area	No Action Alternative	Proposed Action
Noise	There would be no change in existing conditions and no impacts to noise.	Construction Period: Construction of the proposed project would produce short-term noise within the project area as a result of the operation of graders, excavators, trucks, and other heavy equipment. No noise-sensitive uses are located nearby. Reasonable and standard practices would be used to mitigate construction noise; however, if noise is expected to exceed the state's maximum permissible property line noise levels, a permit would be obtained from the State Department of Health (DOH). Operational Period: Sound from the proposed project is not expected to result in a significant impact on the surrounding community. The agricultural areas closest to the proposed Kahuku Wind Power facility (such as Ki'i Road Farms) would experience the greatest increase in ambient sound, up to 3 dB, but this change in sound is not a perceptible difference to most listeners and the total sound level would still be well below the DOH limit.
Scenic Resources	There would be no change in existing conditions and no impacts to scenic resources.	Construction Period: During construction, visible components of the project would include construction equipment, transport and assembly of facility parts, and temporary dust and smoke from construction vehicles. The contractor would be required to minimize fugitive dust in accordance with applicable law, and the other visible activities during construction would be minor and temporary in nature. Operational Period: The WTGs would introduce a new vertical element into the landscape. However, the proposed project is expected to complement the rural atmosphere and agricultural character of the area. From many of the vantage points, WTGs and associated facilities would be screened by vegetation, houses, or other physical features in the landscape.
Public Health and Safety	There would be no change in existing conditions and no impacts to public health and safety.	Construction Period: Construction would involve the use, transportation, or storage of small amounts of several hazardous materials that require special handling and storage. These would be identified, along with measures for containment and spill prevention, in a Spill Prevention, Countermeasure, and Control (SPCC) Plan. The risk of harm would be minimized by requiring the contractor to follow BMPs. The batteries that would be delivered are considered non-hazardous. Operational Period: Operation of the facility would require on-site use and storage of several materials that require special handling including common lubricants, petroleum products, or other chemical products cleaning products. The SPCC Plan and Kahuku Wind Power Site Safety Plan, including BMPs, would minimize the risk of harm. The potential for the project to result in impacts from intentionally destructive acts is negligible.

Resource Area	No Action Alternative	Proposed Action
Land Use	There would be no change in existing conditions and no impacts to land use.	Construction Period: The project would not limit access to other land served by the existing access road or interfere with other existing or potential uses of land in the vicinity. The proposed facility is compatible and consistent with federal, state, and county land use policies, plans, and regulations. Operational Period: Same as above.
Flora	There would be no change in existing conditions and no impacts to flora.	Construction Period: No state or federally listed threatened, endangered, or candidate plant species occur in the areas to be directly affected by construction. Vegetation in areas that would be disturbed consists of non-native species common throughout O‘ahu and the main Hawaiian Islands. Operational Period: Mechanical methods would be used to clear vegetation in some areas during operation. Only non-native species are expected to establish in these areas; therefore, there would be no significant adverse impact on botanical resources.
Wildlife	There would be no change in existing conditions and no impacts to wildlife.	Construction Period: The impact on non-listed wildlife species would be minor. Incidental take may occur as a result of listed species colliding with the WTGs, equipment, vehicles, and other proposed facilities. The seven federally listed species that could be impacted include: Hawaiian stilt, Hawaiian coot, Hawaiian duck, Hawaiian moorhen, Newell’s shearwater, Hawaiian petrel, and Hawaiian hoary bat. The only state listed species that could be impacted is the Hawaiian short-eared owl or pueo. The proposed project includes measures to avoid, minimize, and mitigate take of these species as outlined in the Habitat Conservation Plan (HCP). Operational Period: Impacts during operation are roughly the same as above, except that the WTGs would have greater potential to affect listed species once they begin operating than they would during the construction period (when the rotors are not turning). The proposed project includes measures to avoid, minimize, and mitigate take of these species during operation as outlined in the HCP.
Socioeconomic Characters	There would be no change in existing conditions and no impacts to Socioeconomic conditions.	Construction Period: Construction of the proposed facility would employ an average of 15 to 20 people per day. No adverse impacts are anticipated. Operational Period: The project is not expected to result in new residents moving to the area due to increased energy availability and would therefore not be considered growth inducing. Operation would result in employing a regular staff of four to five people and generating ongoing expenditures for materials and outside service. No disproportionate adverse health or environmental impacts would occur to any low-income or minority population.

Resource Area	No Action Alternative	Proposed Action
Historic, Cultural, and Archaeological Resources	There would be no change in existing conditions and no impacts to cultural resources.	Construction Period: No adverse impacts to Site 4707 are expected as a result of construction. The project would preserve the coral bluff areas and any associated cultural or historical resources located on and near the project area. If any archaeological deposits or human burials are encountered, the contractor would halt work and contact the State Historic Preservation Division. Operational Period: Given that the coral bluff areas are preserved, the project would have no potential to negatively impact archaeological or historic sites or cultural resources in the project area. The project would not preclude or limit access to the area by cultural practitioners beyond existing conditions.
Utilities and Public Services	There would be no change in existing conditions and no impacts to utilities and public services.	Construction Period: The project has little potential to adversely affect utilities and public services during construction. It would generate a maximum of 40 one-way vehicle trips daily, 80 oversized equipment delivery trips, and 100 one-way cement truck trips. Minor traffic delays could result during transport of large parts and components to the project area, but the increase would not be sufficient to have a measurable effect on the level of service. Operational Period: The proposed project would place no additional burden on public services. It would consume only small amounts of electrical power, while generating potentially 30 MW of power. All of the water needed for the facility would be obtained by an existing well located on an adjacent site, and an on-site septic tank system would be constructed to handle wastewater. Operation would generate 10 one-way vehicle trips per day.
Cumulative Impacts	There would be no cumulative impacts.	The cumulative contribution of impacts that the proposed action would make on the various environmental resources is expected to be minor.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ACHP	Advisory Council on Historic Preservation
AG	Attorney General
ALISH	Agricultural Lands of Importance to the State of Hawaii
APE	area of potential effects
BA	biological assessment
BCR	Bird Conservation Region
BESS	Battery Energy Storage System
BLNR	Board of Land and Natural Resources
BMPs	Best Management Practices
BO	biological opinion
CAA	Clean Air Act
CADNA	Computer Aided Noise Abatement
CDP	Census Designated Place
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CUP-M	Conditional Use Permit-Minor
CWA	Clean Water Act
CZM	Coastal Zone Management
DBEDT	Department of Business, Economic Development, and Tourism
DLNR	Department of Land and Natural Resources
DOE	U.S. Department of Energy
DOFAW	Department of Forestry and Wildlife
DOH	Department of Health
DOR	Department of Transportation
DPP	Department of Planning and Permitting
EA	Environmental Assessment

EF	emission factors
EHSD	Environmental Health Service Division
EIS	environmental impact statement
EPA	Environmental Protection Agency
EPAct 2005	Energy Policy Act of 2005
EPO	Environmental Planning Office
ESA	Endangered Species Act
ESRC	Endangered Species Recovery Committee
FAA	Federal Aviation Administration
FCB	firing circuit board
FIRM	Flood Insurance Rate Maps
FONSI	Finding of No Significant Impact
HAR	Hawaii Administrative Rule
HC	hydrocarbons
HCP	Habitat Conservation Plan
HECO	Hawaiian Electric Company
Hg	mercury
HIOSH	Hawaii Occupational Safety and Health
HRS	Hawai‘i Revised Statutes
IGBT	Insulated-Gate Bi-polar Transistor
IPCC	Intergovernmental Panel on Climate Change
IRS	Interconnection Requirement Study
ITL	Incidental Take License
kV	kilovolt
KWP	Kaheawa Wind Power
MARAMA	Mid-Atlantic Regional Air Management Association
MBTA	Migratory Bird Treaty Act
mg/l Cl^-	milligrams per liter chloride
MOU	Memorandum of Understanding
MW	megawatt
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_X	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
O&M	operations and maintenance
O_3	ozone
OHA	Office of Hawaiian Affairs
OSHA	Occupational Safety and Health Administration
OWP	Oahu Wind Partners LLC
Phase I ESA	Phase I Environmental Site Assessment
PLC	programmable logic controller
PM_{10}	particulate matter smaller than 10 microns
$PM_{2.5}$	particulate matter smaller than 2.5 microns
PPA	Power Purchasing Agreement

RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendment Reauthorization Act
SCADA	Supervisory Command and Data Acquisition
SHA	Safe Harbor Agreement
SHPD	State Historic Preservation Division
SHPO	State Historic Preservation Officer
SMA	Special Management Areas
SO_2	sulfur dioxide
SO_X	sulfur oxides
SPCC	Spill Prevention, Countermeasure, and Control
TMK	Tax Map Key
TSCA	Toxic Substances Control Act
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WTG	wind turbine generator

CHAPTER 1: PURPOSE AND NEED

1.1 Purpose and Need for Action

The proposed action evaluated by the U.S. Department of Energy (DOE) in this environmental assessment (EA) is the issuance of a $117 million loan guarantee to Kahuku Wind Power LLC to support construction of the proposed 30 megawatt (MW) Kahuku Wind Power facility in Kahuku, O‘ahu, Hawai‘i. The proposed facility would consist of 12 Clipper Liberty^{TM} 2.5-MW wind turbine generators (WTGs), an operations and maintenance (O&M) building, one permanent unguyed meteorological (met) tower, one on-site and up to two off-site microwave towers, an electrical substation, a Battery Energy Storage System (BESS), and a network of unpaved service roadways. A full description of the proposed project is provided in Section 2.2.

The Energy Policy Act of 2005 (EPAct 2005) established a federal loan guarantee program for eligible energy projects in the U.S. that employ innovative energy technologies. Title XVII of the EPAct 2005 authorizes the Secretary of Energy to issue loan guarantees to eligible projects that “(1) avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases; and (2) employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued” (42 USC 16513). The two principal goals of the loan guarantee program are to encourage commercial use in the U.S. of new or significantly improved energy-related technologies and to achieve substantial environmental benefits. The purpose and need for agency action is to comply with DOE’s mandate under EPAct 2005 by selecting eligible projects that meet the goals of the Act. DOE is using the National Environmental Policy Act (NEPA) process to assist in determining whether to issue a loan guarantee to Kahuku Wind Power LLC to support the proposed project.

Kahuku Wind Power LLC is proposing to integrate installation of Xtreme Power’s (“Xtreme”) BESS and the Clipper Liberty^{TM} WTGs, two new or significantly improved technologies compared to commercial technologies currently available in the U.S. These technologies will reduce the variability of the power output from wind generation and provide power quality support to the local utility on a low-voltage transmission-distribution line. Successful integration of the new and improved technologies proposed at the Kahuku Wind Power facility has the potential to serve as a model for other renewable energy opportunities in Hawai‘i and elsewhere in the U.S, particularly in regions with isolated power grids with minimal electric utility infrastructure.

Xtreme’s BESS technology has never been used before in a MW-scale utility application. The BESS for the proposed project is designed as the first technology of its kind that will enable safe operation on a 46-kilovolt (kV) electric distribution line which directly serves consumer loads. The BESS buffers highly variable wind power and achieves grid stability by managing the change in output of WTGs and the change in total output of the facility. The Xtreme BESS absorbs or generates power to limit change of wind output to less than 1 MW per minute. Compared to all currently available energy storage and power management solutions, the BESS enables more efficient use of existing large-scale power generation and distribution resources, improving overall grid operations.

The Clipper Liberty^{TM} WTG provides a significant improvement over existing WTG technology as it combines the advantages of a multiple gear box, permanent magnet, and synchronous generator in a design not available from other wind turbine manufacturers. The Clipper Liberty^{TM} turbines are capable of extracting more energy than smaller turbines, while at the same time using a lighter weight drive train. This allows for a lighter weight crane for lifting the turbine and results in a lower cost of energy production.

The proposed Kahuku Wind Power facility would reduce the need for fossil based fuel, thereby significantly reducing greenhouse gas emissions and other pollutants that are harmful to the environment and human health. The 30 MW of power potentially generated by the proposed facility would be able to eliminate the use of approximately 154,550 barrels of oil annually that would otherwise be used to produce conventional power. Eliminating the consumption of this amount of oil would in turn reduce emissions of the following air pollutants:

- carbon dioxide (CO_2): 159 million lbs (72.4 million kg) annually and 3.2 billion lbs (1.4 billion kg) over the life of the project;
- sulfur dioxide (SO_2): 330 thousand lbs (149.8 thousand kg) annually and 6.6 million lbs (2.7 million kg) over the life of the project;
- nitrogen oxides (NO_X): 237 thousand lbs (107 thousand kg) annually and 4.7 million lbs (2.1 million kg) the life of the project; and
- mercury (Hg): 1.5 lbs (0.7 kg) annually and 30 lbs (13.6 kg) over the life of the project.

Additionally, the BESS should reduce the need for on-line reserve capacity (spinning reserves) on the electricity grid, which would allow existing fossil fuel plants to run more efficiently, further reducing fossil fuel use and the resulting emissions. Therefore, the proposed Kahuku Wind Power facility would contribute to the avoidance and reduction of air pollutants and anthropogenic emissions of greenhouse gases, as required by EPAct 2005.

1.2 Background

EPAct 2005 established a federal loan guarantee program for eligible energy projects that employ innovative technologies. The two principal goals of the program are to encourage commercial use in the United States of new or significantly improved energy related technologies and to achieve substantial environmental benefits. DOE believes that commercial use of these technologies would help sustain and promote economic growth, produce a more stable and secure energy supply and economy for the United States, and improve the environment. DOE published a Final Rule that establishes the policies, procedures, and requirements for the loan guarantee program (10 Code of Federal Regulations [CFR] Part 609). In June 2008, DOE issued a solicitation announcement inviting interested parties to submit proposals for projects that employ energy efficiency, renewable energy, and advanced transmission and distribution technologies that constitute New or Significantly Improved Technologies (as defined in 10 CFR Part 609). Kahuku Wind Power LLC submitted an application to DOE for a loan guarantee in February 2009.

On November 13, 2009, DOE made a formal determination that an EA was the appropriate level of environmental review for the proposed action and sent a notification letter to the Hawaii Office of Environmental Quality Control. The letter described the proposed action and stated that a draft EA would be sent to the state for review. On February 26, 2010, DOE sent the draft EA to the Hawaii Office of Environmental Quality Control. The draft EA was also posted on the Loan Guarantee Program Office website and a notice of availability was published in the Honolulu *Advertiser* and the Honolulu *Star Bulletin*.

1.3 Scope of This Environmental Assessment

This Environmental Assessment (EA) presents information on the potential impacts associated with guaranteeing a loan to Kahuku Wind Power LLC and covers the construction and operation of the Kahuku Wind Power facility. DOE has prepared this EA to comply with the National Environmental Policy Act of 1969 (NEPA), Council on Environmental Quality (CEQ) regulations implementing NEPA

(40 CFR Parts 1500−1508), and DOE NEPA Implementing Procedures (10 CFR 1021). If no significant impacts are identified during preparation of this EA, DOE would issue a Finding of No Significant Impact (FONSI). If potentially significant impacts are identified, DOE would prepare an environmental impact statement (EIS).

This EA: (1) describes the affected environment relevant to the impacts of the proposed action and No Action Alternative; (2) describes the proposed action; (3) analyzes environmental impacts associated with the proposed action and No Action Alternative; and (4) identifies and characterizes cumulative impacts that could result from the proposed action in relation to other ongoing or proposed activities within the surrounding area.[1]

---

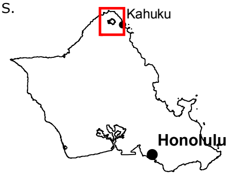
[1] Throughout this document, Hawaiian words and place names are spelled according to Pukui et al. (1974) and Pukui and Elbert (1971).

Legend

▭ Project Parcels

Key Map

N.T.S.



Source: USGS - Kahuku Quad

Vicinity Map

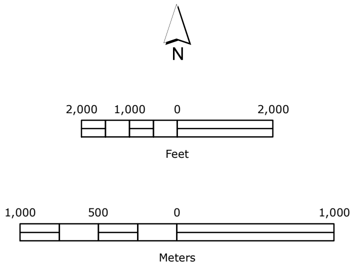


Figure 1-1

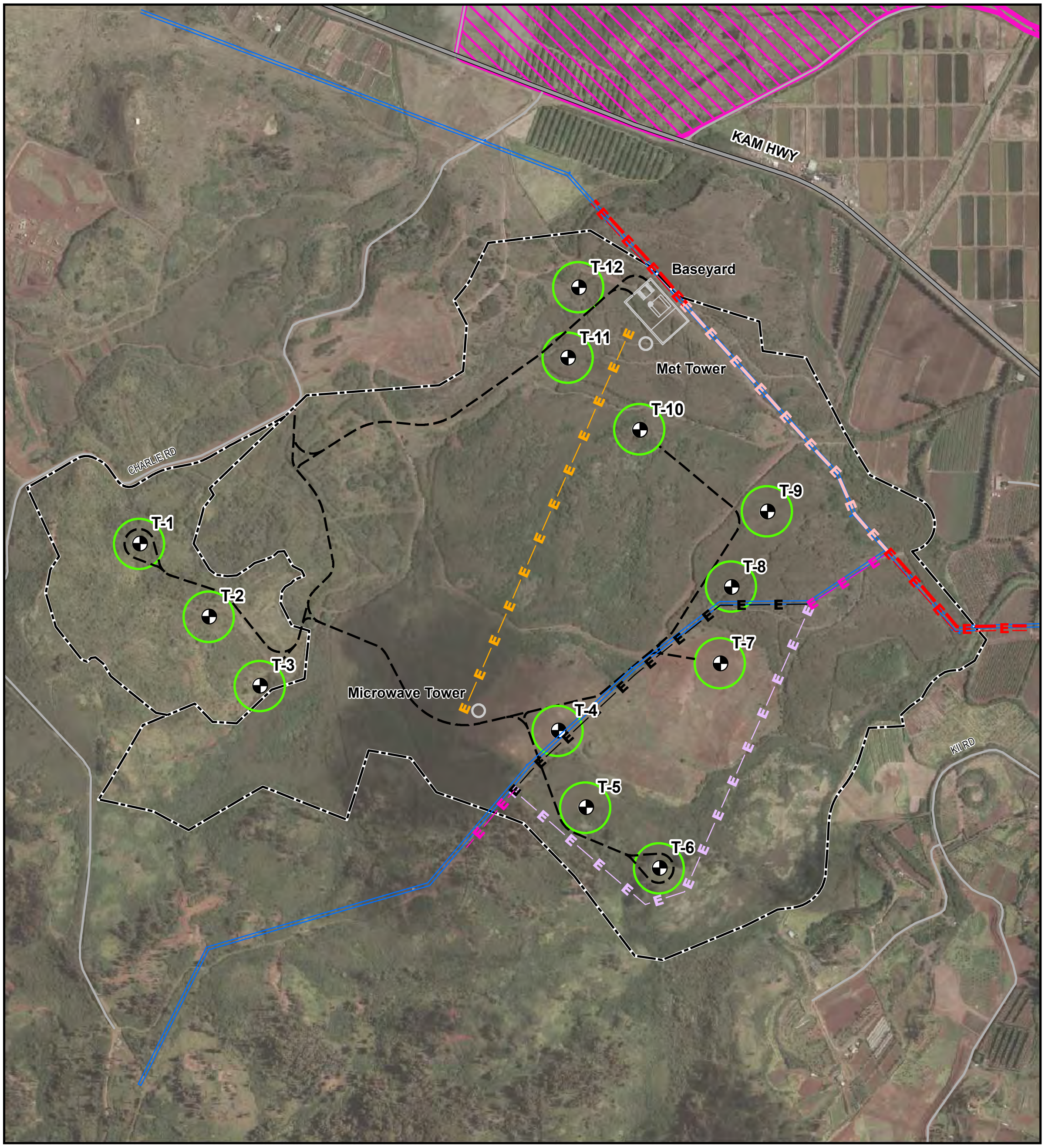
CHAPTER 2: PROPOSED ACTION AND ALTERNATIVES

This chapter provides information on the proposed Kahuku Wind Power facility and discusses the proposed action and No Action Alternative. Alternatives considered, but not analyzed are also briefly mentioned.

2.1 Proposed Action

DOE's proposed action is to issue a $117 million loan guarantee to Kahuku Wind Power LLC to support construction of the proposed 30 MW Kahuku Wind Power facility in Kahuku, O‘ahu, Hawai‘i. Kahuku Wind Power LLC is a subsidiary of First Wind, a Boston-based wind energy generation firm, and was created for the express purpose of developing a new wind generation facility in Kahuku, O‘ahu.

The proposed facility would consist of 12 Clipper Liberty^{TM} 2.5-MW WTGs, an O&M building, one permanent unguyed met tower, seven microwave dishes, one on-site and up to two off-site microwave towers, an electrical substation, a BESS, and a network of unpaved service roadways. The proposed location for the Kahuku Wind Power facility is on approximately 578 ac (234 ha) in the community of Kahuku in the Ko‘olauloa District on the northeastern portion of O‘ahu. First Wind secured rights to the project area from Continental Pacific, LLC, a large agricultural developer. Approximately 70 ac (28 ha) of the project area is leased from Continental Pacific, LLC and the remainder was purchased by Kahuku Wind Power LLC in May 2007. The project area includes two parcels (Tax Map Key (TMK) 5-6-005:007 and 5-6-5:014) located roughly 0.2 mi (0.3 km) mauka (inland) of Kamehameha Highway, 1.25 mi (2 km) northwest of Kahuku Town, and 1.2 mi (2 km) southeast of the entrance to Turtle Bay Resort (Figure 1-1). The project area is accessible via Charlie Road off Kamehameha Highway. It is bounded on the east by pasture and agricultural lands along the Kamehameha Highway and on the west and south by agricultural land owned by the State of Hawai‘i. The north and northwestern portions abut a ti (*Cordyline fruticosa*) plantation and a training facility for the Union of Operating Engineers. The southwest portion of the project area is bordered by federal land including the U.S. Army Kahuku Training Range. The James Campbell National Wildlife Refuge (NWR) lies nearby to the east (makai or seaward) of Kamehameha Highway. The two off-site microwave tower sites are located in the Waialua District on the northern portion of O‘ahu (see Section 2.1.5).



Data Sources: State of Hawaii GIS;
City and County of Honolulu; USGS
Aerial Source: State of Hawaii GIS;
Site Plan Source: M&E Pacific Inc.

Kahuku Wind Power Layout

Figure 2-1

The proposed facility would consist of the following components:

2.1.1 Wind Turbine Generator (WTG) Sites

The facility would include 12 Liberty™ 2.5-MW WTGs manufactured by Clipper Windpower. The WTGs would be arranged in four arrays of three WTGs each (Figure 2-1). Figure 2-2 shows the Clipper Liberty™ turbine and its key components. Each of the 12 turbine sites would consist of a turbine pad, a pad-mounted transformer, a power distribution panel, a turbine tower, a turbine rotor, a nacelle, and a gravel access drive and appropriate buffer area. Each turbine site would encompass roughly 1.78 ac (0.72 ha) in size. An additional 1.30 ac (0.53 ha) surrounding each turbine site would be temporarily disturbed during construction and revegetated following completion of the turbine components.

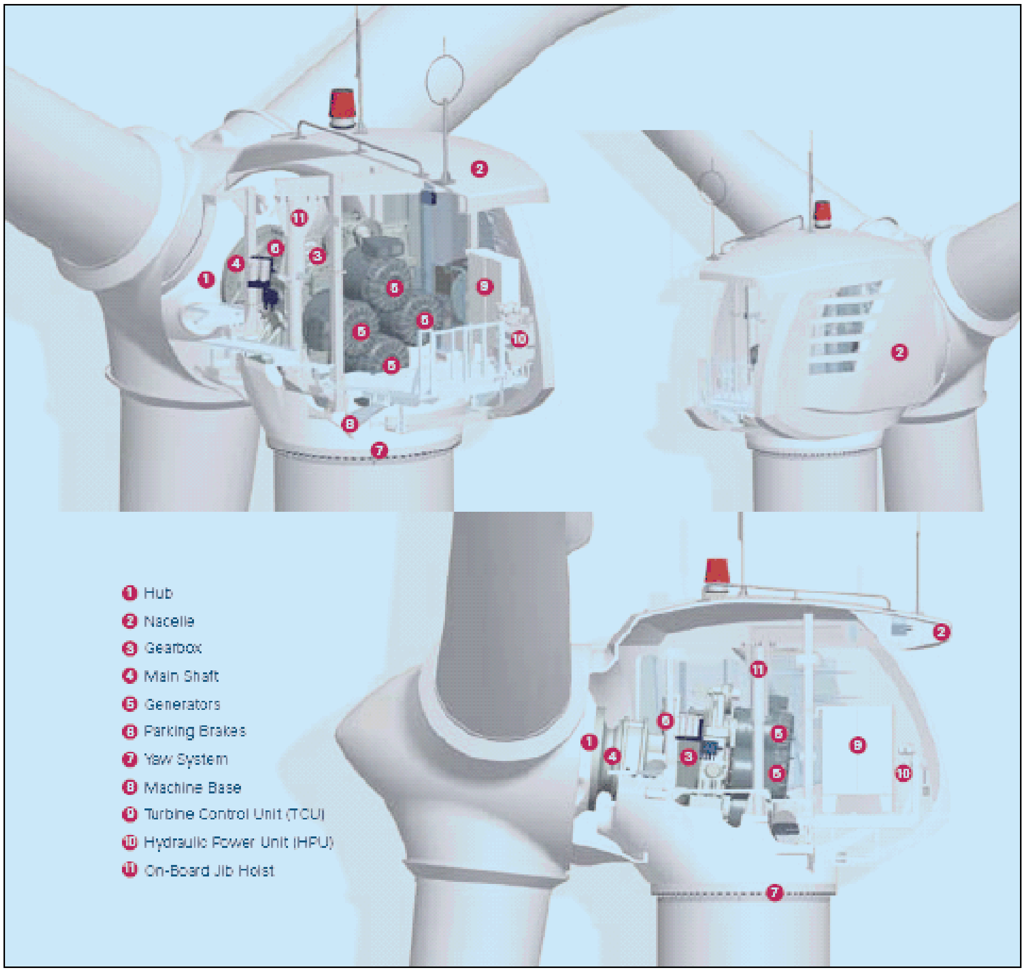


Figure 2-2. Clipper Liberty™ WTG key components.

- Rotor: The rotor of the WTG has three blades and a diameter of 314 ft (96 m). The speed of the rotor varies from 9.6 to 15.5 revolutions per minute depending on the wind speed.

- Nacelle: The nacelle is a housing that contains a gearbox, main shaft, four generators, and brake. Access to the nacelle is provided via a 6 by 12 ft (1.8 by 3.6 m) door.

- Tower: The conical- tubular steel turbine towers proposed for the project are approximately 262 ft (80 m) in height. Thus, the maximum height of the turbines from tower base to highest blade tip would be 420 ft (127 m). The base of the turbine tower would be 14 ft (4.4 m) in diameter. A buffer of at least 450 ft (137 m) would be provided between any turbine tower and the property boundary.

- Pad-mounted Transformers: The pad-mounted transformers would each have a base of 4 ft by 6 ft (1.2 by 1.8 m) and a height of approximately 6 ft.

- Power Distribution Panel: The power distribution panels would have a base of approximately 1 ft by 3 ft (0.3 by 0.9 m).

- Gravel and Buffer Area: A 315-ft (96-m) diameter buffer area would be provided around each turbine foundation. A buffer zone of 30 ft (9 m) of graveled surface would extend out from the tower in all directions, and a 30-ft wide graveled drive would lead from the access road through the buffer zone to the tower itself. No other construction or secondary land usage would be allowed inside the 315 ft buffer zone.

2.1.2 Meteorological Monitoring Tower

Meteorological (met) monitoring towers are tall tubular or lattice towers that contain sensors to measure wind speed and direction at a site (Figure 2-3). These towers can be secured to the ground with tensioned cable referred to as guy wires (guyed met tower) or free standing without the use of guy wires (unguyed met tower).

Figure 2-3. Unguyed met tower, approximately 262.5 ft (80 m) tall, similar to the one proposed for the Kahuku Wind Power facility.

Three temporary met towers were installed on the property in October 2007 in order to collect wind resource data. Two met towers were dismantled in early December 2008 and currently only one temporary met tower remains in the project area. Prior to construction, three temporary met towers would be present on site for a period of up to four months for power-curve testing[2] and dismantled prior to the erection of the WTGs. All temporary met towers would be guyed and approximately 262 ft (80 m) tall. One permanent unguyed met tower would be erected during construction and remain for the duration of the project. This permanent met tower would be approximately 262 ft tall, with a concrete foundation approximately 625 ft^2 (58 m^2) in area.

2.1.3 Base Yard

The base yard would be a 460 by 290 ft (140 x 88 m) fenced area located in the northern portion of the project area. The base yard would contain three structures – the O&M building, BESS enclosure, and the electrical substation (Figure 2-4). Concrete foundations would be required for the three structures, as

---

[2] Power curve testing is a process by which the future performance of individual turbines is predicted by correlating the overall wind measurements at the site over a year or more to temporary met towers erected at specific turbine sites for a shorter time period, usually on the order of 2-4 months.

described in Sections 2.1.4 and 2.1.6. Any area within the fence not covered by concrete would be covered with gravel to minimize erosion and surface runoff. During construction of the base yard, an additional 2.1 ac (0.85 ha) outside of the base yard would be disturbed but revegetated once construction is complete.

2.1.4 Operations and Maintenance (O&M) Building

The proposed project would also include construction of a single-story, 7,000 ft^2 (650 m^2) O&M building to house operation personnel, wind generating facility controls, maintenance equipment, and spare parts. This building would have a maximum height of 29.25 ft (8.8 m) and would be located in the base yard area. A dirt and gravel parking area for the O&M building would be provided for at least 14 vehicles (Figure 2-4).

2.1.5 Microwave Dishes and Towers

Once complete, the facility would be incorporated into the Hawaiian Electric Company's (HECO) power grid, and Kahuku Wind Power LLC would be required to provide secure high-speed communications between Kahuku Wind Power and HECO's system on O‘ahu. The microwave communication system would involve the placement of seven microwave dishes at several locations (both on and off-site) between the project area and the two HECO electrical substations located at Wahiawa and Waialua. Seven locations would be utilized for the placement of microwave dishes. The placement of one microwave dish would be either at an existing tower or on a new tower. If placed on a new tower, as evaluated in this EA, two microwave dishes would require the construction of new towers off-site, two would be within the project area (one of which would require the construction of a new tower), and three would be co-located on existing communications towers. In total, the proposed project would involve building up to three new microwave towers. All microwave towers would be lattice type, either three-leg or four-leg with concrete footings. Dish antennas, approximately 6 ft (1.8 m) in diameter, would be mounted horizontally on the towers.

One of the three towers would be built on-site for transmitting data from the facility to HECO substations. This tower would be approximately 30 ft (9.1 m) tall and built on a concrete foundation approximately 144 ft^2 (13.5 m^2) in area.

Two other towers would be erected off-site. The proposed location for the off-site “Waialua Substation” microwave tower is the HECO Waialua Substation at 66-011 Waialua Beach Road in a rural residential area in Hale‘iwa. This site is roughly 11.1 mi (17.8 km) from the Kahuku project area. This tower would be approximately 60 ft (18 m) in height and built on a concrete foundation approximately 169 ft^2 (16 m^2) in area.

The second new microwave tower (if the dish is not co-located on an existing tower) would be located on agricultural land at “Flying R Ranch” in Waialua. This site is owned by Waialua Ranch Partners. The Flying R Ranch site is located 13.6 mi (21.9 km) southwest of the Kahuku project area and 2.6 mi (4.2 km) southwest of the Waialua microwave tower site. The height of the Flying R Ranch tower would be approximately 40 ft (12 m). Similar to the Waialua microwave tower, this tower would be built on a 169 ft^2 concrete foundation. Approximately 1,000 linear ft (305 m) of overhead cable, supported on wooden poles approximately 50 ft (15 m) high, would be required to transmit electricity from the nearest existing HECO electrical distribution line to the proposed Flying R Ranch microwave tower.

The locations of the proposed off-site microwave towers are shown in Figure 2-5.

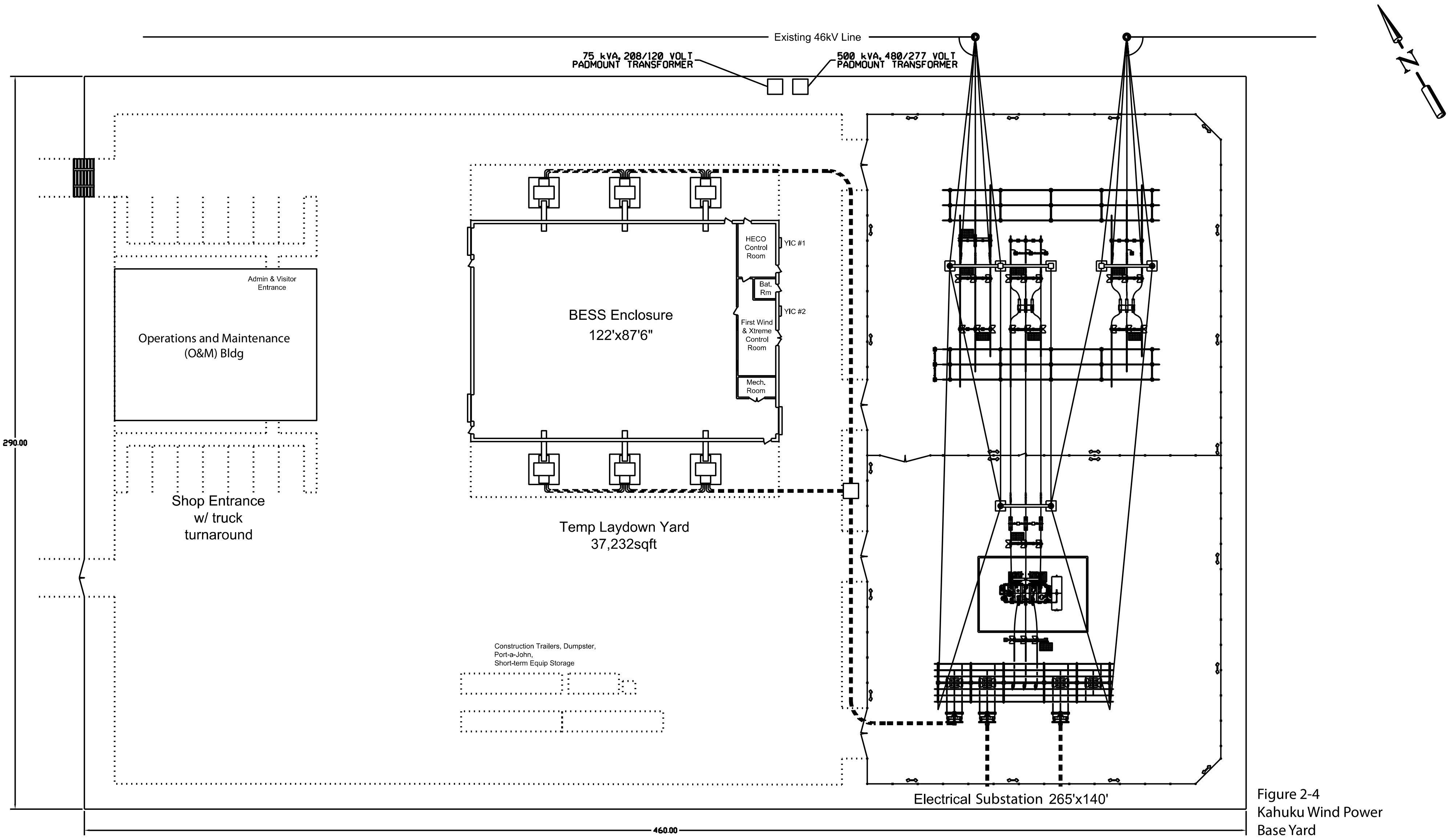


Figure 2-4
Kahuku Wind Power
Base Yard

713402_001.dgn Model 8/5/2009 4:24:03 PM

Source(s):
Tower Locations - Harris Stratex Networks
Image - LANDSAT
Roads - State of Hawaii GIS
TMK Boundary - City and County of Honolulu

Locations of Off-site Microwave Towers

Figure 2-5

2.1.6 Electrical System Components

2.1.6.1 Electrical Collection System

Electrical power generated by the WTGs would be transformed and collected through a network of underground and overhead collection circuits. The pad-mounted transformers located at the base of each WTG would increase the voltage of electricity generated by each WTG to 23-kV. Kahuku Wind Power LLC would install an underground and overhead collection system to bring electrical output from the pad-mounted transformers at each WTG to the electrical substation. The collection system would consist of two underground collection circuits and one 23-kV overhead collection circuit. The underground collection cables would total approximately 11,000 linear ft (3,353 m) and would be buried in trenches approximately 3.0 ft (0.9 m) wide and 4.0 ft (1.2 m) deep, then backfilled and returned to pre-construction elevations. Disturbed areas would be revegetated following excavation and burying of cables.

The overhead segment of the collection system would bring electrical output from the furthest six WTGs to the substation. This segment is overhead rather than underground because of the difficult terrain of the area and the presence of Kalaeokahipa Gulch, which is subject to discretionary U.S. Army Corps of Engineers jurisdiction (see Section 3.5.2). The overhead cable would be approximately 3,000 linear ft (914 m) and would be supported on approximately 15 new wooden utility poles roughly 45 ft (14 m) in height.

No new transmission lines would be constructed as part of the project; however, HECO would relocate an existing 11-kV electrical distribution line toward the southwestern boundary of the project area to accommodate construction of the WTGs. The existing line is 2,937 linear ft (895 m) long and the relocated line would be approximately 4,217 linear ft (1,286 m) long, approximately 1,280 linear ft (390 m) longer than the existing line. Similar to the existing line, the relocated line would be supported on wooden poles. The relocated distribution line would be cleared of vegetation to a width of approximately 15 ft (4.5 m).

2.1.6.2 Electrical Substation

An electrical substation would be constructed to transform the voltage from the on-site collection system and facilitate the interconnection to the existing HECO electrical transmission line. The electrical substation would feed electricity into an existing 46-kV HECO electrical transmission line that crosses the northeastern portion of the project area to the north of the base yard (Figure 2-4). The electrical substation would consist of four main structures: 1) a control building; 2) a 34-kV column/recloser; 3) a transformer; and 4) an “A” frame/circuit breaker. Each is described below. The entire substation would be fenced within a 37,100 ft^2 (3,450 m^2) area located within the fenced base yard. Depending on HECO’s requirements, however, these dimensions could be much smaller.

- Control Building: The control building would be 14 by 20 ft (4.3 by 6.1 m) at the base and approximately 15 ft (4.6 m) tall.

- 34-kV column/recloser: The 34-kV column/recloser would stand approximately 24.5 ft (7.5 m) tall, and have a base of 15 by 32 ft (4.6 by 9.6 m).

- Transformer: The transformer would be approximately 11 ft (3.4 m) tall, and have a base of approximately 11 by 16 ft (3.4 by 4.9 m).

- "A" frame/circuit breaker: The "A" frame and circuit breaker structure would stand approximately 52 ft (15.8 m) tall, and have a base of 12 by 36 ft (3.7 by 11 m).

2.1.6.3 Battery Energy Storage System (BESS)

Due to fluctuations in power output from existing wind farms on other islands, HECO has imposed power output requirements for the Kahuku Wind Power project. The BESS would enable large amounts of energy to be stored, managed, controlled, and fed into the HECO electrical transmission line as needed. Thus, this system would buffer the high variability of wind power and maintain grid stability.

Kahuku Wind Power LLC is proposing to use a BESS device provided by Xtreme. This system absorbs or generates power to limit the change of wind output to less than 1 MW per minute, enabling more efficient use of existing large-scale power generation and distribution resources.

The proposed BESS enclosure would be built immediately adjacent to the substation within the base yard area (Figure 2-4). It would consist of a 10,675 ft^2 (992 m^2) building roughly 25 ft (7.6 m) high to house the components of the 15 MW Xtreme BESS and the HECO Control Room. The BESS consists of three key components: 1) PowerCells, 2) power electronics, and 3) a control system.

- PowerCell: The PowerCell product is an advanced dry cell battery based on innovative lead acid battery chemistry. Each PowerCell is a 12 volt, 1kWhr building block roughly 5 x 5 x 30 inches (13 x 13 x 76 cm). The BESS building would house ten 1.5 MW/1 MWhr channels; each channel consists of a 1.5 MW inverter/charger and 1 MWhr rack of PowerCells (15 MW storage matrix assembled from a total of 10,000 PowerCells). The PowerCell achieves significant electrochemical efficiencies through the use of bi-polar plates comprised of coextruded wire woven into a bi-grid mesh and coated with active material paste. The bi-polar plates are stacked inside the PowerCell (Figure 2-6), surrounded with wax, and inserted into the PowerCell case to create the finished PowerCell (Figure 2-6).

- Power Electronics: The solid-state, industrial-grade power electronics module is capable of delivering 1.5 MWs at an operating efficiency of 95 to 98%. Xtreme's Insulated-Gate Bi-polar Transistor (IGBT) components can handle over 1 MW of power per device. The power electronics comprise a full four-quadrant system.

- Control System: The patented solid-state control system would enable power delivery with sub-cycle control at the MW level for effective power management. The system features three levels of control hierarchy: 1) real-time Supervisory Command and Data Acquisition (SCADA) control; 2) programmable logic controller (PLC); and 3) intelligent firing circuit board (FCB).

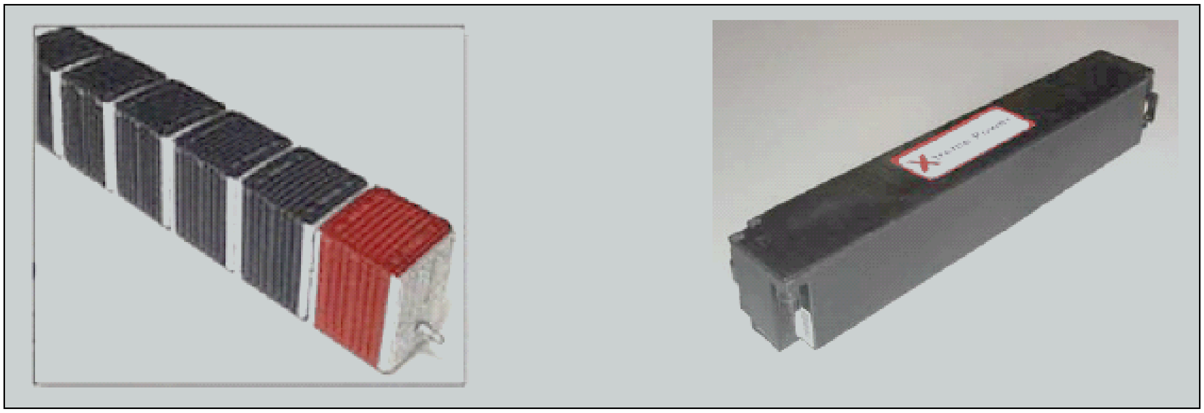


Figure 2-6. Bi-polar plates (left) and finished PowerCell (right).

2.1.7 Road Network

Approximately 1.25 mi (2 km) of existing unpaved roads in the project area would be expanded to about 3.0 mi (4.8 km) of improved but unpaved roads. The road network would provide access to the project area, each turbine location, and the base yard. The cleared and graded area for the proposed new access roads would be approximately 36 ft (11 m), with a 16 ft (5 m) wide gravel area and a 10 ft (3 m) wide shoulder on either side. The width of the roads is designed to accommodate large trucks and cranes. Individual spur roads would branch off from the main connector roads to each WTG site.

Construction of the proposed facility would disturb approximately 67 ac (27 ha) of land or approximately 11.5% of the project area; the remainder would remain undisturbed. The total "developed" area (or the total area that would contain structures, hardened surfaces, and associated setbacks) is anticipated to be roughly 32 ac (13 ha), or approximately 5.6% of the project area. Table 2-1 summarizes the area that would be disturbed and occupied by each of the major components of the proposed project.

Table 2-1. Area disturbed and developed by the proposed Kahuku Wind Power facility.

Project Component	Approximate Area	
	Disturbed	Developed
12 WTG Foundations & Pads[1]	36.90 ac (14.93 ha)	21.36 ac (8.64 ha)
Trenching for Underground Electrical Cables[2]	0.76 ac (0.31 ha)	0
Permanent Unguyed Met Tower	0.13 ac (0.05 ha)	0.014 ac (0.006 ha)
Base Yard Area (O&M Building, BESS Enclosure, Electrical Substation)	5.00 ac (2.02 ha)	2.90 ac (1.17 ha)
On-Site Microwave Tower	0.02 ac (0.008 ha)	0.003 ac (0.001 ha)
Access Roads and Spur Roads	17.30 ac (7.00 ha)	7.60 ac (3.07 ha)
Relocated Distribution Line	1.50 ac (0.61 ha)	0.01 ac (0.004 ha)
Temporary Truck Turnaround and Temporary Staging Areas	5.00 ac (2.02 ha)	0
TOTAL	66.61 ac (26.96 ha)	31.89 (12.90 ha)

1) Each developed turbine site would be 1.78 ac (0.72 ha) in size.
2) Estimate based on 3.0 ft (0.9 m) wide trenches.

2.1.8 Project Schedule and Timeline

Construction of the Kahuku Wind Power facility is estimated to require six months. The turbines would likely be constructed in the fourth month and would be erected with the assistance of one large construction crane. It is expected that the crane would be on-site for approximately two weeks.

Once operational, Kahuku Wind Power LLC estimates that the proposed facility would have a lifespan of approximately 20 years. After this time period, Kahuku Wind Power LLC would arrange to either extend the life of the project or remove the facility components and remediate/stabilize the project area. Removal of the structures would generate waste that would be disposed of and/or recycled according to recycling technologies and markets and disposal regulations existing at the time of demolition or renovation.

2.1.9 Permits and Authorizations

The proposed project obtained a Conditional Use Permit-Minor (CUP-M) from the City and County of Honolulu’s Department of Planning and Permitting (DPP) in January 2008. Due to proposed design modifications to the project, a new CUP was applied for in October 2009 and approved in December 2009. A Power Purchasing Agreement (PPA) was finalized with HECO in July 2009. Final grading permits were submitted to the City and County of Honolulu and building permits were submitted in January 2010. The Interconnection Requirement Study (IRS) drafted by HECO is expected to be finalized by January 31, 2010. This study addresses the transmission and distribution interactions between the proposed facility and HECO’s system.

Based on information provided by Kahuku Wind Power LLC and informal consultation with the U.S. Fish and Wildlife Service (USFWS), DOE determined that the proposed project is likely to adversely affect seven federally listed threatened or endangered species and one state listed endangered species. DOE consulted with USFWS under Section 7 of the Endangered Species Act (ESA) to address the potential for construction and operation of the facility to adversely affect federally listed threatened and endangered species. Kahuku Wind Power LLC is in the final stages of obtaining an Incidental Take License (ITL) in accordance with Chapter 195-D, Hawaiʻi Revised Statutes (HRS), which is issued by the Hawaiʻi Department of Land and Natural Resources (DLNR). A detailed discussion of DOE’s consultation with USFWS under Section 7 of ESA and Kahuku Wind Power LLC’s consultation with DLNR in accordance with Chapter 195-D, HRS is contained in Section 3.12.

2.2 No Action Alternative

Under the No Action Alternative, DOE would not issue a loan guarantee for the proposed Kahuku Wind Power facility. Without the DOE loan, it is unlikely that Kahuku Wind Power LLC would implement the project as currently planned. Thus, the No Action Alternative is that no wind power facility would be constructed, and the Island of Oʻahu’s energy needs would continue to be provided primarily by imported fossil fuels.

The decision for DOE consideration covered by this NEPA review is whether or not to approve the loan guarantee for the Kahuku Wind Power facility. Kahuku Wind Power LLC’s decision process in selecting the Kahuku site is described in Section 2.3.1 and supported by state and local approvals (see Section 3.10.1.1 and 3.10.1.2, and Appendix D). Further, there are no unresolved conflicts concerning alternative uses of available resources associated with the project area that would suggest the need for other alternatives (40 CFR 1508.9(b)). Therefore, other than no action, there is no alternative to the proposed action considered in this NEPA review.

2.3 Alternatives Considered But Eliminated

2.3.1 Alternate Project Locations

The proposed project area was selected based on the existing needs for renewable energy in Hawaiʻi, evaluation of wind resources on Oʻahu, and a thorough consideration of alternative sites in the area. While wind power is a commercially viable utility-scale renewable energy resource, Oʻahu's wind resources, topography, and high land values make developing wind energy projects on the island a challenge. A recent report on renewable resources in Hawaiʻi found that "with its high competition for land available for development and protected natural features, it is much more difficult to identify ideal sites for renewable energy projects on Oʻahu than on the other Hawaiian Islands. The best potential combination of land available for wind development and a strong, proven wind resource is found in the Kahuku area" (Global Energy Concepts LLC, December 2006). Kahuku was the location of several previous wind energy projects in the 1980s and early 1990s and has a well-documented wind regime. The area also benefits from existing electrical transmission lines and a community that is largely familiar with, and supportive of, wind energy generation.

This study also identified two other sites on Oʻahu with reasonable potential for wind development, Kaʻena Point to the west of Kahuku and Kahe Ridge to the south. Kaʻena Point was ruled out because it has limited transmission infrastructure and possesses important cultural significance and protected wildlife habitats. Kaʻena Point also has one of the largest seabird colonies on the main Hawaiian Islands (DOFAW 2007). While none of the three nesting seabird species are endangered [Laysan albatross (*Phoebastria immutabilis*), wedge-tailed shearwater (*Puffinus pacificus*) and white-tailed tropicbird (*Phaethon lepturus*)], the construction of a wind facility close to large seasonal concentrations of these breeding seabirds is undesirable (Appendix A). Moreover, nine other species of seabirds, the native pueo (*Asio flammeus sandwichensis*), and numerous migratory birds are regularly seen in the area and may be vulnerable to collisions with wind facility infrastructure.

Kahe Ridge was previously proposed as the site of a wind facility by HECO, but the project was cancelled in 2005 when the Mayor of Honolulu announced that permits would not be issued for the project based on concerns expressed at public meetings. Consequently, both Kaʻena Point and Kahe Ridge were discounted as potential sites for the proposed project.

Once Kahuku was identified as the most viable location for the proposed project, Kahuku Wind Power LLC evaluated undeveloped land in and around Kahuku proximate to existing transmission infrastructure. A potential site in Pūpūkea-Paumalū, to the southwest of the proposed project area, was eliminated after it was determined that access to the site would be difficult, gaining site control for the amount of land necessary for a utility-scale wind energy project was improbable, and the site was bordered by a satellite communications facility on one side and a conservation trust on the other. Additionally, undeveloped lands to the west and south of this site are controlled by the U.S. Army and regularly used for aircraft maneuvering and parachute training exercises. After careful consideration and elimination of these alternate sites, Kahuku Wind Power LLC selected the proposed project area and purchased the property to facilitate the planning and permitting of the Kahuku Wind Power facility.

2.3.2 Alternative Site Layouts

Kahuku Wind Power LLC determined the optimum configuration for the turbine layout based on meteorological data collection and analysis of the wind resource of the property over 12 months. Wind turbines are sited where they would produce the most energy given the area's wind resource and topography. The initial configuration contemplated a layout consisting of two parallel rows of turbines set perpendicular to a presumed dominant northeasterly wind direction. However, after collecting and analyzing the on-site meteorological equipment data, it was discovered that the predominant wind direction is more easterly than expected. Kahuku Wind Power LLC therefore adjusted the layout of the turbines to maximize their production from this wind profile.

A study of the on-site meteorological conditions was performed concurrently with avian surveys described in Section 3.12. Results from these surveys and avian impact modeling described in Section 3.12.2.1 provided Kahuku Wind Power LLC with an expectation that annual mortality rates of listed species with the proposed layout would be exceedingly low. Estimated mortality rates are on average from 0.03 to 0.4 individuals per species per year. Given these very low numbers and knowledge that risk of mortality cannot reach zero, Kahuku Wind Power LLC did not examine alternate turbine configurations with regard to their potential to further reduce the potential for avian and bat collisions.

CHAPTER 3: AFFECTED ENVIRONMENT AND ENVIRONMENTAL EFFECTS

3.1 Introduction

This chapter describes the existing physical, biological, and socioeconomic conditions of the project area and the potential environmental effects that could result from implementation of the proposed action or No Action Alternative described in Chapter 2. A discussion of potential cumulative effects is also provided in this Chapter.

3.2 Climate

3.2.1 Current Climatic Conditions

The climate of the Hawaiian Islands varies little throughout the year, with only minor periods of diurnal and seasonal variability. Generally, temperatures during the summer season (May through September) are warm, conditions are dry, and persistent trade winds originate from the northeast. The winter season (October through April) is characterized by cooler temperatures, higher precipitation, and less equable winds (Juvik and Juvik 1998).

Local climatic conditions at the project area are characteristic of lowland areas on the windward side of O‘ahu, with relatively constant temperatures and persistent northeast trade winds. Annual temperatures range from approximately 68.9 to 80.8°F (20.5 to 27.1°C) and annual precipitation is between 37.88 and 40.86 inches (96.2 and 103.8 cm) (NOAA 2002, DBEDT 2008a). Due to its location on the northern corner of O‘ahu, Kahuku is considered a high wind energy site (Lau and Mink 2006). Northeasterly trade winds are present nearly 90% of the year in Kahuku and the southerly Kona winds are present approximately 10% of the year (Smith, Young & Assoc. 1990).

Climatic conditions at the two off-site microwave tower areas are generally similar to conditions in Kahuku. Hale‘iwa has an average annual rainfall of approximately 28 inches (71 cm) and an average temperature of 70°F (21°C) (Thompson 2005). The Flying R Ranch area experiences a higher average annual rainfall, with approximately 39 inches (99 cm) (Giambelluca et al. 1986). Both areas experience persistent northeast trade winds during most of the year.

3.2.1.1 Potential Impacts of the Proposed Action

WTGs of the type and number that are proposed at Kahuku do not have the potential to affect temperature, rainfall, humidity, or most other meteorological parameters. By altering the atmospheric mixing that occurs as wind passes over a site, the WTGs do have the potential to slightly affect certain aspects of the local wind regime; however, Kahuku Wind Power would extract only a small percentage of the wind energy at elevations above ground level, and no existing or proposed uses in the area would be affected by minor changes in wind speed and/or velocity.

3.2.1.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, there would be no change from the existing conditions.

3.2.2 Global Climate Change

Global temperatures on the Earth’s surface have increased by an average of 1.33°F (0.74°C) over the last 100 years; this warming trend has accelerated within the last 50 years, increasing by 0.23°F (0.13°C) each decade (Solomon et al. 2007). An increase in the average temperature of the Earth may produce changes in sea levels, rainfall patterns, and intensity and frequency of extreme weather events. Global mean sea levels are currently rising at twice the average rate recorded during the 20th century (3 mm/yr instead of 1.6 mm/yr). Collectively, these effects are referred to as “climate change” (National Energy Information Center 2008).

According to the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), global climate change is very likely due to anthropogenic greenhouse gas concentrations (IPCC 2007). Greenhouse gases, which include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are chemical compounds in the Earth’s atmosphere that trap heat. Of these gases, CO_2 is recognized by the IPCC as the primary greenhouse gas affecting climate change (IPCC 2007). Present atmospheric concentrations of CO_2 are believed to be higher than at any time in at least the last 650,000 years, primarily as a result of combustion of fossil fuels (IPCC 2007). It is also very likely that observed increases in CH_4 are also partially due to fossil fuel use (IPCC 2007).

The maritime location of the Hawaiian Islands makes the archipelago relatively well buffered climatically (Benning et al. 2002). However, climatic changes have been documented throughout the state. Average air temperature increases of 0.3196°F (0.1776°C) per decade have been recorded in Hawaiʻi (Giambelluca et al. 2008), with higher elevations warming faster than lower elevations. Tide gauges at sea level at the Honolulu Harbor estimate that sea level has risen at 1.4 ± 0.3 mm/year over the past century (Caccamise et al. 2005). Some estimates project that a 3.3 ft (1 m) rise in sea level is possible by the end of the century for Hawaiʻi (Fletcher 2009). Sea surface temperatures near the islands have been increasing recently, showing an average 0.72°F (0.4°C) rise between 1957 and 1987 (Giambelluca et al. 1996). Temperatures are expected to rise at least another 2.7 to 3.6°F (1.5 – 2°C) by the end of the century (IPCC 2007). Global increase in sea surface temperatures has been associated with causing more intense hurricanes in the Pacific and Atlantic (Webster et. al 2005, U.S. Climate Change Science Program 2009) and could result in higher peak wind speeds and heavier rainfall (IPCC 2007).

Climate change also has the potential to impact a phenomenon known as the trade wind inversion layer. In Hawaiʻi, descending air in the Hadley cell warms as it is compressed, while moist air at the surface progressively cools as it rises. Where rising and sinking air meet, a layer is formed (the trade wind inversion layer) in which warm air overlies cool air (Juvik and Juvik 1998). Typically, this layer occurs between 5,000 and 10,000 ft (1,500 and 3,000 m); however, climate change may raise or lower the altitude at which the trade wind inversion layer currently occurs (Pounds et al. 1999, Still et al. 1999). The formation of the trade wind inversion strongly influences climate by altering precipitation inputs from mist and fog drip (Miller 2008, Benning et al. 2002). Thus, changes in the inversion layer can result in hydrological and ecological changes (Giambelluca and Nullet 1991). Studies show the tradewind inversion layer has already responded substantially to past climate changes (Benning et al. 2002).

3.2.2.1 Potential Impacts of the Proposed Action

The proposed Kahuku Wind Power project is expected to have a beneficial impact on the climate by decreasing fossil fuel consumption and decreasing emission of greenhouse gases. The proposed project would eliminate the use of approximately 154,550 barrels of oil annually that would otherwise be used to produce conventional power. Eliminating the consumption of this amount of oil would reduce emissions of CO_2 and nitrogen oxides (NO_X) by approximately 159.6 million pounds (72.4 million kg) and 237.7 thousand pounds (107.8 thousand kg) per year, respectively.

The primary greenhouse gas contribution from the proposed project would be from CO_2 produced by burning fossil fuels during the short-term construction phase. A summary of estimated emissions during construction and operation of the project is provided in Section 3.6.2.1. Although construction and operation of the facility would result in some emissions of CO_2 (employee trips, transporting materials, etc.), reductions that would result from replacing fossil fuel-generated power with wind-generated power produced by the proposed project would more than offset these emissions.

3.2.2.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, there would be no change from the existing conditions. Global climate change benefits from reduced emissions of greenhouse gases and other air pollutants would not occur if the facility were not constructed and operated.

3.3 Topography

The topography of Oʻahu is characterized by a broad central plateau bounded by the Koʻolau Mountains to the east and the Waiʻanae Mountains to the west. The mountain ranges are roughly parallel and oriented on a northwest to southeast axis. Both mountain ranges have tall, steep slopes as a result of erosion from wind, rain, and sea (Moore 1964, Polhemus 2007).

The project area is located on a small plateau lying above low coastal terraces (Hunt and DeCarlo 2000) near Kahuku Point. The seaward edge of the plateau consists of lithified sand from ancient coastal dunes that are now eroded and sculpted by the wind. Inland of the plateau, the land slopes upward into hills and gullies (Hobdy 2007). Incised hillsides present in the project area generally increase in elevation to the west. Elevation of the project area ranges from approximately 40 ft (12 m) above mean sea level on the eastern edge to approximately 525 ft (161 m) on the western side. The average elevation is roughly 218 ft (67 m). Highly weathered, remnant limestone reef escarpments are found along the northern edge of the project area. No other notable topographic features are present. Three intermittent gulches and gullies formed by soil excavation and other activities cut across the area.

The Waialua Substation off-site microwave tower site is located on relatively flat terrain at an approximately 26 ft (8 m) elevation. The Flying R Ranch microwave tower site is located at 700 ft (213 m) elevation roughly 2.3 mi (3.7 km) from Kamaohanui summit. The site slopes roughly 30 degrees in the northwest direction.

3.3.1 Potential Impacts of the Proposed Action

Grading would be required for the turbine pads, internal access roads, and substation associated with the proposed facility. Additional minor grading would occur on the property to prevent ponding. This grading would cause minor alterations of local topography, but no alteration of major topographic features. Therefore, it is not expected that the proposed alterations to the site would significantly affect the natural topography.

No grading is proposed at the Waialua Substation microwave tower site. Approximately 1,600 ft^2 (149 m^2) would be graded at the Flying R Ranch site; however, this is not expected to substantially alter the topography of the area.

3.3.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, no adverse impacts to the existing topography would be expected.

3.4 Geology, Soils, and Geologic Hazards

The Hawaiian Islands continue to be formed by a series of volcanic eruptions that have occurred at various hotspots beneath the Earth's crust. As the tectonic plate supporting the islands has slowly drifted northwestward, magma has welled up from fixed spots creating, in conjunction with subsidence and erosion, a linear chain of islands. Oʻahu, the third largest island in the Hawaiian archipelago, was created by several geological processes. These include shield-building volcanism, subsidence, weathering, erosion, sedimentation, and rejuvenated volcanism (Hunt 1996). Oʻahu is mostly composed of the heavily eroded remnants of two large Pliocene shield volcanoes - Waiʻanae and Koʻolau (Juvik and Juvik 1998). The extinct Koʻolau Volcano, which formed about 2.2 to 2.5 million years ago, is comprised of shield lavas, referred to as Koʻolau Basalt, as well as rejuvenated stages, termed the Honolulu Volcanics (Juvik and Juvik 1998, Lau and Mink 2006).

The proposed project area is located at the foot of the Koʻolau Mountains. Eroded shield volcanoes, such as the Koʻolau Volcano, typically have dike complexes of basaltic material associated with active rift zones that extend vertically into the lava flows, inhibiting normal groundwater flow (Hunt 1996). The majority of the project area is underlain by Koʻolau Basalt lava flows that were active 1.8 to 3 million years ago. A narrow strip of alluvial sand and gravel runs through roughly the middle of the project area. Older dune deposits, as well as lagoon and reef deposits (limestone and mudstone), are present near the seaward (makai) boundary of the property (Belt Collins Hawaiʻi Ltd. 2007a).

Coral reefs now exposed as escarpments in the northern portion of the project area formed during a time when the ocean was at a higher level. The coral reef escarpments are pockmarked with shallow overhangs and small caves due to erosion. Consultation meetings and presentations with the public highlighted the rich history of these escarpments. In response to community concerns, Kahuku Wind Power has committed to preserve the coral escarpments located on the project area, as well as to document the moʻolelo (stories, legends) concerning these areas. Sixty-ft (18-m) buffer areas would be placed around these coral escarpment areas. No other unique or unusual geologic resources or conditions are known to occur on-site.

The Waialua Substation microwave tower site is situated within the Waialua-Haleʻiwa coastal plain, a narrow plain along Oʻahu's northern coastline that was formed by lava flows from the Koʻolau and Waiʻanae Mountain Ranges (Stearns 1985). The Flying R Ranch site is located on the northern portion of the Waiʻanae Mountain Range. No unique or unusual geologic resources or conditions are known to occur at either of the off-site microwave tower sites.

Various soil types have developed throughout the Island of Oʻahu as the basaltic lavas and volcanic ash from the volcanoes have weathered and decomposed (Juvik and Juvik 1998). Soils on the Island of Oʻahu were classified and defined by the U.S. Department of Agriculture (USDA) Soil Conservation Service and Natural Resource Conservation Service (NRCS) (Foote et al. 1972). Soil types and features identified by the NRCS in the project area are summarized in Table 3-1 and shown in Figure 3-1. According to the NRCS National Hydric Soils List, none of the soils in the project area is considered hydric.

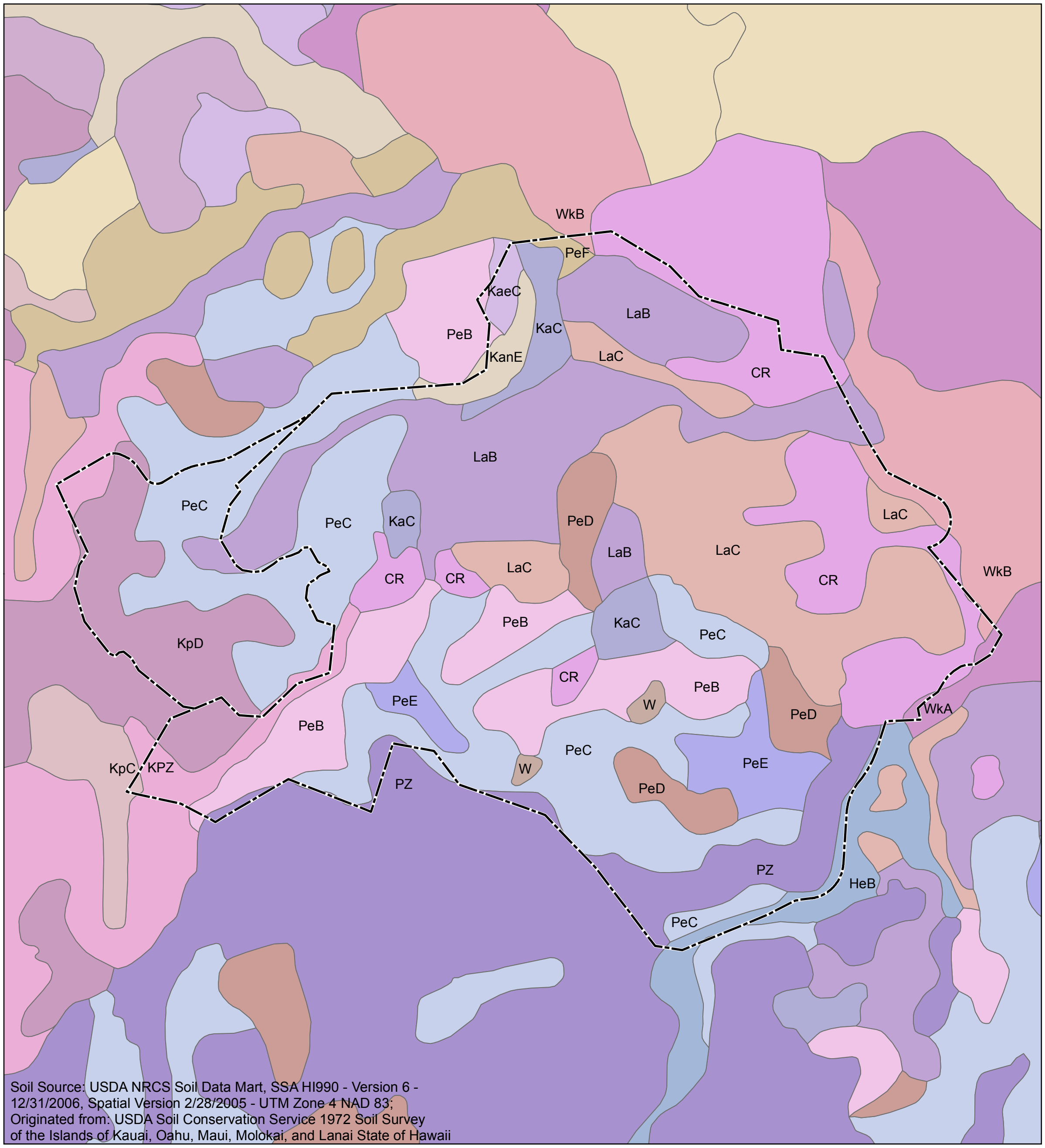
Soils on-site generally consist of well-drained silty clay soils that developed in old alluvium and colluvium derived from basic igneous rock. Only a thin layer of friable, red soil material is present within the cracks, crevices, and depressions of the coral outcrop. A narrow strip of alluvial sand and gravel underlies a portion of the property, roughly bisecting the middle of the project area. Large areas of the property are devoid of topsoil due to erosion associated with past land uses, such as sugar cultivation, grazing, and soil excavation. Between 1987 and 1991, approximately 47 ac (19 ha) of soil was excavated from portions of the site for use as fill material for the Arnold Palmer Golf Course at the Turtle Bay Resort (Belt Collins Hawaiʻi Ltd. 2007a). Kahuku Wind Power LLC is a member of the Oʻahu Soil and Water Conservation District, and is working with the NRCS to develop a conservation plan for the property to manage soil erosion.

Sites proposed for the off-site microwave towers are located on disturbed soils or existing asphalt pavement. The soils at the Waialua Substation site are classified as Waialua silty clay, 0 to 3% slopes. While these soils presumably underlie the site, the entire parcel is covered in asphalt pavement or gravel. The soils in the Flying Ranch site are classified as Kemoʻo silty clay, 12 to 20% slopes.

3.4.1 Potential Impacts of the Proposed Action

No significant impacts to geological resources or conditions are expected to occur as a result of the proposed action. Grading for new roads, WTG pads, and other project components would cause shallow alteration of bedrock (i.e. occur on or near the surface of the ground) in some areas. The coral reef exposures would be protected and avoided. No significant geologic resources are known or expected to occur in the project area, so geologic alterations are expected to be minor.

Approximately 32 ac (13 ha) of ground would be disturbed by construction of the proposed project (Table 2-1). Temporary construction activities would include establishment of an on-site construction staging and stockpiling area approximately 1.72 ac (0.69 ha) in area, which would be surfaced with gravel to minimize erosion. Grading/scraping would impact soils in the disturbed areas and expose the areas to increased erosion hazard. Kahuku Wind Power LLC also intends to grade some low-lying areas of the project area during construction to improve drainage and prevent standing water from collecting after heavy rain (see Section 3.5.3).



Soil Source: USDA NRCS Soil Data Mart, SSA HI990 - Version 6 - 12/31/2006, Spatial Version 2/28/2005 - UTM Zone 4 NAD 83; Originated from: USDA Soil Conservation Service 1972 Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai State of Hawaii

Soil Type

- ● CR, Coral outcrop
- ● HeB, Haleiwa silty clay, 2 to 6 percent slopes
- ● KPZ, Kemoo-Badland complex
- ● KaC, Kaena clay, 6 to 12 percent slopes
- ● KaeC, Kaena stony clay, 6 to 12 percent slopes
- ● KanE, Kaena very stony clay, 10 to 35 percent slopes
- ● KpC, Kemoo silty clay, 6 to 12 percent slopes
- ● KpD, Kemoo silty clay, 12 to 20 percent slopes
- ● LaB, Lahaina silty clay, 3 to 7 percent slopes
- ● LaC, Lahaina silty clay, 7 to 15 percent slopes
- ● PZ, Paumalu-Badland complex
- ● PeB, Paumalu silty clay, 3 to 8 percent slopes
- ● PeC, Paumalu silty clay, 8-15 percent slopes
- ● PeD, Paumalu silty clay, 15 to 25 percent slopes
- ● PeE, Paumalu silty clay, 25 to 40 percent slopes
- ● PeF, Paumalu silty clay, 40 to 70 percent slopes
- ● W, Water > 40 acres
- ● WkA, Waialua silty clay, 0 to 3 percent slopes
- ● WkB, Waialua silty clay, 3 to 8 percent slopes

Figure 3-1

Soil Types within the Kahuku Wind Power Project Area

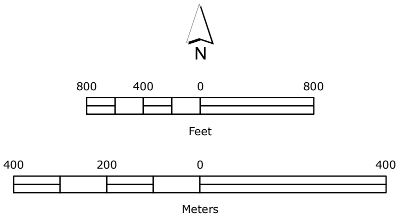


Table 3-1. Soil types and characteristics within the Kahuku Wind Power project area based on classifications from Foote et al. (1972).

Soil Type	Slopes	Key Characteristics	Site Coverage
Paumalū silty clay	8-15%	Permeability moderately rapid; runoff slow to medium; erosion slight to moderate	22.25%
Lahaina silty clay	3-7%	Permeability moderate; runoff: slow; erosion slight.	15.70%
Lahaina silty clay	7-15%	Permeability moderate; runoff medium; erosion moderate.	14.55%
Coral Outcrop	--	--	10.08%
Paumalū silty clay	3-8%	Permeability moderately rapid; runoff slow; erosion slight	8.92%
Kemo‘o silty clay	12-20%	Permeability moderate/moderately rapid; runoff medium; erosion moderate.	6.75%
Paumalū-badland complex	--	Permeability moderately rapid; runoff medium to rapid; erosion moderate to severe.	4.88%
Paumalū silty clay	15-25%	Permeability moderately rapid; runoff medium; erosion moderate.	4.11%
Paumalū silty clay	25-40%	Permeability moderately rapid; runoff medium to rapid; erosion moderate to severe.	3.32%
Ka‘ena clay	6-12%	Permeability slow; runoff: slow to medium; erosion slight to moderate.	3.17%
Kemoo-badland complex	--	Permeability moderate/moderately rapid; runoff medium to rapid; erosion moderate to severe.	2.25%
Ka‘ena very stony clay	10-35%	Permeability slow; runoff medium to rapid; erosion moderate to severe.	1.15%
Hale‘iwa silty clay	2-6%	Permeability moderate; runoff slow; erosion slight.	0.71%
Waialua silty clay	3-8%	Permeability moderate; runoff: slow; erosion slight.	0.70%
Ka‘ena stony clay	6-12%	Permeability slow; runoff slow to medium; erosion slight to moderate.	0.53%
Water > 40 ac	--	--	0.43%
Paumalū silty clay	40-70%	Permeability moderately rapid; runoff rapid; erosion severe.	0.28%

Soil Type	Slopes	Key Characteristics	Site Coverage
Waialua silty clay	0-3%	Permeability moderate; runoff: slow; erosion slight.	0.19%
Kemo‘o silty clay	6-12%	Permeability moderate/moderately rapid; runoff medium; erosion: slight to moderate.	0.05%

All surface alterations associated with the proposed project would comply with applicable construction codes for erosion and sedimentation control during the construction process. Best Management Practices (BMPs) would be employed to prevent and minimize soil erosion during construction and operation of the proposed project. The BMPs are outlined in Table 3-2. Permanent soil stabilization (i.e., graveling or re-planting/re-seeding of vegetation) would occur in temporarily disturbed areas as soon as practical after final grading. Impacts to soils are expected to be minor because of the use of the BMPs and revegetation of temporarily disturbed areas.

3.4.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, no impacts to geologic features or soils would be expected.

Table 3-2. Potential pollutants from construction activities and Best Management Practices.

Pollutant	Source/Activity	BMP
Soil/ Sediment/ Rock	Excavation, grading, stockpiles, runoff from watering for dust	Silt fences, protection of stockpiles, natural vegetation, sand bags, construction entrance stabilization, temporary soil stabilization, geotextile mats (internal access road slopes), avoid excess dust by control watering
Oil and Gas	Construction equipment, vehicles	Regular vehicle and equipment inspection, prohibition of on-site fuel storage, drip pan for on-site tanker fueling, spill kits
Construction Waste	Construction debris, select fill, paint, chemicals, etc.	Protection of stockpiles, dumpsters, periodic waste removal and disposal, compaction and swales, containment pallets
Concrete Wash Water	Pouring of WTG foundations	Containment in wash water pits, silt fences
Equipment and Vehicle Wash Water	Cleaning construction equipment	Containment berms around equipment washing area, off-site vehicle washing
Sanitary Waste	Portable toilets or septic tank	Sanitary/septic waste management
Source: Department of Environmental Services, City and County of Honolulu (1999).		

3.5 Water Resources

3.5.1 Regulatory Framework

The Clean Water Act (CWA), formerly known as the Federal Water Pollution Control Act, is the primary statute governing water pollution and water quality in wetlands or other waters subject to U.S. Army Corps of Engineers (USACE) jurisdiction. Section 404 of the CWA regulates the discharge of dredged or fill material into jurisdictional waters of the United States. The USACE is authorized to issue permits for the discharge of dredged or fill materials into the waters of the United States at specified disposal sites.

Executive Order 11990 requires federal agencies to ensure their actions minimize the destruction, loss or degradation of wetlands. In carrying out their actions, each agency shall preserve and enhance the natural and beneficial values of wetlands.

Executive Order 11988 directs federal agencies to take actions to reduce the risk of flood loss, minimize flood impacts on human safety, health and welfare, and restore and preserve floodplain natural and beneficial values. The Executive Order is designed to preserve and restore the natural and beneficial values that floodplains provide.

The Wild and Scenic Rivers Act (16 USC 1271 et seq.) was created to identify and preserve rivers that possess outstanding scenic, recreational, geologic, fish and wildlife, historic, and cultural attributes. Rivers designated under this Act are protected to enhance the value(s) for which they were designated. There are no rivers designated under this Act in the State of Hawaiʻi; therefore, the Wild and Scenic Rivers Act is not applicable to the proposed project.

3.5.2 Surface Water

Stream flow and other hydrologic processes in Hawaiʻi are influenced by the climatic and geological features of the area, including rainfall and wind patterns. The majority of the perennial streams on Oʻahu (84%) are located in the windward Koʻolau Mountains which produce a larger amount of orographic precipitation compared to the leeward side (Polhemus 2007). Permeable underlying rock may also cause some streams on Oʻahu to have lengthy dry reaches under natural conditions. Streams in the Kahuku area are considered to be naturally intermittent (Polhemus et al. 1992) and are typically short and steep, with permeable upland soils creating rapid infiltration into the Koʻolau aquifer. As a result, streams in the lowland areas have periods of high peak floods and little base flow (Hunt and De Carlo 2000).

Three intermittent streams occur on portions of the project area- Ohiaʻai Gulch, Kalaeokahipa Gulch, and an unnamed headwater tributary to James Campbell NWR (Smith, Young & Assoc. 1990). Ohiaʻai Gulch drains along the eastern boundary of the property and is referred to as Kiʻi Ditch at lower elevation. Kalaeokahipa Gulch transverses the northwestern portion of the project area. The unnamed headwater tributary to James Campbell NWR parallels Nudist Camp Road, which is makai of Kamehameha Highway (Figure 3-2). These three streams are the primary drainage areas within the Kiʻi watershed, in which to proposed project lies. The Kiʻi watershed is approximately 3,968 acres (1,606 ha) in area (DAR 2008). Various other smaller drainage gulches occur within the watershed on the lowland area makai of the proposed Kahuku Wind Power facility.

In the late 1970s, USFWS Division of Ecological Services biologists used U.S. Geological Survey (USGS) 7.5-minute quadrangle maps and georectified orthophotos to spot check and map wetlands in Hawaiʻi as a part of the National Wetlands Inventory (NWI) Program (Cowardin et al. 1979). According to the Cowardin classification schema, three wetlands occur within the project area: Ohiaʻai Gulch/Kiʻi Ditch, Kalaeokahipa Gulch, and the unnamed tributary to James Campbell NWR. All of these were described by USFWS as being palustrine, forested, broad-leafed evergreen, seasonal (PFO3C) wetlands. A fourth wetland (Hoʻolapa Gulch) was identified outside of the project area in the lower reach of Ohiaʻai Gulch/Kiʻi Ditch. This wetland was described as palustrine, emergent, persistent, seasonally flooded, excavated.

SWCA biologists conducted a wetland jurisdictional boundary determination in the project area to identify any wetlands or other waters subject to USACE jurisdiction under Section 404 of the CWA (Appendix B). No permanent surface water is present in the project area. Certain low-lying areas within the project area can temporarily hold ponded water after periods of extended heavy rainfall. Contrary to the NWI mapping, no wetlands meeting the three established criteria of hydrophytic vegetation, hydric soils, and water regime were found to occur within project area boundaries (SWCA 2008). Ohiaʻai and Kalaeokahipa gulches are subject to discretionary USACE jurisdiction because of their "significant nexus" to waters at James Campbell NWR (Figure 3-2). Thus, activities involving the discharge of dredge or fill materials into these waters would require a permit from the USACE.

No permanent surface water exists at any of the off-site microwave tower sites.

3.5.2.1 Potential Impacts of the Proposed Action

Potential impacts to water resources as a result of the project have been avoided by proper siting of the individual turbines, associated facilities, and roadways, and incorporation of BMPs into construction plans. Ohiaʻai Gulch, Kalaeokahipa Gulch, and the unnamed headwater tributary to James Campbell NWR are not proposed to be dredged or filled, and these waters lie outside the areas of the proposed facilities. Therefore, Kahuku Wind Power LLC does not need to obtain a CWA Section 404 permit.

The proposed action would result in only slight increases in impervious surfaces (approximately 26 ac). This represents less than 1% of the watershed that drains the area. Thus, the project would not significantly increase the volume of stormwater runoff leaving the project area. Localized topographic alterations resulting from site grading and the construction of building pads and roads would alter local drainage patterns and stormwater runoff pathways.

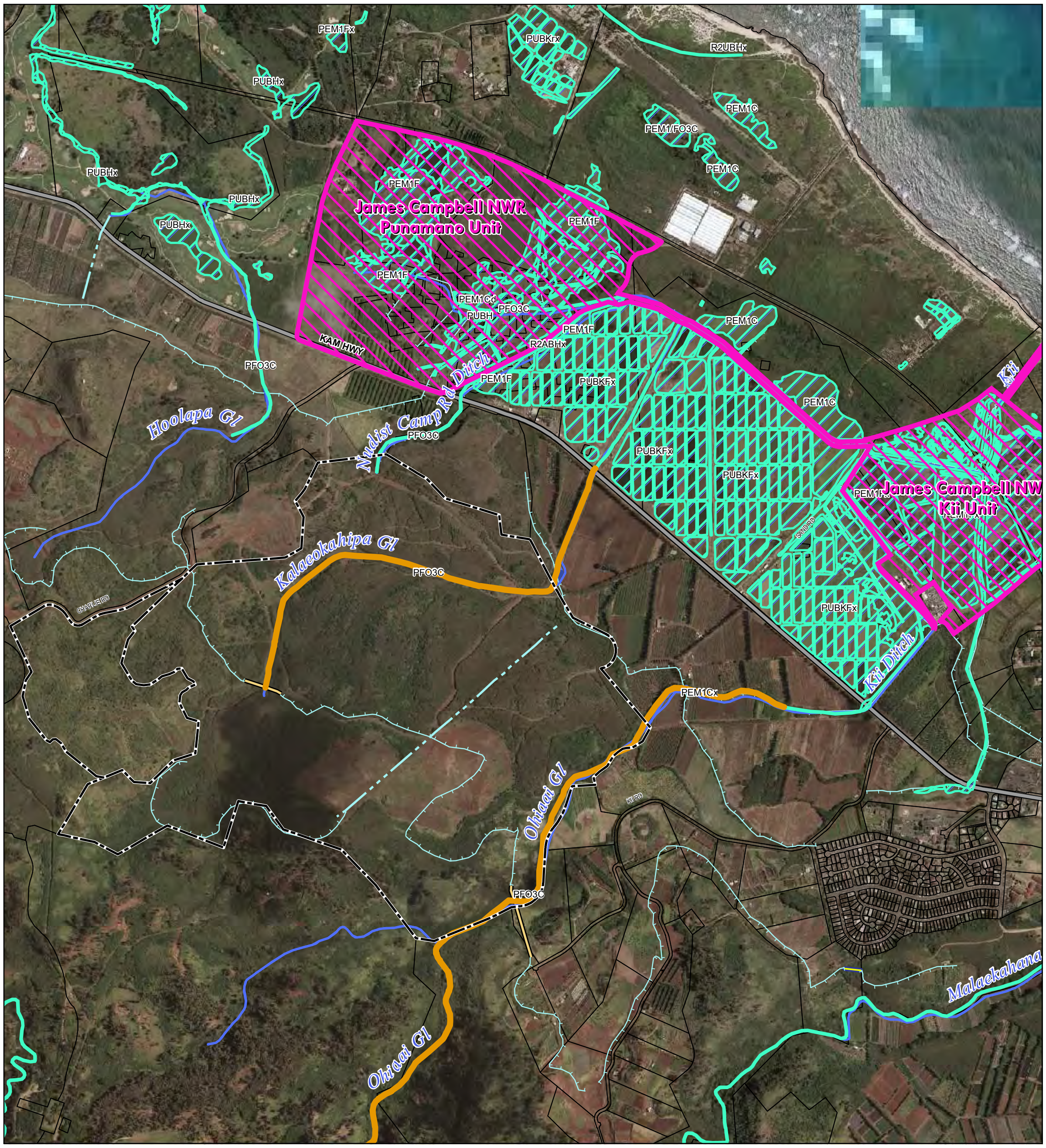


Figure 3-2

Jurisdictional waters at the Kahuku Wind Power project area

Data Sources: State of Hawaii GIS; City and County of Honolulu; USGS

During construction, ground disturbance would have the potential to increase the level of sediment and other pollutants in stormwater runoff, which could change the water quality of receiving waters. The areas most likely to receive stormwater runoff would be Ohiaʻai Gulch, Kalaeokahipa Gulch, and the unnamed headwater tributary to James Campbell NWR. However, BMPs and general construction management techniques would be implemented (see Table 3-2) to minimize any impacts to these areas.

No grading is proposed at the Waialua microwave tower site and construction of this tower would not result in an increase in impervious surfaces. Grading at the Flying R Ranch site would be minor (approximately 1,600 ft^2), and construction of this tower would not result in a large increase in impervious surfaces (approximately 169 ft^2). Therefore, no impacts to surface water hydrology or stormwater runoff at any of these sites are anticipated.

Kahuku Wind Power LLC received a Notice of General Permit Coverage for construction-related stormwater runoff pursuant to National Pollutant Discharge Elimination System (NPDES) regulations. BMPs anticipated to be used for the project are identified in Table 3-2. In addition to these BMPs, the following general construction management techniques would be incorporated to reduce impacts to hydrology, drainage, and water features under the proposed action:

- Clearing and grubbing would be held to the minimum necessary for grading, access and equipment operation.
- Erosion and sediment control measures would be in place prior to initiating earth moving activities. Functionality would be maintained throughout the construction period.
- Construction would be sequenced to minimize the exposure time of the cleared surface area.
- Temporary soil stabilization measures would be used on disturbed areas remaining exposed for more than 30 days.
- Disturbed areas would be protected and stabilized prior to initiating new disturbance.
- Control measures (i.e., silt fences, sand bag barriers, sediment traps, geotextile mats, and other measures intended for soil/sediment trapping) would be inspected once a week during dry periods and repaired as necessary.
- Control measures (i.e., silt fences, sand bag barriers, sediment traps, geotextile mats, and other measures intended for soil/sediment trapping) would be inspected and repaired as needed within 24 hours after a rainfall event of 0.5 inch or greater over a 24-hour period. During periods of prolonged rainfall, daily inspection would occur, unless extended heavy rainfall makes access impossible or hazardous.
- Records for all inspections and repairs would be maintained on site.
- Permanent soil stabilization (i.e., graveling or re-planting of vegetation) would be applied as soon as practical after final grading.

Kahuku Wind Power LLC has joined the Windward Oʻahu Soil and Water Conservation District as an active member and would continue to work with the district on issues regarding on-site drainage.

3.5.2.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, no changes would occur to existing surface water conditions.

3.5.3 Flooding

Executive Order 11988 requires federal agencies to avoid adverse impacts to floodplains to the extent possible. Flood Insurance Rate Maps (FIRM) prepared by the Federal Emergency Management Agency's National Flood Insurance Program depict flood hazard areas through the state. The maps classify land into four zones depending on the expectation of flood inundation and extent of investigation. The Kahuku Wind Power project area is entirely located in Flood Zone D where analysis of flood hazards has not been conducted and flood hazards are undetermined. The Flying R Ranch site is also located in an area identified as Flood Zone D. In general, because of topographic relief, potential for flooding at the Flying Ranch microwave tower site or in the project area, outside of the immediate vicinity of the gulches, appears to be very low. The Waialua Substation is located in Flood Zone X, outside the 100-year floodplain. Areas in Zone X have a 1% annual chance of sheet flow flooding where average depths are less than 1 ft (0.3).

Surface water generally drains from the southwest to northeast on the Kahuku Wind Power project area (Belt Collins Hawaiʻi Ltd. 2007a). Areas of standing water may be found in localized areas following prolonged periods of heavy rainfall. These highly ephemeral features lack both hydric soils and hydrophilic vegetation; yet when present, they have been found on occasion to attract waterbirds. In order to minimize risk of avian collision mortality, Kahuku Wind Power LLC intends to grade the low-lying areas during construction to improve drainage and prevent standing water from collecting after heavy rain, thereby eliminating the potential to attract waterbirds to the project area.

3.5.3.1 Potential Impacts of the Proposed Action

The level of flood risk on the project area is unknown. The National Flood Insurance Program does not have any regulations for developments within Zone D; however, no structures would be located within areas know to collect water after heavy rain. Minor grading or alterations that would be conducted on-site to prevent areas of standing water are not anticipated to affect the natural topography and drainage beyond the immediate area of the work. Thus, flood hazard would not be increased as a result of the proposed project.

None of the proposed microwave tower sites would involve work that could affect flood hazard.

3.5.3.2 Potential Impacts of the No Action Alternative

Existing conditions would not be impacted if the facility was not constructed and operated.

3.5.4 Groundwater

Oʻahu has a vast amount of groundwater, which supplies most of the domestic water supply (Macdonald et al. 1983, Lau and Mink 2006). Groundwater in Kahuku is part of the Koʻolauloa Aquifer system of the Windward Aquifer sector that extends from Punaluʻu Valley to Kahuku Point (Mink 1982). This aquifer primarily occurs as a basal freshwater lens in the dike-free Koʻolau Basalt and overlying unconsolidated and consolidated sedimentary deposits. Salinity is less than 250 milligrams per liter chloride [mg/l Cl^-]. It is currently used for drinking water, but has a high vulnerability to contamination (Belt Collins Hawaiʻi Ltd. 2007a).

Depth to groundwater in the project area is estimated to range from approximately 20 to 400 ft (6 to 122 m) below ground surface (Belt Collins Hawaiʻi Ltd. 2007a). Regionally, groundwater moves from the volcanic-rock aquifers into the overlying sedimentary deposits and eventually discharges to the ocean. The precise direction of groundwater flow beneath the property is not known (Belt Collins Hawaiʻi Ltd. 2007a). Mean annual groundwater recharge in the Koʻolau region due to rainfall infiltration is approximately 3.8 million gallons per day; however, ground water flow through the area is anticipated to be higher due to inflow from the adjacent dike complex (Miller et al. 1999).

The off-site microwave towers are in the Waialua Aquifer system of the North Aquifer sector area. Sedimentary caprock in the aquifer confines water within a thick basal lens in the dike-free Koʻolau Basalt. Groundwater in the region moves in a seaward direction and has been impacted by agricultural activities (Wilson Okamoto & Associates, Inc. 2000).

3.5.4.1 Potential Impacts of the Proposed Action

As stated previously, the proposed project would result in only slight increases in impervious surfaces. Because precipitation falling on these impervious surfaces would likely runoff to adjacent open lands where aquifer recharge would occur, the slight increase in impervious surfaces is not expected to measurably reduce potential for groundwater recharge.

Kahuku Wind Power LLC plans to tap an existing well located on an adjacent site for its water requirements (see Section 3.15.6). Given the nature of the proposed project and low number of people working on-site, water usage would be very low, and is not expected to adversely affect the amount of groundwater in the aquifer. Therefore, no components of the project would adversely affect the quantity of water available in basal groundwater.

Construction, operation, and decommissioning activities associated with the proposed action would require the use of some hazardous materials, although the variety and amounts of hazardous materials present during operation would be minimal. Types of hazardous materials to be used would include fuels (e.g., gasoline, diesel fuel), lubricants, cleaning solvents, and paints (see Section 3.9.2). With the implementation of the appropriate management practices discussed below, the adverse impacts of hazardous materials and wastes on groundwater are expected to be negligible to non-existent.

Prior to construction, Kahuku Wing Power LLC would prepare a Spill Prevention, Countermeasure, and Control (SPCC) Plan for the facility. The SPCC Plan would identify where hazardous materials and wastes are stored on-site, spill prevention measures to be implemented, training requirements, appropriate spill response actions for each material or waste, the locations of spill response kits on-site, a procedure for ensuring that the spill response kits are adequately stocked at all times, and procedures for making timely notifications to authorities. The plan would identify and address storage, use, transportation, and disposal of each hazardous material anticipated to be used in the project area. It would establish: inspection procedures; storage requirements; storage quantity limits; inventory control; nonhazardous product substitutes; disposition of excess materials; and material safety data sheets of hazardous materials. The SPCC would also identify requirements for notices to federal and local emergency response authorities and include emergency response plans.

Therefore, although groundwater in the project area has been identified with a high vulnerability to contamination, with the implementation of the measures outlined in the SPCC Plan, adverse impact of hazardous materials on groundwater is considered negligible.

3.5.4.2 Potential Impacts of the No Action Alternative

No change in existing groundwater conditions would occur if the facility was not constructed and operated.

3.6 Air Quality

3.6.1 Regulatory Framework

The Clean Air Act (CAA) authorizes the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS). These standards cover seven major air pollutants: carbon monoxide (CO), nitrogen oxides (NO_X), ozone (O_3), particulate matter smaller than 10 microns (PM_{10}), particulate matter smaller than 2.5 microns ($PM_{2.5}$), sulfur oxides (SO_X), and lead (CFR Title 40, Part 50).

Air quality is also regulated by the State Department of Health (DOH), Clean Air Branch. HAR Title 11, Chapter 59 (Ambient Air Quality Standards) establishes ambient air quality standards for six of the air pollutants mentioned above (all but $PM_{2.5}$), as well as hydrogen sulfide (H_2S) (HAR, Chapter 59). These standards are monitored and enforced by the Clean Air Branch. Six DOH air quality monitoring stations are present on the Island of O‘ahu. The closest station to the project area is located in Pearl City, roughly 19.3 mi (31 km) to the south of the Kahuku project area and on the leeward side of the island. Criteria pollutant levels at this station were well below state and federal ambient air quality standards during 2007 (DOH Clean Air Branch 2008).

HAR Title 11, Chapter 60.1 (Air Pollution Control) states that “no person, including any public body, shall engage in any activity which causes air pollution or causes or allows the emission of any regulated or hazardous air pollutant without first securing approval in writing from the director” (§11-60.1-2). According to Chapter 60.1, Air Pollution Control Permits are required prior to constructing, reconstructing, modifying, or operating a stationary air pollution source. Certain air pollution sources are exempt from these requirements including vehicles, trucks, cranes, graders, loaders, etc (§11-60.1-62d). Stationary sources with potential emissions of less than 1.0 ton per year for each air pollutant are also exempt from Air Pollution Control Permit requirements. Due to the type of equipment anticipated for use during construction and operation of the project, and the low levels of emissions anticipated as described below, Kahuku Wind Power LLC is not applying for an Air Pollution Control Permit from the Clean Air Branch. However, if additional equipment is needed that requires an Air Pollution Control Permit, Kahuku Wind Power LLC would apply for a permit at that time.

3.6.2 Regional and Local Air Quality

Air quality in Hawai‘i is consistently among the best in the nation, and criteria pollutant levels remain well below state and federal ambient air quality standards (DOH Clean Air Branch 2008). Few significant sources of air pollution occur near the project area. The most significant is windblown dust that naturally arises when strong winds sweep across eroded or overgrazed areas. Other sources of airborne contaminants on or near the project area include vehicular emission on the nearby Kamehameha Highway and other roads, wildfires and anthropogenic fires, agricultural sources, and irregular natural volcanic emission from the Island of Hawai‘i. As Kahuku is on the northeast-facing side of O‘ahu, air in the region is continually refreshed by the persistent northeast tradewinds for much of the year.

3.6.2.1 Potential Impacts of the Proposed Action

The construction and operation (including monitoring) phases of the proposed project would result in emissions of low levels of air pollutants. These emissions would be temporary or infrequent, and would be generated primarily through combustion of gasoline and diesel fuel for construction and maintenance vehicles.

Construction Phase:

Potential air pollutants that may be emitted (depending on the equipment used) during the construction phase include hydrocarbons (HC), fugitive dust (PM_{10}), CO, NOx, SO_2, and CO_2. These pollutants would be released by equipment during earthmoving operations, by vehicles traveling project roadways, and by vehicles traveling to and from the project area. Emissions would primarily occur locally, intermittently, and at low levels. Expected construction emissions for criteria pollutants are summarized in Table 3-3.

Table 3-3. Construction emissions for criteria pollutants (tons per year).

Emission Source	**HC**	**CO**	**NOx**	**SO_2**	**PM_{10}**	**CO_2**
Construction Equipment Emissions[1]	0.2	0.9	2.1	0.1	0.2	259.1
Fugitive Road Dust[2]	-	-	-	-	3.1	-
Fugitive Construction Dust[3]	-	-	-	-	3.9	-
Vehicle Emissions[4]	0.2	2.0	0.8	-	-	219.9
Total	0.4	2.9	2.9	0.1	6.2	479.0

1) Construction emission factors (EF) were generated from the EPA NONROAD2008 model for the 2010 calendar year.

2) Based on EPA AP-42: Equations for vehicle fugitive dust on unpaved, industrial roads. Assumes 80% control by BMP implementation.

3) Fugitive dust based on 35 acres of land disturbance and EF from Mid-Atlantic Regional Air Management Association (MARAMA). Fugitive Dust-Construction Calculation Sheet, online at: http://www.marama.org/visibility/Calculation_Sheets/. MRI= Midwest Research Institute, Inventory of Agricultural Tiling, Unpaved Roads, Airstrips and construction Sites., prepared for the U.S. EPA, PB 238-929, Contract 68-02-1437.

4) Vehicle mission rates were generated using EPA MOBILE6.2 highway vehicle emission factor model. Fleet Characterization: 25 POVs commuting to work, assuming 50% are pickup trucks and 50% passenger cars, and 53 heavy duty diesel trucks.

Construction-related emissions would comply with HAR Title 11 Chapter 60.1 regarding air pollution control, specifically Section 11-60.1-33, regarding fugitive dust and the prohibition of visible dust emissions at property boundaries. In order to minimize any adverse effect on air quality, Kahuku Wind Power LLC would require construction contractors to adhere to the following measures:

- Maintain all construction equipment in proper tune according to manufacturer's specifications.
- Fuel all off-road and portable diesel powered equipment, including but not limited to bulldozers, graders, cranes, loaders, scrapers, backhoes, generator sets, compressors, auxiliary power units, with motor vehicle diesel fuel.
- Maximize to the extent feasible the use of diesel construction equipment meeting the latest certification standard for off-road heavy-duty diesel engines.
- Minimize the extent of disturbed area where possible.

- Use water trucks or sprinkler systems (with no chemical additives) in sufficient quantities to minimize the amount of airborne dust leaving the site.
- Cover or continuously wet dirt stockpile areas (water with no chemical additives) containing more than 100 yards^3 (76.5 m^3) of material.
- Implement permanent dust control measures identified in the project landscape plans as soon as possible following completion of any soil disturbing activities.
- Stabilize all disturbed soil areas not subject to revegetation, paving, or development using approved chemical soil binders, jute netting, or other methods.
- Lay building pads and foundations as soon as possible after grading unless seeding or soil binders are used.
- Limit vehicle speed for all construction vehicles moving on any unpaved surface at the construction site to 15 mph (24 kph) or less.
- Cover all trucks hauling dirt, sand, soil, or other loose materials.

Because emissions during the construction phase would be temporary, relatively low level, and would be minimized by the measures stated above, construction of the project is not expected to result in appreciable degradation of air quality.

Operation Phase:

During operation (including environmental monitoring), there would be minor air emissions from staff and vendor vehicles. It is estimated that there would be a maximum of 10 one-way employee vehicle trips per day during operation. There would also be minor emissions from periodic use of cranes used for maintenance of the facility components. In addition to the maintenance equipment and vehicle emissions, operation of the electrical substation and BESS equipment would result in minor indirect emissions of greenhouse gases as a result of fossil fuel energy use for electricity. Expected operation emissions for criteria pollutants are summarized in Table 3-4.

Because vehicle usage in the area would be very low and emissions from operation of the facility would be minor, minimal adverse long-term impacts to air quality are anticipated to result from operation of the proposed project.

The proposed wind energy facility is expected to result in positive long-term impacts to regional air quality. The 30 MW of power potentially generated by the proposed facility would be able to eliminate the use of approximately 154,550 barrels of oil annually that would otherwise be used to produce conventional power. This in turn would reduce emissions of air pollutants; approximately 159.6 million pounds of CO_2 (79,800 tons), 330.3 thousand pounds of SO_2, 237.7 thousand pounds of NO_x, and 1.46 pounds of mercury per GWh per year.[3] Therefore, the proposed project has the potential to reduce the emission of major air pollutants that are products of generating electricity through combustion of fossil fuel. The proposed project would generate approximately 228.4 tons of CO_2 per year and potentially reduce approximately 79,800 tons of CO_2 per year, thus resulting in a net reduction of 79,571.6 tons or 159.1 million pounds per year of operation.

---

[3] These numbers are considered a conservative approximation, as the addition of the battery storage system should reduce the need for spinning reserves on the electricity grid, which would allow existing fossil fuel plants to run more efficiently, further reducing fuel use and emissions.

Table 3-4. Operation emissions for criteria pollutants (tons per year).

Emission Source	**HC**	**CO**	**NOx**	**SO_2**	**PM_{10}**	**CO_2**
Maintenance Equipment Emissions[1]	0.0007	0.0023	0.011	0.0003	0.0005	1.4
Vehicle Emissions[2]	0.3	2.9	0.2	-	-	148.6
Facility Electricity Usage[3]	-	-	-	-	-	78.4
Total	0.3007	2.9023	0.211	0.0003	0.0005	228.4

1) Assumes quarterly heavy overhaul/maintenance requiring 1 day of crane activity for 8 hours.

2) Same EF assumptions as above. Fleet characterization: 10 POVs commuting to work daily, assuming 50% are pickup trucks and 50% passenger cars, 1 weekly delivery truck for supplies, and 4 quarterly heavy duty diesel truck trips for maintenance.

3) Based on estimated fossil fuel use for the electrical substation and BESS equipment. Values estimated based on 14,400 kwh/month electricity usage.

3.6.2.2 Potential Impacts of the No Action Alternative

If the facility was not constructed and operated, no new emissions or changes in air quality over baseline conditions would occur as described above. The No Action Alternative would decrease the potential for replacing energy sources that burn fossil fuels and emit greenhouse gases with renewable wind power. The air quality benefits from reduced emissions of greenhouse gases and other air pollutants would not occur.

3.7 Noise

Noise is defined as any unwanted sound. Whether sound is perceived as a noise by a receiver depends on subjective factors, including the amplitude and duration of the sound (Rodgers and Manwell 2004). The frequency of a sound also greatly influences the ability of a receiver to hear a sound; people are generally more sensitive to certain higher frequency sounds than lower frequency sounds. The A-weighted sound level, or dBA, is the sound level measurement (in decibels) that accounts for this preferential response to frequency and provides some correlation with the sensitivity of the human ear to that sound. Typical dBA values of common indoor and outdoor noise sources are shown in Figure 3-3.

3.7.1 Regulatory Framework

The State of Hawaiʻi regulates noise levels through the DOH regulations (HAR Title 11, Chapter 46). These regulations are also intended to protect public health and welfare, and to prevent significant degradation of the environment and quality of life. Maximum permissible sound levels are dependent on zoning designations and time of day (Table 3-5). The maximum permissible sound levels specified in the Community Noise Control Rule do not apply to any particular distance from a source (such as a WTG), but apply to sound levels at the property boundary (DLAA, Ltd. 2009).

Table 3-5. Maximum permissible sound levels in dBA.

Zoning Districts	Daytime (7AM to 10PM)	Nighttime (10PM to 7AM)
Class A (residential, conservation, preservation, public space, open space)	55	45
Class B (multi-family dwellings, apartment, business, commercial, hotel, resort)	60	50
Class C (agriculture, country, industrial, similar)	70	70
Source: HAR Title 11, Chapter 46, Community Noise Control.		

The proposed project would be subject to the Community Noise Control Rule. The project area is considered a Class C Zoning District; therefore, noises produced by the project cannot exceed 70 dBA[4] *at the project area property line*. Some adjacent residential properties are considered a Class A Zoning District; therefore, *at the property lines of these adjacent residences*, noise levels from the project cannot exceed 55 dBA during the daytime or 45 dBA during the nighttime (DLAA, Ltd. 2009).

---

[4] dBA is the sound level, in decibels, read from a standard sound-level meter using the “A-weighting network.”

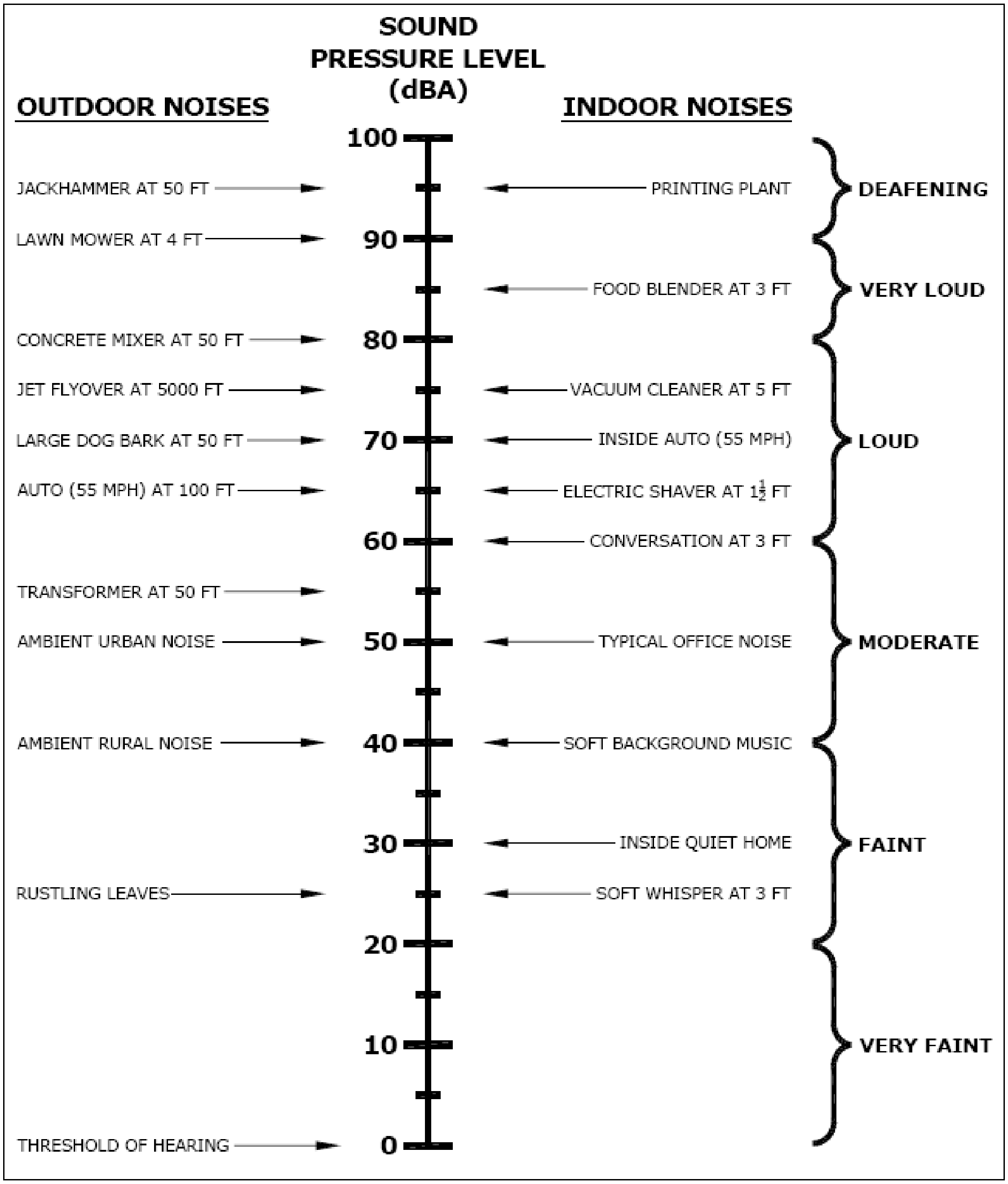


Figure 3-3. Typical dBA values of common indoor and outdoor noise sources from DLAA, Ltd. (2009).

3.7.2 Ambient Sound Levels

Ambient sound levels must be identified in order to determine whether sounds produced by the WTGs would be audible over background levels. Long-term ambient sound measurements were conducted by D.L. Adams Associates (DLAA), Ltd. in November and December 2008 in two regions - “Community” and “Property Line.” The Community measurements were conducted at six locations in the communities of Kahuku and Kuilima, which lie adjacent to the project area. Property Line measurements were conducted at six locations on or near the property lines of the proposed Kahuku Wind Power facility. All 12 measurement locations are shown in Figure 3-4.

Ambient sound measurement results are included in Table 3-6. The average calculated day-night level, L_{dn}, ranged from 46 to 60 dBA in the project area and 53 to 68 dBA in the surrounding communities (DLAA, Ltd. 2009). The measurements are fairly consistent for all locations indicating a generally uniform ambient sound environment throughout the project area. Contributing sound sources included wind, birds, occasional aircraft flyovers, community noises, landscaping or grading equipment, and vehicular traffic noise from Kamehameha Highway (DLAA, Ltd. 2009).

Table 3-6. Ambient sound measurement results.

Location	Daily Avg. Sound Level L_{eq} (Day)[1]	Daily Avg. Sound Level L_{eq} (Night)[2]	Daily Avg. Day-Night Level L_{dn}[3]
Community			
Turtle Bay Resort	50 - 58 dBA	44 - 55 dBA	53 - 61 dBA
Romy's Shrimp Trucks[4]	61 - 67 dBA	56 - 61 dBA	64 - 68 dBA
Kahuku Medical Center	48 - 55 dBA	47 - 52 dBA	54 - 59 dBA
Kahuku High School	46 - 59 dBA	46 - 53 dBA	53 - 60 dBA
Mauka Village	51 - 58 dBA	44 - 54 dBA	53 - 61 dBA
Ki'i Road Farms[5]	46 - 52 dBA	46 - 51 dBA	53 - 57 dBA
Property Line			
North Property Line	45 - 54 dBA	42 - 47 dBA	50 - 56 dBA
North East Property Line	44 - 55 dBA	40 - 53 dBA	47 - 60 dBA
East Property Line	44 - 53 dBA	41 - 44 dBA	48 - 53 dBA
South Property Line	50 - 60 dBA	41 - 48 dBA	50 - 60 dBA
West Property Line	42 - 54 dBA	38 - 44 dBA	47 - 52 dBA
Center of Property	42 - 54 dBA	39 - 43 dBA	46 - 54 dBA

1) L_{eq}(day) is an average of the hourly equivalent sound levels during the daytime hours only (between 7:00 am and 10:00 pm) within a 24-hour measurement period. The range represents the quietest and noisiest day measured within the 7-day measurement period.

2) L_{eq}(night) is an average of the hourly equivalent sound levels during the nighttime hours only (between 10:00 pm and 7:00 am) within a 24-hour measurement period. The range represents the quietest and noisiest night measured within the 7-day measurement period.

3) The L_{dn} represents the lowest and highest calculated average day-night level from the 7-day measurement period.

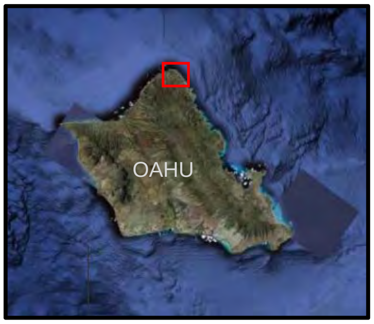
4) Romy's is a popular, commercial (stationary) shrimp truck vendor along Kamehameha Highway.

5) Peaks caused by overload or environmental conditions were removed from the average sound and day-night levels for the Ki'i Road location.

Source: DLLA Ltd. 2008.

LEGEND

C1	Turtle Bay Resort	P1	North Property Line
C2	Shrimp Trucks	P2	North East Property Line
C3	Kahuku Medical Center	P3	East Property Line
C4	Kahuku High School	P4	South Property Line
C5	Mauka Village	P5	West Property Line
C6	Kii Road Farms	P6	Center of Property



Sound Measurement Locations

Date	Project No.	Drawn By	Figure No
Sept 2009	08-26	DFD	3-4

Ambient sound measurements were not conducted at the off-site microwave towers because no additional noise is expected following construction. The Waialua site is located in a relatively quiet residential area; therefore, ambient noise levels are anticipated to be relatively low. Ambient sound levels at the Flying R Ranch are anticipated to be relatively low due to the lack of noise sources in the vicinity.

3.7.2.1 Potential Impacts of the Proposed Action

Construction Phase:

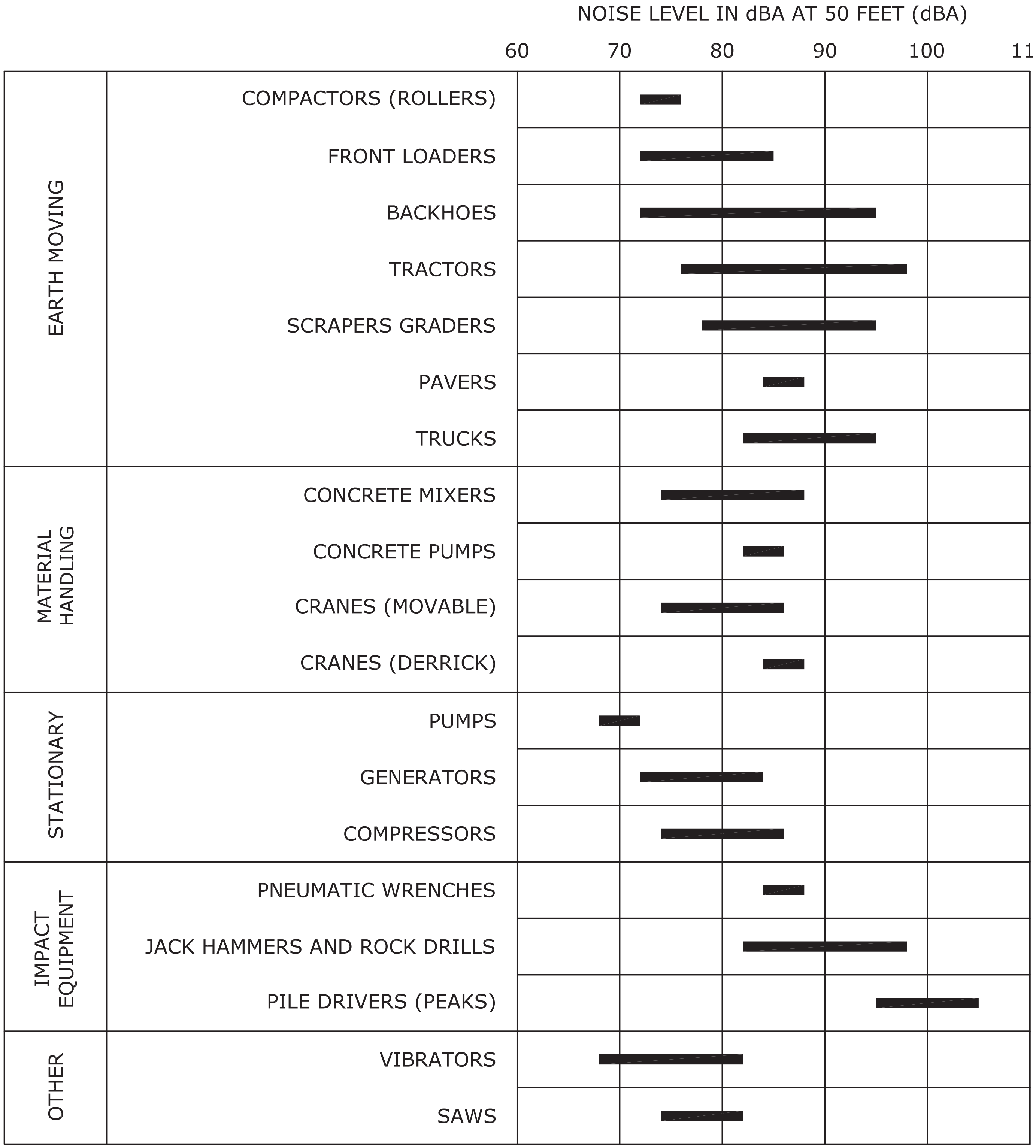
Construction of the proposed project would produce short-term noise within the project area due to the use of graders, excavators, bulldozers, cranes, cement trucks, haul trucks, compactors, and other heavy equipment. The actual noise levels produced during construction would be a function of the methods employed during each stage of the construction process (DLAA, Ltd. 2009). Typical sound levels produced by construction equipment are shown in Figure 3-5. Earth-moving equipment would probably be the loudest equipment used during construction.

Kahuku Wind Power LLC would use reasonable and standard practices to mitigate construction noise, as needed, such as using mufflers on diesel and gasoline engines and using properly tuned and balanced machines. In cases where construction noise exceeds, or is expected to exceed the State’s maximum permissible property line noise levels, a permit would be obtained from the State DOH to allow the operation of vehicles, cranes, construction equipment, and power tools that emit sound levels in excess of the "maximum permissible" levels (DLAA, Ltd. 2009). This permit provides restrictions on the time of day when construction activities may emit noise in excess of the maximum permissible sound levels, but does not restrict the amount of noise that can be generated. In order for the State DOH to issue a construction noise permit, the contractor would submit a noise permit application to the DOH that describes the construction activities for the proposed project. Prior to issuing the noise permit, the State DOH may require action by Kahuku Wind Power LLC to incorporate noise mitigation into the construction plan and/or it may require Kahuku Wind Power LLC to conduct noise monitoring or community meetings inviting the neighboring residents and business owners to discuss construction noise (DLAA, Ltd. 2009).

Operation Phase:

Following construction, the only project components expected to generate sound on a regular basis would be the WTGs. WTGs generate sound via various routes, both mechanical and aerodynamic. Wind turbines potentially produce four types of sound: broadband, tonal, low frequency (including infrasound), and impulsive. Sound emission from modern WTGs is dominated by the aerodynamic broadband type, which occurs as the revolving rotor blades encounter atmospheric turbulence, creating a rhythmical “swishing” sound. Tonal sounds are typically mechanical in origin, and are sounds that occur at discrete frequencies, such as a generator hum or other mechanical sound. Low frequency sound is the portion of broadband sound at the low end of the frequency spectrum, near the lower limit of human hearing. Low frequency sound can also include infrasound, which is defined as sound below the limit of human hearing (commonly known as vibration). Impulsive noise, or short acoustic impulses, can be caused by the interaction of wind turbine blades with disturbed air flowing around the tower of a downwind machine (Rogers and Manwell 2004, Pedersen and Waye 2007), although such machines are not typical of modern installations such as Kahuku, which use upwind-mounted rotor technology. As wind speed varies, lower or higher rotational speed of the turbines would typically result in lower or higher sound levels (van den Berg 2004).

The noise impact of the WTGs is dependent in part on the ambient sound levels. Assessments of the existing background sound levels help to determine whether wind turbine sound would be audible over background sound levels. If ambient sound is high, wind turbine sound gets lost in the background (Rogers and Manwell 2004). Although increases over existing ambient noise levels can be measured, it is important to note that the public's perception of the noise impact (i.e. unwanted sound) of WTGs is in part a subjective determination. Due to the variation in the levels of individual tolerance for noise, there is no completely satisfactory way to measure the subjective impacts of noise that may result from the proposed facility (Rogers and Manwell 2004).



NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES

Typical Sound Levels from Construction Equipment

Kahuku Wind Farm

Not to Scale

Date
September 2009

Project No.
08-26

Drawn By
TRB

Figure No
3-5

DLAA, Ltd. (2009) used a computer software program (CADNA or Computer Aided Noise Abatement) to develop a sound propagation model of the project area and the vicinity to predict wind turbine sound at the property lines of the proposed project area and at nine locations in the surrounding community. The sound propagation model was based on the site plan, topographical data, sound data for similar wind turbines[5], and proprietary information provided by First Wind. The model assumes a scenario in which meteorological conditions, receiver height, and ground attenuation are favorable to sound propagation. A more detailed description of the model is provided in Appendix C.

The predicted sound levels at selected sites that are of specific interest regarding potential sound impacts are shown in Table 3-7. Figures 3-6 and 3-7 show the predicted sound level contours and area contours for the surrounding communities and the project area, respectively. Based on the predicted sound levels, Kahuku Wind Power would be compliant with the Community Noise Control Rule because the predicted wind turbine sound levels do not exceed the DOH maximum permissible sound limits at the property line or in the surrounding communities (DLAA, Ltd. 2009).

Table 3-7. Predicted Wind Turbine Sound Levels at Selected Sites.

Location	**Distance[1]**	**Predicted Sound Level[2]**	**DOH Limit[3]**
Turtle Bay Resort	10,000 ft (3,050 m)	< 33 dBA	50 dBA
Turtle Bay Entrance	6,500 ft (2,000 m)	33 dBA	50 dBA
Romy’s Shrimp Trucks	2,110 ft (650 m)	48 dBA	50 dBA
Kahuku Medical Center	5,000 ft (1,500 m)	41 dBA	50 dBA
Kahuku High School	6,400 ft (1,950 m)	38 dBA	45 dBA
Mauka Village	4,300 ft (1,300 m)	42 dBA	45 dBA
Ki‘i Road Farms	1,900 ft (600 m)	46 dBA	70 dBA
Marconi Area	4,900 ft (1,500 m)	40 dBA	70 dBA
Kupuna Housing	7,600 ft (2,300 m)	36 dBA	45 dBA
Site Property Lines	Varies	54-58 dBA	70 dBA

1) Approximate distance from indicated location to closest WTG.

2) The predicted sound levels are based on the conditions indicated above.

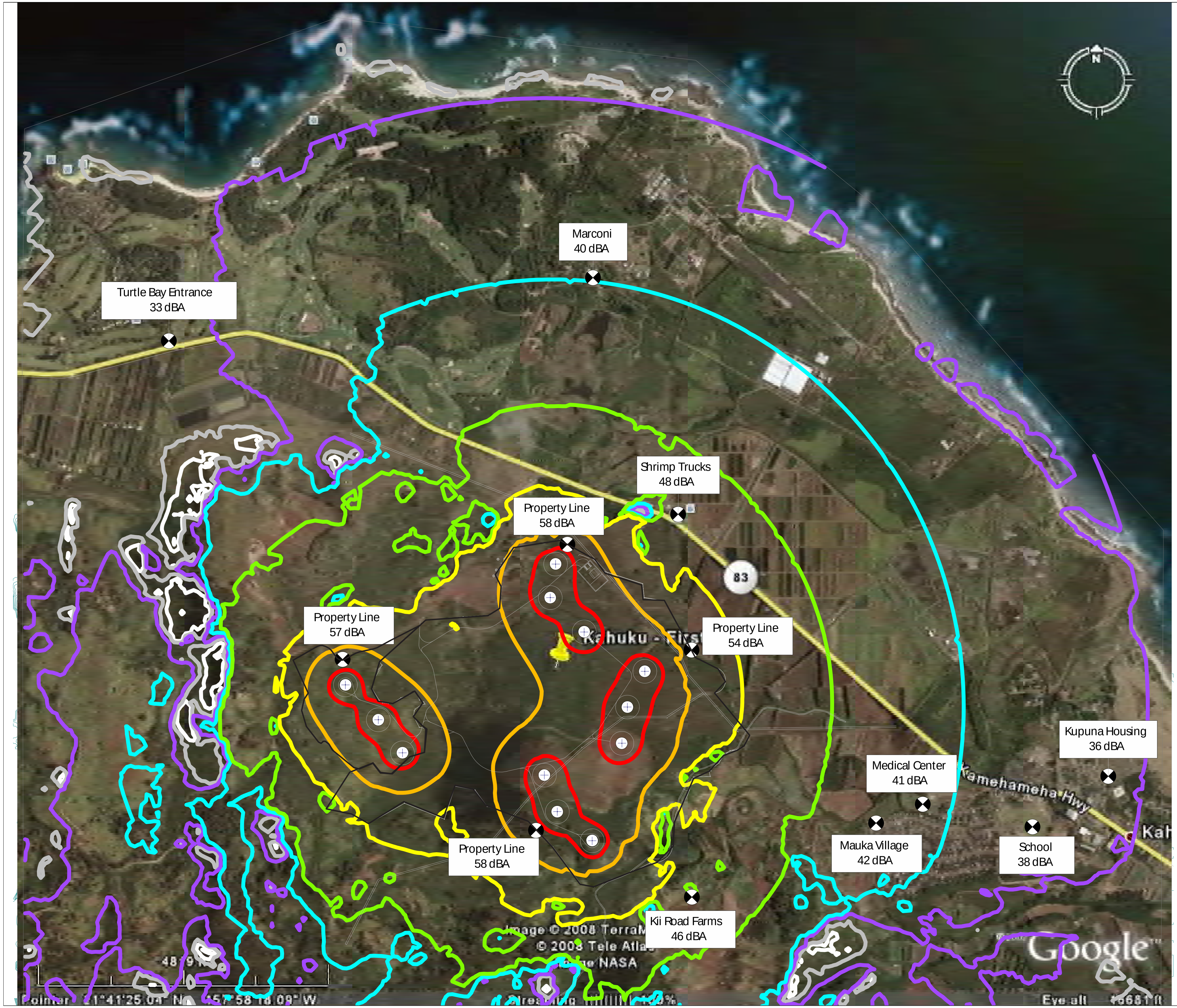
3) The DOH maximum permissible nighttime sound limits are based on the zoning of the indicated location.

---

[5] A complete sound power data report, per IEC 61400 requirements, is currently not available for the Clipper C96 turbines. It is expected that the sound data for the Clipper C96 turbines will be similar to the sound data that was estimated for use in the model. However, it is possible that the actual wind turbine sound data could vary slightly from the estimated sound data.

To determine if sound from the future WTGs would impact the adjacent properties and nearby neighborhoods, the results of the sound propagation model were compared to the existing ambient sound levels measured at the 12 ambient sound measurement locations. As shown in Table 3-8, WTGs at the proposed Kahuku Wind Power facility are expected to increase the ambient sound environment in the surrounding communities from 0 to 3 dB. A change in sound level of less than 3 dB is not a perceptible difference to most listeners (DLAA, Ltd. 2009). The agricultural areas closest to the proposed Kahuku Wind Power facility (such as Kiʻi Road Farms) would experience the greatest increase in ambient sound, up to 3 dB, but the total sound level would still be well below the DOH limit.

It is expected that the WTGs would not usually be audible in the surrounding communities over typical ambient sounds that occur throughout the day and night. On very quiet nights when the wind speed is not sufficient to drive the wind turbine, sound from the WTGs is expected to be minimal and not significant. However, a phenomenon is known to occur where local atmospheric and terrain conditions occasionally produce wind speeds sufficient to drive the wind turbines although the surrounding community experiences low wind speeds, and accordingly, low ambient sound levels. On these occasions, WTGs at Kahuku Wind Power may be audible in the neighboring community (DLAA, Ltd. 2009). However, because the WTGs would not be continually audible, the proposed project is not expected to significantly impact the adjacent properties or the surrounding area.



Kahuku Wind Farm

Kahuku, Oahu, Hawaii

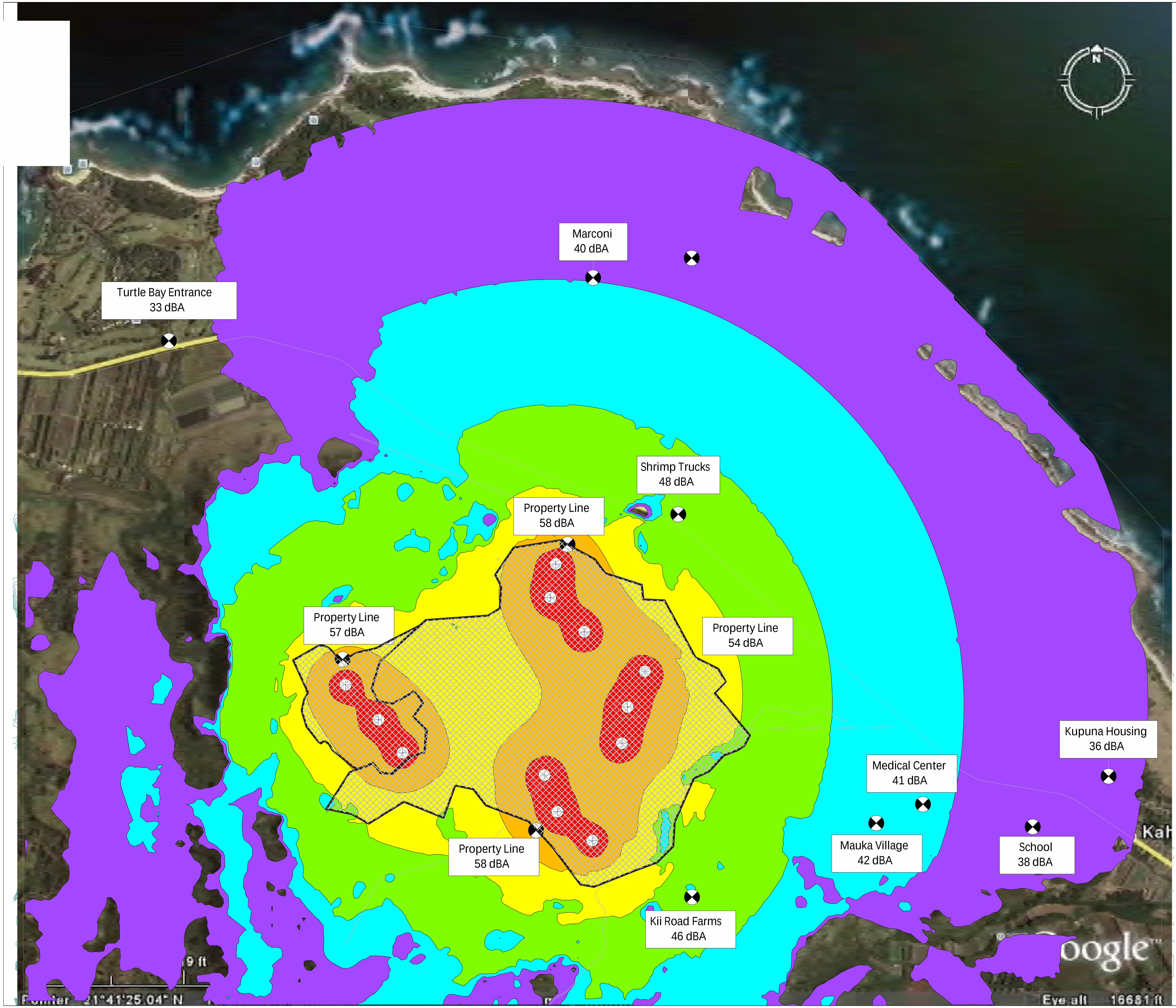
Prepared for First Wind Energy, LLC

September 2009

Figure 3-6

Predicted Sound Level Contours for the Surrounding Communities

- ⬜ = 25 dBA
- ▨ = 30 dBA
- 🟪 = 35 dBA
- 🟦 = 40 dBA
- 🟩 = 45 dBA
- 🟨 = 50 dBA
- 🟧 = 55 dBA
- 🟥 = 60 dBA



Kahuku Wind Farm

Kahuku, Oahu, Hawaii

Prepared for First Wind Energy, LLC

September 2009

Figure 3-7

Predicted Sound Level Area Contours for the Project Area

- 🟪 > 35 dBA
- 🟦 > 40 dBA
- 🟩 > 45 dBA
- 🟨 > 50 dBA
- 🟧 > 55 dBA
- 🟥 > 60 dBA

Table 3-8. Predicted Wind Turbine and Existing Ambient Sound Levels in the Vicinity of Kahuku Wind Power.

Location	DOH Limit	Predicted Sound Level	Measured Min. Average L_{eq}(Night)	Combined Sound Level[1]	Δ due to New WTGS[2]
Turtle Bay Resort	50 dBA	33 dBA	44 dBA	44 dBA	+ 0 dB
Romy's Shrimp Trucks	50 dBA	48 dBA	56 dBA	56 dBA	+ 0 dB
Kahuku Medical Center	50 dBA	41 dBA	47 dBA	48 dBA	+ 1 dB
Kahuku High School	45 dBA	38 dBA	46 dBA	47 dBA	+ 1 dB
Mauka Village	45 dBA	42 dBA	44 dBA	46 dBA	+ 2 dB
Ki'i Road Farms	70 dBA	46 dBA	46 dBA	49 dBA	+ 3 dB

1) Combined sound level is the logarithmic addition of the predicted sound level plus the measured ambient sound level.

2) The predicted change (in dB) due to wind turbines is the amount by which the ambient sound environment is expected to increase with the addition of the Kahuku Wind Power facility.

3.7.2.2 Potential Impacts of the No Action Alternative

If the facility was not constructed and operated, no change in existing noise conditions would occur in the project area.

3.8 Scenic Resources

A scenic viewshed is broadly defined as a vista visible from a human observation point. Any structure or emission that decreases the aesthetics of a scenic viewshed is considered to have an impact on scenic resources.

Most of the lands within and surrounding the project area are uninhabited former cane lands that have been more recently used for cattle grazing. Hence, the project area presents a rural and agricultural view from the surrounding Kahuku town and Kamehameha Highway with few man-made features on the hillsides. The closest non-agricultural land uses in the vicinity are residences in Kahuku town and Turtle Bay Resort, which are located 4,300 and 6,500 ft (1,300 and 2,000 m) away, respectively. Few vertical features are currently present in the area, including the 197 ft (60 m) tall temporary met towers and two HECO electrical transmission lines supported on 50 ft utility poles (one line crosses the northeastern portion of the project area and the other crosses the southwestern portion). These vertical features are not immediately visible from many vantage points.

The Kahuku Wind Power project area is not specifically identified as a scenic vista or viewshed in county or state plans or studies. The Koʻolau Loa Sustainable Communities Plan (1999) identifies the need to "preserve the region's rural character and its natural, cultural, scenic and agricultural resources." The

City and County of Honolulu’s Coastal View Study (1987) identifies the importance of open spaces, as well as vegetation and agricultural uses in this portion of the island. These planning documents note the importance of preserving the rural character of the area by visually maintaining open spaces and viewsheds, low density development, and agricultural areas.

The location of the Waialua Substation site is not identified as a scenic vista or viewshed in county or state plans or studies. The entire Waiʻanae Mountain Range, where the Flying R Ranch site is located, is identified as a scenic resource at several vantage points throughout the north shore of Oʻahu (DPP 2000). The most prominent man-made structure in the vicinity of the Flying R Ranch site is a red and white lattice tower (owned by Crown Castle) over 100 ft (30 m) tall. Utility lines, supported on approximately 50 ft tall wooden utility poles, also occur throughout the landscape and immediately below the proposed tower site.

3.8.1 Potential Impacts of the Proposed Action

Belt Collins Hawaiʻi Ltd. conducted an initial view analysis of the wind energy project in September 2007, which encompassed land from the shoreline to 12 mi (20 km) mauka of the property boundary. The analysis produced computer simulated visualizations of the proposed project and identified line-of-sights using ESRI® ArcGIS™/ArcScene™ view analysis and viewshed mapping (Belt Collins Hawaiʻi Ltd. 2007b). In August 2009, an updated view analysis was performed to reflect the current turbine layout (Belt Collins Hawaiʻi Ltd. 2009). Figure 3-8 indicates the number of turbines within the line-of-sight from each 10 m^2 cell on the surface map, based on the updated analysis. Within the 12 mi study area, the number of turbines visible generally increases with distance from the project area.

Photoshop® renderings were also produced in which wind turbine images were overlaid on photos taken from 17 roadside locations. Only WTGs were used in the photo rendering because they are much taller and bulkier than the other structures associated with the project (i.e. overhead cable, utility poles, buildings) and thus are considered the most visible structures. Photo renderings were not revised for the current layout; however, the current layout is not expected to substantially affect the visibility depicted in the September 2007 renderings because many of the turbine locations remained essentially the same (Belt Collins Hawaiʻi Ltd. 2009).

In many of the photo renderings, turbines are not evident as they are screened by vegetation, houses, or other physical features in the landscape. The 17 photo renderings are shown in Figures 3-9 to 3-17, and each roadside location is briefly described below.

Location A, Kahana Bay: Some of the WTGs are slightly visible along the horizon; most are obscured by vegetation.

Location B, BYU: The WTGs in the photo rendering appear among the tree tops and are obscured by vegetation.

Location C, Mālaekahana State Recreation Park Entrance: The WTGs are visible, but screened by vegetation and the ridgeline.

Location D, Kahuku Village: Vegetation and houses screen the WTGs from this photo location.

Location E, Kahuku Golf Course Parking Lot: A clear view of the WTGs is provided from this perspective at an elevation of approximately 30 ft (9 m) overlooking the Puʻuluana Street Senior Housing area.

Location F, Puʻuluana Street Senior Housing Area: The vegetation and houses screen some of the WTGs from this photo location.

Location G, Kahuku Superette: The vegetation and houses screen most the WTGs.

Location H, Kahuku High School Football Field: Some of the WTGs are obscured by the vegetation.

Location I, Kahuku Hospital: All the WTGs are clearly visible, although some are outside of the photo frame.

Location J, Kamehameha Highway near Romy's Shrimp Truck: Few WTGs are visible because they are obscured by the 60- to 80-ft (18- to 24-m) tall trees located along Kamehameha Highway. Only three WTGs are slightly visible behind the group of trees in the center of the photo.

Location K, Kamehameha Highway Northwest of Romy's Shrimp Truck: Trees obscure the visibility of the WTGs, although few of the WTG blades are visible between the tree line break in the center of the photo.

Location L, Kamehameha Highway outside of the Army Training Area entrance gate: This photo location presents a clear and close view of the WTGs. No vegetation obscures the visibility and the tips of the turbines blades protrude from behind the nearby hill.

Location M, Kamehameha Highway east of the Turtle Bay Resort entrance: Of the 12 WTGs, the row of turbines closest to Kamehameha Highway is visible from this photo location. The other seven WTGs are screened by the nearby hill located on the right side of the photo rendering.

Location N, Army Training Area: A clear view of WTGs is provided from this perspective.

Location O, Turtle Bay Resort: Because of the heavy landscaped vegetation around the resort, none of the WTGs are visible from this location.

Location P, Kawela Bay: No WTGs are visible from this location because they are screened by trees ranging from 60 to 80 ft in height.

Location Q, Sunset Beach: No turbines are visible from this location.

©2009 Belt Collins Hawaii Ltd. W 2007.33.1900/007-2 kya 2009Jul20 1

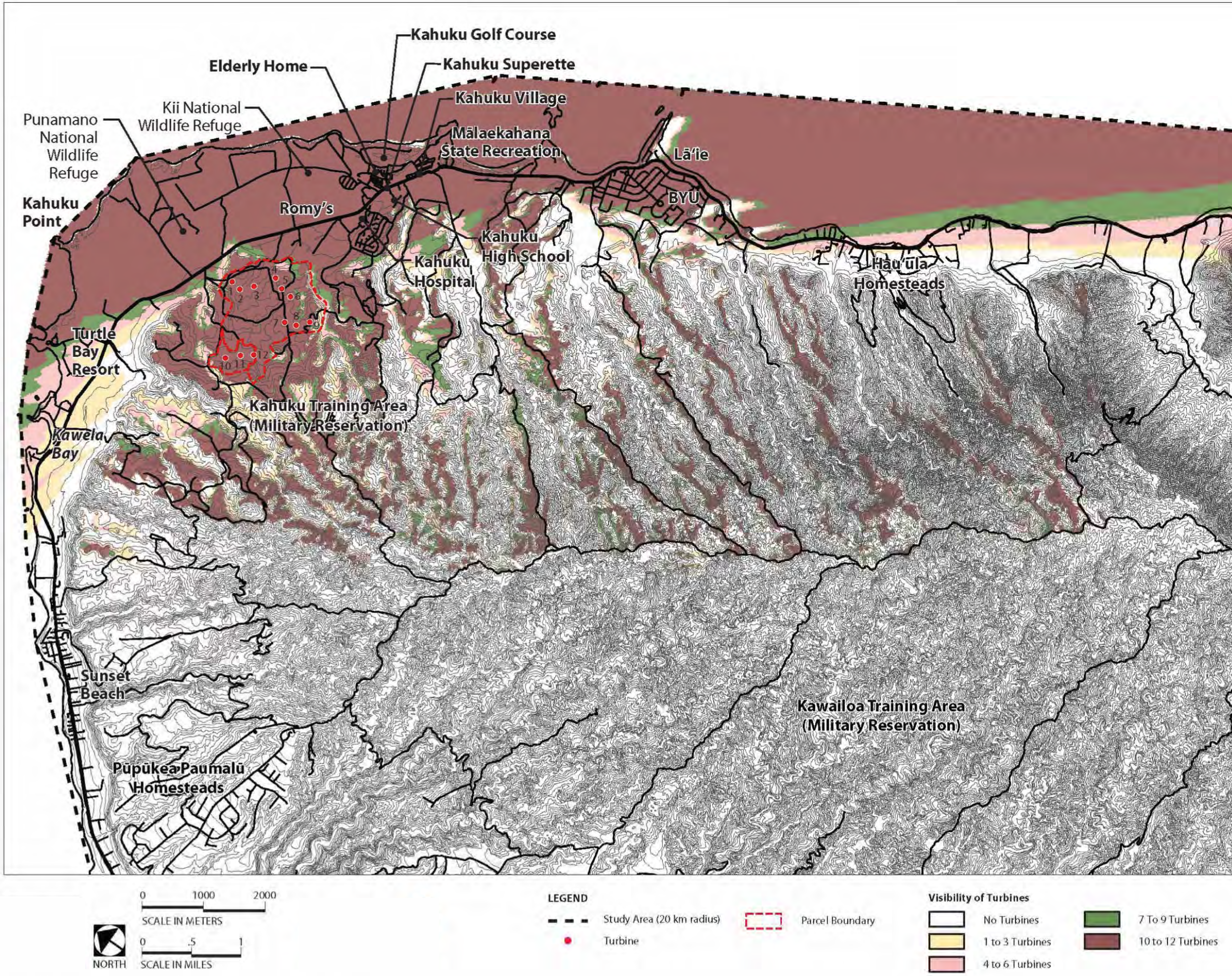


FIGURE 3-8
Number of Turbines Within Line-of-Sight

August 2009

©2007 Belt Collins Hawaii Ltd.

Location A
VIEW FROM KAHANA BAY
Figure 3-9
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location B
VIEW FROM BYU IN LA`IE
Figure 3-9
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location C
VIEW FROM MALAEKAHANA STATE RECREATION PARK

Figure 3-10
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location D
VIEW FROM KAHUKU VILLAGE

Figure 3-10
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location E
VIEW FROM KAHUKU GOLF COURSE
Figure 3-11
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location F
VIEW FROM PU`ULUANA STREET SENIOR HOUSING
Figure 3-11
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location G
VIEW FROM KAHUKU SUPERETTE
Figure 3-12
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location H
VIEW FROM KAHUKU HIGH SCHOOL FOOTBALL FIELD
Figure 3-12
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location I
VIEW FROM KAHUKU HOSPITAL
Figure 3-13
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location J
VIEW FROM KAMEHAMEHA HIGHWAY-ROMY'S SHRIMP TRUCK
Figure 3-13
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location K
VIEW FROM KAMEHAMEHA HIGHWAY NORTHWEST OF ROMY'S
Figure 3-14
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location L
VIEW FROM KAMEHAMEHA HIGHWAY-ARMY TRAINING AREA ENTRANCE GATE
Figure 3-14
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location M
VIEW FROM KAMEHAMEHA HIGHWAY-EAST OF TURTLE BAY RESORT
Figure 3-15
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location N
VIEW FROM ARMY TRAINING AREA
Figure 3-15
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location O
VIEW FROM TURTLE BAY RESORT
Figure 3-16
Photo Rendering
September 2007

©2007 Belt Collins Hawaii Ltd.

Location P
VIEW FROM KAWELA BAY
Figure 3-16
Photo Rendering
September 2007


©2007 Belt Collins Hawaii Ltd.

Location Q
VIEW FROM SUNSET BEACH
Figure 3-17

Photo Rendering
September 2007

In summary, the proposed WTGs would be most visible at the following roadside locations considered in the view analysis: Kahuku Golf Course, Puʻuluana Street Senior Housing area, Kahuku Hospital, along Kamehameha Highway outside of the Army Training Area entrance gate, Kamehameha Highway east of the Turtle Bay Resort entrance, and the U.S. Army Training Area. Therefore, individuals most likely to experience impacts to scenic viewsheds include recreational users at the Kahuku Golf Course, residents at the Puʻuluana Street Senior Housing area, patients and workers at Kahuku Hospital, and employees at the U.S. Army Training Area.

Regarding views from residential areas near the proposed project area, there are residential homes around Kahuku Hospital, including Mauka Village. Figure 3-13 shows that WTGs are visible from the hospital; therefore, WTGs may also be visible from homes in that area. There are also residential homes and a park, Kahuku District Park, within a mile of Kahuku High School (Figure 3-12) from which WTGs may be visible. While Figure 3-8 shows that it is possible for 10 to 12 turbines to be visible from most of the town of Kahuku, which includes these and other residential areas, visibility of the WTGs would vary due to screening by vegetation and houses, as shown in the view from a roadside location in Kahuku Village (Figure 3-10, Location D).

In accordance with Federal Aviation Administration (FAA) aviation safety guidance, 8 of the 12 WTGs would be lit with medium intensity, synchronized red-flashing lights. All WTGs must be painted white to comply with FAA guidance (FAA 2009e).

In the past, WTGs were previously located on adjacent plots (0.6 to 0.7 mi or 1.0 to 1.1 km northwest of the proposed project area) for many years. However, these were removed over 20 years ago, so the proposed project would introduce a new vertical element into the landscape. However, relative to other potential projects (i.e. residential developments and projects with large buildings); the proposed project would complement the rural atmosphere and agricultural character of the area (USFWS 2007). The perception of these features would vary depending on the observer. While some individuals may prefer the setting as it now exists without the WTGs, others may find it an interesting or even aesthetic point of visual interest on the landscape (U.S. DOE 2009). Time of day, time of year, and weather conditions can also influence the appearance and perception of the WTGs.

Other components of the project not assessed by computer simulated visualizations (met tower, overhead cable, utility poles, buildings) may be visible from some public vantage points. The temporary and permanent met towers would also be lit with medium intensity, synchronized red-flashing lights (FAA 2009a, 2009b, 2009c, 2009d). However, once the WTGs are constructed and lighting installed, Kahuku Wind Power LLC may be able to turn off the light on the permanent met tower due to its proximity to the lighted turbines. To minimize visual impacts due to lighting, on-site operational lighting would be minimal and shielded. Because these components of the project would be few and relatively similar in height to other structures currently in the vicinity, they are not anticipated to have a noticeable impact to scenic resources.

A view analysis and photo renderings were not prepared for the Waialua Substation site. Structures of similar height (50-60 ft utility poles and traffic lights) already exist at the Waialua Substation and therefore the single proposed tower is not expected to adversely impact scenic resources.

As stated in Section 2.2, approximately 1,000 linear ft (305 m) of overhead cable, supported on wooden poles approximately 50 ft (15 m) high, would be required to transmit electricity from the nearest existing HECO electrical distribution line to the microwave tower at the Flying R Ranch. The area is visually dominated by the red and white lattice tower present in the vicinity of the site. The proposed Flying R Ranch microwave tower would be painted green to blend with the landscape and would be similar in height to the surrounding vegetation. In addition, views of the proposed Flying R Ranch tower and utility poles from public vantage points would be screened by ridgelines and vegetation. Therefore, the impact of the proposed Flying R Ranch tower on scenic resources would be minimal.

3.8.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, there would be no change in the visual setting and no impact on scenic resources.

3.9 Public and Occupational Health and Safety

This section describes concerns related to the health and safety of the public and workers as a result of hazardous materials and conditions present during the construction and operation phases of the proposed project. Hazardous materials are defined as waste, or combination of wastes, which may cause, or significantly contribute to an increase in mortality, serious, irreversible, or incapacitating reversible illness, or a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

3.9.1 Regulatory Framework

Hazardous materials, substances, and waste are regulated by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), the Superfund Amendment Reauthorization Act (SARA), the Toxic Substances Control Act (TSCA), as well as other federal and state regulations. According to RCRA, all generators of hazardous waste must follow specific procedures for the treatment, storage, and disposal of hazardous wastes.

Occupational health and safety rights for both workers during the construction and operation phases of the facility are protected through the federal Occupational Safety and Health Act (29 USC 651 et seq.). Under this act, Congress created the Occupational Safety and Health Administration (OSHA), an agency of the U.S. Department of Labor. OSHA’s mission is to assure the safety and health of America’s workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health.

Kahuku Wind Power LLC would comply with the above mentioned regulations, as well as other appropriate safety and security laws and regulations established by the Hawaiʻi Occupational Safety and Health (HIOSH) Division, Department of Transportation (DOT), and EPA.

3.9.2 Existing Safety Hazards

A Phase I Environmental Site Assessment (Phase I) was conducted for the Kahuku Wind Power project area by Belt Collins Hawaiʻi Ltd. (2007a) to identify the presence of recognized environmental conditions. This assessment consisted of a site reconnaissance, review of appropriate federal and State regulatory lists and databases, review of maps/photographs, and interviews with past and present owners.

The Phase I did not reveal evidence of recognized environmental contaminants or hazardous conditions on the property; however, there was insufficient information on several past on-site activities that are likely to have used petroleum products and/or hazardous substances. These activities include sugar cane and pineapple cultivation, earth moving, and military activities (Belt Collins Hawaiʻi Ltd. 2007a).

No environmental contaminants or hazardous conditions are known to occur at the off-site microwave tower sites, although Phase I ESAs have not yet been conducted. Phase I ESAs would be completed as appropriate for financing and construction.

3.9.2.1 Potential Impacts of the Proposed Action

No hazardous substances or toxic waste would be generated or created by the construction or operation of the proposed facility. As discussed elsewhere in this report, small amounts of hazardous materials may be used during construction and operation of the project. A SPCC Plan would be prepared for the facility prior to beginning construction and operation. The SPCC would include procedures for handling and storing hazardous materials and other substances, procedures for preventing spills, emergency contacts, an emergency action plan, organizational roles and responsibilities, site-specific contingency plans, information on hazards analysis, response functions, public information and community relations, as well as information on spill containment and cleanup.

Construction Phase:

Construction sites can be high-risk environments for workers. These areas offer many opportunities for falls, trips, impacts, exposure to hazardous materials, and other injuries. The disturbance of contaminated soils introduces an additional risk of hazardous material exposure, which could lead to various medical conditions depending upon the contaminant, the level of exposure, and the person being exposed. Construction of the facility would adhere to OSHA standards to maximize worker safety. No additional risks to worker safety are expected because no recognized environmental contaminants were identified in the project area.

Construction sites also have the potential to be high-risk environments for members of the general public who access the site unauthorized. The access road to the project area is gated and monitored by the Union of Operating Engineers for 24 hours each day; therefore, the risk of health and safety impacts to members of the general public would be minor.

During the construction phase, small amounts of several hazardous materials that require special handling and storage would be transported, used, and stored on-site. These may include such materials as gel-cell batteries, fuel, combustible liquid materials, chemicals, and paint. Risk of harm would be minimized by requiring the contractor to follow BMPs, including proper containment of staging and stockpiling areas, provision of spill kits, regular waste collection and disposal, frequent equipment inspection, and off-site refueling and vehicle washing at an approved location.

The construction phase would include delivery and placement of 10,000 Xtreme PowerCell “dry-cell” batteries. According to an independent assessment of the battery technology, the battery would not leak, even if the case is cracked (hence the “dry-cell” designation). The battery is also reported as very robust and able to withstand severe shock and vibration (Kema, Inc 2009). According to the manufacturer, the batteries operate over a wide temperature range with no containment risk. The batteries are double encapsulated, encased in a thermal setting material and enclosed in an outer plastic case. The DOT classifies these batteries as non-hazardous material. The battery components are described in Table 3-9.

Table 3-9. Components of the Xtreme Powercell.

Material	% by Wt or Volume	CAS Number	Exposure Limits	
			OSHA[1]	ACGIH[2]
Lead and lead compounds	75	7439-92-1	0.05 mg/m3	0.15 mg/m3
Electrolyte	20	7664-93-9	1.0 mg/m3	1.0 mg/m3
Case Material (Polypropylene)/ Separator Paper / Glass Fiber	5	9003-07-0	N/A	

[1] Occupational Safety and Health Administration.

[2] American Conference of Governmental Industrial Hygienists.

Because the batteries do not leak even if the case is cracked, and the solid lead compounds are secured within the battery case, health and safety risks to employees and the public and impacts related to their use are expected to be negligible to none.

The Power Electronics and Control system would include a solid-state, industrial-grade power electronics module capable of delivering 1.5 MWs at an operating efficiency of 95 to 98%, and a solid-state control system for effective power management. The system features three levels of control hierarchy: 1) real-time Supervisory Command and Data Acquisition (SCADA) control; 2) programmable logic controller (PLC); and 3) intelligent firing circuit board (FCB). Installation and operation of the electronics and controls would not generate hazardous waste or health and safety risks to employees or to the public.

Operation Phase:

Operation of the facility would be performed in accordance with the Kahuku Wind Power Site Safety Plan. This plan would be modeled after the Kahuku Wind Power LLC Site Safety Plan (First Wind 2006) and include topics such as accident reporting, electrical safety, fall protection, and the use of personal protective equipment. This plan is expected to minimize impacts to workers' health and safety during operation. In addition, all operation activities would be carried out in compliance with OSHA requirements.

Routine operation and maintenance of the proposed facility would require the use of several materials that require special handling. These include common lubricants (e.g. gearbox oils, hydraulic fluids, insulating fluids), petroleum products, or other chemical products (e.g. oil-filled transformers, capacitors, batteries). Storage of containerized chemical products used for maintenance of the WTGs and substation would be limited, incidental, and contained to the on-site operations and maintenance building. Examples of these products include lubricating oils, aerosol lubricants, non-chlorinated dielectric solvents, and insect spray. Bulk quantities of petroleum products, pesticides, herbicides, fertilizer, or other products would not be stored on-site.

As stated above, 10,000 of the Xtreme PowerCell batteries would be in use at any given time. According to the manufacturer, the lifespan of a battery is expected to be approximately 10 years. Approximately 2 to 3%, or 200 to 300 spare batteries, would be stored on-site to replace those that fail or exceed their lifespan. Used batteries would be stored on-site prior to shipment back to the manufacturer for recycling in the State of Oklahoma. The DOT classifies these batteries as non-hazardous material. Kahuku Wind

Power LLC would be responsible for returning power cells to Xtreme for recycling. Roughly 85 to 95% of the battery is recyclable.

Accidental operational releases of hazardous materials would most likely emanate from one of the following: the O&M building, WTGs, or the substation and BESS enclosure. The O&M building would contain products/materials needed for routine operations and maintenance, including mineral oil, hydraulic oil, grease tubes, a waste oil container, and cleaner/degreaser. These items would be stored on a spill retentive skid or absorbent sheets. Diesel fuel would be stored in small containers outside the O&M building (Planning Solutions 2009).

Each WTG would contain potentially hazardous materials in the gear box (at the top of the WTG tower) and pad-mounted transformer (at the base of the WTG). The gear boxes would store hydraulic and lubricating oils, while the pad-mounted transformer would contain mineral oil. The electrical substation would also store mineral oil (Planning Solutions 2009).

Vegetation in the project area is likely to be controlled using mechanical methods; however, in the event that herbicides are used on-site, only herbicides that are registered with the EPA for the proposed use would be used. All herbicide applications would be carried out by licensed applicators in accordance with approved procedures and product labels.

Intentionally Destructive Acts:

DOE believes that the proposed facility presents an unlikely target for an intentionally destructive act and has an extremely low probability of attack. The access road to the project area is gated and access is controlled by the Union of Operating Engineers. All project facility buildings would be access controlled and all authorized personnel would be issued access key fobs to regulate entry into the facility. These measures would limit access and deter intruders.

The microwave towers are also considered very unlikely targets for acts of terrorism. The Waialua Substation site is located in a locked area. Access to the Flying R Ranch site is via a privately owned road that has several locked gates which are controlled by the landowner, Waialua Ranch Partners. The site is roughly 1.5 mi (2.4 km) from the nearest public road (Farrington Highway).

The potential for the proposed action to result in impacts from an intentionally destructive act is negligible.

3.9.2.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, there would be no impact on public and occupational health and safety and no change from existing conditions.

3.10 Land Use

3.10.1 Existing, Past, and Future Land Uses

The proposed project is located in the community of Kahuku in the Koʻolauloa District on the northeastern portion of Oʻahu. The project area encompasses two parcels (Tax Map Key 5-6-005:007 and 5-6-005:014), which are owned by Kahuku Wind Power LLC. This property is bounded on the northwest by Charlie Road, a paved access road off Kamehameha Highway. It is bounded on the east by pasture and agricultural lands along the Kamehameha Highway and on the west and south by agricultural land owned by the State of Hawaiʻi. The north and northwestern portions abut a ti plantation, which are leased by a ti farmer. The Operating Engineers train students on operating and maintaining heavy equipment on lands to the west of the property. The Kahuku Training Area military reservation is south of the property (Belt Collins Hawaiʻi Ltd. 2007a). Notable nearby land uses within the vicinity of the project area include: James Campbell NWR expansion area (0.2 mi or 0.3 km); Kuilima-owned golf courses (0.3 mi or 0.5 km); Romy's Shrimp Truck (0.4 mi or 0.6 km); Kahuku High School (1.0 mi or 1.6 km); Kahuku Town (1.25 mi or 2 km); Turtle Bay Resort Entrance (1.2 mi or 2 km); and Mālaekahana State Recreation Park Entrance (2.5 mi or 4 km). The U.S. Army utilizes approximately 9,363 acres (3,789 ha) of mauka lands above the Turtle Bay Resort and Kahuku Town for military training (DPP 1999).

Past land uses have significantly impacted the property, resulting in a patchwork of invasive plant species throughout the project area and a large, barren spot that is missing topsoil. From the mid-1870s to 2005, the property was owned by The James Campbell Trust Estate (Campbell Estate). The property was used for sugar cane cultivation from the 1870s until 1971. FPI Commercial and Amorient Aquaculture were previous tenants of Campbell Estate during this time, using the land for aquaculture and subletting portions to farmers. Between 1987 and 1991, soil was excavated from portions of the project area for use as fill and topsoil material for the Arnold Palmer Golf Course at the Turtle Bay Resort (Belt Collins Hawaiʻi Ltd. 2007a). Three previous wind power projects operated in the area (including on portions of the site) in the 1980s and 1990s, but have since been dismantled.

In August 2005, Continental Pacific, LLC, a large agricultural developer, bought the property from Aina Nui, which was a former entity of Campbell Estate. The property had several lessees including: one for cattle grazing, Operating Engineers, and Gunstock Ranch. Operating Engineers occupied the northwestern side of the property to train students on operating and maintaining heavy equipment (Belt Collins Hawaiʻi Ltd. 2007a, Rechtman 2009). Kahuku Wind Power LLC purchased the property in May 2007, with the exception of approximately 70 ac (28 ha) that is leased from Continental Pacific, LLC.

All lands and waters in the State are classified into one of four districts: Agriculture, Rural, Conservation, or Urban (HRS Chapter 205). The project area and surrounding lands are in an Agricultural District (Figure 3-18). State Conservation District lands are mauka of the property and across Kamehameha Highway from the project area. The City and County of Honolulu zoning ordinance defines the project area as AG-1 Restrict Agricultural District. Adjoining land is also zoned AG-1 Restricted or AG-2 General.

According to the State Department of Agriculture's Agricultural Lands of Importance to the State of Hawaiʻi (ALISH) system, less than 60% (341 ac or 138 ha) of the agricultural areas on the project area is designated as Prime Farmland and 23% (134 ac or 54 ha) is defined as Other. Remaining areas are unclassified. Prime agricultural land is defined as land with soil temperature, soil pH, moisture supply, and growing season needed to produce high yields of crops when treated and managed according to modern farming methods. The Other designation refers to land that is important to agriculture, but lacks properties to be Prime or Unique; this land usually has slopes less than 35% and has been used or could be used for grazing. Wind energy facilities are permitted uses on agricultural areas, per HRS Chapter 205-4.5.

As described in Section 2.2, the Kahuku Wind Power facility would consist of 12 WTGs, an O&M building, one permanent unguyed met tower, one on-site and two off-site microwave towers, an electrical substation, a BESS, and a network of unpaved service roadways. Construction of the proposed facilities would disturb approximately 67 ac of the 578 ac project area (about 11.5%). Roughly 32 ac of the disturbed areas (about 5.6% of the project area) would contain structures, hardened surfaces, and associated setbacks (Table 2-1). The remainder would remain undisturbed. Kahuku Wind Power LLC is in the process of evaluating the possibility of complementary agricultural uses in the project area including community gardens, small plot farming, and grazing of livestock. However, no finalized plans have been put in place nor have definite areas been designated for these secondary usages (Environet, Inc. 2009). Any such uses would be excluded from the 60-ft setbacks afforded the coral reef escarpments.

The Waialua Substation site is located within a rural residential area characterized by single-family homes. Agricultural, commercial, and light industrial uses occur in the vicinity. The site is within an Urban District zoned as R-5 Residential District. The site is entirely owned by HECO.

The Flying R Ranch site is owned by Waialua Ranch Partners. A single residence is located roughly 722 ft (220 m) from the proposed site. Privately owned pasture land and related structures occur in the vicinity. The nearest residential neighborhood is roughly over 1.1 mi (1.8 km) away. The site is accessed via a private road at the intersection of Kaukonahua Road and Farrington Highway. Flying R Ranch site is located in an Agricultural District and is zoned AG-1 Restricted. The ALISH system ranks the site as Other.

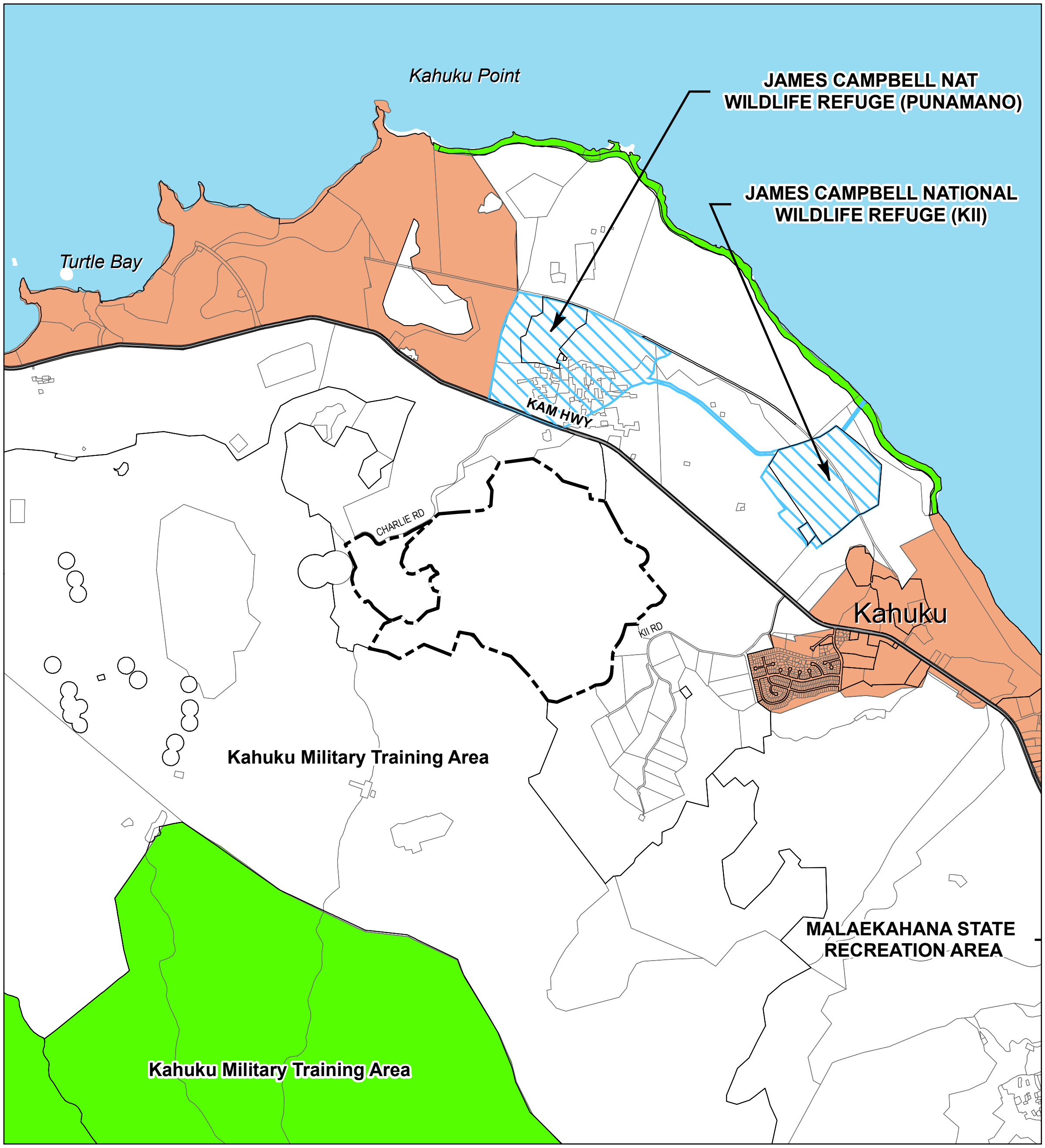
3.10.1.1 Applicable Land Use Policies, Plans, and Regulations

Federal, state, and county land use policies, plans, and regulations that are applicable to the proposed action are listed below. A complete description of these policies, plans, and regulations is provided in Appendix D. Other federal and state policies, plans, and regulations that apply to land use (such as the Federal Endangered Species Act, Migratory Bird Treaty Act, National Historic Preservation Act, and Clean Water Act) are discussed in their respective sections.

Federal
- National Environmental Policy Act (42 U.S.C. 4371 et seq.)
- Farmland Protection Policy Act (7 USC 4201)

State
- Hawai‘i State Plan
- Hawai‘i Revised Statutes, Chapter 195D
- Hawai‘i Revised Statutes, Chapter 343
- Hawai‘i Revised Statutes, Chapter 205
- Hawai‘i Agricultural Land Use Map
- University of Hawai‘i’s Land Study Bureau Detailed Land Classification
- State Department of Agriculture’s Agricultural Lands of Importance to the State of Hawai‘i
- Hawai‘i’s Coastal Zone Management (CZM) Program

County
- General Plan for the City and County of Honolulu
- Ko‘olau Loa Sustainable Communities Plan
- City and County of Honolulu Zoning



Legend

- ⬚ Project Parcel
- ▨ James Campbell NWR
- ☐ TMK Parcels

State Land Use Districts

- ☐ Agricultural
- 🟩 Conservation
- 🟧 Urban
- 🟦 Ocean

Data Sources: State of Hawaii GIS;
City and County of Honolulu; USGS

State of Hawaii Land Use District Boundaries Map

Figure 3-18

3.10.1.2 Potential Impacts of the Proposed Action

The proposed facility would be located on highly disturbed land owned by Kahuku Wind Power LLC. The presence of the WTGs, site access roads, substation, and related facilities would not limit access to other land served by the existing access road (Charlie Road). Discussions with personnel at the Kahuku Training Range and the Operating Engineers Union have indicated that the proposed wind generation facility would not have a negative impact on training activities on these parcels.

A wind energy project is an allowable use in areas zoned AG-1 Restricted with acquisition of a Conditional Use Permit (City and County of Honolulu, Land Use Ordinance, Chapter 21, Section 5.700). The proposed project obtained a Conditional Use Permit-Minor (CUP-M) from the City and County of Honolulu’s Department of Planning and Permitting (DPP) in January 2008. Due to proposed design modifications to the project, a new CUP was applied for in October 2009 and approved in December 2009. Future potential agricultural uses in the project area would be evaluated to ensure that these uses are complementary with the wind facility. Also, the presence of Kahuku Wind Power is not likely to deter or encourage any future potential land uses in the area.

A Farmland Conversion Impact Rating form and supporting documentation were completed and submitted to NRCS. The rating that resulted from the NRCS evaluation did not exceed 160 points. According to the Farmland Protection Policy Act, sites with a rating less than 160 need no further consideration.

The Waialua Substation and Flying R Ranch sites would be leased from HECO and Waialua Ranch Partners, respectively. Both leases would be turned over from Kahuku Wind Power LLC to HECO after commissioning. The presence of the microwave towers would not limit access to other land served by the access roads and would not have a negative impact on adjacent land uses. In addition, the presence of the off-site microwave towers is not likely to deter or encourage any future potential land uses.

Hawai‘i’s Coastal Zone Management (CZM) Program (HRS 205A-2) includes a permit system to control development within Special Management Areas (SMAs), which include lands within 300 ft (91 m) of the shoreline. The project area is not located within a SMA, nor do any of the possible off-site microwave tower locations. The proposed project does not involve the placement, erection, or removal of materials near the coastline and does not require a CZM Federal consistency determination because the type and scale of the action does not have the potential to affect coastal resources significantly.

Hawai‘i has environmental planning requirements outlined in Hawai‘i Revised Statutes, Chapter 343 (Environmental Impact Statements). Chapter 343 “establishes a system of environmental review [at the state and county levels] which shall ensure that environmental concerns are given appropriate consideration in decision making along economic and technical considerations” (§343-1). The only component of the proposed action that would trigger HRS Chapter 343 is the construction of a fence for predator control at a seabird colony on West Maui at Makamaka‘ole (see Section 3.12.4.1). Because Makamaka‘ole is situated on State land within a Conservation District, a State EA would be prepared prior to construction in accordance with Chapter 343 of HRS.

The proposed facility is compatible and consistent with these and the other above listed federal, state, and county land use plans and policies. See Appendix D for a complete discussion.

3.10.1.3 Potential Impacts of the No Action Alternative

If no construction would occur, there would be no change in existing land uses. However, it is possible the project area could ultimately be used for some other purpose if the facility is not constructed.

3.11 Flora

3.11.1 Regulatory Framework

Federal Endangered Species Act (16 U.S.C. 1531-1544).

Established in 1973, the Endangered Species Act (ESA) protects plants, fish, and wildlife that have been listed as threatened or endangered and conserves ecosystems on which the species depend. Candidate species, which may be listed in the near future, are not afforded protection under the ESA. Section 7 of the ESA mandates that all actions of federal agencies support the purposes of the ESA and outlines procedures for federal agencies to follow when taking actions that may adversely affect federally threatened or endangered species or designated critical habitats. A more detailed discussion of this Act and its applicability to the project is provided in Section 3.12.1.

Hawaiʻi Revised Statutes, Chapter 195D

The purpose of HRS, Chapter 195D is "to insure the continued perpetuation of indigenous aquatic life, wildlife, and land plants, and their habitats for human enjoyment, for scientific purposes, and as members of ecosystems…" (§195D-1). Section 195D-4 states that any endangered or threatened species of fish or wildlife recognized by the ESA shall be so deemed by State statute (see Section 3.12.1).

Executive Order 13112

Executive Order 13112 was signed in 1999 to prevent the introduction of invasive species and provide for their control. According to this Executive Order, an invasive species is defined as "an alien species (a species that is not native to the region or area) whose introduction does or is likely to cause economic or environmental harm or harm to human health." The Executive Order was designed to enhance federal coordination and response to the complex and accelerating problem of invasive species (National Invasive Species Council 2005).

Hawaiʻi Statute Chapter 152 Noxious Weed Control

HRS, Chapter 152 (Noxious Weed Control) prohibits the introduction or transport of "specific noxious weeds or their seeds or vegetative reproductive parts into any area designated pursuant to section 152-5 as free or reasonably free of those noxious weeds" (§152-3). The objectives of Hawaiʻi Administrative Rules (HAR), Title 4, Chapter 68 are to implement the requirements of HRS Chapter 152, and to establish criteria for designation, control, or eradication of noxious weeds (§4-68-1). HAR, Title 4, Chapter 68 contains a list of plant species designated as noxious weeds by the Department of Agriculture for eradication or control purposes.

3.11.2 Previous Surveys and Description of Flora

Botanical surveys of the Kahuku Wind Power project area were conducted by Robert Hobdy in April 2007 and July 2009 (Appendix E). Hobdy walked a series of routes throughout the property and more intensively examined areas most likely to support native or rare plants (e.g., gullies and rocky outcrops). A supplemental wetland plant survey was conducted in the same area by SWCA botanists in June 2008 (SWCA 2008). Approximately 128 plant species were recorded during the survey by Hobdy in 2007 and an additional four species were found during the SWCA survey. In 2009, Hobdy recorded approximately 99 plant species in a 68.5 ac (27.7 ha) area within the project area. No state or federally listed endangered, threatened, or candidate plant species, nor species considered rare throughout the Hawaiian

Islands, were found in the project area by Hobdy or SWCA. No portion of the project area has been designated as critical habitat for any listed species.

The majority of the project area (about 80%) is covered with dense brush or trees and the abundant and common plants are not native to the Hawaiian Islands. In general, vegetated areas mostly support dense brush composed of koa haole (*Leucaena leucocephala*) trees with a mix of grasses and herbaceous plants in the understory. Cocklebur (*Xanthium strumarium*), allspice (*Pimenta dioica*), sourgrass (*Digitaria insularis*), kolomona (*Senna surratnesis*), pitted beardgrass (*Bothriochloa pertusa*), Chinese violet (*Asystasia gangetica*), Christmas berry (*Schinus terebinthifolius*), parasol leaf tree (*Macaranga tanarius*), common beggarticks (*Bidens alba*), sourbush (*Pluchea carolinensis*), lantana (*Lantana camara*), Jamaica vervain (*Stachytarpheta jamaicensis*), and pea aubergine (*Solanum torvum*) are some of the other common species through the area. A comparatively large clearing is present in the southwest portion of the project area where topsoil was removed for use on the aforementioned golf course, and other smaller open areas are scattered throughout.

Few native plant species exist on-site as a result of topsoil disturbance from sugar production and cattle grazing. Native species are generally located on rocky outcrops and on exposed ridge tops in the upper portion of the property (SWCA 2008). Twelve native plant species were identified in the project area, of which three are endemic to the Hawaiian Islands - ‘akia (*Wikstroemia oahuensis*), ni‘ani‘au (*Nephrolepis exaltata* subsp. *hawaiiensis*), and kīlau (*Pteridium aquilinum* var. *decompositum*). Table 3-10 lists native plant species recorded in the project area by Hobdy (2007, 2009) and SWCA (2008).

Table 3-10. Native Hawaiian plants observed in the project area.

Scientific Name	Common, Hawaiian Name(s)	Status[1]	Abundance[2]
FERNS AND FERN ALLIES			
DENNSTAEDTIACEAE			
Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaudich.) R.M. Tryon	kīlau	E	Rare
LINDSAEACEAE			
Sphenomeris chinensis (L.) Maxon	pala‘ā	I	Rare
NEPHROLEPIDACEAE			
Nephrolepis exaltata (L.) Schott subsp. hawaiiensis W.H.Wagner	ni‘ani‘au	E	Rare
MONOCOTS			
POACEAE			
Chrysopogon aciculatus (Retz.) Trin.	pi‘i pi‘i	I	Uncommon
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	pili	I	Uncommon

Scientific Name	**Common, Hawaiian Name(s)**	**Status**[1]	**Abundance**[2]
DICOTS			
MENISPERMACEAE			
Cocculus orbiculatus (L.) DC	huehue	I	X
PIPERACEAE			
Peperomia blanda Kunth var floribunda (Miq.) H.Huber	‘ala‘ala wai nui	I	Rare
PLUMBAGINACEAE			
Plumbago zeylanica L.	‘ilie‘e	I	Rare
ROSACEAE			
Osteomeles anthyllidifolia (Sm.) Lindl.	‘ūlei	I	Rare
SOLANACEAE			
Solanum americanum Mill.	popolo	I	Rare
STERCULIACEAE			
Waltheria indica L.	‘uhaloa	I	Uncommon
THYMELAEACEAE			
Wikstroemia oahuensis (A. Gray) Rock	‘akia	E	Uncommon

(1) E= endemic (native only to Hawai‘i); I= indigenous (native to Hawai‘i and elsewhere).

(2) Common= widely scatted throughout the project area or locally abundant; uncommon= scattered sparsely throughout the project area or occurring in a few small patches; rare= only a few isolated individuals at the project area; X = observed by SWCA, but abundance not recorded.

The Waialua Substation tower would be located in a fenced area that is completely paved or covered in gravel. Landscaped areas are present outside of the fenced area.

SWCA conducted a botanical survey of the Flying R Ranch off-site microwave tower site in December 2009. State or federally listed endangered, threatened, or candidate plant species were not observed during the survey, nor were any species considered rare throughout the Hawaiian Islands (T. Thair/SWCA, personal observation). The area is dominated by non-native species including Java plum (*Syzygium cumini*), Guinea grass (*Urochloa maxima*), and maile honohono (*Ageratum conyzoides*). Only one native species (*Dodonea viscosa*) was observed in the vicinity, roughly 85 ft (26 m) from where the microwave tower foundation would be constructed. A complete list of the plant species documented at the Flying R Ranch site is included in Appendix F.

3.11.2.1 Potential Impacts of the Proposed Action

Construction Phase:

Under the proposed action, construction of the proposed project would have a minor impact on existing flora at the project area due to ground clearing. The proposed roads, construction activities, and regular operation of the facility would result in disturbance of approximately 32 ac (13 ha) of the project area. Acres of vegetation disturbed in the project area could be greater if the land is also allowed to be used for farming and other agricultural purposes.

No state or federally listed threatened, endangered, or candidate plant species have been documented at the Kahuku project area. Vegetation in areas that would be disturbed consists of non-native species common throughout Oʻahu and the main Hawaiian Islands. The few native species documented in the project area are generally located on rocky outcrops and on exposed ridge tops outside of areas proposed to be used for construction and are therefore not likely to be impacted by the proposed project. Due to the general condition of the habitat and the overall lack of native plant species in the project area, the proposed Kahuku Wind Power facility is not expected to have an adverse impact on botanical resources on Oʻahu.

Invasive plants, such as Christmas berry, lantana, and cocklebur, are widespread at the Kahuku Wind Power project area and in neighboring parcels. Due to the existing conditions of the project area, the potential for the project to result in an increase in the number or distribution of invasive plant species would be minor. Similarly, control measures are not expected to result in a significant decrease in the number or distribution of invasive plant species currently occurring in the project area. However, to minimize the potential for introducing new invasive plants to the project area, Kahuku Wind Power LLC would ensure that off-site sources of revegetation materials (seed mixes, gravel, mulches, etc.) are certified weed-free or inspected prior to transport to the project area. All areas that are hydroseeded would be monitored for six months after hydroseeding to ensure removal of any invasive plants that have established from seeds inadvertently introduced as part of the seed mixes.

Kahuku Wind Power LLC is not proposing to intentionally introduce or transport any invasive plant species, including species listed as noxious weeds by the Department of Agriculture. To avoid the unintentional introduction or transport of these species through soil and debris, all construction equipment and vehicles arriving from outside of the Island of Oʻahu would be washed prior to entering the project area. In addition, Kahuku Wind Power would ensure that construction materials arriving from outside of Oʻahu are washed and/or visually inspected (as appropriate) for excessive debris, plant materials, and invasive or harmful non-native species prior to transportation to the project area. Most inspection and cleaning activities would be conducted at a vacant 6.8 acre parcel immediately adjacent to the Barbers Point Harbor, which would be leased by Kahuku Wind Power LLC. Equipment and material arriving through Honolulu Harbor would be inspected and/or cleaned (as appropriate) at a designated location prior to entering the project area. Kahuku Wind Power LLC would document all inspection and cleaning activities using inspection forms. At the end of the construction period, areas impacted by construction of the project would be surveyed to ensure that no problematic and/or invasive species had established. Appropriate remedial actions would be undertaken in consultation with DLNR and USFWS (as appropriate) to facilitate containment or eradication of the target species as soon as reasonably possible.

Upon completion of earthwork, some portions of the project area that would be disturbed during construction would be revegetated. Areas suitable for stabilization by revegetation include cut and fill slopes and turbine pads. Kahuku Wind Power LLC intends to revegetate these areas by hydroseeding and/or outplanting suitable ground cover. The primary goal of the revegetation would be to immediately stabilize soil and prevent erosion following construction. Native species may be re-introduced where feasible.

Vegetation that would be disturbed at the off-site microwave tower sites consists of non-native species common throughout Oʻahu and the main Hawaiian Islands. Due to the overall lack of native plant species at the off-site microwave tower sites, there would be no impacts to flora as a result of construction or operation of the two towers.

Operation Phase:

To improve searcher efficiency during monitoring of the WTGs and met tower, the previously disturbed turbine pads and a circular area under the met tower would be regularly cleared of vegetation using mechanical methods. Because non-native species are capable of quickly establishing in disturbed areas compared to native species, only non-native species currently present in the project area (primarily grasses and herbs) are expected to establish in these areas. Therefore, operation of the Kahuku Wind Power facility is not expected to have an adverse impact on botanical resources on Oʻahu.

3.11.2.1 Potential Impacts of the No Action Alternative

No changes in floristic conditions would occur in the project area in the short-term if the facility was not constructed (other than natural successive processes). Vegetation occurring on the property could be disturbed in the long-term if the land were to ultimately be used for some other purpose.

3.12 Wildlife

3.12.1 Regulatory Framework

Federal Endangered Species Act (16 U.S.C. 1531-1544).

Established in 1973, the ESA protects plants, fish, and wildlife that have been listed as threatened or endangered and conserves ecosystem in which the species depend. Candidate species, which may be listed in the near future, are not afforded protection under the ESA. Section 7 of the ESA mandates that all actions of federal agencies support the purposes of the ESA and outlines procedures for federal agencies to follow when taking actions that may adversely affect federally threatened or endangered species or designated critical habitats.

“Take” means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect species listed as endangered or threatened, or to attempt to engage in any such conduct (50 CFR 17.3). “Harm” has been defined by USFWS to mean an act which actually kills or injures wildlife, and may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). “Harass” has been defined to mean an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering (50 CFR 17.3). Because the proposed project involves a federal action, it is subject to Section 7 of the ESA.

Hawaiʻi Revised Statutes, Chapter 195D

The purpose of HRS, Chapter 195D is “to insure the continued perpetuation of indigenous aquatic life, wildlife, and land plants, and their habitats for human enjoyment, for scientific purposes, and as members of ecosystems…” (§195D-1). Section 195D-4 states that any endangered or threatened species of fish or wildlife recognized by the ESA shall be so deemed by State statute. Like the ESA, the unauthorized "take" of such endangered or threatened species is prohibited [§195D-4(e)].

Under Section 195D-4(g), the Board of Land and Natural Resources (BLNR), after consultation with the State's Endangered Species Recovery Committee (ESRC), may issue a temporary license (subsequently referred to as an "ITL") to allow a take otherwise prohibited if the take is incidental to the carrying out of an otherwise lawful activity. In order to qualify for an ITL, an Applicant must implement a Habitat Conservation Plan (HCP). Section 195D-21 outlines the requirements of HCPs, which are similar to those in federal regulations. All HCPs and their actions authorized under the HCP should be designed to result in an overall net benefit to the threatened and endangered species in Hawai‘i (Section 195D-30). Kahuku Wind Power LLC is in the final stages of obtaining an ITL and has an approved HCP, as described below.

Section 195D-25 also provides for the creation of the ESRC, which is composed of biological experts, representatives of relevant federal and state agencies (i.e. USFWS, USGS, DLNR), and appropriate governmental and non-governmental members to serve as a consultant to the DLNR and the BLNR on matters relating to endangered, threatened, proposed, and candidate species. ESRC reviews all applications for HCPs and makes recommendations to the DLNR and the BLNR on whether they should be approved, amended, or rejected.

Consultation Process with State and Federal Agencies

The USFWS has been consulted throughout the preparation of this EA and the HCP and has participated in meetings with the State Department of Forestry and Wildlife (DOFAW) and the ESRC. Consultation with USFWS regarding potential impacts to federally listed species began in January 2007 when Kahuku Wind Power LLC submitted a CUP Application to DPP for the proposed project. At that time, USFWS identified four federally listed waterbird species (Hawaiian coot, Hawaiian duck, Hawaiian stilt, and Hawaiian moorhen) that might be impacted as a result of construction and operation of the proposed project. USFWS recommended that DPP require Kahuku Wind Power LLC to consult with USFWS and DOFAW about these potential impacts as a condition of CUP approval (P. Leonard/USFWS, letter to City and County of Honolulu Department of Planning and Permitting, dated 7 January 2007). Three other federally listed species (Newell's shearwater, Hawaiian petrel, and Hawaiian hoary bat) and one state listed species (Hawaiian short-eared owl or pueo) were added to the consultation process as a result of wildlife surveys of the project area.

A USFWS representative holds a voting seat on the ESRC, and USFWS representatives have been involved in several meetings to discuss the HCP. Kahuku Wind Power LLC was introduced to ESRC in October 2008. An HCP pre-application was submitted to DOFAW in early November 2008, starting the formal HCP process. Because the HCP is a state document, the state is the lead agency for the permit and therefore takes the lead in all discussions regarding impacts and mitigation to listed species. However, throughout this process, DOFAW has been in consultation with USFWS and the ESRC. Kahuku Wind Power LLC received comments on the proposed project from DOFAW on November 24, 2008, providing guidance on take estimates with regards to unobserved take and indirect take. Concurrence was given on the species covered in the HCP. Further discussions about the project and development of mitigation options with DOFAW and USFWS occurred on December 4 and December 18, 2008, and DOFAW visited the project area on December 12, 2008 and February 17, 2010.

The draft HCP was reviewed by the ESRC during their meeting in July 2009. During this meeting, mitigation measures were refined and additional options were incorporated into the HCP based on the feedback received. The draft HCP was subsequently approved by BLNR for release for public review in August 2009. The public comment period extended from September 28 to November 23, with a public meeting on November 4, 2009. Two comment letters on the draft HCP were received, one from Office of Hawaiian Affairs (OHA) and one from the state Attorney General (AG). No comments were received during the public meeting. The OHA comment expressed a need for reassurance that mitigation commitment should last the duration of the project, and the state AG asked for clarification on the Administrative Rules for the HCP as well as clarification on how mitigation sites were chosen. The USFWS also provided comments on the draft HCP on November 12, 2009. Comments were wide ranging. Key comments included: a request for a waterbird management plan; a formal letter of agreement with DOFAW for waterbird mitigation at Hamakua, a state managed wetland site; a request for discussion about climate change under Changed Circumstances; comments on monitoring procedures; and comments on HCP funding. In response to comments, Kahuku Wind Power LLC revised the HCP. The final HCP was approved by ESRC in February 2010 and by BLNR on March 11, 2010, and issuance of the ITL is expected in May or June of 2010.

DOE consulted with USFWS under Section 7 of the ESA to address the potential for construction and operation of the facility to adversely affect federally listed threatened and endangered species. DOE made a determination of “may affect, and is likely to adversely affect” for the federally listed species covered in the HCP. Under the direction of the USFWS, DOE submitted the HCP and a draft of this EA as the biological assessment (BA) to describe the expected impact that the proposed project would have on threatened and endangered species. USFWS issued a biological opinion (BO) on May 13, 2010. In the BO, USFWS determined that the proposed wind project would not jeopardize the survival and recovery of any federally listed threatened or endangered species and adopted the conservation measures in the HCP as the reasonable and prudent measures required to minimize incidental take.

In addition to the ESA consultation process, DOE provided USFWS, Pacific Islands Fish and Wildlife Office, with an opportunity to comment on the draft of this EA. USFWS responded with a request for additional information in the EA on measures to control invasive species from construction materials and on the benefits and potential impacts of mitigation measures for covered species required in the HCP. DOE added text to Sections 3.11.2.1 and 3.12.4.1 of the EA to address USFWS comments, which are included in Appendix K.

Migratory Bird Treaty Act (16 U.S.C. 703-712).

All native migratory birds of the United States are protected under the Migratory Bird Treaty Act (MBTA) of 1918, as amended (16 U.S.C. 703-712 *et. seq.*). This act states that it is unlawful to pursue, hunt, take, capture or kill; attempt to take, capture or kill; possess, offer to or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product. “Take” is defined as “to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect (16 U.S.C. 703-712).” No process for authorizing incidental take of MBTA protected birds or providing permits is described in the MBTA (USFWS and NMFS 1996).

Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds, directs Federal agencies to take certain actions to further implement the Act. In 2006, DOE and USFWS signed a Memorandum of Understanding (MOU) regarding the implementation of Executive Order 13186. This MOU requires DOE to integrate migratory bird conservation principles, measures, and practices into DOE activities. The MOU also commits DOE to avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources.

In Hawai‘i, the requirements of the MTBA and Executive Order 13186 apply to all MTBA birds found within Bird Conservation Region (BCR) 67 (Hawai‘i). To avoid and minimize impacts to MBTA-protected species within BCR 67, Kahuku Wind Power LLC has incorporated design and operational features based on the USFWS Interim Guidance on Avoiding and Minimizing Impacts to Wildlife from Wind Turbines (issued May 13, 2003). These guidelines contain materials to assist in evaluating possible wind power sites, wind turbine design and location, and pre- and post-construction research to identify and/or assess potential impacts to wildlife. Specific measures that have been adopted by Kahuku Wind Power LLC to avoid and minimize the potential for impacts to MBTA-protected species are discussed in Appendix A.

In addition to the measures contained in Appendix A, Kahuku Wind Power would ensure that all active nests of MBTA birds listed within BCR 67 are not disturbed, especially during the breeding season. The only MBTA bird within BCR 67 that has the potential to nest in the project area is the Hawaiian short-eared owl or pueo. If active pueo nests are found, Kahuku Wind Power LLC would not remove the nest until all birds, including young, have left the nest and are no longer using the nest. A protective buffer area would be established around the nest during clearing/construction activities.

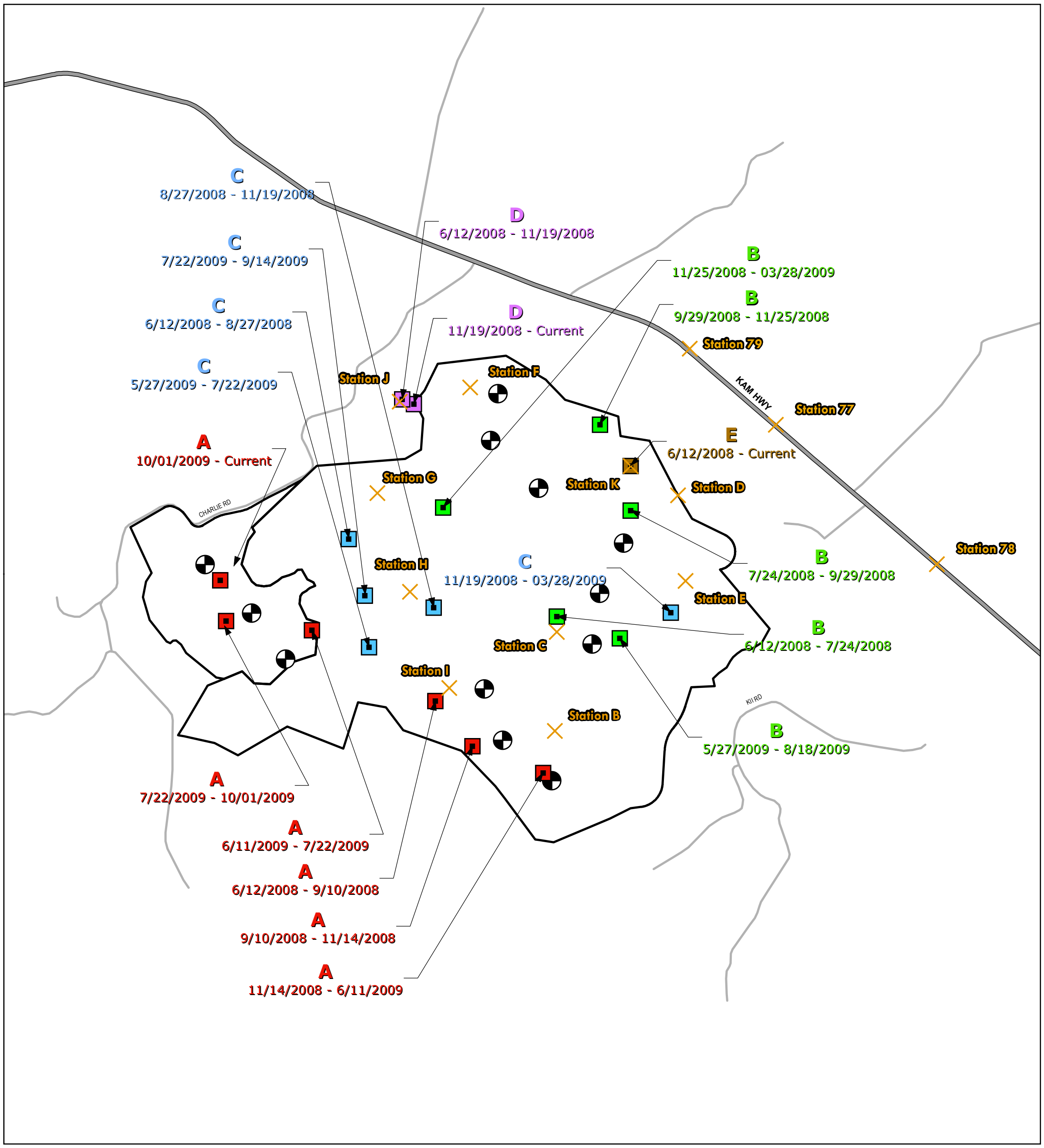
3.12.2 Previous Wildlife Surveys

Wildlife occurring on or flying over the project area has been investigated by Kahuku Wind Power LLC and its consultants through pedestrian surveys (Hobdy 2007, 2009), avian point count surveys (SWCA 2008; Appendix G), nocturnal radar surveys (Day and Cooper 2008; Appendix H), and the use of night vision equipment and bat detection devices (SWCA 2008). No other wildlife surveys are known to have been conducted on-site. The methodology and results of these wildlife investigations are discussed below.

Hobdy (2007) conducted a walk-through survey on the site using binoculars and listening to vocalizations. Species abundance and locations were noted, as well as observations of trails, tracks, scat and signs of feeding. An evening visit was made to record crepuscular activities and vocalizations for evidence of the Hawaiian hoary bat (*Lasiurus cinereus semotus*).

Kahuku Wind Power LLC and SWCA biologists conducted avian point count surveys between October 2007 and December 2008 for a total of 65.3 observation hours. Point count surveys were conducted by Kahuku Wind Power LLC from October 2007 to May 2008, and by SWCA from June 2008 to December 2008 using identical methods. Ten point count stations were established on the site (Figure 3-19) and four to eight point count stations were surveyed during each session. Sessions were conducted in the morning (0600 – 1000 h), afternoon (1000 – 1400 h) and evening (1400 – 1800 h). Each point count lasted 20 minutes per station.

Three point counts were also conducted at adjacent wetlands located 1,640 to 3,280 ft (500 to 1,000 m) makai of the project area to describe the flight activity of endangered Hawaiian waterbirds due to the few observations recorded at the established on-site point count locations. This was an effort to gain a better understanding of the activity patterns of the endangered species covered by the HCP, particularly those known to occur at the nearby James Campbell NWR, as well as to document the arrival and activity patterns of non-listed migratory bird species. Endangered species known to occur at the NWR include Hawaiian duck (*Anas wyvilliana*), Hawaiian stilt (*Himantopus mexicanus knudseni*), Hawaiian coot (*Fulica alai*), and Hawaiian moorhen (*Gallinula chloropus sandvicensis*).



Avian Point Count Stations and Anabat™ Locations

Figure 3-19

Legend

Turbines

Project Parcel

× Point Count Locations

Anabat Sensors

- 🟥 A
- 🟩 B
- 🟦 C
- 🟪 D
- 🟫 E

N

1,000 500 0 1,000

Feet

500 250 0 500

Meters

All passerines, owls (Strigiformes), and doves (Columbiformes) observed within a 656-ft (200-m) radius of a count location were recorded. Bird species aurally detected within a 200-m radius were also recorded. Waterbirds and seabirds, which are larger and more visible, were recorded out to a 1,312-ft (400-m) radius of the count station. Data recorded during surveys included time of day, bird species, size of flock, flight direction, flight altitude, distance of bird from observer, habitat, location (on-site or off-site), and sex and age of bird, if possible. Single occurrences of birds detected during surveys, whether individuals or flocks, are hereafter referred to in this document as “flights.” Weather variables recorded were wind speed, wind direction, cloud cover, visibility, and precipitation. Mammals observed incidental to the bird surveys were also recorded during each point count survey.

Nocturnal radar surveys were conducted on-site in fall 2007 (five evenings, 1800-2100 h, October 16-20) and summer 2008 (eight evenings, 1800-2100h, and mornings, 0400-600h from 1-8 July) in an effort to identify seabirds that may potentially transit the Kahuku Wind Power project area during crepuscular and night periods (Cooper and Day 2008). The fall surveys coincided with the Hawaiian petrel (*Pterodroma sandwichensis*) and Newell’s shearwater (*Puffinus auricularis newelli*) fledging periods and the summer surveys coincided with the post-hatching nestling care periods for both species.

Birds detected by the radar surveys included probable Newell’s shearwater, Hawaiian short-eared owl, and barn owl (*Tyto alba*). These species were not detected on-site or overflying the project areas during the day. Criteria used to establish the detection of shearwaters/petrels were based on identifying targets on radar flying at airspeeds greater than 30 mi/h (48 km/h), of the appropriate size, flying inland or seaward only (not parallel to shore) and exhibiting directional flight. As discussed in Section 3.12.4, timing of radar detections was used to tentatively identify these birds as Newell’s shearwaters rather than Hawaiian petrels. The Hawaiian short-eared owl was heard by the radar technicians and the barn owl visually sighted and identified.

During these surveys, a total of 24 bird species were observed on the Kahuku Wind Power project area, 19 of which are non-native to the Hawaiian Islands. Table 3-11 identifies all birds detected during the point count and radar surveys. Included in this table are scientific and common names of each species as standardized by the American Ornithologists’ Union, status of each species on O‘ahu, federal listing status, indication of whether the observed species is protected by the MBTA, and an indication of whether the species was detected on-site, off-site, or both.

Nocturnal visual surveys were also conducted twice a month from October 2007 to December 2008 for a total of 18 observation hours. Four to eight point counts were surveyed for 20 minutes each field session. The point count locations used were the same as bird point count locations. Night vision goggles (Kerif ITT PVS-7 F5001 Series) and infra-red spotlights (Brinkmann Q-beam Max Million III) were used and provided ability to detect bats out to a distance of 100 ft (30 m) from the observer. No bats were detected visually during these observations.

Five Anabat™ detectors (Titley Electronics, NSW, Australia) were deployed at various locations at Kahuku Wind Power beginning April 2008 to present (Figure 3-19) in an effort to detect the presence of bats by recording ultrasonic sounds emitted by bats during echolocation. Anabat™ detectors were moved monthly to new locations if no bat calls were detected during the previous month. A low but consistent level of bat activity was recorded at Anabat™ detectors throughout the year with a slight increase in activity from June to September (see Section 3.12.4 and Appendix G).

3.12.3 Non- Listed Species

Most non-federally or state listed wildlife species detected on and adjacent to the project area during general biological, point count, and radar surveys are not native to the Hawaiian Islands; however, non-listed endemic and indigenous species also occur in the vicinity of the project area. Key avian species (i.e. waterbirds and seabirds) that occur in the vicinity of the Kahuku Wind Power project area are discussed below following discussion of the potential microwave tower sites.

Based on general observations, birds that frequent the Waialua Substation site are non-native species common to altered rural environments on Oʻahu. These include zebra dove, spotted dove, rock pigeon (*Columba livia*), common myna, Japanese white-eye, red-vented bulbul, red-whiskered bulbul, house finch, common waxbill, house sparrow, and Java sparrow (L. Ong/SWCA, pers. obs.).

Non-native birds are also common at the Flying R Ranch site. These include the common myna, zebra dove, spotted dove, Japanese white-eye, house finch, red-vented bulbul, Japanese bush warbler, peacock, red crested cardinal, Erckel's francolin (*Francolinus erckelii*), and, possibly, barn owl (L. Ong/SWCA, pers. obs.). The only non-federally listed endemic bird that could potentially occur in the vicinity of the site is the pueo or Hawaiian short-eared owl. This species is listed as endangered by the State of Hawaiʻi for Oʻahu.

Table 3-11. Birds detected on and adjacent to Kahuku Wind Power project area during point count and radar surveys.

Scientific Name	Common Name	Status[1]	Protection		Observed[3]	
			ESA[2]	MBTA	On-Site	Adjacent Wetlands
Puffinus auricularis newelli	Newell's shearwater[4]	E	T	X	X (F)	
Fregata minor	great frigatebird	I		X	X (F)	X
Bubulcus ibis	cattle egret	NN		X	X	X
Anas sp.	Hawaiian (?) duck[5]	E	E	X	X (F)	X
Fulica alai	Hawaiian coot	E	E	X		X
Himantopus mexicanus knudseni	Hawaiian stilt	E	E	X	*	X
Phasianus colchicus	ring-necked pheasant	NN			X	X
Pluvialis fulva	Pacific golden-plover	V		X	X	X
Arenaria interpres	ruddy turnstone	V		X	X	X
Heteroscelus incanus	wandering tattler	V		X		X
Calidris alba	sanderling	V		X		X
Streptopelia chinensis	spotted dove	NN			X	X
Geopelia striata	zebra dove	NN			X	X

Scientific Name	Common Name	Status[1]	Protection		Observed[3]	
			ESA[2]	MBTA	On-Site	Adjacent Wetlands
Tyto alba	barn owl	NN		X	X	
Asio flammeus Sandwichensis	Hawaiian short-eared owl	E		X	X	
Pycnonotus cafer	red-vented bulbul	NN			X	X
Pycnonotus jocosus	red-whiskered bulbul	NN			X	
Cettia diphone	Japanese bush warbler	NN			X	
Copsychus malabaricus	white-rumped shama	NN			X	
Acridotheres tristis	common mynah	NN			X	X
Zosterops japonicus	Japanese white-eye	NN			X	
Cardinalis cardinalis	northern cardinal	NN		X	X	
Paroaria coronata	red-crested cardinal	NN			X	X
Carpodacus mexicanus	house finch	NN		X	X	X
Passer domesticus	house sparrow	NN			X	X
Estrilda astrild	common waxbill	NN			X	X
Padda oryzivora	Java sparrow	NN			X	
Lonchura cantans	African silverbill	NN			X	
Lonchura punctulata	nutmeg mannikin	NN			X	
Lonchura malacca	chestnut munia	NN			X	

1) E = endemic; I = indigenous, V = native visitor; NN = non-native permanent resident

2) E = federally endangered; T = federally threatened

3) X = Detected during surveys; F = only detected flying over site; * downed bird collected

4) Identification inferred from interpretation of radar data

5) All free-flying “Hawaiian” ducks on O‘ahu appear to actually be Hawaiian duck x mallard (*Anas platyrhynchos*) duck hybrids

Herons and Egrets:

The indigenous black-crowned night-heron (*Nycticorax nycticorax*) is a cosmopolitan species resident on the main Hawaiian Islands (Pratt et al. 1987, Hawaiʻi Audubon Society 2005). The black-crowned night-heron was identified as a species of "Moderate Concern" in *The North American Waterbird Conservation Plan* (Kushlan et al. 2002). Populations of species given this designation are declining with moderate threats or distribution, stable with known or potential threats and moderate to restricted distributions, or are relatively small with relatively restricted distributions. In Hawaiʻi, this species is considered a nuisance by aquaculture farmers. A small concentration of this species occurs at the Kiʻi Unit of the James Campbell NWR because of the abundance of potential prey (e.g., crustaceans, insects, fish, and frogs) at the NWR and within nearby aquaculture farms (Mitchell at el. 2005). Between 2001 and 2006, an average of 13 birds was recorded per month at the Kiʻi Unit (USFWS, unpubl. data). No black-crowned night-herons were observed in the Kahuku Wind Power project area during any of the avian surveys and they are not expected to occur regularly on the site owing to a lack of suitable wetland habitat. Potential exists for individuals of this species to occasionally fly over the project area, especially the lower elevation makai portions.

The cattle egret was introduced to Hawaiʻi from Florida for insect control in the mid 20th century and has become a widespread species across the main Hawaiian Islands. This species was identified as "Not Currently At Risk" in *The North American Waterbird Conservation Plan* (Kushlan et al. 2002). On Oʻahu, large concentrations of this species can be found at Pearl Harbor, Kaneʻohe Bay, and Kahuku. Cattle egrets eat a wide variety of prey including insects, spiders, frogs, prawns, mice, crayfish, and the young of native waterbirds (Pratt et al. 1987, Telfair 1994, Robinson et al. 1999, Brisbin et al. 2002, Engilis et al. 2002, Hawaiʻi Audubon Society 2005, USFWS 2005a). Cattle egrets were observed regularly during the avian surveys at Kahuku Wind Power and accounted for approximately 17% (5.36 flocks/hr/point count) of all flights observed on site.

Seabirds:

The indigenous wedge-tailed shearwater (*Puffinus pacificus*) is common throughout the tropical and subtropical Pacific and Indian Oceans. Worldwide, over one million breeding pairs are believed to occur. The species was identified as of "Low Concern" in *The North American Waterbird Conservation Plan* (Kushlan et al. 2002). Populations of species designated of "Low Concern" are either stable with moderate threats and distribution, or are increasing or stable, but with known or potential threats and moderate to restricted distributions. The species is considered of least concern in the Pacific because of its wide distribution and population size (USFWS 2005b).

Over a quarter of the known population of this species (275,000 pairs) breeds in the Hawaiian Islands (Whitton 1997, USFWS 2005b). On Oʻahu, wedge-tailed shearwaters are known to nest at Kaʻena Point, Mokapu Peninsula, Kūpikipikiʻō Point, Mālaekahana State Recreation Area, and the Kahuku Golf Course. Wedge-tailed shearwaters also nest at five offshore State Seabird Sanctuaries around Oʻahu (Mokuʻauia, Kīhewamoku, Pulemoku, Kukuihoʻolua, and Mokuālai) (Smith et al. 2002, Mitchell et al. 2005). To date, no wedge-tailed shearwaters have been seen flying over the Kahuku Wind Power project area. Wedge-tailed shearwaters typically excavate ground burrows for nesting, but will also nest on the ground surface (USFWS 2005b). The main threats to wedge-tailed shearwaters nesting on Oʻahu are predation by introduced mammalian predators and human disturbance by trampling burrows (Mitchell et al. 2005). Young birds are also threatened by disorientation from urban lighting. On the northern tip of Oʻahu, young shearwaters have been observed flying into lights while leaving their colonies in the late fall. A wedge-tailed shearwater rescue plan has been developed by the Turtle Bay Resort in the case that downed birds are found on resort grounds (Kusao & Kurahashi, Inc. 2003).

Laysan albatross (*Diomedea immutabilis*) have consistently been observed during bird surveys conducted by USFWS makai of the Kahuku Wind Power project area at the Kiʻi Unit of the James Campbell NWR (USFWS, unpubl. data). This species is considered of "High Concern" by the *Regional Seabird Conservation Plan* (USFWS 2005b) and *The North American Waterbird Conservation Plan* (Kushlan et al. 2002). Populations of species identified as "High Concern" are known or thought to be declining and have some other known or potential threats. Approximately 93% of the breeding pairs of Laysan albatross occur on Midway and Laysan Islands. Some albatrosses are known to nest at Kaʻena Point and have attempted to nest at Dillingham Airfield, Kahuku Golf Course, and the Marine Corps Base Hawaiʻi in Kaneʻohe on Oʻahu (USFWS 2005b). In the past, Laysan albatross have also attempted unsuccessfully to nest at Kahuku Point (E. VanderWerf, pers. comm.). This species typically nests on beaches and other low grounds generally near the ocean.

To date, no Laysan albatross have been seen flying over the Kahuku Wind Power project area. Potential for Laysan albatross to fly over the site appears to be extremely low because this species nests near water and otherwise stays at sea.

Other Birds:

For centuries, migratory ducks, geese, and other waterfowl have wintered on the Hawaiian Islands. Table 3-12 provides a list of migratory waterfowl that have been observed utilizing the James Campbell NWR. The indicated fulvous whistling-duck (*Dendrocygna bicolor*) established a small temporary breeding population at the refuge (Pratt et al. 1987, Hawaiʻi Audubon Society 2005), but was last observed in December 2001 (USFWS 2002).

Table 3-12. Migratory waterfowl observed on the nearby James Campbell NWR.

Scientific Name	Common Name
Dendrocygna bicolor	fulvous whistling-duck
Anser albifrons	greater white-fronted goose
Chen caerulescens	snow goose
Branta bernicla	brant
Branta canadensis	Canada goose
Branta hutchinsii	cackling goose
Anas crecca	green-winged teal
Anas platyrhynchos	mallard
Anas acuta	northern pintail
Anas querquedula	garganey
Anas discors	blue-winged teal
Anas cyanoptera	cinnamon teal

Scientific Name	Common Name
Anas clypeata	northern shoveler
Anas strepera	gadwall
Anas penelope	Eurasian wigeon
Anas americana	American wigeon
Aythya valisineria	canvasback
Aythya americana	redhead
Aythya collaris	ring-necked duck
Aythya fuligula	tufted duck
Aythya marila	greater scaup
Aythya affinis	lesser scaup
Netta peposaca	rosy-billed pochard
Bucephala albeola	bufflehead
Mergus merganser	common merganser
Sources: USFWS (2003b), Pyle and Pyle (2009).	

James Campbell NWR is also an important wintering ground for shorebirds in the Hawaiian Islands (Engilis and Naughton 2004). Shorebirds primarily utilize wetlands and tidal flats; however, estuaries, grasslands, uplands, beaches, golf courses, and even urban rooftops are important habitats for some species (Engilis and Naughton 2004). The Island of O‘ahu offers the most diverse shorebird habitat of all the Hawaiian Islands. Threats to shorebirds in the Pacific region include habitat loss (urban, industrial, military, agricultural and recreational development), invasive non-native plants, non-native animals (which cause predation, disease, and competition), human disturbance, and environmental contaminants (Engilis and Naughton 2004). Species of shorebirds that have been observed at James Campbell NWR are listed in Table 3-13.

Table 3-13. Migratory shorebirds observed on the nearby James Campbell NWR.

Scientific Name	Common Name
Pluvialis squatarola	black-bellied plover
Pluvialis fulva	Pacific golden-plover
Charadrius semipalmatus	semipalmated plover
Charadrius vociferus	killdeer

Scientific Name	Common Name
Himantopus mexicanus knudseni	Hawaiian stilt
Actitis maclaria	spotted sandpiper
Tringa solitaria	solitary sandpiper
Heteroscelus brevipes	gray-tailed tattler
Heteorscelus incanus	wandering tattler
Tringa melanoleuca	greater yellowlegs
Tringa flavipes	lesser yellowlegs
Numenius phaeopus	whimbrel
Numenius tahitiensis	bristle-thighed curlew
Limosa limosa	black-tailed godwit
Limosa fedoa	marbled godwit
Arenaria interpres	ruddy turnstone
Calidris canutus	red knot
Calidris alba	sanderling
Calidris pusilla	semipalmated sandpiper
Calidris mauri	western sandpiper
Calidris ruficollis	red-necked stint
Calidris minutilla	least sandpiper
Calidris fuscicollis	white-rumped sandpiper
Calidris bairdii	Baird’s sandpiper
Calidris melanotos	pectoral sandpiper
Calidris acuminata	sharp-tailed sandpiper
Calidris alpina	dunlin
Calidris ferruginea	curlew sandpiper
Calidris himantopus	stilt sandpiper
Tryngites subruficollis	buff-breasted sandpiper

Scientific Name	Common Name
Philomachus pugnax	ruff
Limnodromus griseus	short-billed dowitcher
Limnodromus scolopaceus	long-billed dowitcher
Gallinago sp.	snipe
Phalaropus tricolor	Wilson’s phalarope
Phalaropus fulicaria	red phalarope
Source: USFWS, unpublished.	

The *U.S. Pacific Islands Regional Shorebird Conservation Plan* (Engilis and Naughton 2004) identifies three shorebird species of primary importance in Hawai‘i: the Hawaiian stilt, Pacific golden-plover, and bristle-thighed curlew. The only permanent resident shorebird, the endemic Hawaiian stilt, is discussed in Section 3.12.4. Pacific golden-plovers are of primary importance because Hawai‘i supports a substantial number during the winter (an estimated 15,000 to 20,000 individuals) and the bristle-thighed curlew is the only migratory species that winters exclusively in the Pacific (Engilis and Naughton 2004). The wandering tattler is considered a species of importance and the ruddy turnstone is considered a species of secondary importance (Engilis and Naughton 2004).

Pacific golden-plover and ruddy turnstone are the only two shorebirds that were detected utilizing the Kahuku Wind Power project area during the avian surveys conducted by Kahuku Wind Power LLC and SWCA. Data suggests that these birds start arriving in the vicinity of the proposed Kahuku Wind Power facility in September and most leave in May. Pacific golden-plovers were seen in flight more often than ruddy turnstones (0.57 vs 0.02 flights/hr/point count), and only Pacific golden-plovers were recorded at flight altitudes that fall within the rotor swept zone of the proposed turbines.

Mammals:

The Hawaiian hoary bat is the only terrestrial mammal native to Hawai‘i. Apart from attempts to determine status of Hawaiian hoary bat in the project area, no surveys for mammals have been conducted in the project area. Non-native wild and domestic mammals observed in the Kahuku Wind Power project area incidental to the avian surveys include small Indian mongoose (*Herpestes javanicus*), domestic cow (*Bos taurus*), horse (*Equus caballus*), feral pig (*Sus scrofa*), feral cat (*Felis catus*), and dog (*Canis lupus familiaris*). Although not seen during the surveys, it is also anticipated that rats (*Rattus* sp.) and house mice (*Mus musculus*) occur on the Kahuku Wind Power project area.

Based on general observations, small Indian mongoose, rats, house mice, and cats are likely common at the Waialua Substation and Flying R Ranch sites. Cows and horses were also observed at the Flying R Ranch site (L. Ong/SWCA, pers. obs.).

3.12.3.1 Potential Impacts of the Proposed Action

The proposed action could impact non-listed wildlife through collisions with wind turbine rotors, the met tower, and the microwave towers. Clearing for the project would also remove a small amount of habitat used by non-listed, mostly non-native, species.

Avian Species:

Under the proposed action, the proposed facility would result in the permanent loss of approximately 32 ac of vegetation composed mostly of non-native plant species. Non-listed birds known to occur in the general area are also mostly non-native (introduced) (Table 3-11). Non-listed bird species occurring in the project area are largely common and widespread on Oʻahu, and most are tolerant of some degree of development and human presence. The proposed project would reduce the amount of habitat available for non-listed bird species. This could result in the displacement of some individuals and slight reduction in some local numbers. However, because these birds are generally common and widespread, the amount of habitat lost represents a very small part of the total range available to each species. Consequently, any impacts to non-listed bird species are not expected to be significant at the population level. Clearing for WTG pads and road edges may provide increased foraging area for some birds, including the Pacific golden-plover.

Non-listed birds also have potential to collide with WTGs and the met towers. Documented avian fatality rates at wind energy facilities differ throughout the world; however, Erickson et al. (2001) estimated that an average of 2.19 bird fatalities occur per wind turbine annually in the United States. Some bird species appear to have a higher risk of collision with wind energy facilities than others. Passerines are known to have comparatively high fatality rates (Erickson et al. 2001, NWCC 2004, Kingsley and Whittam 2007). Some birds, including waterfowl and shorebirds, seem to avoid turbines, but appear to be susceptible to collision with associated wires, particularly when located near wetlands (Curtis 1977, Olsen and Olsen 1980, Percival 2005, Kingsley and Whittam 2007, Powlesland 2009). For this reason, the single permanent met tower would be unguyed to reduce the risk of avian species colliding with the tower. Theoretically, any of the bird species occurring in the general project area would have potential to collide with the proposed WTGs and met towers.

Avian fatalities at wind energy facilities are very low compared to the numbers of fatalities resulting from some other human-related causes. Known sources of anthropogenic bird losses outside of wind energy sites include: lighted buildings, windows, communications towers, power lines, smokestacks, vehicles, cat predation, pesticides, and hunting (Podolsky et al. 1998, Erickson et al. 2001, Martin and Padding 2002, Woodlot Alternatives, Inc. 2003, Federal Register 2004, Mineau 2005). Mortality from these other sources is many orders of magnitude higher than that which occurs at wind facilities.

Mammals:

The non-listed mammals present in the project area, all of which are non-native, have the potential to degrade ecosystems by consuming or trampling native flora and fauna, accelerating erosion, altering soil properties, and promoting the invasion of non-native plants (Stone et al. 1992, Courchamp et al. 2002, USFWS 2008). Because native Hawaiian flora and fauna did not evolve with these mammals, native species are not adapted to take advantage of, or protect themselves from, the activities of these animals (Stone 1985, Stone et al. 1992). Loss of vegetation in the project area would reduce the amount of habitat available for mammals and therefore could result in displacement of some individual mammals and slight reduction in local numbers. Loss of mammals may also occur occasionally as a result of collisions with project vehicles. Potential to cause adverse impacts to introduced mammals could be considered a positive effect of the proposed project, although given the scale of the project, any actual change in local mammal numbers is likely to be so low as to be insignificant. Therefore, the proposed project is generally expected to have a neutral effect on mammals.

The proposed mitigation measures that are required in the HCP are planned to compensate for adverse impacts to listed species (SWCA and First Wind 2010). However, some of these measures also have the potential to benefit some non-listed avian species by decreasing their risk of predation by introduced mammals (e.g., rats, mongoose, cats, and dogs).

A wildlife education and observation program would be conducted for all regular on-site staff (Appendix I). The program would be long-term, on-going, and updated as necessary. Staff would be trained to identify listed and non-listed native species of birds that may be found on-site, to record observations of species protected by the ESA and/or MBTA, and to take appropriate steps when and if downed wildlife is found.

As part of their safety training, temporary employees, contractors, and any others that may drive project roads would be educated as to project road speed limits and the possibility of downed wildlife being present on roads. The protocol for the recovery, handling, and reporting of downed wildlife would follow that developed for Kaheawa Wind Power (KWP) Energy Generation Facility (Kaheawa Wind Power LLC, 2006). This protocol was developed in cooperation with DLNR and USFWS. All regular on-site staff would be trained in the protocol, which would include documenting all observed mortality or injury to wildlife (including MBTA-protected birds not otherwise covered by this HCP). Non-listed species would also be collected by a permitted specialist if requested by USFWS or DLNR; collections would be made only by staff personnel permitted by USFWS and DLNR to handle and salvage wildlife. Injured individuals or carcasses would be handled according to guidelines in Appendix J.

3.12.3.2 Potential Impacts of the No Action Alternative

If the facility was not constructed and operated under the No Action Alternative, there would be no impacts to non-listed wildlife.

3.12.4 Listed Species

No federally listed endangered, threatened, or candidate species are known to occur regularly on the Kahuku Wind Power project area and no portion of the project area has been designated as critical habitat for any listed species. The endangered Hawaiian hoary bat or ‘ope‘ape‘a has been documented flying over the project area and low bat activity has been recorded on the acoustic bat detectors. Several federally listed endangered and threatened bird species occur regularly on nearby properties and individuals of some or all of these species may occasionally transit through the airspace of the proposed Kahuku Wind Power facility. Presumed Newell’s shearwaters were detected flying over the Kahuku Wind Power project area during nocturnal radar surveys. No birds believed to be Hawaiian petrels, which also may fly inland at night, were detected during the radar surveys. One state listed endangered species, the Hawaiian short-eared owl or pueo, was heard in the Kahuku Wind Power project area by the radar technicians and is believed to occur at least infrequently.

The proposed WTGs, on-site microwave tower, and met tower associated with the Kahuku Wind Power project would create collision hazards for seven federally listed threatened or endangered species: the Hawaiian stilt or ae‘o, Hawaiian coot or ‘alae ke‘oke‘o, Hawaiian duck or koloa maoli, Hawaiian moorhen or ‘alae ‘ula, Newell’s shearwater or ‘a‘o, Hawaiian petrel or ua‘u, and Hawaiian hoary bat or ‘ope‘ape‘a. These facilities would also create a collision hazard for the state listed Hawaiian short-eared owl. In this document, these eight species are also collectively referred to as the “covered species” because Kahuku Wind Power LLC is seeking to have incidental take of these eight species covered by a

State of Hawaiʻi ITL. Table 3-14 lists the federally and state listed species with potential to be adversely impacted by operation of the Kahuku Wind Power project and for which federal or state authorization of incidental take is being sought.

Table 3-14. Federally or state listed species with potential to be impacted by the Kahuku Wind Power project.

Scientific Name	Common, Hawaiian Name(s)	Date Listed	Status[1]
Birds			
Puffinus auricularis newelli	Newell's shearwater, ʻaʻo	10/28/1975	T
Pterodroma sandwichensis	Hawaiian petrel, uaʻu	3/11/1967	E
Anas wyvilliana	Hawaiian duck, koloa maoli	3/11/1967	E
Himantopus mexicanus knudseni	Hawaiian stilt, aeʻo	10/13/1970	E
Fulica alai	Hawaiian coot, ʻala ekeʻokeʻo	10/13/1970	E
Gallinula chloropus sandvicensis	Hawaiian moorhen, ʻalae ʻula	3/11/1967	E
Asio flammeus sandwichensis	Hawaiian short-eared owl, pueo	--	SE
Mammals			
Lasiurus cinereus semotus	Hawaiian hoary bat, ʻopeʻapeʻa	10/13/1970	E
1) E = federally endangered; T = federally threatened; SE = state endangered			

No federally listed endangered, threatened, or candidate wildlife species are expected to occur at either of the off-site microwave tower sites. However, no radar studies have been conducted at the sites, so it is not known whether Newell's shearwaters or Hawaiian petrels fly past these locations during the nesting season.

Information on each of the eight covered species is briefly summarized below. More detailed information on these species and the potential impacts from the proposed project is provided in Appendix K of this report and in the HCP (SWCA and First Wind 2010).

Newell's Shearwater

The Newell’s shearwater is an endemic Hawaiian sub-species of the nominate species, Townsend’s shearwater (*Puffinus a. auricularis*) of the eastern Pacific. The most recent population estimate of Newell’s shearwater was approximately 84,000 birds, with a possible range of 57,000 to 115,000 birds (Ainley et al. 1997).

Day and Cooper (2008) found an extremely low number of targets exhibiting flight speeds and flight patterns that fit the “shearwater/petrel” category during surveillance radar and audiovisual sampling at the project area (Day et al. 2003b). Over five nights of sampling in fall 2007, two petrels or shearwaters were detected flying inland over the Kahuku Wind Power project area toward the Koʻolau Range and two were detected flying seaward over the site from the Koʻolau Range. No petrels or shearwaters were detected flying inland during seven nights of sampling in summer 2008, while seven petrels and/or shearwater-like targets were recorded flying seaward. No visual identification of these birds was possible, but Day and Cooper (2008) suggested that the individuals were likely Newell’s shearwaters and not Hawaiian petrels since all targets were recorded after complete darkness.[6] While the uppermost elevation of the site reaches the lower elevation limit for known nesting by this shearwater, no evidence was obtained to suggest that these birds could be nesting on-site.

Newell’s shearwater has not been confirmed as a nesting species on Oʻahu. Assuming the detected birds were Newell’s shearwaters, then their observed behavior of flying to and from the Koʻolau Range suggests strongly that at least a small number of these birds are breeding in these mountains. Because of the few detections obtained during the Day and Cooper study and lack of radar studies from adjacent lands, it is not known whether the Kahuku Wind Power project area lies within a corridor used regularly by these few birds as they move between their nesting areas and the ocean. Observations of Newell’s shearwaters in the Hawaiian Islands indicate that approximately 65% of shearwaters would fly at or below turbine height.

Hawaiian Petrel

The Hawaiian petrel was once abundant on all main Hawaiian Islands except Niʻihau (Mitchell et al. 2005). The population was most recently estimated to be approximately 20,000, with 4,000 to 5,000 breeding pairs (Mitchell et al. 2005). Today, Hawaiian petrels breed in high-elevation colonies on Maui, Hawaiʻi, Kauaʻi and Lānaʻi (Richardson and Woodside 1954, Simons and Hodges 1998, Telfer et al. 1987, DOFAW unpublished data 2006, 2007). Radar studies conducted in 2002 also suggest that breeding may occur on Molokaʻi (Day and Cooper 2002). Breeding is no longer thought to occur on Oʻahu (Harrison 1990).

As discussed in the previous section, 11 birds that met the identification criteria for either Newell’s shearwaters or Hawaiian petrels were detected by radar flying over the Kahuku Wind Power site. No visual identification of these birds was possible, but Day and Cooper (2008) suggested that the individuals were likely Newell’s shearwaters and not Hawaiian petrels since all targets were recorded after complete darkness. However, because of a lack of definitive identification of these birds, it is considered possible that a small number of Hawaiian petrels could occasionally fly over the Kahuku Wind Power project area during their nesting season (March through September). Hawaiian petrels fly at higher altitudes than Newell’s shearwater on average (626 ± 80 ft vs. 410 ± 13 ft, or 191 ± 25m vs 125± 4 m) and would be less likely to collide with the wind turbines and blades than Newell’s shearwater.

Hawaiian Duck

The Hawaiian duck is a non-migratory species endemic to the Hawaiian Islands, and the only endemic duck extant in the main Hawaiian Islands (Uyehara et al. 2008). The known historical range of the Hawaiian duck includes all the main Hawaiian Islands, except for the Islands of Lānaʻi and Kahoʻolawe. The only naturally occurring population of Hawaiian duck exists on Kauaʻi, with reintroduced populations on Oʻahu, Hawaiʻi, and Maui (Pratt et al. 1987, Engilis et al. 2002, Hawaiʻi Audubon Society 2005).

Due to the close genetic relationship with mallards, Hawaiian ducks will readily hybridize with mallards and allozyme data indicate there has been extensive hybridization between Hawaiian duck and feral mallards on Oʻahu, with the near disappearance of koloa maoli alleles from the population on the island

---

[6] Newell’s shearwaters move to the interior portions of the islands starting about 30 min after sunset, while Hawaiian petrel movements begin at sunset to about 60 min after sunset (Day et al. 2003b).

(Browne et al. 1993, A. Engilis/UC Davis, pers. comm.). Uyehara et al. (2007) found a predominance of hybrids on Oʻahu and samples collected by Browne et al. (1993) from ducks and eggs at the Kiʻi Unit of the James Campbell NWR found mallard genotypes. In 2005, a peak count of 141 Hawaiian duck x mallard hybrids were recorded on the Kiʻi Unit of the James Campbell NWR (USFWS, unpubl). The current wild population of pure Hawaiian ducks is estimated at approximately 2,200 birds. Because of similarities between the species, it can be difficult to distinguish between pure Hawaiian ducks, feral hen mallards, and hybrids during field studies.

Permanent suitable habitat for Hawaiian duck does not occur at the Kahuku Wind Power project area. Presumed hybrid Hawaiian ducks were seen flying over the lower elevation eastern portion of the Kahuku Wind Power project area on three occasions during point count surveys and once incidental to the surveys (SWCA and First Wind 2008). None of these individuals was observed landing in the project area. A pair of ducks that resembled Hawaiian ducks was also observed on-site following a period of heavy rain in a flooded depression in the area where topsoil had been historically excavated (L. Ong/SWCA pers. obs.). The formation of this and similar areas of standing water that form after heavy rains may occasionally attract ducks to the project area. The portion of the project area where these areas of standing water form is planned to be graded to improve drainage and prevent ponding. This would remove the potential for ducks to be attracted to the project area when the project is in operation. Ducks flying over nearby wetlands have been observed up to heights of approximately 200 ft (60 m). Thus, while flying over the Kahuku Wind Power project area, ducks may be vulnerable to colliding with the WTGs, turbine blades, and the on-site met tower. Based on observations made during the point-count surveys, the estimated passage rate of Hawaiian duck-like ducks over the Kahuku Wind Power project area is 0.003 birds/ha/hr or 8.0 birds/day for the entire site (SWCA and First Wind 2008). Because of hybridization with feral mallards, it is questionable whether the ducks present on Oʻahu are the endemic koloa and are protected under Section 9 of the ESA. However, at the request of the USFWS, Kahuku Wind Power LLC has agreed to treat the Hawaiian duck-like ducks present in the general project vicinity as if they were pure Hawaiian ducks.

Little is known about the interaction of Hawaiian ducks with wind turbines. Studies of wind energy facilities located in proximity to wetlands and coastal areas in other parts of the United States and the world have shown that waterfowl and shorebirds have some of the lowest collision mortality rates at these types of facilities, suggesting that these types of birds are among the best at recognizing and avoiding wind turbines (e.g., Koford et al. 2004, Jain 2005, Carothers 2008). In support of these findings, high avoidance of turbines has also been documented by nēnē or Hawaiian goose (*Branta sandvicensis*) at the KWP facility on Maui, where mortality has been recorded at the average rate of one goose per year (Kaheawa Wind Power 2008).

Hawaiian Stilt

The Hawaiian stilt is a non-migratory endemic subspecies of the black-necked stilt (*Himantopus mexicanus*), which occurs in the western and southern portions of North America, southward through Central America and the West Indies to southern South America and also the Hawaiian Archipelago (Robinson et al 1999). Oʻahu supports the largest number of stilts in the state, with an estimated 35 to 50% of the population residing on the island. Some of the largest concentrations can be found at the James Campbell NWR, Kahuku aquaculture ponds, Pearl Harbor NWR, and Nuʻupia Ponds in Kaneʻohe (USFWS 2005a). The Kiʻi Unit of the James Campbell NWR, and the Waiawa Unit and Pond 2 of the Honouliuli Unit of the Pearl Harbor NWR are the most productive stilt habitats, with birds numbering near 100 or above during survey counts (USFWS 2002, USFWS unpubl. data).

Suitable habitat for Hawaiian stilt is usually absent from the Kahuku Wind Power project area. Given the ability of the species to exploit ephemeral habitats, the formation of ephemeral areas of standing water in low-lying portions of the project area after heavy rains may occasionally attract stilts. However, as discussed for Hawaiian duck, Kahuku Wind Power LLC is planning to grade the low-lying areas to improve drainage, which would prevent these ponds from forming and attracting stilts when the project is in operation. No Hawaiian stilts were seen flying over the project area during the avian point count surveys conducted by Kahuku Wind Power LLC and SWCA. One dead stilt has been found on the site next to a temporary met tower. A post-mortem investigation by USFWS veterinarians indicated that the bird was emaciated and carried a heavy parasite load, but had no broken bones or abrasions to indicate a collision with the met tower or its guy wires had occurred. The bird was considered most likely to have died of natural causes. However, since the carcass was found at the base of a met tower, the final cause of death was declared indeterminate and not attributed to the met tower (K. Swindle/USFWS, pers. comm.). Because of the known dispersal capabilities of these birds and their regular occurrence at the nearby Kiʻi Unit of James Campbell NWR, it is expected that individual stilts fly over the Kahuku Wind Power project area on a very irregular basis while moving between wetlands, ephemeral ponds, and islands.

Little is known about the interaction of black-necked stilts with turbines in the United States. One black-necked stilt mortality was reported at the Altamont Pass Wind Resource Area from 2005-2007 (Altamont Pass Avian Monitoring Team 2008). The adjusted fatality per turbine was 0.00193 stilt per turbine. In general, low mortality of waterbirds has been documented at wind turbines situated coastally, like the proposed Kahuku Wind Power project, despite the presence of high numbers of waterbirds in the vicinity (Kingsley and Whittam 2007, Carothers 2008). Many studies of coastal wind energy facilities have shown that waterbirds and shorebirds are among the birds most wary of turbines and that these birds readily learn to avoid the turbines over time (Carothers 2008).

Hawaiian Coot

The Hawaiian coot is an endangered species endemic to the main Hawaiian Islands, except Kahoʻolawe. The Hawaiian coot is non-migratory and believed to have originated from migrant American coots (*Fulica americana*) that strayed from North America (Pratt et al. 1987, Brisbin et al 2002). The population of Hawaiian coot has fluctuated between 2,000 and 4,000 birds. Of this total, roughly 80% occur on Oʻahu, Maui, and Kauaʻi (Engilis and Pratt 1993, USFWS 2005a). The Oʻahu population fluctuates between approximately 500 to 1,000 birds. Hawaiian coots occur regularly in the Kiʻi Unit of the James Campbell NWR, with peak counts in 2005 and 2006 reaching nearly 350 birds (USFWS 2002, USFWS 2005a, USFWS unpubl. data).

No Hawaiian coots were observed in flight at the Kahuku Wind Power project area during the year-long avian point count survey. However, Hawaiian coots are known to disperse between islands, so there is potential for coots to occasionally fly over the lower elevations of Kahuku Wind Power project area if moving between wetlands or islands. No suitable habitat for Hawaiian coot occurs in the Kahuku Wind Power project area. This species appears less apt to utilize ephemeral habitats than Hawaiian ducks or Hawaiian stilts because such habitats typically lack the emergent wetland vegetation used for cover. However, it is conceivable that the ephemeral ponds that form in the low-lying portion of the project area after heavy rains may rarely attract coots. Because of the plans to grade this area to improve drainage, no ponding would occur in the future and these features would not be present to attract coots to the site when the project is in operation.

Hawaiian Moorhen

The Hawaiian moorhen is an endangered, endemic, non-migratory sub-species of the cosmopolitan common moorhen (*Gallinula chloropus*). It is believed that the sub-species originated through colonization of Hawaiʻi by stray North American migrants (USFWS 2005a). Originally occurring on all the main Hawaiian Islands (excluding Lānaʻi and Kahoʻolawe), Hawaiian moorhen is currently limited to regular occurrence on the Islands of Kauaʻi and Oʻahu (Hawaiʻi Audubon Society 2005, USFWS 2005a). A population was reintroduced to Molokaʻi in 1983, but no individuals remain on the island today.

No Hawaiian moorhens were detected during the year of avian point count surveys on the Kahuku Wind Power project area or on adjacent wetlands, although the birds are known to occur regularly at the Kiʻi Unit of James Campbell NWR. This lack of detection is likely because moorhens rarely fly and typically remain within or close to dense vegetation. However, as colonization of Hawaiʻi by moorhens does attest, members of the species are able to fly considerable distances when they so desire. It is considered very unlikely that Hawaiian moorhens regularly fly over the Kahuku Wind Power project area; however, given their ability to fly and their regular occurrence at the nearby Kiʻi Unit of James Campbell NWR, it is possible that individual Hawaiian moorhens would very occasionally fly over the site, especially the lower elevation eastern portion nearest the adjacent wetlands.

No suitable habitat for Hawaiian moorhen occurs in the Kahuku Wind Power project area. This species is not expected to utilize the ephemeral areas of standing water that can form in the project area after heavy rains because these areas lack the emergent wetland vegetation the birds use for cover. Because of the grading plans to improve drainage, ponding would not occur during project operation and no potential would exist for moorhens to be attracted to the project area.

Hawaiian moorhens are considered to be at low risk from wind farms because there have only been a few published reports of the closely related common moorhen colliding with turbines in Europe (Ireland, Percival 2003) and Netherlands (Hotker et. al 2006) and none in the United States. This is despite the fact that common moorhens are frequently found around wind turbines located near wetlands. However, one study in Spain lists the common moorhen at “some” collision risk with power lines due to their flight performance and also records one instance of mortality due to collision (Janss 2000).

Hawaiian Short-eared Owl

The Hawaiian short-eared owl is an endemic subspecies of the nearly cosmopolitan short-eared owl (*Asio flammeus*). This is the only owl native to Hawaiʻi and it is found on all the main islands from sea level to 8,000 ft (2,450 m). The Hawaiian short-eared owl is listed by the State of Hawaiʻi as endangered only on the Island of Oʻahu. No surveys have been conducted to date to estimate the population size of Hawaiian short-eared owl. The species was widespread at the end of the 19th century, but numbers are thought to be declining (Mostello 1996, Mitchell et al. 2005).

Habitats present in the project area match those typically associated with Hawaiian short-eared owl. No Hawaiian short-eared owls were detected on or over the Kahuku Wind Power project area during any of the avian point count surveys conducted by First Wind and SWCA. One Hawaiian short-eared owl was heard on-site in July 2008 by personnel conducting the radar survey for seabirds. Because these owls can be active during daytime and crepuscular periods, it seems probable that they would have been detected during the avian point counts if resident on-site, since more time was spent conducting the point count surveys than was spent conducting the radar surveys. Given this discrepancy, it seems that Hawaiian short-eared owl is most likely an irregular visitor to the Kahuku Wind Power project area.

Little information is available on the impacts of wind facilities on owls. However, four fatalities of short-eared owl (*Asio flammeus flammeus*) have been recorded at McBride Lake, Alberta, Canada, Foote Creek Rim, Wyoming, Nine Canyon, Wyoming, and Altamont Wind Resource Area, California (Kingsley and Whittam 2007). Hawaiian short-eared owls are present year-round and observed regularly in the vicinity of the KWP facility on Maui, with no fatalities reported in approximately three and a half years of operation. In the vicinity of turbines, most observations of Hawaiian short-eared owl have been below the rotor swept zone of the turbines and thus their susceptibility to collision appears to be low (G.

Spencer/First Wind, pers. comm.). At Wolfe Island, Ontario, it was observed that short-eared owls were most vulnerable to colliding with turbine blades when avoiding predators and during aerial flight displays (Stantec Consulting Ltd. 2007). Short-eared owls on O‘ahu have no aerial predators and thus may only be vulnerable to colliding with turbines during flight displays.

Hawaiian Hoary Bat

The Hawaiian hoary bat is the only native land mammal present in the Hawaiian archipelago. It is a sub-species of the hoary bat (*Lasiurus cinereus*), which occurs across much of North and South America. The bat has been recorded on Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i, but no historical population estimates or information exist for this sub-species. Population estimates for all islands in the state in the recent past have ranged from hundreds to a few thousand bats (Menard 2001). However, based on monitoring currently underway on the Island of Hawai‘i, the population is estimated to possibly be as high as 100,000 bats on the Island of Hawai‘i alone (F. Bonaccorso/USGS, pers. comm.).

Bat activity was recorded by the Anabat™ detectors from April 2008 to April 2009 at a rate of 0.0130 bat passes/detector/night or 0.016 bat call sequences/detector/night. The limited data suggest that bat activity may increase from June to September and is lowest or absent from December to February. The detection rates at Kahuku Wind Power are 40-fold lower than detection rates recorded at Hakalau National Wildlife Refuge (0.660 passes/detector/night, Bornaccorso, unpubl.). Bat activity at the Kahuku Wind Power project area was similar to the post-construction bat activity recorded at the Kaheawa Wind Power project, which had an activity rate of 0.014 bat call sequences/detector/night (SWCA 2009).

The actual number of bats represented by the detections made by the Anabat™ data-loggers on the Kahuku Wind Power site is not known. No bats were sighted at the Kahuku Wind Power project area during the nocturnal point count surveys conducted from October 2007 through December 2008. Day and Cooper (2008) visually observed one Hawaiian hoary bat on-site incidental to the seabird radar survey in the summer of 2008. Given these results, it is presumed that a very small number of Hawaiian hoary bats forage over the Kahuku Wind Power project area on a somewhat regular basis. Such bats could also roost in trees in the project area. When present, areas of standing water that forms for short periods after heavy rain may provide a source of drinking water for bats. Because presence of this water is infrequent and unpredictable, it is not expected to be an important resource for Hawaiian hoary bats (J. Kwon/USFWS, pers. comm.). The proposed grading would eliminate these areas, thereby also eliminating a potential bat attractant from the project area.

In their North American range, hoary bats are known to be more susceptible to collision with wind turbines than most other bat species (Johnson et al. 2000, Erickson 2003, Johnson 2005). Most mortality has been detected during the fall migration period. Hoary bats in Hawai‘i do not migrate in the traditional sense, although as indicated some seasonal altitudinal movements occur. Currently, it is not known if Hawaiian hoary bats are equally susceptible to turbine collisions during their altitudinal migrations as hoary bats are during their migrations in the continental US. At the KWP facility on Maui, one Hawaiian hoary bat fatality has been recorded after three and a half years of operation (G. Spencer/First Wind, pers. comm.).

3.12.4.1 Potential Impacts of the Proposed Action

Construction and operation of Kahuku Wind Power would create the potential for federally and state listed bird and bat species to collide with wind turbines, temporary and permanent met towers, and cranes used for construction of the turbines. Some limited potential exists for the species to collide with the on-site and off-site microwave towers, overhead collection lines, relocated distribution lines, and utility poles; however, these components are not expected to create a significant collision hazard to any covered species.

The potential for each listed species to collide with on-site project components was identified based on the results of the on-site surveys discussed in Sections 3.12.2 and 3.12.4 and the proposed project design. Avian fatality estimate models were developed that incorporated rates of species occurrence, observed flight heights, encounter rates with turbines and met towers, and considered ability of birds to avoid project components. Ability of birds to avoid turbines was then varied in the models to create a range of probabilities of mortality for each species on an annual basis. Range of expected mortality coincides with the amount of "direct take" expected from construction and operation of the Kahuku Wind Power project.

In addition to "direct take," mortality of listed species resulting from collisions with project components could also result in "indirect take." For example, it is possible that adult birds killed through on-site collisions could have been tending to eggs, nestlings, or dependent fledglings or adult bats could have been tending to dependent juveniles. The loss of these adults would then also lead to the loss of the eggs or dependent young. Loss of eggs or young would be "indirect take" attributable to the proposed project. Methods for determining indirect take are described in detail in the HCP (SWCA and First Wind 2010).

The direct and indirect impacts to each covered species expected to result from construction and operation of the proposed action is summarized briefly below. Extensive information concerning potential direct and indirect impacts of the project is contained in the Kahuku Wind Power HCP (SWCA and First Wind 2010) and in Appendix K of this report. Cumulative impacts are discussed in Section 3.16.11.2.

For most of the covered species, expected rates of take are expected to average less than one individual per year. DOFAW-DLNR requires that applications for ITLs request take authorizations in terms of whole numbers of individuals. Consequently, the HCP also identifies the whole number of individuals for which take authorization is being sought by Kahuku Wind Power LLC. As those numbers reflect requested level of take authorization rather than the expected rate at which mortality would occur (i.e., the actual impact of the proposed action), those numbers are not included in this assessment. A summary of the estimated and requested take of the covered species is provided in Table 3-15.

Mitigation measures proposed by Kahuku Wind Power LLC to compensate for the expected impacts of the project were selected in collaboration with biologists from USFWS, DLNR-DOFAW, First Wind, and SWCA, and with members of the ESRC (Table 3-16). The mitigation proposed to compensate for impacts to the covered species is based on anticipated levels of incidental take as determined through on-site surveys, modeling, and the results of post-construction monitoring conducted at other wind projects in Hawaiʻi and elsewhere in the United States. Mitigation takes into account the expected annual rate of direct and indirect take.

Table 3-15. Summary of estimated and requested authorized take of covered species at the Kahuku Wind Power facility.

covered species	**Expected Rate of Take**		**Requested ITL Authorization**	
	Annual	***20-Yr Project Life***	***Annual***	***20-Yr Project Life***
Hawaiian petrel	0.17 adults 0.17 chicks	4 adults 4 chicks	2 adults 2 chicks	4 adults 4 chicks
Newell's shearwater	0.34 adults 0.16 chicks	7 adults 4 chicks	2 adults 1 chick	8 adults 4 chick
Hawaiian duck	0.026 adults 0.031 ducklings	1 adult 1 duckling	2 adults 2 ducklings	8 adults 8 ducklings
Hawaiian stilt	0.026 adults 0.0012 chicks	1 adult 1 chick	2 adults 1 chicks	8 adults 4 chicks
Hawaiian coot	0.026 adults 0.012 chicks	1 adult 1 chick	2 adults 1 chicks	8 adults 4 chicks
Hawaiian moorhen	0.026 adults 0.017 chicks	1 adult 1 chick	2 adults 2 chicks	8 adults 6 chicks
Hawaiian short-eared owl	0.33 adults 0.31 owlets	7 adults 7 owlets	2 adults 2 owlets	8 adults 8 owlets
Hawaiian hoary bat	0.19 adults 0.34 juveniles	4 adults 7 juveniles	5 adults 3 juveniles	12 adults 9 juveniles

Table 3-16. Proposed mitigation for the covered species: Lower, Baseline and Higher Take Scenarios.

Species	Proposed Mitigation by Measured Take Level			Benefit of Proposed Mitigation
	Baseline	Lower	Higher	
Seabirds	Predator control and a social attraction study for Newell's shearwater and Hawaiian petrel at Makamakaʻole or other suitable seabird nesting sites on Maui, Kauaʻi or elsewhere	Same as Baseline	Increased mitigation efforts at the same site or additional mitigation measures at one or more additional sites on Maui or Kauaʻi or elsewhere	Predation mortality has been documented for adults, fledglings, and eggs. Predator trapping at a chosen seabird colony is expected to increase overall productivity and result in a net benefit to the species. If fencing is erected, cats and mongoose would also be excluded, further increasing productivity. If the social attraction program is implemented, the colony may be further enhanced by attracting a greater number of seabirds to nest in the managed area.
Waterbirds	Predator control, vegetation maintenance, and monitoring at Hamakua Marsh for 3 to 5 years; removal of feral ducks, mallards, and Hawaiian duck hybrids; subsequent mitigation efforts to meet baseline requested take as required	Same as Baseline	Additional mitigation efforts at Hamakua Marsh or predator control and monitoring at additional wetlands	The trapping of cats, dogs, mongoose, and rats at Hamakua Marsh is expected to increase the reproductive success of Hawaiian coot, Hawaiian stilt, and Hawaiian moorhen. The eradication of hybrid and feral ducks is expected to reduce the continued hybridization of feral mallards with the Hawaiian duck.

Species	Proposed Mitigation by Measured Take Level			Benefit of Proposed Mitigation
	Baseline	Lower	Higher	
Hawaiian short-eared owl	Upfront contribution of $25,000 for research and rehabilitation and $25,000 up to a maximum of $50,000 for management as it becomes available	Same as Baseline	Additional funding of $15,000 for research and rehabilitation and $15,000 up to a maximum of $30,000 to implement management strategies	As little is known about the life history of the Hawaiian short-eared owl, research could be designed to develop protocols to monitor Hawaiian short-eared owl populations, determine habitat use and preferences, evaluate the effectiveness of habitat management techniques, and subsequently implement practicable management actions to aid in the recovery of the species. Injury due to vehicular collisions is identified as a cause of death for Hawaiian short-eared owls on Maui, Oʻahu, and Kauaʻi. Thus, implementation of the rehabilitation program may minimize these deaths.
Hawaiian hoary bat	Up to a maximum of $150,000 for management of bat habitat	Same as Baseline	Low-wind speed curtailment and additional funding of $15,000 up to a maximum of $75,000 for management	Because of the lack of life history information on the Hawaiian hoary bat, research is identified as one of the key components in the recovery of this subspecies. The Recovery Plan for the Hawaiian Hoary Bat (USFWS 1998) states that "Research is the key to reaching the ultimate goal of delisting the Hawaiian hoary bat because currently available information is so limited that even the most basic management actions cannot be undertaken with the certainty that such actions will benefit the subspecies." In-house research is also expected to advance avoidance and minimization strategies that wind facilities in Hawaiʻi and elsewhere can employ to reduce bat fatalities. Additionally, native habitat plant restoration is expected to increase foraging and roosting habitat for the Hawaiian hoary bat and result in a long-term net benefit to the species.

In addition to the species specific mitigation measures, general wildlife-related measures have also been proposed by Kahuku Wind Power LLC. A wildlife education and observation program would be conducted for all regular on-site staff (Appendix I). Furthermore, all regular on-site staff would be trained in the wildlife casualty monitoring protocol which would include documenting all observed mortality or injury to wildlife (including MBTA-protected birds not otherwise covered by the Kahuku Wind Power HCP). This protocol was developed in cooperation with DLNR and USFWS. Injured individuals or carcasses would be handled according to guidelines in Appendix J.

A summary of mitigation efforts proposed by Kahuku Wind Power LLC for the covered species and their anticipated benefits is provided in Table 3-16. Additional details regarding mitigation measures and their potential impacts are provided in this section. Kahuku Wind Power LLC would be required to implement these mitigation measures under the ITL, and they are included in the EA as an integral part of the proposed project. A more detailed description of the mitigation measures, the criteria used for determining appropriate mitigation measures, the goals of the mitigation measures, and rationale for the proposed levels of effort is outlined in the HCP (SWCA and First Wind 2010) and Appendix K.

Newell's Shearwater

Newell’s shearwaters are not known nor expected to breed in the project area, so the proposed action would not result in any habitat impacts for this species. Newell’s shearwaters do have the potential to collide with WTGs or met towers associated with the proposed project. Given the brevity of the construction period and the low occurrence rate of Newell’s shearwater over the project area, potential for Newell’s shearwaters to collide with construction cranes is considered to be negligible. Some potential exists for construction or maintenance vehicles to strike downed shearwaters (birds already injured by collision with turbines or towers) while traveling project roads. However, this source of mortality does not result in an increase in the amount of direct take expected from the proposed project because these birds are accounted for in the collision strike mortality modeling.

Expected rates of take for Newell’s shearwater, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Expected Rate of Take

Annual average	0.34 adults and 0.16 chicks
20-year project life	7 adults and 4 chicks

Direct and indirect take is expected to result in the loss of an average of 0.50 shearwater per year (0.34 adult + 0.16 juvenile = 0.50 bird). One-half bird per year represents approximately 0.0005% to 0.001% of the estimated Newell’s shearwater population. Given these very low percentages, it is considered extremely unlikely that take caused by the proposed project would result in significant adverse effects to Newell’s shearwater at the population level.

The major threats identified for the covered seabirds are introduced predators, which can prey on adults, eggs, and fledglings; feral ungulates, which degrade habitat and may trample burrows; and artificial lighting, which may disorient fledglings and increase their risk of collision with artificial structures (Mitchell et al. 2005). As described in the HCP, Kahuku Wind Power LLC proposes, with the concurrence of ESRC, USFWS, and DLNR, that mitigation for Newell’s shearwaters and Hawaiian petrels would consist of predator control, fencing, or colony and habitat enhancement at a seabird colony on Maui, Kaua‘i or elsewhere. Suppressing predator populations is expected to increase nesting success and adult survival rates at the colony. If fencing is erected, cats and mongoose would also be excluded, further increasing productivity. If insufficient naturally occurring burrows are found within the fenced area, Kahuku Wind Power LLC may consult with USFWS and DLNR to implement social attraction techniques for both covered seabird species within the fenced area to increase the number of active burrows. If the social attraction program is implemented, the colony may be further enhanced by attracting a greater number of seabirds to nest in the managed area. Currently, the preferred mitigation site is situated on West Maui at Makamakaʻole.

The cat-proof fence at Makamakaʻole would be approximately 1.6 - 2 miles (2.6 – 3.2 km) long. The actual length and location of the fence, and the size of the enclosed area, would be determined in concurrence with USFWS and DLNR. Construction of the fence at Makamakaʻole would result in the disturbance and removal of limited amounts of vegetation. The fence would be approximately 1.6 to 2 mi long and a swath of no greater than 12 ft of vegetation would be cleared, resulting in a maximum potential disturbance of approximately 2.9 acres (2 mi x 12 ft = 126720 sq ft = 2.9 acres) (1.17 ha). Prior to construction, the final fence alignment would be surveyed by qualified specialists to ensure the fence would be appropriately placed to avoid adverse impacts to sensitive biological and cultural resources.

Designated critical habitat for two endangered plant species, *Cyrtandra munroi* (haʻiwale) and *Clermontia oblongifolia ssp. mauiensis* (ʻoha wai), occurs in the vicinity of the Makamakaʻole colony. The current potential fence boundary includes roughly 95.0 ac (38.0 ha) and 127.0 ac (52.0 ha) of critical habitat for *C. oblongifolia ssp. mauiensis* and *C. munroi*, respectively. It is unknown whether individuals of these plants actually occur in the area; however, fence construction and monitoring, predator control, social attraction studies, and habitat management activities proposed as seabird mitigation may potentially impact listed plants and their designated critical habitats. In order to avoid and minimize impacts to listed plants and critical habitat, Kahuku Wind Power LLC would hire a qualified botanist to fully survey the area and proposed fence line prior to construction and management activities. Any listed or candidate plant species discovered in the area would be clearly flagged, and appropriate protocols would be used to avoid direct or indirect impacts to listed plants. The initial survey would document baseline conditions at the site for assessing impacts to listed plants and designated plant critical habitat. If listed plants or their designated critical habitats appear to be impacted, construction and monitoring methods may be modified in consultation with DLNR and USFWS and mitigation would be prescribed, as appropriate.

In addition, fence contractors would be educated regarding the sensitivity of this project including working in critical habitat. For this analysis, the conservative estimate of 2.9 acres is used; however, the actual impact should be far less. Common species of native plants would be removed only when necessary, and removal of native plants greater than 6 inches in diameter would be avoided as much as possible. Cut vegetation would be left to decompose.

Fence construction can create conditions that facilitate the establishment of non-native species, primarily due to soil and vegetation disturbance. Furthermore, the fencing crew has the potential to unintentional introduce non-native species via equipment and field gear (packs, rain gear, etc). Gear-cleaning procedures to reduce the introduction of noxious plant seeds and propagules, as well as arthropods such as exotic ants, would be strongly enforced. To reduce the potential for introduction of non-native invasive species at the site, all equipment and materials (including boots) would be stored in a weed-free area and inspected and cleaned prior to accessing the area. Inspection protocols and the need for any post-construction monitoring would be determined in cooperation with DOFAW, USFWS, and the Maui Invasive Species Committee (MISC).

The disturbance is expected to be short-term as native vegetation would regenerate post construction. The plant critical habitat protected by the fence would benefit as herbivory and trampling by feral pigs may be reduced. By implementing the measures described above, adverse effects to listed plant species and plant critical habitat would be minor.

To minimize soil erosion and impacts to the habitat, only the minimal amount of clearing would be done in order for the fence to be built. To minimize the potential for erosion, the extent and steepness of exposed ground areas would be reduced to the maximum extent possible. BMPs would also be incorporated as appropriate (e.g. avoiding earthwork during inclement weather, temporary stabilization with geotextile mats, and revegetation with native species).

Prior to construction, the final fence alignment would be surveyed by a qualified biologist to document sensitive wildlife, particularly seabird burrows and the Hawaiian hoary bat. The fence would be appropriately placed to avoid adverse impacts to these resources. Fence contractors would be trained to identify seabird nesting burrows and to be aware of endangered species and sensitive habitats. Noise associated with construction may temporarily disrupt seabirds nesting within the area; therefore, all construction activities would be conducted outside of the nesting season of the two covered seabird species to minimize impacts. To minimize the potential for birds to collide with the fence, Kahuku Wind Power LLC would improve the visibility of the fence with steel reinforced white poly-vinyl tape. The tape would be interwoven horizontally at various heights along the fence.

Hawaiian hoary bats roost during the day in trees and shrubs. Trees greater than 15 feet would be removed only when necessary and tree cutting or clearing would be avoided during the bat-pupping season (April – August) in order to avoid potential for harm to non-volent juvenile bats. During fence construction, if a Hawaiian hoary bat (adult or pup) is discovered near construction activities, the area would be avoided as long as the bat is present. The completed fence could serve as a hazard for Hawaiian hoary bats flying or roosting in the area. Due to the possibility of fence line impacts involving bats, there would be no barbed wire on any portion of the fence, thereby reducing any possible impalement on the fence. Because the project is designed to protect native habitat through fencing and predator removal, the total impact on the bat population is anticipated to be positive.

The covered seabird species are not expected to be attracted to rodenticide (if used to control rats within the fence) because the adults of the covered seabird species feed by foraging for fish and other marine organisms offshore (DOFAW 2009). Seabirds are not expected to eat organisms that have been contaminated by eating rodenticide. Thus, the use of rodenticides is not anticipated to negatively impact seabird populations.

Prior to construction of the fence, the area to be disturbed would be surveyed by a qualified specialist to ensure that all historical, cultural, and archaeological resources are avoided. Construction of the fence is not expected to impact cultural practices by restricting access due to the remote location of the fence and the size of the area expected to be fenced.

Makamaka‘ole is situated on State land within a Conservation District; therefore a State EA would be prepared by DLNR DOFAW prior to construction in accordance with Chapter 343 of HRS. This process would more specifically assess impacts of the proposed fence and include consultation with the State Historic Preservation Division.

Proposed mitigation measures are expected to more than offset the anticipated take and contribute to both species' recovery by providing a net conservation benefit, as required by State law. For this reason, no significant adverse impacts to the species' overall populations are expected.

No seabird mortality (or mortality of any other listed species) has been recorded at the existing Crown Castle tower near Flying R Ranch or at the Waialua Substation site, although DOE is not aware that any systematic mortality monitoring has been conducted at these locations. Because the proposed Waialua Substation and Flying R Ranch towers would be located in areas with structures similar in height to the proposed microwave towers (utility poles, street pole, etc.) and associated power lines, and because they would be immobile, the towers are not expected to create a significant collision hazard to any covered species if they should happen to transit the tower location. Studies have shown that only 1% of Newell's shearwaters (n = 688 birds; B. Cooper, pers. comm.) fly below 60 ft and of these individuals, the estimated collision avoidance rate is 97% (Day et al., In prep). It is expected that Newell's shearwater individuals could occasionally transit over the off-site microwave tower sites, but at much higher altitudes than the towers themselves (average flight height estimated at 627 ± 82 ft or 191 ± 25 m). Given that the seabird traffic rate on O'ahu is extremely low, the likelihood of a seabird flying at such low altitudes and colliding with the microwave towers, overhead cable, or utility poles related to the microwave tower is considered to be remote. Therefore, the proposed off-site microwave towers were not identified as a potential source of take of Newell's shearwater in the mortality modeling performed for the species and, thus, the amount of take requested to be authorized through the ITL is based solely on mortality expected to occur as a result of construction and operation of the WTGs and associated on-site facilities.

However, if in the unlikely event a seabird mortality is found in the future and that mortality can be attributed to the on-site construction cranes, Kahuku Wind Power microwave towers, or associated overhead cables or utility poles, Kahuku Wind Power LLC would mitigate for that loss at a level commensurate with any take recorded on-site and through the methods described in the HCP. After commissioning, the lease for both off-site microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility (if any) associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS).

Hawaiian Petrel

Like Newell's shearwater, Hawaiian petrels are not known nor expected to breed in the Kahuku Wind Power project area. Consequently, the proposed action is not expected to result in any habitat impacts for this species. No birds believed to be Hawaiian petrels were recorded flying over the site during the radar studies, and their documented numbers on O'ahu are very low. Because no Hawaiian petrels were identified flying over the site, mortality modeling for this species would identify an expected rate of take of zero. Given the results of the radar studies and the very low number of petrels believed to occur on O'ahu, it does seem that the risk of the proposed project causing take of this species is very low, but not zero. Therefore, the Kahuku Wind Power HCP assumed that the average annual rate of direct take of adult Hawaiian petrel would be half that of Newell's shearwater (0.34 shearwater/year), or 0.17 petrel/year (SWCA and First Wind 2010). This estimate includes potential fatality caused by collision with turbines, met towers, and associated structures, as well as mortality due to vehicular strikes. Over the 20-year life of the project, this equates to loss of approximately 4 Hawaiian petrels (0.17 petrel/year x 20 years = 3.4 petrels).

Expected rates of take for Hawaiian petrel, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Expected Rate of Take

Annual average	0.17 adults and 0.17 chicks
20-year project life	4 adults and 4 chicks

The current population of Hawaiian petrel is estimated to be approximately 20,000 birds, with 4,000 to 5,000 breeding pairs (Mitchell et al. 2005). The average rate of take of Hawaiian petrel is expected to be no more than 0.34 petrel/year (0.17 adults and 0.17 chicks). This represents less than 0.009% of the estimated Hawaiian petrel breeding population and less than 0.002% of the estimated total population. Given these very low percentages, it is considered extremely unlikely that take of Hawaiian petrel caused by the proposed project would result in significant adverse effects to Hawaiian petrel at the population level.

The major threats identified for the covered seabirds are introduced predators, which can prey on adults, eggs, and fledglings; feral ungulates, which degrade habitat and may trample burrows; and artificial lighting, which may disorient fledglings and increase their risk of collision with artificial structures (Mitchell et al. 2005). Predation has been shown to have significant negative effects on fledging success for the Hawaiian petrel (Hodges 1994, Hu et al. 2001, Hodges and Nagata 2001, Telfer 1986), and predation on adults has also been documented (Simons 1983). In Haleakalā National Park, Hodges and Nagata (2001) identified predation as accounting for 41% of total terrestrial mortality (adults, fledglings, and eggs) in cases in which a cause of death could be determined. Predation mortality was attributed to cats and mongooses (38%), rats (41%), dogs (14%) and owls (6%) (Hodges and Nagata 2001). Data from Hodges (1994), Hu et al. (2001), and Hodges and Nagata (2001) show that predator control (trapping and fencing) generally results in a significant increase in Hawaiian petrel nesting success. Suppressing predator populations is also expected to increase adult survival rates.

Similar to Newell’s shearwaters, the mitigation for Hawaiian petrels would consist of predator control, fencing, or colony and habitat enhancement at a seabird colony on Maui, Kaua‘i or elsewhere. One possible mitigation alternative to the Makamaka‘ole colony that has emerged through discussion with the National Park Service (NPS) is the opportunity to participate in the management of the Hawaiian petrel colony in the crater of Haleakalā located on the eastern portion of Maui. NPS has indicated that a roughly 220 ac (89 ha) area with approximately 100 burrows are protected from habitat damage by feral goats and pigs, but are not protected from predators. NPS does not have funds to conduct the needed predator control in this area and does not anticipate receiving funds in the near future (Bailey, pers. comm.). Kahuku Wind Power would contract the labor and purchase equipment required to conduct predator trapping in this area and to conduct monitoring to document success.

Gear-cleaning procedures to reduce the introduction of noxious plant seeds and propagules, as well as arthropods such as exotic ants would be strongly enforced for biologists and/or contractors that conduct predator control or monitoring efforts. There is some potential for seabirds to get caught in traps, and on rare occasions, this can result in the death of the bird. Trapping and monitoring at Haleakalā would closely follow the protocols that have already been established by NPS. This includes appropriate trap placement and regular monitoring. Therefore, potential adverse impacts to seabirds as a result of the proposed mitigation are not anticipated. If diphacinone (or another rodenticide) is used to control rats at Haleakalā, the adults of the covered seabird species are not expected to be attracted to the toxin or eat organisms that have been contaminated (as described above). Thus, the use of rodenticides is not anticipated to negatively impact seabird populations.

Designated critical habitat for the threatened *Argyroxiphium sandwicense spp. macrocephalum* (‘ahinahina or Haleakalā silversword) occurs in the vicinity of the proposed Haleakalā mitigation site. Predator control activities, as well as increased foot traffic through the area for deployment of monitoring of traps may adversely impact the species and its critical habitat. In order to avoid impacts to listed plants, all listed individuals in the vicinity would be clearly flagged, and appropriate protocols would be used to avoid direct or indirect impacts to listed plants. Because the mitigation would closely follow protocols that have already been established by NPS at nearby areas that also contain critical habitat for *A. sandwicense spp. macrocephalum*, adverse impacts would be minor.

Proposed mitigation measures are expected to more than offset the anticipated take and contribute to species’ recovery by providing a net conservation benefit, as required by State law. For this reason, no significant adverse impacts to the species’ overall populations are expected.

Similar to Newell’s shearwater, no radar studies were conducted at the off-site microwave tower sites because the low heights of the towers (60 ft or less) and their small profiles would present minimal collision risk to petrels. It is expected that Hawaiian petrel individuals could occasionally transit over the off-site microwave tower sites, but at much higher altitudes than the towers themselves (average flight height estimated at 410 ± 13 ft or 125± 4 m). Given that the seabird traffic rate on Oʻahu is extremely low, the likelihood of a seabird flying at such low altitudes and colliding with the microwave towers, overhead cable, or utility poles related to the microwave tower is considered to be remote. Therefore, the proposed off-site microwave towers were not identified as a potential source of take of Hawaiian petrel in the mortality modeling performed for the species and, thus, the amount of take requested to be authorized through the ITL is based solely on mortality expected to occur as a result of construction and operation of the WTGs and associated on-site facilities.

Hawaiian Duck Hybrids

Grading to eliminate the formation of areas of standing water that form after heavy rain events would result in loss of some habitat available to (hybrid) Hawaiian ducks. However, because the presence of these features is infrequent and unpredictable, this habitat resource is not considered important to these ducks (J. Kwon/USFWS, pers. comm.). Given this, removal of the ability of this area to hold water and attract ducks to the project area is considered a beneficial component of the proposed project as it would reduce the risk of collision with WTGs and other project facilities during the operation phase.

Low mortality of waterbirds has been documented at wind turbines situated coastally, like the proposed Kahuku Wind Power project, despite the presence of high numbers of waterbirds in the vicinity (Kingsley and Whittam 2007). Studies at wind energy facilities located in proximity to wetlands and coastal areas have shown that waterbirds and shorebirds are among the birds most wary of turbines and that these birds readily learn to avoid the turbines over time (Koford et al. 2004, Jain 2005, Carothers 2008).

The potential for hybrid Hawaiian ducks to collide with construction cranes is considered to be negligible. In addition to the cranes being on-site for only a few months, the ducks are primarily diurnal and the cranes would be highly visible and so should be readily avoided. Some potential exists for construction or maintenance vehicles to strike downed ducks (ducks already injured by collision with turbines or towers) while traveling project roads. As for Newell’s shearwater and Hawaiian petrel, this potential source of mortality is accounted for in the collision mortality estimate and so does not result in an increase in the amount of take expected from the proposed project.

Expected rates of take for Hawaiian duck hybrids, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Expected Rate of Take

Annual average	0.026 adult ducks and 0.031 ducklings
20-year project life	1 adult duck and 1 duckling

An estimated 300 hybrid Hawaiian ducks are present on Oʻahu (Engilis et al. 2002, USFWS 2005a). The expected level of take over the 20-year life of the project is approximately one adult duck and whatever number of eggs or ducklings being tended at the time of collision. Mortality realized at this very low rate is not expected to cause significant negative impacts to the Oʻahu population of hybrid Hawaiian ducks. Regardless, because it is anticipated that all hybrid Hawaiian ducks on Oʻahu will ultimately be removed/relocated to allow for the reintroduction of pure Hawaiian ducks, loss of hybrid ducks as a result of operation of the Kahuku Wind Project is not considered to be biologically significant or adverse.

The Kahuku Wind Power HCP proposes to mitigate for possible impacts to Hawaiian duck, Hawaiian stilt, Hawaiian coot, and Hawaiian moorhen concurrently at one wetland site because of the similar habitat requirements of these species, and because they face similar threats to their habitat and reproductive success. Proposed mitigation for the take of waterbirds by operation of the Kahuku Wind Power project would focus on predator control and vegetation maintenance at one or more wetland sites on Oʻahu that has regular waterbird nesting activity, as identified by DLNR-DOFAW and USFWS (see Appendix K). As no pure Hawaiian ducks exist on Oʻahu due to hybridization, mitigation for Hawaiian ducks would also include removal of feral ducks, mallards, and Hawaiian duck hybrids at the mitigation site. Currently, the preferred mitigation site is Hamakua Marsh, a 23-acre wetland located on east Oʻahu.

Concern was expressed by USFWS about the possible take of waterbirds as a consequence of predator trapping at the marsh. Moorhen are attracted to traps (DesRochers et al. 2006) and moorhen on Oʻahu have been documented entering live traps (DesRochers et al. 2006, Nadig pers. comm.). Thus, predator trapping poses some risk of harassment due to capture, and may result in injury or mortality to the covered waterbird species. However, at Hamakua Marsh, traps are not placed within moorhen habitat (Misaki, pers. comm.) and in the five years of predator trapping, no injuries or fatalities due to the by-catch of moorhen or any of the other covered waterbird species have been reported. Due to the minimal risk of injury or mortality expected at Hamakua Marsh, no additional take is requested for any of the covered waterbird species. However, in the unlikely event a waterbird mortality or injury is caused by the mitigation measures, Kahuku Wind Power LLC would mitigate for that loss at a level commensurate with any take that occurs and measures would be put in place to prevent a repeat of the same occurrence as far a practicable.

The trapping of cats, dogs, mongoose, and rats at Hamakua Marsh, is expected to increase the reproductive success of Hawaiian coot, Hawaiian stilt, and Hawaiian moorhen. The eradication of hybrid and feral ducks is expected to reduce the continued hybridization of feral mallards with the Hawaiian duck. These proposed mitigation measures are expected to more than offset the anticipated take and contribute the species' recovery by providing a net conservation benefit, as required by State law. For this reason, no significant adverse impacts to the covered waterbirds' overall populations are expected.

Hawaiian duck hybrids frequently fly at altitudes that the on-site and off-site microwave towers, collection lines and utility poles would extend to (see HCP). Therefore, potential for ducks to collide with these structures exists. However, as Hawaiian hybrid ducks are primarily diurnal, they are expected to easily avoid the microwave tower which would be highly visible during daylight hours. Observations of ducks conducted at nearby wetlands demonstrated that Hawaiian duck hybrids easily negotiated the overhead powerlines strung across the wetland habitat. No ducks were observed to have any collisions or near-collisions with the overhead powerlines or utility poles (147 flocks observed, average of two birds per flock). Consequently, potential for hybrid Hawaiian ducks to collide with the microwave towers, collection lines and utility poles associated with the project is considered to be negligible.

Pure Hawaiian Ducks

The possibility of existence of genetically pure Hawaiian ducks on Oʻahu is currently considered very remote (Engilis et al. 2002, USFWS 2005a, A. Engilis pers. comm to SWCA.). However, as discussed, the USFWS is planning on James Campbell NWR playing a key role in the future reintroduction of pure Hawaiian ducks to Oʻahu (USFWS 2005a, Kwon/USFWS pers. comm.). At present it is uncertain when that will occur, but it is possible that reintroductions could occur during the 20-year life of the project.

The reintroduction of pure Hawaiian ducks would first require the removal of all hybrid Hawaiian ducks and feral mallards from Oʻahu. If that were to occur during the life of the project, the potential for hybrid ducks to be killed through collision with project components as described above would be eliminated and replaced with potential for project operations to cause mortality of pure Hawaiian ducks. There likely would be some interval of time between eradication of the hybrid ducks and re-introduction of the pure ducks in which no potential existed for Hawaiian-type ducks to collide with the proposed turbines and met tower.

It is not known how many pure Hawaiian ducks would be released or what behavior patterns they would establish, so it is not possible at this time to estimate accurately an expected passage rate and model expected mortality rates. However, it does seem probable that the number of pure ducks released would be lower than the number of hybrid Hawaiian ducks currently present in the general project area, and that the population of pure ducks would eventually build to approximate that of the current hybrid population. Consequently, it appears the potential for collisions would initially be lower than that expected for the hybrid ducks but could eventually match it. Thus, it appears that the project should have potential to result in the direct loss of no more than one pure adult Hawaiian duck over the 20-year life of the project.

Should reintroduction of pure Hawaiian ducks occur during the lifetime of the project, Kahuku Wind Power LLC believes the same take authorizations and limits should be applied to the species as requested for the hybrid ducks above.

Mitigation measures of the pure Hawaiian duck would be the same as the hybrids. Proposed mitigation measures are expected to more than offset the anticipated take and contribute to species' recovery by providing a net conservation benefit, as required by State law.

Impacts as a result of construction and operation of the off-site microwave towers are the same as those described for the hybrid Hawaiian duck.

<u>Hawaiian Stilt</u>

The areas of standing water that occasionally form in the project area after heavy rain events may create temporary habitat for a small number of Hawaiian stilts. Given that these areas form on an infrequent and unpredictable basis, they are not considered to provide habitat important for the species (J. Kwon/USFWS, pers. comm.). The proposed grading would eliminate the ability of these areas to form; however, because the areas of standing water are not considered to provide important habitat for Hawaiian stilts, elimination of this possible attractant in conjunction with project operation is considered beneficial.

As with Hawaiian petrel, no Hawaiian stilts were observed flying over the project area during the avian surveys so modeling would result in an estimated take rate of zero. Because Hawaiian stilts occur regularly in the Kahuku area, it is considered that the project would create some risk of causing take of this species, however small. Therefore, the Kahuku Wind Power HCP assumed the rate of take of Hawaiian stilt would be the same as for Hawaiian duck hybrids, or an average of 0.026 stilt/year lost through collision with turbines, the met tower, and other associated structures, as well as vehicular strikes (SWCA and First Wind 2010). The assumed rate of direct take of 0.026 stilt/year equates to direct loss of essentially one stilt over the 20-year life of the project as it did for hybrid Hawaiian duck.

Expected rates of take for Hawaiian stilt, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Annual Expected Rate of Take

Annual average	0.026 adults and 0.0012 fledglings
20-year project life	1 adult and 1 fledgling

O‘ahu supports 35-50% of the state’s stilt population with approximately 450 to 700 birds present on the island. The take of stilts at the expected rate of one adult stilt over 20 years is not expected to significantly impact the stilt population on O‘ahu. Moreover, the proposed mitigation (as briefly described in the previous section) is expected to more than offset the anticipated take of one bird per year and contribute to the species’ recovery by providing a net conservation benefit, as required by State law. The mitigation is expected to be successful as the Hawaiian stilt is classified as a species with a high potential for recovery (USFWS 2005a) where the biological and limiting factors are well understood, the threats are understood and easily alleviated and intensive management is not needed or the known techniques have been documented with a high probability of success (USFWS 1983).

Higher levels of take, depending on the actual rate, might be capable of impacting the island population due to its small population numbers in absence of mitigation. As stated previously, mortality of waterbirds at wind farms has historically been low, despite the proximity of large populations of waterbirds near turbines. Waterbirds also learn to avoid turbines over time (Kingsley and Whittam 2007, Carothers 2008). Therefore, occurrence of take at a higher rate is not expected. Because mitigation efforts would be adjusted in response to occurrence of take at higher levels, a higher level of take is expected to be offset such that this level of take also would not affect Hawaiian stilt at the population level.

Impacts as a result of construction and operation of the off-site microwave towers are the same as those described for the Hawaiian duck.

Hawaiian Coot

The areas of standing water that occasionally form in the project area after heavy rains are generally not expected to attract Hawaiian coots because they lack emergent wetland vegetation favored by the species. Even if these areas could receive occasional use by coots, given that these areas form on an infrequent and unpredictable basis they are not considered to provide habitat important for the species (J. Kwon/USFWS, pers. comm.). The proposed grading would eliminate the ability of these areas to form; however, because the areas of standing water are not expected to be used by, nor considered to provide important habitat for, Hawaiian coots, elimination of this possible attractant in conjunction with project operation is considered beneficial.

No Hawaiian coots were observed flying over the project area during avian surveys so mortality modeling for this species would result in an estimated take rate of zero. As for Hawaiian stilt, because Hawaiian coots occur regularly in the Kahuku area, it is considered that the project would create some risk of causing take of this species, however small. Therefore, also as for Hawaiian stilt, the Kahuku Wind Power HCP assumed the rate of take of Hawaiian coot would be the same as for Hawaiian duck hybrids, or an average of 0.026 coot/year lost through collision with turbines, met towers, and other associated structures, as well as vehicular strikes (SWCA and First Wind 2010). The assumed rate of direct take of 0.026 coot/year equates to direct loss of essentially one coot over the 20-year life of the project. Expected rates of take for Hawaiian coot, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Annual Expected Rate of Take

Annual average	0.026 adults and 0.012 chicks
20-year project life	1 adult and 1 chick

O‘ahu supports between 500 and 1,000 coots, or up to 33% of the state population. The expected loss of one adult coot over the life of the project, if realized, is not expected to have a significant impact on the population of the coot on O‘ahu. The proposed mitigation is expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. The mitigation is expected to be successful as the Hawaiian coot is classified as a species with a high potential for recovery (USFWS 2005a) where the biological and limiting factors are well understood, the threats are understood and easily alleviated and intensive management is not needed or the known techniques have been documented with a high probability of success (USFWS 1983).

Higher levels of take, depending on the actual rate, might be capable of impacting the island population of Hawaiian coot in absence of mitigation. As stated previously, mortality of waterbirds at wind farms has historically been low, despite the proximity of large populations of waterbirds near turbines. Waterbirds also learn to avoid turbines over time (Kingsley and Whittam 2007, Carothers 2008). Therefore, occurrence of take at a higher rate is not expected. Because mitigation efforts would be adjusted in response to higher take levels, take at the higher level would be offset such that this level of take also would not affect Hawaiian coot at the population level.

Impacts as a result of construction and operation of the off-site microwave towers are the same as those described for the Hawaiian duck.

Hawaiian Moorhen

No direct impacts to habitat for Hawaiian moorhen would occur as a result of the proposed action. No habitat for this sub-species occurs in the project area, and the areas of standing water that sometimes form in the area are not expected to attract moorhens because of their lack of emergent cover. The proposed grading would eliminate any potential for these areas to attract Hawaiian moorhens to the project area during the operational phase of the project.

No Hawaiian moorhens were detected at Kahuku Wind Power during the 15-month long avian point count survey and are thought to be at very low risk of collision with turbines because of their sedentary habits (see Section 3.12.4). For the same reasons discussed for Hawaiian stilt and Hawaiian coot, risk of collision by this species is not zero and in the HCP is assumed to occur at the same rate assumed for those species, or on an average of 0.026 moorhen/year as a result of collision with turbines, met towers and associated structures, as well as mortality due to vehicular strikes (SWCA and First Wind 2010). This equates to essentially one Hawaiian moorhen lost to collision mortality over the 20-year life of the project.

Expected rates of take for Hawaiian moorhen, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Annual Expected Rate of Take

Annual average	0.026 adults and 0.017 chicks
20-year project life	1 adult and 1 chick

Biannual waterbird surveys record an average of 341 moorhens throughout the state (USFWS 2005a). This average is likely an inaccurate under-estimate of true population size as moorhens are secretive and difficult to census (USFWS 2005a). Given that the population of Hawaiian moorhen is at least the measured average, the expected loss of one adult Hawaiian moorhen over the 20-year project life is not expected to result in significant adverse effects to the sub-species at the population level. The proposed mitigation is expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. The mitigation is expected to be successful as the moorhen is classified as a species with a high potential for recovery (USFWS 2005a), where the biological and limiting factors are well understood, the threats are understood and easily alleviated and intensive management is not needed or the known techniques have been documented with a high probability of success (USFWS 1983).

Higher levels of take, if realized, may have potential to adversely impact the state population given its presumed small size in the absence of compensatory mitigation. Higher levels of take are considered extremely unlikely to be realized because of the tendency of moorhens to swim or walk rather than fly (Bannor and Kiviat 2002), and lack of suitable habitat to attract moorhens to the project area. Moorhens in Hawaiʻi are highly sedentary and no records of inter-island flights have been documented (Bannor and Kiviat 2002). Because mitigation efforts would be adjusted in response to higher take levels, take at the higher level would be offset such that this level of take also would not affect Hawaiian moorhen at the population level.

Impacts as a result of construction and operation of the off-site microwave towers are the same as those described for the Hawaiian duck.

Hawaiian Short-eared Owl

No Hawaiian short-eared owls were seen during the avian point count surveys conducted over 15 months at the Kahuku Wind Power project area. However, because one Hawaiian short-eared owl was heard in the project area in July 2008 during the seabird radar survey (see Section 3.12.2); it is assumed the sub-species occurs in the project area on at least an irregular basis. Project construction would result in the loss of approximately 32 ac of vegetation within the 578-ac project area. This would reduce the amount of foraging area available to any short-eared owls present in the general vicinity, and the loss of vegetation may result in a slight decrease in the number of potential prey items (e.g., mice) available to owls. Because the vegetation clearing would be spread across a relatively large area rather than concentrated in one area, the reduction in number of potential prey items in any particular area is expected to be slight. Thus, the loss of potential foraging area and any reduction in numbers of prey items is not expected to significantly affect the ability of any owls that utilize the project area from being able to sustain themselves.

Post-construction monitoring data from North America suggest the species is generally not vulnerable to collision with wind turbines. Data on status of Hawaiian short-eared owl in the project area is too scant to enable a reasonable estimation of the mortality rate for this species that may result from completion of the proposed project. Observations of short-eared owls at the KWP facility on Maui suggest most generally fly low over the ground, preferring open pastures and grasslands away from most structures (G. Spencer/First Wind, pers. comm.). Potential for short-eared owls to collide with wind turbines seems it would be greatest when birds were performing aerial breeding displays or if the birds were needing to avoid some aerial predator. The paucity of observations of this species from the project area strongly suggests Hawaiian short-eared owls do not breed in or directly adjacent to the project area, so the probability of short-eared owls colliding with wind turbines while performing breeding displays appears to be exceedingly low. No potential aerial predators of Hawaiian short-eared owl occur on Oʻahu, so it also appears very unlikely that short-eared owls would collide with any of the proposed wind turbines for this reason.

Potential for short-eared owls to collide with the permanent, unguyed met tower or cranes during the turbine construction period is considered negligible because these structures would be immobile and stationed in cleared sites. Thus, the tower and cranes should be readily visible to, and avoidable by, owls.

The expectation that short-eared owls are not likely to collide with the proposed turbines and met tower, or with construction cranes, is supported by the results of post-construction monitoring and general observations made at the KWP facility on Maui. Short-eared owls are observed regularly at the KWP facility yet, as indicated above, no short-eared owl fatalities have been recorded after three and a half years of operation (G. Spencer/First Wind, pers. comm.). Lack of recorded fatalities at a site where the species occurs regularly and, hence, has greater exposure to collision hazards, suggests strongly that risk of collision at the Kahuku Wind Power facility would be very low given that it has not been documented on the site.

Some very low potential exists for construction or maintenance vehicles to strike short-eared owls that may be hunting low over the project area. Project personnel would be educated regarding the possibility of owls flying low across project roadways or resting on the ground adjacent to roadways and speed limits (10 mph) would be emplaced and enforced on project roadways to minimize potential for vehicle strikes to harm short-eared owls.

Given the above information, it is possible that no Hawaiian short-eared owl fatalities would be realized during the life of the Kahuku Wind Power project. However, because the species is known to occur in the general vicinity of the project area at least on occasion, the risk of collision cannot therefore be considered zero. Given the on-site survey results and monitoring results from the KWP site on Maui, it seems reasonable to assume that the chance of the proposed project causing a short-eared owl fatality in any given year is well less than 1.0. The Kahuku Wind Power HCP assumed that the proposed project would on average result in the loss of 0.33 Hawaiian short-eared owl/year (SWCA and First Wind 2010). This equates to one owl every three years or about seven owls over the 20-year life of the project, and was chosen as a conservative estimate based on the findings at KWP where no short-eared owls have been lost to project operations after more than three years.

Expected rates of take for Hawaiian short-eared owl, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Expected Rate of Take

Annual average	0.33 adults and 0.31 owlets
20-year project life	7 adults and 7 owlets

No population numbers for Hawaiian short-eared owl are available for the Island of O‘ahu or any of the other Hawaiian Islands. However, given the rate of assumed loss, it is unlikely that the proposed project would cause a significant impact on the Hawaiian short-eared owl population on O‘ahu.

Higher levels of take may impact the O‘ahu population of Hawaiian short-eared owl if its population is small, but realization of take at higher levels is considered extremely unlikely to occur because Hawaiian short-eared owl have been heard only once at the Kahuku Wind Power site over the course of 15 months of surveys, and given the rate of owl mortality observed to date at KWP on Maui.

Mitigation for possible take of the Hawaiian short-eared owl by Kahuku Wind Power LLC would consist of three parts: funding research; rehabilitation of injured owls; and subsequently implementing management actions on O‘ahu as they are identified and as needed to bring mitigation ahead of take (i.e., provide a net benefit). No adverse impacts are anticipated as a result of implementing these mitigation measures. All individuals involved in the research and rehabilitation programs would be trained on how to appropriately handle and care for injured Hawaiian short-eared owls. Kahuku Wind Power LLC's proposed mitigation for the anticipated take would contribute to a greater understanding of the species' occurrence and status on O‘ahu, which in turn would help guide future management and recovery efforts and should result in an overall net conservation benefit for the species. For this reason, no significant adverse impacts to the species' overall populations are expected.

Potential for short-eared owls to collide with the off-site microwave towers is considered negligible because these structures would be immobile and stationed in cleared sites. Thus, the towers should be readily visible to, and avoidable by, owls.

Hawaiian Hoary Bat

Based on surveys conducted to date, a low but consistent level of Hawaiian hoary bat activity occurs year-round on site with some small increase in activity between June and September (Appendix G). The proposed construction would eliminate approximately 32 ac of vegetation that could support and produce insects preyed upon by Hawaiian hoary bats, as well as provide roosting sites for bats. Clearing of trees during construction is proposed to be performed outside the bat breeding season to avoid potential to directly harm any young bats that would be incapable of avoiding machinery used to clear vegetation. The loss of 32 ac of vegetation represents an approximately 5.6% loss of vegetation across the 578-ac project area. This relatively small amount of impact is not considered likely to significantly affect the prey base available to Hawaiian hoary bats in the project area given the small number of bats that appear to utilize the area.

The HCP identifies an estimated average rate of take for the Kahuku Wind Power project of 0.016 bat/turbine/year. This equates to a total average take of 0.19 bat/year or roughly one bat every five years for all 12 turbines on the site.

Potential for bats to collide with met towers or cranes is considered to be negligible because they would be immobile and should be readily detectable by the bats through echolocation. While the guy wires on the temporary met towers may pose a somewhat greater threat to bats, bats at KWP on Maui have not been found to have collided with the guyed met towers after three years of operation nor with any cranes during the construction phase of that project. Of 64 wind turbines studied at Mountaineer Wind Energy Center in the Appalachian plateau in West Virginia, bat fatalities were recorded at operating turbines, but not at a turbine that remained non-operational for control purposes during the study period (Kerns et al. 2005). This supports the expectation that presence of the stationary structures such as met towers and cranes should not result in bat fatalities.

Expected rates of take for Hawaiian hoary bat, based on the information provided in Appendix K and the HCP (SWCA and First Wind 2010), is summarized below.

Expected Rate of Take

Average	0.19 adults and 0.34 juveniles	0.44 bats/year
20-year project life	4 adults and 7 juveniles	

No recent population estimates exist for Hawaiian hoary bat, though previous estimates have ranged from several hundred to several thousand (Tomich 1969, Menard 2001). Although overall numbers of Hawaiian hoary bats are believed to be low, they are thought to occur in the greatest numbers on the Islands of Hawaiʻi and Kauaʻi (Menard 2001).

The assumed level of take is low and commensurate with the results of mortality observed to date at the KWP facility on Maui. Because of this, it is considered unlikely to result in a significant impact on the overall population of the Hawaiian hoary bat. Higher levels of take may adversely impact the Oʻahu population if the population is very small, but they would not likely impact the status of the species on other islands where populations are assumed to be more robust.

Mitigation for the Hawaiian hoary bat by Kahuku Wind Power LLC was developed through discussions with USFWS, DLNR, and bat experts at USGS. Kahuku Wind Power LLC proposes to participate in research by monitoring Hawaiian hoary bats on-site, as well as documenting how Hawaiian hoary bats interact with wind facilities. Kahuku Wind Power LLC would also fund a native habitat restoration program to improve bat habitat. Native habitat plant restoration at the Polipoli area of the Kula Forest Reserve in East Maui has been identified as a potential location for enhancing bat habitat.

Several listed plant species have designated critical habitat in the vicinity of the Kula Forest Reserve: *Argyroxiphium sandwicense ssp. macrocephalum* (ʻahinahina), *Bidens micrantha ssp. kalealaha* (koʻokoʻolau), *Clermontia lindseyana* (ʻoha wai), *Diellia erecta*, and *Geranium arboretum* (Hawaiian ref-flowered geranium). Increased foot traffic and the potential introduction of non-native species associated with the proposed mitigation may adversely impact the listed species and their critical habitat. In order to avoid and minimize impacts to listed plants and critical habitat, all restoration materials would be certified weed-free and appropriate BMPs would be implemented by the contractor during the native plant restoration. Gear-cleaning procedures to reduce the introduction of invasive species would be strongly enforced for biologists and/or contractors. By implementing the measures described above, adverse impacts of the proposed mitigation measures would be minor.

The amount of habitat restored would be at a level that is commensurate with the requested take and would provide a net benefit to the species (Appendix K). Proposed mitigation measures are expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. For this reason, no significant adverse impacts to the species' overall populations are expected.

The potential for bats to collide with the off-site microwave towers is considered to be negligible because they would be immobile and should be readily detectable by the bats through echolocation.

3.12.4.2 Potential Impacts of the No Action Alternative

The No Action Alternative is not expected to cause any adverse impacts to the seven federally listed species and one state listed species because no potential for collision with wind turbines or project infrastructure would be created. However, the No Action Alternative would not provide the net benefits to the covered species expected under the proposed action because proposed beneficial measures would not be implemented. Thus, the No Action Alternative would not contribute to recovery efforts, research, or habitat protection for listed species.

3.13 Socioeconomic

3.13.1 Social and Economic Environment

The proposed Kahuku Wind Power facility is located in the community of Kahuku, within the Koʻolau Loa District, on the Island of Oʻahu. The total resident population of the Island of Oʻahu is approximately 905,034 individuals (DBEDT 2009). The majority of the resident population on Oʻahu lives in the District of Honolulu. The Koʻolau Loa District is not heavily populated compared to other districts on the island; it represented less than 2.2% of the entire island's population in 2000 (DBEDT 2009). The district experienced a 2.5% change in population between 1990 and 2000.

The most recent estimate of the population of the Kahuku Census Designated Place (CDP), as defined at the U.S. Census Bureau, is 2,097 individuals (U.S. Census Bureau 2003). Kahuku has experienced relatively minor population growth since 1990. The Kahuku area did not support many residents until the development and distribution of water made agriculture possible in the late 1800s (R.M. Towill Corporation 2008). Estimated population figures for these areas are summarized in Table 3-17.

Table 3-17. Population figures for selected areas.

Area	1980	% change	1990	% change	2000	% change	2005
O‘ahu Island	762,534	9.7	836,231	4.8	876,156	3.2	904,645
Ko‘olau Loa District	14,195	29.9	18,443	2.5	18,899	--	--
Kahuku CDP	--	--	2,063	1.6	2,097	--	--
Source: (DBEDT 2009), US Census Bureau (2003).							

During the plantation days, both economic and social activity in Kahuku centered around a sugar mill (R.M. Towill Corporation 2008). Since that time, the sugar mill has closed and most residents of the Kahuku area are now employed in the services industry. Job growth in the Ko‘olau Loa District is anticipated to increase by 32% from 2000 to 2030. Most of this growth is expected to occur in the service sector. Compared to the rest of the island, this growth is low.

In 2008, the estimated median household income for the Kahuku area was $51,432 and the estimated per capita income was $15,488 (R.M. Towill Corporation 2008). In 1999, the median household income in the Kahuku CDP was $39,135 and the median per capita income was $12,340. In 2000, approximately 11.8% of families and 14.6% of individuals in the Kahuku CDP had an income below poverty level. In comparison, on O‘ahu, families and persons living below the poverty level comprised 7% and 9.9%, respectively (U.S. Census Bureau 2003). Throughout the State of Hawai‘i, approximately 7.6% of families and 10.7% of individuals are considered to be living below poverty level.

3.13.1.1 Potential Impacts of the Proposed Action

Adverse short-term or long-term impacts to the social or economic condition of the area are not expected to occur as a result of the proposed action. The proposed action would not result in a large number of new residents moving to the Kahuku area or the Island of O‘ahu. Energy generated from the facility would provide power “as available” and would be used to substitute other energy sources. The population of the area is not expected to increase due to increase energy availability; therefore, the project would not be considered growth inducing. The proposed action is not anticipated to impact housing costs or availability.

Because the proposed action would support construction and operation of the wind energy facility, it does have the potential to benefit the community due to direct socio-economic effects. During the construction phase, Kahuku Wind Power may employ an average of 15 to 20 people per day, with an anticipated maximum level of 40 employees. The work would include general construction and more specialized installation of electrical equipment and wind turbine components. Local residents of Kahuku or O‘ahu may be employed during the general construction of the project. Following construction, the operation of the wind facility would be staffed by four to five full-time, regular employees working on-site Monday through Friday (Environet, Inc. 2009). These employees would include biologists, road maintenance workers, engineers, and technicians. The proposed off-site microwave towers would be serviced intermittently by maintenance personnel. Local residents of Kahuku or O‘ahu may be employed during operation of Kahuku Wind Power; however, because the operations staff would be small, the project is not expected to result in a substantial long- term employment increase for the area. Another socio-economic benefit of the proposed project would be ongoing expenditures for materials and outside services.

3.13.1.2 Potential Impacts of the No Action Alternative

No changes in existing social or economic conditions would occur under the No Action Alternative. The positive socio-economic effects of the proposed action would not occur under the No Action Alternative.

3.13.2 Environmental Justice

Executive Order 12898 requires federal agencies to take appropriate steps to identify and avoid disproportionately high and adverse effects of federal actions on the health and surrounding environment of minority and low-income populations. All federal programs, policies, and activities that substantially affect human health or the environment shall be conducted to ensure that the action does not exclude persons or populations from participation in, deny persons or populations the benefits of, or subject persons or populations to discrimination under such actions because of their race, color, income level, or national origin. The Executive Order was also intended to provide minority and low-income communities with access to public information and public participation in matters relating to human health and the environment.

The Council on Environmental Quality (CEQ) has issued guidance to federal agencies to ensure that environmental justice concerns are effectively identified and addressed throughout the NEPA process. DOE guidance recommends that DOE consider pathways or uses of resources that are unique to a minority or low-income community before determining that there are no disproportionately high and adverse impacts on the minority or low-income population.

The State of Hawaiʻi has also developed its own legislation and guidance related to environmental justice. Act 294 was signed by Governor Lingle in July 2006 to define environmental justice in the unique context of Hawaiʻi and to develop and adopt environmental justice guidance that addresses environmental justice in all phases of the environmental review process (Kahihikolo 2008).

Race data for Kahuku in 2000 is shown in Figure 3-20. The population of Kahuku in 2000 was primary composed of Native Hawaiian and other Pacific Islanders (27.3% alone, 25.2% in combination[7]) and Asians (26.8% alone, 24.5% in combination). In comparison, the largest racial group on the Island of Oʻahu is Asian (46% alone, 15.5% in combination). Native Hawaiians and Other Pacific Islanders represent a much smaller percentage of Oʻahu's population (8.9% alone, 12.7% in combination) (US Census Bureau 2000).

---

[7] In combination with one or more of the other races listed. The numbers and percentages for race "alone or in combination" may add to more than the total population because individuals may report more than one race.

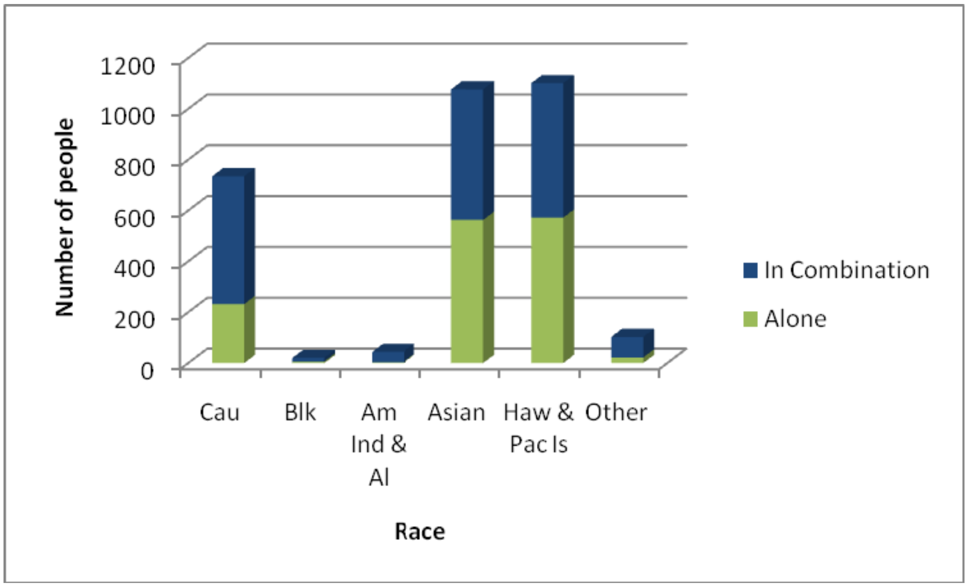


Figure 3-20. Breakdown of the racial composition of the Kahuku CDP.
Notes: “In Combination” means that one or more race listed was selected by a respondent. Cau = Caucasian; Blk = Black or African American; Am Ind & Al = American Indian and Alaska Native; Haw & Pac Is = Native Hawaiian and Other Pacific Islander.

The project area is located adjacent to the rural commercial center in Kahuku. Rural commercial centers are a mix of retail shopping, restaurant, personal service, entertainment and professional office uses that serve residents and some tourists. These establishments are typically small stores (markets, restaurants, retail shops, etc) concentrated along Kamehameha Highway (DPP 1999).

3.13.2.1 Potential Impacts of the Proposed Action

Typically, minorities are defined as individuals who are members of the following population groups: African Americans, American Indians, Alaskan Natives, Asians, Hispanics, Native Hawaiians, or Other Pacific Islanders. However, as recognized in the Hawai‘i Environmental Justice Initiative Report (Kahihikolo 2008), the minority population distribution of Hawai‘i differs greatly from that of the continental U.S. In contrast to the continental U.S., where Caucasians account for the majority of the population, no racial group in Hawai‘i comprises even as much as half of the state population. On the Island of O‘ahu, the largest racial group is Asian, comprising 46% of the island’s population (OMPO and DPP 2004). O‘ahu (and the state in general) is also unique in that 20% of the O‘ahu population reported multiple races; only 2.4% did so in the continental U.S. Thus, the minority definitions developed to determine environmental justice impacts on the mainland U.S. may not be applicable or appropriate for O‘ahu (OMPO and DPP 2004).

The percentage of Native Hawaiian and other Pacific Islanders (alone) living in Kahuku is more than three times the island average for that group (27.3% alone vs. 8.9% alone). However, the population of Native Hawaiians and other Pacific Islands (alone) in Kahuku is still less than 50%.

Low-income populations are defined using the poverty thresholds as defined by the U.S. Census Bureau. As stated in Section 3.13.1, the percentage of families and individuals in the Kahuku CDP with an income below poverty level is slightly greater than the averages for O‘ahu (U.S. Census Bureau 2000). However, there are no concentrations of low income or minority populations in the vicinity of the project area.

The proposed project complies with Executive Order 12898. No persons would be displaced as a result of this project. The proposed project is not expected to result in substantial environmental, human health, or economic impacts on surrounding populations. Furthermore, since the proposed action would benefit the local economy, including low-income and minority households in Kahuku, these individuals would not experience a disproportionate share of the impacts of the project.

3.13.2.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, there would be no environmental justice impacts.

3.14 Historic, Archaeological, and Cultural Resources

3.14.1 Regulatory Framework

The National Historic Preservation Act of 1966 (NHPA) is the primary federal law protecting cultural, historic, Native American, and Native Hawaiian resources. Section 106 of the NHPA (36 CFR 800) requires federal agencies to assess and determine the potential effects of their proposed undertakings on prehistoric and historic resources (e.g. sites, buildings, structures, and objects) and to develop measures to avoid or mitigate any adverse effects. Compliance with Section 106 requires consultation with the State Historic Preservation Officer (SHPO).

Detailed requirements for complying with Section 106 of the NHPA are addressed in regulations promulgated by the Advisory Council on Historic Preservation (ACHP) under 36 CFR 800. Section 800.16(l)1 of the ACHP regulations defines a “historic property” as “any prehistoric or historic district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places maintained by the Secretary if the Interior.” Section 800.16(d) of the ACHP regulations requires agencies to determine the area of potential effects (APE), defined as “the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist.”

In consultation with SHPO, a roughly 230 ac (93 ha) APE was decided upon for this study (Figure 3-21). The APE was defined given the nature of the proposed development, the history of past land use, and the expressed community desire (following extensive consultation) to preserve the coral escarpment formations that exist within the subject property (Rechtman 2009). With the exception of the two off-site microwave towers, there would be no development activities planned for any areas outside of the defined APE.

3.14.2 Pre-Contact and Historical Context

The project area is located in the ahupuaʻa of Kahuku.[8] Kahuku literally translates as “the projection” (Pukui et al. 1974). The naming of Kahuku is suggested in old stories. Traditional legends relate that Kahuku was once a floating island that had been struck apart from Oʻahu by Lonokaʻeho. After blowing around in the ocean, the island was reattached to Oʻahu by the people of the Koʻolauloa District with hooks and ropes (Rechtman 2009). Several versions of this story are told (Rechtman 2009).

---

[8] An ahupua’a is a wedge or pie-shaped land unit that became the equivalent of a local community, with its own social, economic, and political significance. Ahupua'a were ruled by *aliʻi ʻai ahupuaʻa,* or lesser chiefs, and managed by a *konohiki*, or headman under the chief (Rechtman 2009).

Distinctive features of the Kahuku ahupuaʻa include: a rich fishery; a broad coastal plain of wetlands (makai of the present day highway), springs, and brackish pools; and Kalaiokahipa ridge, the coral reef escarpment that juts up above the Kahuku plain (Rechtman 2009). Caves in the porous formation of Kalaiokahipa ridge and more inland areas were used as places of burial by the old Hawaiians and hiding places. Prior to European contact and during early Historic times, the Kahuku plain was known for its hala groves (Rechtman 2009).

After European contact, socioeconomic and demographic changes influenced by Westerners promoted the establishment of a Euro-American style of land ownership. Beginning in the 1850s, Kahuku and the surrounding area were leased and sold to foreigners, who established sheep and cattle ranches. Sugar cultivation by the Kahuku Plantation Company became the dominant industry in Kahuku during the late 19th century.

The historical record indicates that by 1935, irrigated sugarcane fields covered nearly the entire APE and project area. An artesian well and a several acre reservoir were also located in the area (Rechtman 2009). The Kahuku Plantation Company continued to operate in the project area and the surrounding area until 1971. Evidence of this use is present across the parcel in the form of earthen ditches, concrete and metal flumes, and old roadways. Other remnants of sugarcane cultivation on the property include concrete foundations, a dry reservoir, old utility poles, and a large metal water pipe line. After sugarcane cultivation ceased, the project area was used as pasture for horses and cattle and briefly as a wind farm (Rechtman 2009).

3.14.3 Previous Archaeological Research and Historic Sites

Three previous archaeological studies were conducted on portions of the project area by Paul H. Rosendahl, Inc. (Jensen 1989), Archaeological Consultants of Hawaiʻi (Kennedy 1989), and Cultural Surveys Hawaiʻi, Inc. (Stride et al. 2003). Collectively, these surveys resulted in the identification of 18 archaeological sites in the project area containing 42 features. All but three of the previously recorded sites were assigned State Inventory of Historic Places (SIHP) site numbers (Rechtman 2009).

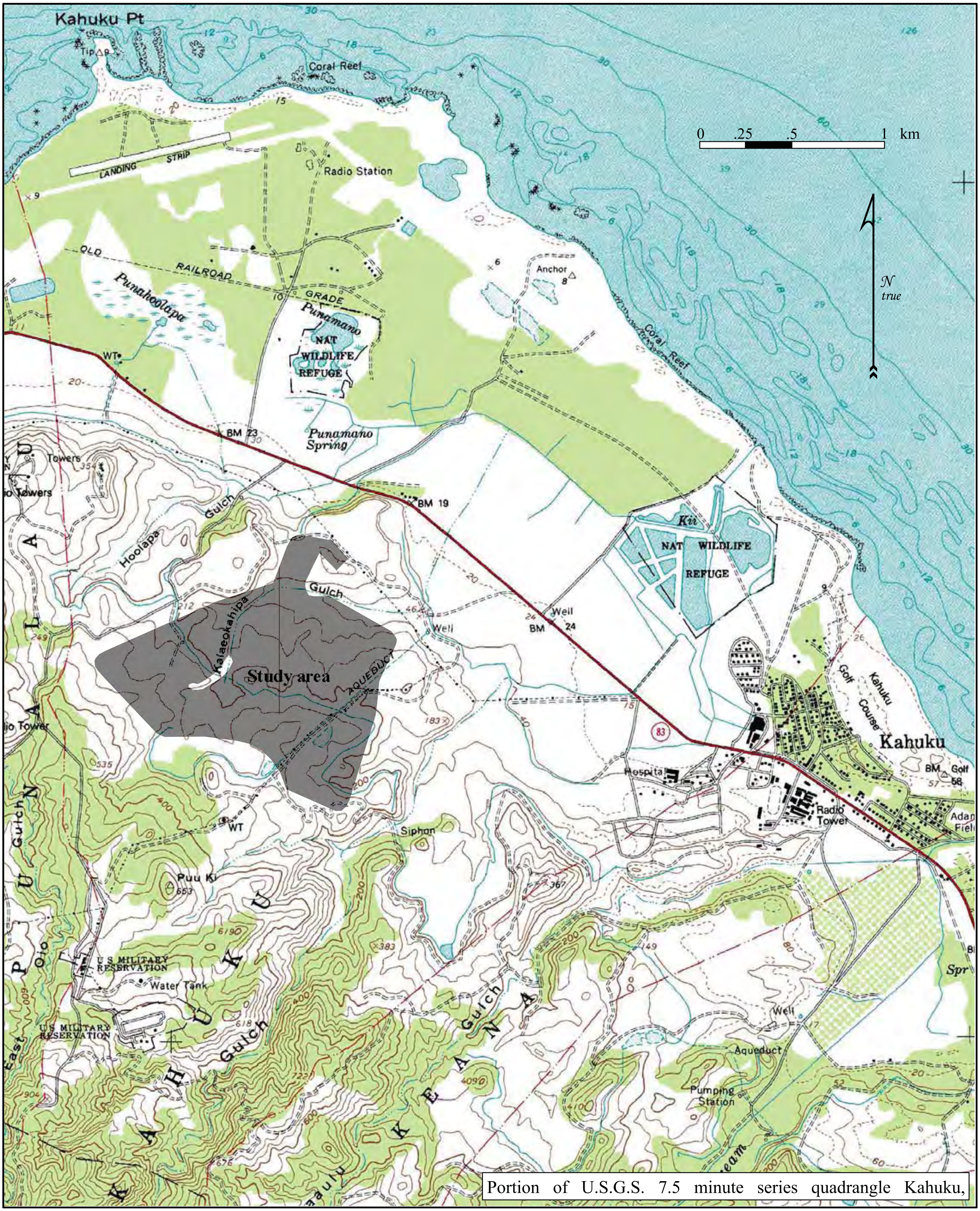
None of these sites were identified within the currently defined APE, although one site, SIHP Site 4707, was assigned to an irrigation feature that is undoubtedly related to the historic sugar plantation infrastructure that also exists within the current APE (Rechtman 2009).

Rechtman Consulting, LLC (2009) conducted a comprehensive archaeological survey of the project area in August-September 2007 and July 2009 (Appendix L). This survey involved mapping, photographing, and describing any archaeological resources encountered along transects spaced throughout the APE. In addition to the archaeological fieldwork, archival cartographic material relative to the plantation infrastructure was obtained and correlated with the field findings (Rechtman 2009).

The survey by Rechtman Consulting, LLC indicated the presence of an extensive network of irrigation features within the project area associated with the former sugarcane cultivation. Fieldwork and archival review indicated that, with the exception of a few small areas of wasteland, the entire APE was once planted in sugarcane (Rechtman 2009).

One historical site was recorded within the APE during the field investigation. This site, SIHP Site 4707, incorporates the extensive sugarcane field infrastructure (primarily an irrigation network) that still remains within Kahuku. Features of Site 4707 are widespread within the current APE. Functionally related features of Site 4707 also exist outside of the APE within the surrounding area. This sugarcane field infrastructure was developed by the Kahuku Sugar Plantation between 1890 and 1971. Dates inscribed in concrete at features within the APE suggest that the major infrastructural development for sugarcane cultivation within the APE likely took place between 1925 and 1943 (Rechtman 2009).

Although impacted by modern land disturbance, vegetation, and erosion, much of the sugarcane irrigation infrastructure is still present within the APE. Specific features of Site 4707 that remain in the APE include flumes, ditches, pipes, reservoirs, wells, pumps and pump houses, markers, roads, and bridges (Rechtman 2009).



Portion of U.S.G.S. 7.5 minute series quadrangle Kahuku,

Figure 3-21. Area of potential effects (APE) consisting of approximately 230 acres.

In addition to the archaeological survey, extensive community consultation with individuals and organizations knowledgeable about the area and past land use practices was conducted by Kahuku Wind Power LLC. Consulted organizations have included the Koʻolauloa Neighborhood Board, the Boards of the Kahuku Village Association and the Kahuku Community Association, Kahuku Elderly Housing, and the Lāʻie Community Association (Rechtman 2009).

Rechtman Consulting, LLC conducted an archaeological survey at the Waialua microwave tower area in October 2009 and at the Flying R Ranch site in January 2010. The Waialua tower would be located within the HECO Waialua Substation in Haleʻiwa, which is an already developed site. The proposed new tower location at Flying R Ranch is situated on the eastern ridge of Kaumoku Gulch at an elevation of roughly 750 feet above sea level. It is contained within a fenced paddock that is currently used as pasture by the Flying R Ranch. The location of the proposed tower places it well to the south and east of the three archaeological sites previously recorded (Appendix L). An inspection of the development area by Rechtman Consulting, LLC on January 8, 2010, revealed that the proposed new tower site has been previously bulldozed, and that no archaeological resources are present. A proposed access road corridor that follows a firebreak road from an existing access road to the proposed tower location was also inspected and no archaeological resources were encountered.

3.14.3.1 Potential Impacts of the Proposed Action

The only historic resource with the potential to be impacted by the proposed action is Site 4707. The significance of Site 4707 was evaluated by Rechtman Consulting, LLC. (2009) based on the National Register Criteria (36 CFR § 60.4), which are as follows:

> The quality of significance in American History, architecture, archaeology, engineering, and culture is present in districts, sites buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and,
>
> a) that area associated with events that have made a significant contribution to the broad patterns of our history; or
> b) that are associated with the lives of persons significant in our past; or
> c) that embody the distinctive characteristics of a type, period, or method of construction; or that represent the work of a master; or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
> d) that have yielded, or may be likely to yield, information important in prehistory or history.

Although Site 4707 is not functional and in a state of disrepair, the site does retain sufficient integrity to be considered significant under Criterion d for the historical information it has yielded relative to the development of the sugarcane industry in Hawaiʻi; thus, the site is potentially eligible for listing in the National Register of Historic Places. The SHPO concurred with DOE's determination that a reasonable and adequate amount of information was collected about this potential historic property during the archaeological study such that no further mitigation is warranted, and a no adverse effect determination for this site with respect to the proposed action is appropriate.

Coordination between Kahuku Wind Power LLC and the community highlighted the rich history of the coral escarpments located in and near the project area (outside of the APE). In response to community concerns, Kahuku Wind Power LLC has committed to preserve the coral escarpment areas located within the project area, as well as to the document the moʻolelo (stories, legends) concerning these culturally significant areas. Sixty-foot buffer areas would be placed around these coral escarpment areas. Thus, the integrity and future preservation of any potential cultural or historical resources in this portion of the project area are not anticipated to be impaired as a result of the project.

The Waialua Substation is an already developed site, and the placement of an additional tower within this site would have no effect on historic properties. The proposed Flying R Ranch site was previously disturbed, and no archaeological resources were encountered during field investigations. No known historical, archaeological, or cultural activities associated with the off-site microwave tower sites are anticipated to be impacted by the proposed project.

DOE determined that no historic properties would be affected by the proposed action under Section 106 of the National Historic Preservation Act, and the SHPO concurred (Appendix L). DOE also notified OHA and two local community leaders of its finding and provided an opportunity for comment. OHA concurred with DOE's no adverse effect determination and requested that consultation with individuals knowledgeable with the Flying R Ranch site be conducted. Based on suggestions from OHA, three individuals were contacted regarding the site. None of these individual were aware of any culturally or historically significant resources at or surrounding the site. In addition to comments received by OHA, DOE received comments on the archeological survey from Mr. Ralph Makaiau, President of Kahuku Community Association. DOE's responses to OHA and Mr. Makaiau are included in Appendix L.

3.14.3.2 Potential Impacts of the No Action Alternative

No impacts on historic, archaeological, or Native Hawaiian resources would occur under the No Action alternative.

3.15 Utilities and Public Services

3.15.1 Energy

The State of Hawaiʻi uses a higher percentage of petroleum to generate electricity than any other state in the U. S. In 2005, oil was used to produce 80% of electricity sold by the State's utilities (Planning Solutions, Inc. 2009). The remaining electricity generation during that year was supplied by coal (13.9%), municipal solid waste (2.6%), geothermal (2%), hydroelectricity (0.7%), bagasse or sugarcane waste (0.6%), wind (0.1%), and a very small amount from solar photovoltaics. Imported oil costs the state between $2 and $4 billion annually (DBEDT 2008b). As a result, Hawaiʻi pays among the highest electricity costs in the country and faces a high level of energy insecurity due to the volatility of oil prices and the potential for disruptions in petroleum supply and shipping.

Fortunately, Hawaiʻi has abundant renewable resources, including a robust wind resource on several islands. Significant potential for small or distributed wind energy projects exists throughout the Hawaiian Islands (Global Energy Concepts LLC 2006). It has been estimated that the state has a combined wind energy potential of 1,000,000 kWh (State of Hawaiʻi and Hawaiian Electric Companies 2008). Due to increasing fossil fuel costs, energy security issues, and concerns over climate change, the State of Hawaiʻi is striving to utilize its own renewable energy (M & E Pacific, Inc. 2008). Hawaiʻi's Renewable Portfolio Standards (HRS Chapters 269-91 to 269-95) present a timeline to increase the amount of electricity generated using renewable resources. According to these standards, each electric utility company that sells electricity for consumption in the state shall establish a renewable portfolio standard of 15% of its net electricity sales by December 31, 2015, and 20% of its net electricity sales by December 31, 2020. A proposal to increase the standard to 40% by 2020 is under consideration by the Hawaiʻi State Legislature.

In January 2008, the State of Hawaiʻi and DOE signed an agreement to establish the Hawaiʻi Clean Energy Initiative (HCEI). The goal of this agreement is to have 70% or more of the state's energy derived from clean, renewable energy for electricity and transportation by 2030. This goal has the potential of reducing Hawaiʻi's current crude oil consumption by 72% (State of Hawaiʻi and USDOE 2008). Hawaiʻi also passed various House bills (HB2848 CD1, HB 2175 CD1, and SB 988 CD1, HB 2505 CD1, HB

2863 CD1) to promote energy efficiency and renewable energy sources. In October 2008, the State of Hawaiʻi signed an Energy Agreement with HECO to help reach the state's energy objectives by facilitating the production of renewable energy sources on the islands, such as wind resources (State of Hawaiʻi and Hawaiian Electric Companies 2008). The agreement includes a commitment by HECO to encourage and explore the development of known project proposals.

In order to meet the 70% clean energy goal, local renewable energy alternatives need to be developed in Hawaiʻi. Several wind energy facilities are already operating in the state and others are being proposed (Table 3-18).

Hawaiʻi Island and Maui currently produce 25% and 16% of their respective energy from renewable sources. Oʻahu, which consumes the vast majority of the state's electricity because of its high population, has proportionally less renewable energy generation. Currently, the largest source of renewable energy on Oʻahu is burning refuse or municipal solid waste at the Honolulu Project of Waste Energy Recovery (H-Power) facility in the Campbell Industrial Park (Rocky Mountain Institute 2008, R W Beck 2008). Burning waste meets only 4% of the island's electrical load. Oʻahu cannot draw on renewable energy generated on neighboring islands until inter-island transmission lines are constructed to connect the different island electrical grids, and the estimated date of construction of such transmission lines is unknown.

Table 3-18. Existing and potential (P) wind energy facilities throughout the State.

Facility Name	Operator	Energy Generated	Island
Lalamilo Wind Farm	Hawaiʻi Electric Light Company	1.2 MW	Hawaiʻi
Pakini Nui	Tawhiri Power, LLC	20.5 MW	Hawaiʻi
Upolu Point	Hawi Renewable Development	10.5 MW	Hawaiʻi
Kaheawa Wind Power (KWP)	First Wind	30 MW	Maui
Auwahi Wind Project (P)	Auwahi Wind Energy LLC	22 MW	Maui
Kaheawa Wind Power (KWP) II (P)	First Wind	21 MW	Maui
Kahuku Wind Power (P)	First Wind	30 MW	Oʻahu
Kawailoa Wind Power (P)	First Wind	50 – 70MW	Oʻahu
Na Pua Makani (P)	Oʻahu Wind Partners LLC	25 MW	Oʻahu
Ikaika Wind Power I (P)	First Wind	50 MW	Molokaʻi
Ikaika Wind Power II (P)	First Wind	200 MW	Molokaʻi
Unknown (P)	Castle & Cooke	200 MW	Lānaʻi
Kauaʻi Wind Power (P)	First Wind	10.5 -15 MW	Kauaʻi

HECO provides all electrical service for the Island of Oʻahu. Its electrical grid is independent, relatively small, and sensitive to power fluctuations. Utility-scale electricity sold by renewable energy producers is sold directly to HECO. A HECO 46-kV electric transmission line runs through the northeastern portion of the project area to the north of the proposed base yard. The electricity generated from the WTGs at Kahuku Wind Power would tie into this line and subsequently flow through Oʻahu's grid, powering approximately 8,900 homes.

3.15.1.1 Potential Impacts of the Proposed Action

With the 30 MW of power potentially generated by the proposed facility, HECO would be able to eliminate the use of approximately 154,550 barrels of oil annually that would otherwise be used to produce conventional power. Reducing the proportion of its energy that comes from fossil fuel would decrease the amount of money that HECO spends on imported fuel and buffer the system from the energy cost fluctuations that accompany volatile oil prices.

The proposed action would contribute to the goals outlined in the Hawaiʻi's Renewable Portfolio Standards and the HCEI by increasing the percentage of the state's energy that is derived from clean, renewable sources. The exact percentage is unknown; however, Kahuku Wind Power is expected to power approximately 8,900 of the 337,152 homes on Oʻahu (DEBDT 2008). It also would support recently passed state statutes designed to promote energy efficiency and renewable energy sources.

The proposed project would consume only small amounts of electrical power, and this would be delivered through the substation and power distribution equipment that are being installed as part of the project. Electrical power generated by the WTGs would be transformed and channeled to the proposed electrical substation via a combination of underground and overhead collection circuits. The electrical substation would transform the voltage from the on-site collection system and facilitate the interconnection to the existing HECO electrical transmission line (see Section 2.2.6).

No new transmission lines would be constructed as part of the project; however, HECO would relocate a portion of an existing 11-kV electrical distribution line toward the southwestern boundary of the project area to accommodate construction of the WTGs.

3.15.1.2 Potential Impacts of the No Action Alternative

Under the No Action Alternative, there would be no change from the existing conditions. The benefits of reducing the proportion of imported fossil fuel would not occur if the facility was not constructed and operated. The No Action Alternative would not support the goals outlined in the Hawaiʻi's Renewable Portfolio Standards or the HCEI.

3.15.2 Police Services

The Kahuku Police Headquarters is located at 56-470 Kamehameha Highway roughly 2.4 mi (3.7 km) southeast of the access gate on Kamehameha Highway. The Wahiawa Police Station is the closest station to the proposed off-site microwave towers. It is located at 330 North Cane Street, approximately 14 mi (23 km) southwest of the Waialua Substation site and 9 mi (14 km) southeast of the Flying R Ranch site.

3.15.2.1 Potential Impacts of the Proposed Action

The facility would not place substantial additional demands upon the existing police service. During construction, there would likely be 24-hour on-site security personnel. During regular operations, only one locked gate would provide road access to the site. No polices services would be required for the off-site microwave towers.

3.15.2.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.3 Fire Protection

The closest fire station to the project area is the Kahuku Fire Station (#13) located 2.4 mi (3.7 km) southeast of the access gate. Two additional fire stations are located in Sunset Beach and Hauula, 7.4 mi (11.9 km) west and 7.9 mi (12.7 km) southeast on Kamehameha Highway, respectively. The Waialua Fire Station (#14) located on Haleʻiwa Road is the closest station to the proposed off-site microwave towers.

3.15.3.1 Potential Impacts of the Proposed Action

Construction and operation of the proposed project would not involve undue use of flammable material or cause undue fire hazards. As such, the proposed facility would have minimal impact on the staffing needs at the Kahuku Fire Station. Kahuku Wind Power LLC is investigating feasible architectural design solutions to ensure that all fire code requirements are met.

3.15.3.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.4 Hospitals

The nearest hospital to the proposed Kahuku Wind Power facility is the Kahuku Medical Center located approximately 5,000 ft (1,500 m) from the project area. Wahiawa General Hospital is the closest medical center to the off-site microwave towers. In case of emergencies, paramedic/ambulance services are available.

3.15.4.1 Potential Impacts of the Proposed Action

The facility is not expected to place substantial additional demands on health care facilities in the area.

3.15.4.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.5 Airports

Wheeler Army Airfield and Dillingham Airfield are located roughly 23 mi (14 km) from the project area. Dillingham Airfield is roughly 8 mi (5 km) from the microwave tower sites, while Wheeler Army Airfield is approximately 13 mi (8 km) distant.

3.15.5.1 Potential Impacts of the Proposed Action

Under the provisions of 49 U.S.C. 44718 and Title 14 of the Code of Federal Regulations, part 77, the FAA conducted an aeronautical study of the temporary and permanent met towers for the project, as well as the proposed WTG. The FAA has determined that the structures do not exceed obstruction standards and would not be a hazard to air navigation provided the structures are marked and/or lighted in accordance with FAA regulations. Eight of the 12 WTGs would be painted white and lit with medium intensity, synchronized red-flashing lights (FAA 2009e). The temporary and permanent met towers would also be lit with medium intensity, synchronized red-flashing lights (FAA 2009a, 2009b, 2009c, 2009d). However, once the WTGs are constructed and lighting installed, Kahuku Wind Power LLC may be able to turn off the light on the permanent met tower due to its proximity to the lighted turbines. To minimize visual impacts due to lighting, on-site operational lighting would be minimal and shielded. This no-hazard determination also includes temporary construction equipment under 424 ft in height (e.g. cranes) used to construct the structures.

The proposed facility would not create a significant aircraft collision hazard and would not have a significant impact on the safe and efficient use of navigable airspace by aircraft.

3.15.5.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.6 Water Supply

Water resources and distribution on O‘ahu is managed by the Board of Water Supply (BWS). A connection to City and County water facilities is not anticipated to be needed for the proposed project. Kahuku Wind Power LLC plans to tap an existing well located on an adjacent site owned by Continental Pacific for its water requirements. Given the nature of the proposed project and small number of people working on-site, water usage would be very low.

3.15.6.1 Potential Impacts of the Proposed Action

Because water for the project would be obtained from a local well, the facility is not expected to be a burden on the island’s municipal water supply. The very low water usage associated with the project is not expected to adversely affect local water availability.

3.15.6.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.7 Wastewater

Wastewater produced by residents in the area is treated at the Kahuku Wastewater Treatment Plant, located near the Ki‘i Unit of the James Campbell NWR (R.M. Towill Corporation 2008). It is anticipated that an on-site septic tank system would be constructed to deal with project-associated wastewater generated from the few people working on-site. The wastewater discharge from the project area would be within the City and County requirement of less than 1,000 gallons per day. The waste that accumulates in the septic tank system would be collected by a private contractor and transported to an appropriate wastewater treatment facility or other approved location for disposal. The small amount of wastewater that this represents can easily be accommodated in the existing treatment and disposal facilities.

3.15.7.1 Potential Impacts of the Proposed Action

Wastewater generated by employees of the proposed facility can easily be accommodated in existing treatment and disposal facilities. Therefore, no significant impact to wastewater treatment facilities is expected from the proposed action.

3.15.7.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.8 Solid Waste

Solid waste generated by the residents in Kahuku is disposed of at the Waimānalo Gulch landfill or burned at the H-Power facility.

3.15.8.1 Potential Impacts of the Proposed Action

Construction and operation of the proposed project is not anticipated to generate a significant amount of solid waste. Although the exact amount is unknown, for other facilities of this kind, waste typically does not exceed one small dumpster per week (Planning Solutions, Inc 2009). During construction, all waste would be transported to and stored within the temporary use area and periodically carried out and properly disposed of in a permitted landfill. During operation, waste would be collected by a private solid waste management company once a week and disposed of in an approved landfill. Some solid waste may be recycled. These materials would be stored and hauled separately to the appropriate recycling company. An on-site septic tank system would be constructed in the project area to handle sewage, as described in Section 3.15.7.

The vast majority of waste created during construction and operation of wind energy facilities is non-hazardous solid waste, such as shipping crates, boxes, and packing material (S. O'Brian/SWCA, pers. comm.). No hazardous solid waste is expected to be generated as a result of construction or operation of the proposed project.

Because only a small amount of solid waste is expected to be generated during construction and operation, and appropriate management practices would be implemented, impacts to solid waste disposal or processing are expected to be minor.

3.15.8.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.9 Parks and Recreation

Three parks or recreational areas occur within a 2 mi (3.2 km) radius of the project area. These are Kawela Bay Beach Park (2 mi away), Kahuku District Park (0.75 mi or 1.2 km away), Kahuku Golf Course (1 mi or 1.6 km away), and Turtle Bay Golf Course (1.2 mi or 2 km away).

3.15.9.1 Potential Impacts of the Proposed Action

WTGs would be visible from the Kahuku Golf Course parking lot and potentially from portions of the course itself. WTGs may also be visible from portions of the other parks and recreation areas. However, the inherent character of these areas or access to any parks or their associated recreational activities would not be affected by the proposed project.

3.15.9.2 Potential Impacts of the No Action Alternative

If the proposed project were not built and operated, there would be no change from existing conditions.

3.15.10 Roadways

Access to the project area would be provided by Charlie Road off Kamehameha Highway. Kamehameha Highway is under the jurisdiction of the State of Hawaiʻi Department of Transportation. According to a 2006 report by the State Highways Division, Highway Planning Branch, the average two-way daily traffic total at the Mālaekahana Stream Bridge along Kamehameha Highway, approximately 1.6 miles (2.6 km) southeast of the project area, is 10,867 cars. Morning peak hour volumes are approximately 322 cars in the southbound direction and 332 cars in the northbound direction, while afternoon peak hour volumes are approximately 459 cars in the southbound direction and 475 cars in the northbound direction (R.M. Towill Corporation 2008).

The traffic monitoring station along Kamehameha Highway between Turtle Bay Golf Course and Kuilima Drive (Station B72008300907) showed an average daily traffic of 4,015.5 per lane per day (for period spanning May 23-25, 2005). Near the shrimp farms along Kamehameha Highway (Station B72008301408) the average daily traffic was 4,020.5 per lane per day (for period spanning March 22-24, 2005) (Environet, Inc. 2009).

3.15.10.1 Potential Impacts of the Proposed Action

Under the proposed action, all of the equipment, employees, and materials needed for construction and operation of the proposed project would access the site from the existing Charlie Road. No paving or road changes are anticipated, although approximately 1.75 mi of unpaved dirt roads are planned within the project boundary.

Construction Phase:

Construction of the proposed project would generate vehicle traffic on roadways in the vicinity throughout the construction period. During the construction period, an average of 15 to 20 employees would be onsite, with an anticipated maximum level of 40 employees. It is anticipated that employees would generate a maximum of 40 one-way vehicle trips daily during the construction period. These trips would likely occur between 6 and 7 a.m. and 3 and 4 p.m. Additional trips to Kahuku town would likely occur during lunchtime.

Equipment delivery trips would involve the transport of large and small pieces of equipment from Barber's Point to the project area. The number of oversized equipment delivery trips during the six-month construction period is estimated to average 80 one-way trips per day. The transport of large pieces of equipment in oversized vehicles may slow traffic and cause minor temporary traffic delays during a small portion of this period. To minimize these delays, the entrance to the access road (Kamehameha Highway/Charlie Road Intersection) would be manned by two people during construction working hours. These flagmen would stop other traffic for the time needed for the large trucks to turn into and out of the site access road.

Select material (e.g. cement) would also be brought from Hālawa to the project area for construction of the turbine pads and other purposes. Approximately 100 one-way cement truck trips would be needed during the construction period per day.

Project-related vehicle traffic would vary greatly over the course of construction. Although the proposed project would result in a short-term increase in traffic during construction, the increase would not be sufficient to have a measurable effect on the level of service.

Operation Phase:

During operation, the majority of the vehicular-traffic associated with the proposed facilities would be employees reporting to or leaving the facility and service trips by HECO maintenance personnel. The maximum number of vehicle trips during operation is estimated to be 10 one-way vehicle trips per day. This represents less than 0.2% of the current traffic load on Kamehameha Highway. Additional trips to Kahuku town would likely occur during lunchtime.

Operation of the proposed facility would cause a slight increase in traffic on Kamehameha Highway and Charlie Road, but would not otherwise impact normal business and organizational functions of surrounding properties. Increases on Kamehameha Highway are not expected to be noticeable to the public. Because the amount of vehicular-traffic associated with the proposed facilities during operation would be minimal, the proposed project is not anticipated to increase traffic volumes on Kamehameha Highway or roadways in the area in the long-term.

3.15.10.2 Potential Impacts of the No Action Alternative

If the facility was not constructed and operated, no change in traffic levels would occur in the project area.

3.16 Cumulative Impacts

This section considers projects in the past, present, and reasonably foreseeable future that involve impacts to resources for which the proposed action could contribute incrementally. “Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time” (40 CFR 1508.7). This discussion is limited to recent past, present, and reasonably foreseeable future actions within the project area and the immediate vicinity (defined as the Kahuku community). However, for impacts to state and federally listed species, cumulative impacts are evaluated for actions within the regional area, defined as the Island of O‘ahu, that may have overlapping impacts to the same state and federally listed species that have the potential to be impacted by the proposed project.

The project area is predominantly rural and comparatively few projects have occurred in the immediate vicinity. No future projects are anticipated to occur in the project area (although small complementary agricultural uses may occur in the project area, as discussed previously). Two reasonably foreseeable future actions were identified within the vicinity of the project area (the Kahuku community) that could affect resources expected to be used or impacted by the proposed project:

1. Kahuku Village: Continental Pacific, LLC has developed a plan for the Kahuku Village located southwest of the project area makai of Kamehameha Highway. The Kahuku Village project would create 175 new lots including residential (165), golf course (2), beach parks (2), cemeteries (2), open space (1), and school lots (1). Of these lots, only 64 are vacant and would be sold to individuals for home construction. The project also includes planned improvements to roadways and public utilities (R.M. Towill Corporation 2008).

2. Na Pua Makani: O‘ahu Wind Partners LLC (OWP) has proposed to develop Na Pua Makani, a 25-MW wind energy facility, on state agricultural land immediately southeast of the proposed project.

OWP has applied to DLNR for a lease to use the state land (WSB-Hawai‘i 2009) and submitted a Draft EA to DLNR; however, OWP has not secured a CUP for the proposed facility from the City and County of Honolulu (WSB-Hawai‘i 2009).

In addition, one reasonably foreseeable future action has the potential to have overlapping impacts to the same state and federally listed species that may be impacted by the proposed project.

3. Kawailoa: First Wind is planning to develop a second wind generation facility on agricultural land at Kawailoa, located near the community of Hale‘iwa. This facility is located roughly 7 mi (11 km) from the proposed project area. Currently, four met towers are located on the Kawailoa site.

Analyses of potential cumulative impacts associated with these reasonably foreseeable future actions focused on the four resource areas most relevant to potential cumulative impacts: climate change, noise, scenic resources, and wildlife.

3.16.1 Climate and Global Climate Change

The proposed action would not adversely affect temperature, rainfall, humidity, wind regime, or other meteorological parameters; therefore, it would not contribute to adverse climate impacts from other projects in the area.

Construction and operation of the proposed project would result in minor emissions of greenhouse gases and therefore would contribute slightly to overall cumulative global greenhouse gas emissions. However, greenhouse gas emissions associated with construction and operation of the proposed project are expected to represent a negligible proportion of Hawai‘i-based greenhouse gases.

Operation of motor vehicles and motorized equipment by residents of Kahuku and visitors to the area also contributes to local emission of greenhouse gases. Local emission of greenhouse gases would be expected to increase slightly with the completion of Kahuku Village and with construction and operation of Na Pua Makani and Kawailoa.

The release of anthropogenic greenhouse gases and their potential contribution to global warming are inherently cumulative phenomena. Greenhouse gas emissions from the proposed action are relatively small compared to the 8,026 million tons (7,282 million metric tonnes) of CO_2-equivalent greenhouse gases emitted in the U.S. in 2007 (Energy Information Administration Report #DOE/EIA-0573) and the 54 billion tons (49 billion metric tonnes) of CO_2-equivalent anthropogenic greenhouse gases emitted globally in 2004 (IPCC 2007). However, emissions from the proposed action in combination with past and future emissions from all other sources would contribute incrementally to climate change impacts. At present there is no methodology that would allow DOE to estimate the specific impacts (if any) this increment of climate change would produce in the vicinity of the facility or elsewhere.

Greenhouse gas emissions caused by construction and operation of the proposed project, Na Pua Makani, and the Kawailoa facility, would be more than offset by allowing for significant decreases in the amount of petroleum currently burned on O‘ahu to generate electricity. The 30 MW of power potentially generated by the Kahuku Wind Power facility would be able to eliminate the use of approximately 154,550 barrels of oil annually. This would reduce emission of approximately 159.6 million pounds of CO_2, 330.3 thousand pounds of SO_2, and 237.7 thousand pounds of NO_x per GWh per year. According to WSB-Hawai‘i (2009), Na Pua Makani would decrease annual emissions by the following amounts: 115 thousand pounds of CO; 106 million pounds of CO_2; 187 thousand pounds of SO_x; 359 thousand pounds of NO_x; 5.69 thousand pounds of particulates; and 6.39 thousand pounds of volatile organic compounds. These amounts far exceed those which would be produced by construction and operation of the wind facilities. Emission reduction estimates are not currently available for the proposed Kawailoa facility; however, the Kawailoa facility is expected to reduce more greenhouse gas emissions than Kahuku Wind Power due to the greater anticipated energy generation of the facility (30 MW vs. 50-70 MW).

Given this, the three wind energy generation facilities currently being planned for Oʻahu are expected to result in beneficial cumulative effects on local and statewide levels of greenhouse gas emissions.

3.16.2 Noise

WTGs at the proposed Kahuku Wind Power facility are not likely to be audible in the surrounding communities under most operating and weather conditions, although they may be audible under especially quiet (and atypical) weather conditions. Ambient noise measures were not taken at the adjacent proposed Na Pua Makani project area; therefore it cannot be determined whether sounds produced by the WTGs would be audible over background levels. However, according to WSB-Hawaiʻi (2009), no receivers in the Kahuku Agricultural Park or Kahuku Town are anticipated to be impacted by noise from the Na Pua Makani facility. The Kahuku Wind Power facility would not add measurably to the sound level at these receptors because it is considerably farther away and on the other side of the Na Pua Makani site. The only potential noise receiver located between the two projects is Kiʻi Road farms. The maximum expected increase in ambient sound at this location as a result of Kahuku Wind Power (3 dB) is not a perceptible difference to most listeners (DLAA, Ltd. 2009). Although the maximum expected increase in ambient sound at this location as a result of the Na Pua Makani facility is not known, the increase may be similar to Kahuku Wind Power, because Kiʻi Road farms is roughly the same distance from the Na Pua Makani facility. If an additional 3 dB was expected from the Na Pua Makani wind facility, the total sound level would still be below the DOH limit of 70 dBA. Thus, cumulative noise impacts are not expected.

3.16.3 Scenic Resources

Construction of the facility would add to the amount of structural development within the visual landscape and would introduce different visual features into the viewshed. Construction of the adjacent Pua Na Makani facility would augment this impact. Both projects are proposing to use Clipper Liberty^{TM} 2.5 MW and therefore the visual impact of the two would be similar. WTGs at both of the projects would be visible from the following vantage points: Kamehameha Highway, Romy's Shrimp Truck, Kahuku Hospital, Kahuku High School, and Kahuku Golf Course. However, the projects would maintain open spaces between the WTGs and the rural character of the community.

3.16.4 Wildlife

3.16.4.1 Non- Listed Species

The proposed action would contribute to a cumulative reduction of habitat for some non-listed wildlife species when added to impacts resulting from projects in the vicinity. However, a large amount of similar habitat is available at other locations on the island. In general, non-listed wildlife species occurring on the property are common and widespread in the region and seemingly tolerant of development. Therefore, cumulative effects to non-listed wildlife are expected to be minor.

3.16.4.2 Listed Species

No ESA Section 10(a)(1)(B) permits for the covered species have been issued through an HCP on the Island of Oʻahu. However, take has been authorized through two Safe Harbor Agreements (SHAs) on Oʻahu (Table 3-19). Under a Safe Harbor Agreement, property owners voluntarily undertake management activities on their property to enhance, restore, or maintain habitat benefiting species listed under the ESA. These agreements assure property owners they will not be subjected to increased property use restrictions if their efforts attract listed species to their property or increase the numbers or distribution of listed species already on their property. The USFWS issues the applicant an "enhancement of survival" permit, which authorizes any necessary future incidental take through Section 10 (a)(1)(A) of the ESA. Accordingly, all impacts associated with these take authorizations have been mitigated.

Table 3-19. Take authorizations for the covered species on Oʻahu through Safe Harbor Agreements.

Applicant	Issued	Duration	Species	Location
Chevron SHA	09/23/2005	6 years	Hawaiian stilt Hawaiian coot	Kapolei, Oʻahu Island
Participants of USDA Farm Bill Conservation Programs	09/12/2007	10 years	Hawaiian stilt Hawaiian coot Hawaiian duck Hawaiian moorhen	Statewide

The proposed adjacent Na Pua Makani wind facility project and Kawailoa project have the potential to result in incidental take of the covered species. Thus, there is a possibility of cumulative impacts to these species. However, it is expected that if approved, the impacts and mitigation for Na Pua Makani and Kawailoa would resemble those discussed for Kahuku Wind Power. The proposed mitigation for Kahuku Wind Power is expected to more than offset the anticipated take and provide a net benefit to the species.

At a broader scale, Kahuku Wind Power represents one of many projects that can be expected to occur on the Island of Oʻahu. Oʻahu has experienced increasing human population growth and real estate development, and will likely continue increasing in the future. Some of the causes of decline of the covered species (such as mammal predation, light disorientation, pesticide use, and loss of nesting or roosting habitats) may be on the increase due to this growth. Through mitigation, projects like Kahuku Wind Power are among the few that are implementing measures to provide a net benefit to the affected species. In general, it is assumed that future development projects would be conducted in compliance with all applicable local, state, and federal environmental regulations.

Seabirds (Newell's Shearwater and Hawaiian Petrel)

Currently, there is no authorized take of Newell's shearwater or Hawaiian petrel in the immediate vicinity (or on Oʻahu). Take authorization for these species will likely be requested for Na Pua Makani and Kawailoa because these projects have the potential to result in incidental take of the species by colliding with WTGs and other project components. The proposed Kahuku Village would also result in slight increases in artificial nighttime lighting, which also has the potential to impact the seabirds.

The proposed mitigation measures described for two seabirds are expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by state law. With the low expected rate of take, the proposed mitigation measures are expected to produce a measurable net benefit in the form of a marginal increase in the species' population. Similar mitigation measures are expected for Na Pua Makani and Kawailoa. For this reason, no significant adverse impacts to the species' overall population, and no significant cumulative impacts to the species, are anticipated.

Waterbirds (Hawaiian Duck, Hawaiian Stilt, Hawaiian Coot, Hawaiian Moorhen)

Currently, there is no authorized take of the Hawaiian duck, Hawaiian stilt, Hawaiian coot, or Hawaiian moorhen in the immediate vicinity. Take authorization for these federally listed waterbirds will likely be requested for Na Pua Makani and Kawailoa because these projects have the potential to result in incidental take of these species by colliding with WTGs and other project components.

The most important causes of decline of the Hawaiian stilt and other Hawaiian waterbirds is the loss of wetland habitat and predation by introduced animals. Other factors that have contributed to population declines include altered hydrology, alteration of habitat by invasive nonnative plants, disease, and possibly environmental contaminants (USFWS 2005a). Development of the Kahuku Wind Power project would not increase losses due to these other causes. However, some of these causes (loss of wetlands and pesticide use) may be on the increase due to continued real estate development on O‘ahu, and will likely continue increasing in the future. Thus, the possibility of cumulative impacts in addition to the anticipated take at Kahuku Wind Power exists.

However, the proposed mitigation measures described for the federally listed waterbirds are expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by state law. With the low expected rate of take, the proposed mitigation measures are expected to produce a measurable net benefit in the form of a marginal increase in the species' population. Similar mitigation measures are expected for Na Pua Makani and Kawailoa. For this reason, no significant adverse impacts to the species' overall population, and no significant cumulative impacts to the federally listed waterbirds, are anticipated.

Hawaiian Short-eared Owl

Currently, there is no authorized take of the Hawaiian short-eared owls in the immediate vicinity (or on O‘ahu). However, take authorizations of this species will likely be requested for Na Pua Makani and Kawailoa.

Some of the major threats to the Hawaiian short-eared owls may be on the increase due to continued real estate development on O‘ahu, and will likely continue increasing in the future. In particular, Hawaiian short-eared owls appear particularly sensitive to habitat loss and fragmentation. Trauma, apparently from vehicular collisions, also causes death of Hawaiian short-eared owls throughout the state. Thus, the possibility of cumulative impacts from these threats, in addition to the anticipated take at Kahuku Wind Power exists.

However, Kahuku Wind Power LLC has proposed mitigation measures for the species that would contribute to a greater understanding of the species' occurrence and status, which in turn would help guide future management and recovery efforts and should result in an overall net conservation benefit for the species. Similar mitigation measures are expected for Na Pua Makani and Kawailoa. For this reason, no significant adverse impacts to the species' overall population are expected, and no significant cumulative impacts to the species, are anticipated.

Hawaiian Hoary Bat

Currently, there is no authorized take of the Hawaiian hoary bat in the immediate vicinity (or on Oʻahu). However, take authorizations of this species will likely be requested for Na Pua Makani and Kawailoa.

Other actions that can be expected to occur on Oʻahu and that have potential to adversely modify habitat used by the species include habitat loss and roost disturbance from resort or recreational developments (e.g. golf courses), housing and commercial developments, road construction, and farming. Pesticide use is also believed to threaten the species (USFWS 1998). The possibility of cumulative impacts from these threats, in addition to the anticipated take at Kahuku Wind Power, exists.

As stated in Section 3.12.4, no historical population estimates exist for the Hawaiian hoary bat. Current population estimates are not based on systematic surveys and methods for accurately estimating population numbers do not exist (USFWS 1998). Thus, as stated in the Recovery Plan for the Hawaiian Hoary Bat (1998), the decline of the bat is largely inferred and the presumed “limited distribution may be, at least partially, an artifact of localized search efforts by researchers.” Because the population of this species is not known, it is difficult to gauge whether the take of Hawaiian hoary bat will result in a significant impact on the overall population. Kahuku Wind Power LLC’s proposed mitigation for the anticipated take of Hawaiian hoary bat would contribute to a greater understanding of the species’ status on Oʻahu, which in turn would help guide future management and recovery efforts and should result in an overall net conservation benefit for the species. Therefore, there is no anticipated cumulative impact to the Hawaiian hoary bat.

Changed Circumstances Provided for in the Habitat Conservation Plan

The HCP includes a discussion of anticipated changes in circumstances affecting the covered species and other species occurring in the project area or the efforts expended towards mitigation that could occur during the life of the HCP (SWCA and First Wind 2010). Possible changed circumstances included in the HCP for the proposed project include: climate change; disease outbreaks in any of the listed species; deleterious change in relative abundance of non-native plant species or ungulates occurring at the mitigation sites for covered species; hurricanes or other major storms that may affect the project area and/or mitigation sites; changes in the price of raw materials and labor; the de-listing of any species covered in the HCP; and the listing of one or more species that already occur on-site, or fly over the site, not currently covered in the HCP.

If these circumstances were to occur, Kahuku Wind Power LLC would consult with DLNR and USFWS to determine if measures to remediate these changes are available, practical, and necessary. Potential remediation measures to address changed circumstances would be identified, approved, conducted, and monitored in consultation with DLNR and USFWS; therefore, any potential impacts to listed species and critical habitat would be minimized. Overall, the remediation measures are anticipated to improve the overall habitat quality and/or health of the covered species following recognition of a changed circumstance.

CHAPTER 4: LIST OF PREPARERS

DOE

McMillen, Matthew. NEPA Compliance Officer.

Thomas, Sharon. NEPA Document Manager.

SWCA Environmental Consultants (SWCA)

Ong, Ling. Wildlife Scientist. Honolulu Office.

Sunby, Paul. Senior Project Manager. Austin Office.

Taira, Ryan. GIS Analyst. Honolulu Office.

Thair, Tiffany. Environmental Planner. Honolulu Office.

First Wind

Cowan, Dave. Vice President, Environmental Affairs. Maine Office.

Spencer, Greg. Senior Wildlife Biologist. Maui Office.

CHAPTER 5: LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS CONTACTED

Federal Agencies

U.S. Fish and Wildlife Service (USFWS)

U.S. Army Corps of Engineers

U.S. Department of Agriculture

State Agencies

Department of Land and Natural Resources (DLNR)
    Division of Forestry and Wildlife (DOFAW)
    State Historic Preservation Division (SHPD)

Office of Hawaiian Affairs (OHA)

Department of Health (DOH)
    Environmental Planning Office (EPO)
    Environmental Health Service Division (EHSD)

Department of Business, Economic Development & Tourism (DBEDT), Office of Planning

Department of Transportation (DOT)

County Agencies

Department of Planning and Permitting (DPP)

Board of Water Supply (BWS)

Organizations

Kahuku High and Intermediate School

Kahuku Community Association

Lāʻie Community Association

Kahuku Village Association

Defend Oʻahu Coalition

Koʻolau Loa Neighborhood Board

North Shore Neighborhood

Hawaiian Electric Company, Inc.

CHAPTER 6: LITERATURE CITED

Adams, J. 2008. “Petrels in the Pacific: Tracking the Far-ranging Movements of Endangered ‘Ua‘u (Hawaiian Petrel).” US Geological Survey, Western Ecological Research Center. Available at: www.microwavetelemetry.com/newsletters/spring_2007Page4.pdf. Accessed February 11, 2008.

Ainley, D.G., L. DeForest, N. Nur, R. Podolsky, G. Spencer and T.C. Telfer. 1995. Status of the threatened Newell’s Shearwater on Kaua‘i: Will the population soon be endangered?
Ainley, D.G., T.C. Telfer, and M.H. Reynolds. 1997. Townsend’s and Newell’s Shearwater (*Puffinus auricularis*). In: The Birds of North America, No. 297. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Altamont Pass Avian Monitoring Team. 2008. Altamont Pass Wind Resource Area Bird Fatality Study. July. (ICF J&S 61119.06.) Portland, OR. Prepared for Altamont County Community Development Agency.

Anamizu, Joy. Ecologist, Army Corps of Engineers, Honolulu District. Personal communication. December 2008.

Arnett, E.B. and M.D. Tuttle. 2004. Cooperative Efforts to Assess the Impacts of Wind Turbines on Bats. Bat Research News 45(4):201-202.

Arnett E.B., M. Schirmacher, M.M.P. Huso and J. Hayes. 2009. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Aviation Systems, Inc. 2008. Kahuku Wind Project, 08-N-0532.013. Letter to Kelly Bronson. Torrance, CA.

Baerwald, E.F., G.H. D’Amours, B.J. Klug, and R.M.R. Barclay. 2008. Barotrauma is a Significant Cause of Bat Fatalities at Wind Turbines. Current Biology 18(16):695-696.

Baldwin, P.H. 1950. Occurrence and Behavior of the Hawaiian Bat. Journal of Mammalogy, 31: 455–456.

Bannor, B.K. and E. Kiviat. 2002. Common Moorhen (*Gallinula chloropus*). In: The Birds of North America, No. 685. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Bellwood, J.J. and J.H. Fullard. 1984. Echolocation and Foraging Behaviour in the Hawaiian Hoary Bat, *Lasiurus cinereus semotus.* Canadian Journal of Zoology 62:2113-2120.

Belt Collins Hawai‘i Ltd. 2007a. Phase 1 Environmental Site Assessment, TMK (1)5-6—5:Parcels 2,5,6,7,14, and 16. Prepared for UPC Hawai‘i Wind Partners, LLC.

Belt Collins Hawai‘i Ltd. 2007b. View Analysis and Photo Renderings. Prepared for UPC Hawai‘i Wind Partners, LLC.

Belt Collins Hawai‘i Ltd. 2009. Updated View Analysis, TMK 5-6-5:7 and 5-6-5:14. Prepared for First Wind.

Benning, T. L., D. LaPointe, C.T. Atkinson, and P.M. Vitousek. 2002. Interactions of climate change with biological invasions and land use in the Hawaiian Islands: Modeling the fate of endemic birds using a geographic information system. *Proc. Nat. Acad. Sci.* 99:14,246–14,249.

Berger, A.J. 1972. Hawaiian birdlife. The University Press of Hawai‘i, Honolulu, HI.

Bjorkman, M. 2004. Long time measurements of noise from wind turbines. Journal of Sound and Vibration 277(3):567-572.

Bradley, J.S., R.D. Wooller, I.J. Skira, and D.L. Serventy. 1989. Age-dependent survival of breeding short-tailed shearwaters *Puffinus tenuirostris*. Journal of Animal Ecology 58:175–188.

Brisbin, Jr., I.L., H.D. Pratt, and T.B. Mowbray. 2002. American Coot (*Fulica Americana*) and Hawaiian Coot (*Fulica alai*). In: The Birds of North America, No. 697. (A. Poole and F. Gill, eds.). Philadelphia, PA.

Browne, R.A., C.R. Griffin, P.R. Chang, M. Hubley, and A.E. Martin. 1993. Genetic divergence among populations of the Hawaiian Duck, Laysan Duck, and Mallard. Auk 110:49–56.

Byrd, G.V. and C.F. Zeillemaker. 1981. Ecology of Nesting Hawaiian Common Gallinules at Hanalei, Hawai‘i. Western Birds 12(3):105-116.

Caccamise, D.J., M.A. Merrifield, M. Bevis, J. Foster, Y.L. Firing, M.S. Schenewerk, F.W. Taylor, and D.A. Thomas. 2005. Sea level rise at Honolulu and Hilo, Hawai‘i: GPS estimates of differential land motion. Geophysical Research Letters 32, L03607.

Carothers, S.W. 2008. Expert Report: Evaluation of Risks to Avian (birds) and Chiropteran (bats) Resources. Gulf Wind Project, Kenedy County, Texas.

Coffman, M., T. Surles, and D. Konan. 2007. Analysis of the Impact of Petroleum Prices on the State of Hawai‘i’s Economy. Prepared for State of Hawai‘i Department of Business, Economic Development & Tourism. Available at: https://www.eere-pmc.energy.gov/states/Hawai‘i_Docs/Petroleum_Price_Impact_Assessment.pdf. Accessed on December 12, 2008.

Cooper, B.A. and R.H. Day. 1998. Summer Behavior and Mortality of Dark-rumped Petrels and Newell's Shearwaters at Power Lines on Kaua‘i. Colonial Waterbirds 21: 11–19.

Courchamp, F., J. Chapuis, and M. Pascal. 2002. Mammal invaders on islands: impact, control and control impact. Biol. Rev. 78:347–383.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. (Version 04DEC98).

Cryan, P.M. 2008. Mating Behavior as a Possible Cause of Bat Fatalities at Wind Turbines. Journal of Wildlife Management 72(3):845-849.

Cryan, P.M. and A.C. Brown. 2007. Migration of Bats Past a Remote Island Offers Clues Toward the Problem of Bat Fatalities at Wind Turbines. Biol. Conserv. 129(1-2):1-11.

Curtis, C. 1977. Birds and transmission lines. Blue Jay 55: 43-47.

Day, R.H. and B.A. Cooper. 1995. Patterns of Movement of Dark-Rumped Petrels and Newell Shearwaters on Kauai. Condor 97(4):1011-1027.

Day, R.H., and B.A. Cooper. 2002. Petrel and shearwater surveys near Kalaupapa, Molokai Island, June 2002. Unpublished report prepared for National Park Service, Hawaiʻi National Park, HI, by ABR, Inc.—Environmental Research & Services, Fairbanks, AK, and Forest Grove, OR. 17 pp.

Day, R.H. and B.A. Cooper. 2003. Movement of the Hawaiian petrel to inland breeding sites on Maui island, Hawai'i. Waterbirds 26(1): 62-71.

Day, R.H. and B.A. Cooper. 2008. Interim Report: Oahu Radar & Audiovisual studies, Fall 2007 and Summer 2008. ABR, Inc.— Environmental Research & Services.

Day, R.H., B.A. Cooper, and T.C. Telfer. 2003a. Decline of Townsend's (Newell's) Shearwaters (*Puffinus auricularis newelli*) on Kauai, Hawaiʻi. Auk 120:669-679.

Day, R.H., B.A. Cooper, Brian A.; Blaha, Richard J. 2003b. Movement Patterns of Hawaiian Petrels and Newell's Shearwaters on the Island of Hawaiʻi. Pacific Science 57(2):147-159.

Del Hoyo, J., A. Elliott and J. Sargatal. 1992. The Handbook of the Birds of the World, Volume I. Ostrich to Ducks. Lynx Edicions, Barcelona.

Department of Health, Clean Air Branch. 2008. Annual Summary of the 2007 Hawaiʻi Air Quality Data. Available at: http://Hawaii.gov/health/environmental/air/cab/cabmaps/pdf/2007_aqbook.pdf. Accessed November 25, 2008.

Department of Land and Natural Resources (DLNR), Natural Area Reserves System (NARS). 2003. Final Environmental Assessment, Kapuna Watershed Protection Project, Pahole Natural Area Reserve. Waialua District, Northern Waiʻanae Mountains, Island of Oʻahu.

Department of Land Utilization, City and County of Honolulu. 1987. Coastal View Study.
Department of Planning and Permitting (DPP), City and County of Honolulu. 1999. Ko'olau Loa Sustainable Communities Plan. Honolulu, HI. Available at: http://www.honoluludpp.org/planning/DevSust_Koolauloa.asp. Accessed November 2, 2008.

Department of Planning and Permitting (DPP), City and County of Honolulu. 2000. North Shore Sustainable Communities Plan. Honolulu, HI. Available at: http://www.honoluludpp.org/Planning/DevSust_NorthShore.asp. Accessed October 6, 2009.

Department of Planning and Permitting (DPP), City and County of Honolulu. 2003. Community Profiles 2000 by Development Plan Area. Available at: http://www.honoluludpp.org/planning/ResearchStats.asp. Accessed November 14, 2008.

Department of Planning and Permitting (DPP), City and County of Honolulu. 2006. Oahu General Plan. Available at: http://www.honoluludpp.org/planning/OahuGenPlan.asp. Accessed September 10, 2009.

Department of Business, Economic Development, and Tourism (DBEDT). 2008a. 2007 State of Hawaiʻi Data Book. Available at: http://Hawaii.gov/dbedt/info/economic/databook/db2007/. Accessed November 3, 2008.

DBEDT. 2008b. State of Hawai‘i Energy Resources Coordinator Annual Report 2008. 15 pp.

DBEDT. 2009. 2008 State of Hawai‘i Data Book. Available at: http://Hawaii.gov/dbedt/info/economic/databook/db2007/. Accessed October 28. 2009.

DesRochers, David W., Michael D. Silbernagle, Aaron Nadig, J. Michael Reed. 2006. Improving population estimates of Hawaiian Moorhen *(Gallinula chloropus sandvicensis)* with call response surveys and banding data, unpublished.

Division of Aquatic Resources (DAR), Hawai‘i Department of Land and Natural Resources. 2008. Hawaiian Watershed Atlas. Available at: http://www.hawaiiwatershedatlas.com/. Accessed October 15, 2009.

Division of Forestry and Wildlife (DOFAW). 2009. Final Environmental Assessment, Ka‘ena Point Ecosystem Restoration Project.

D.L. Adams Associates (DLAA), Ltd. 2009. Environmental Noise Assessment, Kahuku Wing Farm, Kahuku, Oahu, Hawai‘i. September 15, 2009. Prepared for First Wind Energy, LLC.

E.H. Pechan & Associates, Inc. 2007. The Emissions & Generation Resource Integrates Database for 2006 (eGRID2006) Technical Support Document. Prepared for Eastern Research Group and U.S. Environmental Protection Agency.

Engilis, Jr., A., K.J. Uyehara, and J.G. Giffin. 2002. Hawaiian Duck (*Anas wyvilliana*). In: The Birds of North America, No. 694. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Engilis, Jr., A. and M. Naughton. 2004. U.S. Pacific Islands Regional Shorebird Conservation Plan. U.S. Shorebird Conservation Plan. U.S. Department of the Interior, Fish and Wildlife Service. Portland, OR.

Engilis, Jr., A. and T.K. Pratt. 1993. Status and Population Trends of Hawai‘i’s Native Waterbirds, 1977-1987. Wilson Bulletin 105:142-158.

Erickson, W.P. 2003. Updated Information Regarding Bird and Bat Mortality and Risk at New Generation Wind Projects in the West and Midwest. National Wind Coordinating Committee, Wildlife Workgroup Meeting, November 18, 2003. Resolve, Inc., Washington, D.C. Available at: http://www.nationalwind.org/events/wildlife/2003-2/presentations/erickson.pdf.

Erickson, W.P., G.D. Johnson, M.D. Strickland, D.P. Young, Jr., K.J. Sernka and R.E. Good. 2001. Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States. National Wind Coordinating Committee Publication.

Environet, Inc. 2009. City and County of Honolulu CUP minor Permit Application for a proposed Wind Farm Development, Kahuku, Oahu, Hawai‘i. Prepared for Kahuku Wind Power LLC.

Evans, K., D. Woodside and M. Bruegmann. 1994. A Survey of Endangered Waterbirds on Maui and O'ahu and Assessment of Potential Impacts to Waterbirds from the Proposed Hawai‘i Geothermal Project Transmission Corridor. U.S. Fish and Wildlife Services, Ecological Services. Honolulu, Hi.

Federal Aviation Administration (FAA). 2009a. Temporary Determination of No Hazard to Air Navigation. Letter from Federal Aviation Administration to Wren Wescoatt dated 2 October 2009. Aeronautical Study No. 2009-WTW-6800-OE.

Federal Aviation Administration (FAA). 2009b. Temporary Determination of No Hazard to Air Navigation. Letter from Federal Aviation Administration to Wren Wescoatt dated 2 October 2009. Aeronautical Study No. 2009-WTW-6801-OE.

Federal Aviation Administration (FAA). 2009c. Temporary Determination of No Hazard to Air Navigation. Letter from Federal Aviation Administration to Wren Wescoatt dated 2 October 2009. Aeronautical Study No. 2009-WTW-6802-OE.

Federal Aviation Administration (FAA). 2009d. Temporary Determination of No Hazard to Air Navigation. Letter from Federal Aviation Administration to Wren Wescoatt dated 2 October 2009. Aeronautical Study No. 2009-WTW-6803-OE.

Federal Aviation Administration (FAA). 2009e. Temporary Determination of No Hazard to Air Navigation. Letter from Federal Aviation Administration to Wren Wescoatt dated 6 October 2009. Aeronautical Study No. 2009-WTW-6788-OE to 2009-WTW-6799-OE.

Federal Register. 2004. Incidental Take Permit and Habitat Conservation Plan for the Kaua‘i Island Utility Cooperative, Hawai‘i. 69(135): 42447- 42449.

First Wind. 2006. First Wind KWP – Site Safety Plan. Kaheawa Wind Power, Maui, Hawai‘i.

Fletcher, C.H. 2009. Sea level by the end of the 21st century: A review. Shore and Beach 77(4):1-9.

Foote, D.E., E.L. Hill, S. Nakamura, and F. Stephens. 1972. Soil Survey of the Islands of Kaua‘i, O‘ahu, Maui, Moloka‘i, and Lana‘i, State of Hawai‘i. U. S. Department of Agriculture, Soil Conservation Service.

Fullard, J.H. 2001. Auditory Sensitivity of Hawaiian Moths (Lepidoptera: Noctuidae) and Selective Predation by the Hawaiian Hoary Bat (Chiroptera: *Lasiurus cinereus semotus*) Proceedings of the Royal Society of London B. 268:1375-1380.

Giambelluca, T.W. and D. Nullet. 1991. Influence of the trade wind inversion on the climate of a leeward mountain slope in Hawai‘i. Climate Research 1:207-216.

Giambelluca, T.W., M.A. Ridgley, and M.A. Nullet. 1996. Water balance, climate change, and land-use planning in the Pearl Harbor Basin, Hawai‘i. International Journal of Water Resources Development 12: 515-530.

Giambelluca, T.W., M.A. Nullet, and T.A. Schroeder. 1986. Hawai‘i Rainfall Atlas, Report R76, Hawai‘i Division of Water and Land Development, Department of Land and Natural Resources, Honolulu. vi + 267 p.

Giambelluca, T.W., H.F. Diaz, and M.S.A. Luke. 2008. Secular temperature changes in Hawai‘i. Geophysical Research Letters 35(12): L12702.

Global Energy Concepts, LLC. 2006. A Catalog of Potential Sites for Renewable Energy in Hawai‘i. Prepared for the State of Hawai‘i Department of Land and Natural Resources and the Department of Business, Economic Development, and Tourism.

Gorresen, P.M., A.C. Miles, T.M. Todd, F.J. Bonaccorso and T.J. Weller. 2008. Assessing Bat Detectability with Multiple Automated Echolocation Detectors. Journal of Mammalogy 89(1):11-17.

Harrison, C. 1990. Seabirds of Hawaiʻi. Natural History and Conservation. Cornell University Press, Ithaca.

Hawaiʻi Audubon Society. 2005. Hawaiʻi's Birds: 6th Edition. Island Heritage: Waipahu: Hawaiʻi.

Hays, W.S.T. and S. Conant. 2007. Biology and Impacts of Pacific Island Invasive Species. 1. A Worldwide Review of Effects of the Small Indian Mongoose, *Herpestes javanicus* (Carnivora : Herpestidae). Pacific Science 61(1):3-16.

Hobdy, R.W. 2007. Biological Resources Survey for the North Shore Wind Power Project, Kahuku, Koolauloa, Hawaiʻi. Prepared for North Shore Wind Power, LLC.

Hobdy, R.W. 2009. Biological Resources Survey for Kahuku Wind Power Project, Kahuku, Oahu, Hawaiʻi. Prepared for First Wind Energy, LLC.

Hodges, C.S. 1994. Effects of Introduced Predators on the Survival and Fledging Success of the Endangered Hawaiian Dark-rumped Petrel (*Pterodroma phaeo-pygia sandwichensis*). M.S. thesis, Univ. of Washington, Seattle.

Hodges, C.S.N. and R.J. Nagata. 2001. Effects of Predator Control on the Survival and Breeding Success of the Endangered Hawaiian Dark-rumped Petrel. Studies in Avian Biology 22: 308-318.

Horn, J.W., E.B. Arnett, and T.H. Kunz. 2008. Behavioral Responses of Bats to Operating Wind Turbines. Journal of Wildlife Management 72(1):123-132.

Hötker, H, K.M. Thomsen, H. Jeromin. 2006. Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats. Facts, gaps in knowledge, demands for further research, and onithological guidelines for the development of renewable energy exploitation. Michael-Otto-Institut im NABU, Bergenhusen.

Hu, D., C. Glidden, J.S. Lippert, L. Schnell, J.S. MacIvor, and J. Meisler. 2001. Habitat use and limiting factors in a population of Hawaiian Dark-romped Petrels on Mauna Loa, Hawai'i. Pages 234-242 *in* J. M. Scott, S. Conant, and C. van Riper III, eds. Ecology, conservation, and management of endemic Hawaiian birds: A vanishing avifauna. Stud. Avian BioI. 22.

Hunt, C.D. 1996. Geohydrology of Oahu, Hawaiʻi: U.S. Geological Survey Professional Paper 1412-B. 54 p.

Hunt, C.D and E.H. De Carlo. 2000. Hydrology and Water and Sediment Quality at James Campbell National Wildlife Refuge near Kahuku, Island of Oʻahu, Hawaiʻi. U.S. Geological Survey Water-Resources Investigations Report 99-4171.

Intergovernmental Panel on Climate Change (IPCC). 2001. Working Group II to the Third Assessment Report, Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core

Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Jain, A.A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. Masters Thesis, Iowa State University. 113 pp.

Janss, G.F.E. 2000. Avian mortality from power lines: a morphologic approach of a species-specific mortality. Biological Conservation 95:353-359.

Jensen, P. 1989. Archaeological Inventory Survey, Punamano and Malaekahana Golf Courses. Lands of Ulupehupehu, Punaluu, Kahuku, Malaekahana, and Laie Koolauloa District, Island of Oahu. Paul H. Rosendahl, Ph.D., Inc., Report 483-040489. Prepared for Kuilima Resort Company, Honolulu, Hawai‘i.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd and D.A. Shepherd. 2000. Final Report, Avian Monitoring Studies at the Buffalo Ridge, Minnesota Wind Resource Area: Results of a 4-year study. Prepared for Northern States Power Company, Minneapolis, by Western Ecosystems Technology, Inc.

Johnson, G.D., W.P. Erickson, M.D Strickland 2003a. Mortality of Bats at a Large-scale Wind Power Development at Buffalo Ridge, Minnesota. American Midland Naturalist 150(2):332-342.

Johnson, G.D., W.P. Erickson, and M.D. Strickland. 2003b. What is Known and Not Known About Bat Collision Mortality at Windplants? In: Carlton, R. L. (ed.), Proc. Workshop on Avian Interactions at Wind Turbines, 16-17 October, 2002, Jackson Hole, WY. Electric Power Research Inst., Palo Alto, CA.

Johnson, G. D. 2005. A Review of Bat Mortality at Wind-energy Developments in the United States. Bat Research News 46:45-49.

Juvik, S.P. and J.O. Juvik. 1998. Atlas of Hawai‘i, Third edition. University of Hawai‘i Press: Honolulu, HI. 333 pp.

Kaheawa Wind Power, LLC. 2006. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan. Ukumehame, Maui, Hawai‘i.

Kaheawa Wind Power. 2007a. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan 2006 Annual Report Part 1. 43pp.

Kaheawa Wind Power. 2007b. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan 2006 Annual Report Part 2. 52pp.

Kaheawa Wind Power, LLC. 2008a. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 1 Annual Report (Part II). First Wind Energy, LLC, Environmental Affairs, Newton, MA. 23 pp.

Kaheawa Wind Power, LLC. 2008b. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 2 Annual Report. First Wind Energy, LLC, Environmental Affairs, Newton, MA. 26 pp.

Kaheawa Wind Power, LLC. 2009. Kaheawa Pastures Wind Energy Facility, Habitat Conservation Plan: Year 3 Annual Report. First Wind Energy, LLC, Environmental Affairs, Newton, MA 37pp.

Kahihikolo, L.R. 2008. Hawai‘i Environmental Justice Initiative Report. In Harmony Solutions LLC. Prepared for the State of Hawai`i Environmental Council.

Kema, Inc. 2009. Kema Assessment of Battery Technology for Kahuku Battery Energy Storage System. Report prepared for First Wind. Fairfax, Virginia: Kema, Inc.

Kennedy, J. 1989. Archaeological Assessment & Reevaluation Report Concerning the Recently Surveyed, Proposed Punamano Golf Course; A Portion of the Country Courses at Kahuku (TMK:1- 5-6-05, -7-01). Archaeological Consultants of Hawai‘i, Haleiwa, Hawai‘i. Prepared for Mr. William Wanket, Honolulu, Hawai‘i.

Kepler, C.B. and J.M. Scott. 1990. Notes on the Distribution and Behavior of the Endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), 1964–1983. Elepaio 50: 59-64.

Kerns, J., W. P. Erickson, and E. B. Arnett. 2005. Bat and Bird Fatality at Wind Energy Facilities in Pennsylvania and West Virginia. Pages 24–95 In: Arnett, E.B., editor. Relationships Between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. A Final Report Submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas, USA. Available at: http://www.batcon.org/windliterature. Accessed 1 Sep 2007.

Kingsley, A. and B. Whittman. 2007. Wind Turbines and Birds A Background Review for Environmental Assessment. Prepared for Environment Canada/Canadian Wildlife Service.

Koford, R., A. Jain, G. Zenner and A. Hancock. 2004. Avian Mortality Associated with the Top of Iowa Wind Farm: Progress Report, Calendar Year 2003. Iowa Cooperative Fish and Wildlife Research Unit, Iowa State University, Ames, Iowa. 9pp.

Kunz, T.H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szewczak. 2007. Assessing Impacts of Wind-energy Development on Nocturnally Active Birds and Bats: A Guidance Document. Journal of Wildlife Management 71: 2449–2486.

Kusao & Kurahashi, Inc. 2003. Appendix IX: Plan for Handling Downed Wedge-Tailed Shearwaters. Special Management Area Use and Shoreline Setback Variance Permit Application and Final Environmental Assessment for Turtle Bay Resort.

Kushlan, J.A., M.J. Steinkamp, K.C. Parsons, J. Capp, M.A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R.M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas, Washington, DC.

Lau, L.S. and J.F. Mink. 2006. Hydrology of the Hawaiian Islands. University of Hawai’i Press, Honolulu.

M & E Pacific, Inc. 2008. Draft Environmental Assessment Photovoltaic Energy System at Lihue Airport, Lihue, Island of Kauai, Hawai‘i. Prepared for State of Hawai‘i, Department of Transportation.

Macdonald, G.A., A.T. Abbott, and F.L. Peterson. 1983. Volcanoes in the Sea, 2ND Edition. University of Hawai’i Press, Honolulu.

Martin, E.M. and P.I. Padding. 2002. Preliminary Estimates of Waterfowl Harvest and Hunter Activity in the United States During the 2001 Hunting Season. United States Fish and Wildlife Service Division of Migratory Bird Management, Laurel, Maryland.

Menard, T. 2001. Activity Patters of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) in Relation to Reproductive Time Periods. Masters thesis submitted to the Univ. of Hawai‘i, Hawai‘i.

Miller, S.E. 2008. Presentation: HCA Climate Change Forum. Presented at the Hawai‘i Conservation Conference, July 29, in Honolulu, Hawai‘i.

Miller, J.A., R.L. Whitehead, D.S. Oki, S.B. Gingerich, and P.G. Olcott. 1999. Ground water atlas of the United States. Segment 13, Alaska, Hawai‘i, Puerto Rico, and the U.S. Virgin Islands. U.S. Geological Survey.

Mineau, P. 2005. Direct Losses of Birds to Pesticides–Beginnings of a Quantification. Vol. 2. Pages 1065–1070 in C.J. Ralph and T.D. Rich (eds.). Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference, March 20–24, 2002, Asilomar, California. USDA Forest Service General Technical Report PSW-GTR-191.

Mink, J.F. 1982. Koolauloa Water Resources Assessment. Board of Water Supply.

Mitchell, C., C. Ogura, D.W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. Hawai‘i’s Comprehensive Wildlife Conservation Strategy. Department of Land and Natural Resources. Honolulu, HI. Available at: http://www.state.hi.us/dlnr/dofaw/cwcs/index.html. Accessed August 21, 2008.

Moore, J.G. 1964. Giant submarine landsides on the Hawaiian Ridge. United States Geological Survey Professional Paper 501-D:95-98.

Mostello, C.S. 1996. Diets of the Pueo, Barn Owl, the Cat, and the Mongoose in Hawai‘i: Evidence for Competition. Masters Thesis, University of Hawai‘i at Manoa.

National Energy Information Center. 2008. Greenhouse Gases, Climate Change, and Energy. Available at: http://www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html.

National Invasive Species Council. 2005. Five-Year Review of Executive Order 13112 on Invasive Species.44 pp.

National Oceanic and Atmospheric Administration (NOAA). 2002. Climatography of the United States No. 81 Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1971 – 2000, 51 Hawai‘i. National Climatic Data Center Asheville, North Carolina. 21 pp.

National Wind Coordination Collaborative (NWCC). 2004. Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions. Fact Sheet: Second Edition. 7 pp.

Oahu Metropolitan Planning Organization (OMPO) and City and County of Honolulu Department of Planning and Permitting. 2004. Environmental Justice in the OMPO Planning Process: Defining Environmental Justice Populations.

Olsen, J. and P. Olsen. 1980. Alleviating the impact of human disturbance on the breeding peregrine falcon II: public and recreational lands. Corella 4(3): 54-57.

Pedersen, E. and K.P. Waye. 2007. Wind turbine noise, annoyance and self-reported health and well-being in different living environments Occup. Environ. 64:480-486.

Percival, S.W. 2003. Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment. 25 pp.

Percival, S.M. 2005. Birds and windfarms: what are the real issues? British Birds 98:194–204.

Pitman, R.L. 1986. Atlas of Seabird Distribution and Relative Abundance in the Eastern Tropical Pacific. La Jolla, California: NOAA, NMFS, Southwest Fisheries Center Administrative Report LJ-86-02C.

Planning Solutions, Inc. 2009. Draft Environmental Impact Statement Kaheawa Wind Power II Wind Energy Generation Facility, Ukumehame, Maui, Hawai‘i.

Podolsky, R., D.G. Ainley, G. Spencer, L. DeForest, and N. Nur. 1998. Mortality of Newell's Shearwaters Caused by Collisions with Urban Structures on Kaua‘i. Colonial Waterbirds 21: 20–34.

Polhemus, D.A., J. Maciolek and J. Ford. 1992. An ecosystem classification of inland waters for the tropical Pacific Islands. Micronesica 25: 155-173.

Polhemus, D.A. 2007. Biology Recapitulates Geology: the Distribution of Megalagrion Damselflies on the Ko’olau Volcano of O’ahu, Hawai’i. In N.L. Evenhuis & J.M. Fitzsimons (ed.): Bishop Museum Bulletin in Cultural and Environmental Studies 3:233-246.

Polhemus, J.T. and D.G. Smith. 2005. Update on Nesting Activity and Habitat Utilization by Native Waterbirds at the Hamakua Marsh State Wildlife Sanctuary, Kailua, O‘ahu. Elepaio 65(3):17-21

Pounds, A.J., M.P. Fogden, and J.H. Campbell. 1999. Biological response to climate change on a tropical mountain. Nature 398:611–614.

Powlesland, R.G. 2009. Impacts of wind farms on birds: a review. Science for Conservation 289. New Zealand Department of Conservation.

Pratt, T. K. 1988. Recent observations, March-May 1988. ‘Elepaio 48:65–66.

Pratt, H.D., P.L. Bruner, and D.G. Berrett. 1987. The Birds of Hawai‘i and the Tropical Pacific. Princeton University Press, Princeton, NJ.

Pukui, M. and S. Elbert. 1971. Hawaiian Dictionary. Honolulu: University of Hawai‘i Press.

Pukui, M., S. Elbert, and E. Mookini. 1974. Place Names of Hawai‘i. Honolulu: University of Hawai‘i Press.

Rauzon, M.J. and D.C. Drigot. 2002. “Red mangrove eradication and pickleweed control in a Hawaiian wetland, waterbird responses, and lessons learned,” in Turning the Tide: The Eradication of Invasive Species, edited by C.R. Veitch and M.N. Clout, Occasional Paper of the IUCN Species Survival Commission No. 27, IUCN – The World Conservation Union, Gland, Switzerland.

Rechtman Consulting, LLC. 2008. An Archaeological Inventory Plan for the Kahuku Wind Power Kahuku Project Area (TMK:1-5-6-05:007). Prepared by M.R. Clark and R.B. Rechtman. Prepared for Kahuku Wind Power.

Rechtman, B. 2009. A Comprehensive Archaeological Survey of the First Wind Kahuku Wind Power Project Area in Compliance with Section 106 of the National Historic Preservation Act, Kahuku Ahupuaʻa, Koʻolauloa District, Island of Oʻahu. Prepared by Rechtman Consulting, LLC. Hilo. Hawaiʻi.

Reed, J.M., C.S. Elphick, and L.W. Oring. 1998. Life-history and Viability Analysis of the Endangered Hawaiian Stilt. Biological Conservation 84:35-45.

Richardson, F. and D.H. Woodside. 1954. Rediscovery of the nesting of the Dark-rumped Petrel in the Hawaiian Islands. Condor 56: 323-327.

Robinson, J.A., J.M. Reed, J.P. Skorupa, and L.W. Oring. 1999. Black-necked Stilt (*Himantopus mexicanus*). In The Birds of North America, No. 449. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

R.M. Towill Corporation. 2008. Draft Environmental Assessment, Kahuku Village Subdivision, Kahuku, Koʻolau Loa District, Oʻahu, Hawaiʻi.

Rocky Mountain Institute. 2008. Policy Recommendations for Hawaiʻi's Energy Future. Prepared for the State of Hawaiʻi, Department of Business, Economic Development & Tourism.

Rogers, A.L. and J.F. Manwell. 2004. Wind Turbine Noise Issues: A White Paper. Prepared by the Renewable Energy Research Laboratory. Amherst, MA. Available at: http://www.town.manchester.vt.us/windforum/aesthetics/WindTurbineNoiseIssues.pdf. Accessed December 1, 2008.

R W Beck. 2008. Integrated Solid Waste Management Plan Update. Prepared for the City and County of Honolulu.

Schwartz, C.W. and E.R. Schwartz. 1949. A Reconnaissance of the Game Birds in Hawaiʻi. Board of Commissioners of Agriculture and Forestry, Division of Fish and Game, Territory of Hawaiʻi, Hilo.

Simons, T.R. 1983. Biology and conservation of the endangered Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*). CPSU/UW83-2. Seattle: National Park Service, Cooperative Studies Unit, University of Washington, Seattle.

Simons, T.R. 1984. A population model of the endangered Hawaiian dark-rumped petrel. J. Wildl. Mgmt. 48(4) 1065-1076.

Simons, T. R., and C. N. Hodges. 1998. Dark-rumped Petrel (Pterodroma phaeopygia). In The Birds of North America, No. 345 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Smith D.G., J.T. Polhemus. 2003. Habitat Use and Nesting Activity by the Hawaiian Stilt (*Himanotopus mexicanus knudseni*) and Hawaiian Moorhen (*Gallinula chloropus sandvicensis*) at the Hamakua Marsh State Wildlife Sanctuary, Kailua, Oʻahu. ʻElepaio 63(8):59-62

Smith, D.G., J.T. Polhemus, and E.A. VanderWerf. 2002. Comparison of Managed and Unmanaged Wedge-tailed Shearwater Colonies on Oahu: Effects of Predation. Pacific Science 56: 451-457.

Smith, Young & Assoc. 1990. Appendix A. Engineering Studies – The County Courses at Kahuhu, Punamano Site. Final EIS, Volume II, The County Courses at Kahuhu (Punamano), Kahuku, Oʻahu. Prepared for the Estate of James Campbell.

Snetsinger, T.J., S.G. Fancy, J.C. Simon, and J.D. Jacobi. 1994. Diets of Owls and Feral Cats in Hawaiʻi. ʻElepaio 54:47-50.

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller. 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA.

Spear, L.B., D.G. Ainley, N. Nur, S.N.G. Howell, S.N.G. 1995. Population size and factors affecting at-sea distributions of four endangered *procellariids* in the tropical Pacific. Condor 97:613-638.

Spencer, Greg. Senior Wildlife Biologist, First Wind. Personal communication.

Stantec Consulting Ltd. 2007. Environmental Review Report for Wolfe Island Wind Project. Kingston, Ontario.

State of Hawaiʻi and Hawaiian Electric Companies. 2008. Energy Agreement Among the State of Hawaiʻi, Division of Consumer Advocacy of the Department of Commerce & Consumer Affairs, and the Hawaiian Electric Companies. Available at: http://Hawaii.gov/dbedt/info/energy/agreement/. Accessed November 3, 2008.

State of Hawaiʻi and U.S. Department of Energy (USDOE). 2008. Memorandum of Understanding between the State of Hawaiʻi and the U.S. Department of Energy. Available at: http://Hawaii.gov/dbedt/info/energy/hcei/Hawaii_mou.pdf. Accessed November 3, 2008.
Stearns, H.T. 1985. Geology of the State of Hawaiʻi, Second Edition. Pacific Books, Palo Alto, California.

Still, C.J., P.N. Foster, and S. Schneider, S. 1999. Simulating the effects of climate change on tropical montane cloud forests. Nature 398:608–610.

Stone, C.P. 1985. Alien animals in Hawaiʻi's native ecosystems: toward controlling the adverse effects of introduced vertebrates. Pages 251-297 in C.P. Stone and J.M. Scott (eds), Hawaiʻi's terrestrial ecosystems: preservation and management. University of Hawaiʻi Cooperative Resources Studies Unit, University of Hawaiʻi Press, Honolulu.

Stone, C.P., L.W. Cuddihy, and J.T. Tunison. 1992. Responses of Hawaiian ecosystems to the removal of feral pigs and goats. Pages 666-704 In: C.P. Stone, C.W. Smith, and J.T. Tunison (eds.), Alien Plant Invasions in Native Ecosystems of Hawaiʻi: Management and Research. Cooperative National Park Resources Studies Unit, University of Hawaiʻi, Honolulu. 887 pages.

Stride, M., T. Craddock, and H. Hammatt. 2003. Archaeological Inventory Survey of the Proposed 785-Acre Kahuku Agricultural Park (TMK:1-5-6-8:2). Cultural Surveys Hawaiʻi, Inc. Prepared for M and E Pacific, Inc.

SWCA Environmental Consultants (SWCA). 2008. First Wind Kahuku Wind Farm Jurisdictional Wetland Determination Study.

SWCA and First Wind. 2008. Kahuku Wind Power Wildlife Monitoring Report and Fatality Estimates for Waterbirds and Bats (October 2007 – October 2008).

SWCA and First Wind. 2010. Kahuku Wind Power Habitat Conservation Plan. Prepared for Kahuku Wind Power LLC for DOFAW. Approved by BLNR March 11, 2010.

Telfair, R.C., II. 1994. Cattle Egret (*Bulbulcus ibis*). In: The Birds of North America, No. 113. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Telfer, T.C. 1986. Newell's shearwater nesting colony establishment study on the island of Kaua'i. Final Report, Statewide Pittman-Robertson Program. Department of Lands and Natural Resources, State of Hawai'i, Honolulu, HI.

Telfer, T.C., J.L. Sincock, G.V. Byrd, and J.R. Reed. 1987. Attraction of Hawaiian Seabirds to Lights: Conservation Efforts and Effects of Moon Phase. Wildlife Society Bulletin 15:406–413.

Tetra Tech EC, Inc. 2008. Draft Environmental Assessment For Issuance of an Endangered Species Act Section 10 (a)(1)(B) Permit for the Incidental Take of Listed Species for the Lanai Meteorological Towers Project. Castle & Cooke Resorts, LLC. Prepared for U.S. Fish & Wildlife Service.

Thierry, M.W. and J. Hale. 1996. Causes of Owl Mortality in Hawai'i, 1992 to 1994. Journal of Wildlife Diseases 32(2): 266-273.

Thompson, W.Y. 2005. Final Environmental Assessment: Replacement, Repairs & Improvements, Haleiwa Boat Harbor. Haleiwa, Waialua District.

Tomich, P.Q. 1969. Mammals in Hawai'i: A Synopsis and Notational Bibliography. B.P. Bishop Museum, Honolulu, HI. Spec. Pub. 57. 238 pp.

U.S. Census Bureau. 2003. 2000 Census of Population and Housing, Summary Social, Economic, and Housing Characteristics, PHC-2-13, Hawai'i Washington, DC. Available at: http://www.census.gov/prod/cen2000/phc-2-13.pdf. Accessed November 24, 2008.

U.S. Census Bureau. 2000. U.S. Census Bureau 2000 Fact Sheets. Geographic areas: State of Hawai'i, Honolulu County, Kahuku CDP. Available at: http://factfinder.census.gov/home/saff/main.html?_lang=en. Accessed December 14, 2009.

U.S. Climate Change Science Program. 2009. Climate and Coasts. Abstract *In:* Hawai'i Conservation Conference 2009 Hawai'i in a changing climate: ecological, cultural, economic and policy challenges and solutions.
U.S. Department of Energy (DOE). 2009. Final Environmental Assessment for the White Earth National Wind Energy Project, Becker County, Minnesota, White Earth Indian Reservation, U.S.A.

U.S. Department of Transportation, Federal Highway Administration. 2009. Freight Facts and Figures 2008. FHWA-HOP-08-052.

U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics. 2008. National Transportation Statistics. Available at:

http://www.bts.gov/publications/national_transportation_statistics/2008/index.html. Accessed September 30, 2009.

USFWS. 1983. Hawaiian Dark-Rumped Petrel and Newell’s Manx Shearwater Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. 57 pp.

USFWS. 1998. Recovery Plan for the Hawaiian Hoary Bat *(Lasiurus cinereus semotus*). U.S. Fish and Wildlife Service, Portland, OR.

USFWS. 2002. Oʻahu National Wildlife Refuge Complex. Annual Narrative Report Calendar Year 2002. Honolulu, HI.

USFWS. 2003. Interim Voluntary Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines. Available at: http://www.fws.gov/habitatconservation/wind.html. Accessed March 20, 2009.

USFWS. 2005a. Draft Revised Recovery Plan for Hawaiian Waterbirds, Second Draft of Second Revision. U.S. Fish and Wildlife Service, Portland, OR.

USFWS. 2005b. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, OR.

USFWS. 2007. City and County of Honolulu Conditional Use Permit Application No. 2007/CUP-141 for UPC Wind Farm, Kahuku, Oahu, Hawaiʻi. Letter to City and County of Honolulu, Department of Planning and Permitting.

USFWS. 2008. Draft Environmental Assessment for Fencing of the Kona Forest Unit of the Hakalau Forest National Wildlife Refuge Hawaiʻi County, Hawaiʻi. South Kona District
Hawaiʻi County, Hawaiʻi.

USFWS and National Marine Fisheries Service (NMFS). 1996. Habitat Conservation Planning and Incidental Take Permit Processing Handbook.

USFWS and NMFS. 1998. Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act.

Uyehara, K.J., A. Engilis, Jr., and M. Reynolds. 2007. Hawaiian Duck’s Future Threatened by Feral Mallards. U.S. Geological Survey Fact Sheet 2007-3047. Available at: http://pubs.usgs.gov/fs/2007/3047/. Accessed June 20, 2008.

Uyehara, K.J., A. Engilis, B.D. Dugger. 2008. Wetland Features That Influence Occupancy by the Endangered Hawaiian Duck. The Wilson Journal of Ornithology 120(2):311–319.

van den Berg, G.P. 2004. Effects of the wind profile at night on wind turbine sound. Journal of Sound and Vibration 277(5): 955-970.

Webster, P.J., G.J. Holland, J.A. Curry, and H.R. Chang. 2005. Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science 309(5742):1844-1846.

Whitaker, J.O. and P.Q. Tomich. 1983. Food Habits of the Hoary Bat *Lasiurus cinereus*, from Hawaiʻi. Journal of Mammalogy 64:151-52.

Whitton, G.C. 1997. Wedge-tailed Shearwater (*Puffinus pacificus*). In: The Birds of North America, No. 305. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Wiggins, D.A., D.W. Holt and S.M. Leasure. 2006. Short-eared Owl (Asio flammeus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online:
http://bna.birds.cornell.edu.eres.library.manoa.Hawaii.edu/bna/species/062doi:10.2173/bna.62

Winter, L. 2003. Popoki and Hawai‘i’s native birds. ‘Elepaio 63:43-46.

Wilson Okamoto & Associates, Inc. 2000. Final Environmental Assessment and Finding of No Significant Impact, Waialua Well II Exploratory Well Site. Prepared for the City and County of Honolulu, Board of Water Supply.

Woodlot Alternatives, Inc. 2003. An Assessment of Factors Associated with Avian Mortality at Communications Towers – A Review of Existing Scientific Literature and Incidental Observations. Technical comments prepared in response to the August 20, 2003, Notice of Inquiry Issued by the Federal Communications Commission (FCC) WT docket No. 03-187.

WSB- Hawai‘i. 2009. Draft Environmental Assessment Na Pua Makani 25 MW Windfarm, Oahu, Hawai‘i. Prepared for Oahu Wind Power Partners, LLC.

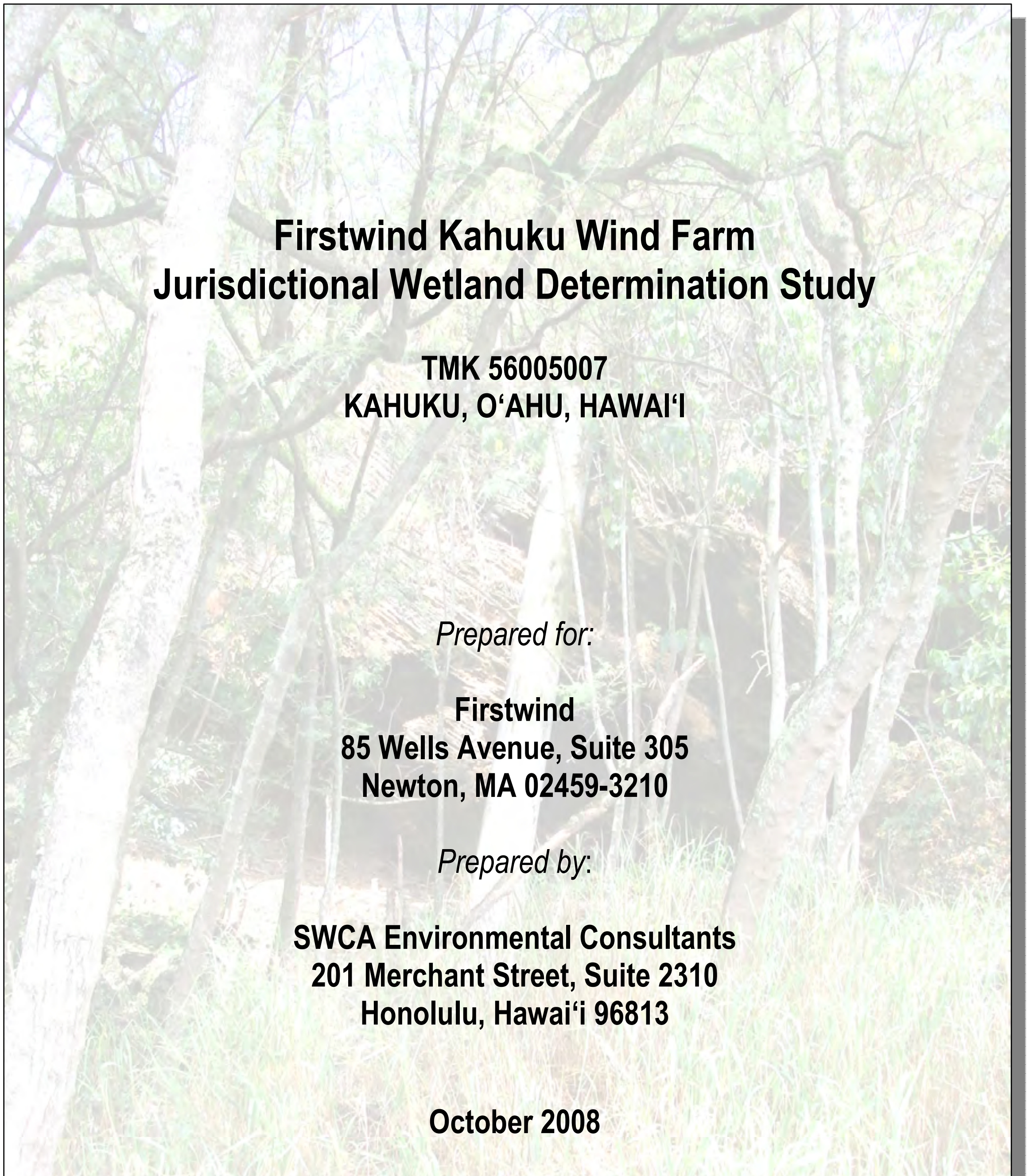
Appendix A.

USFWS Interim Voluntary Guidelines Site Development Recommendations	**Proposed Kahuku Wind Power Project**
Avoid placing turbines in documented locations of any species of wildlife, fish, or plant protected under the Federal Endangered Species Act	No locations on O'ahu were identified that were unlikely to be visited by listed species and were deemed suitable to support a financially viable wind energy generation facility. On-site surveys indicate that the risk to listed species is low, as none of the documented species have been observed utilizing the site and only three (two bird species and one bat species) are known to transit over the site infrequently. The project will reduce risk to listed species as much as possible while achieving the basic project purpose.
Avoid locating turbines in known local bird migration pathways or in areas where birds are highly concentrated, unless mortality risk is low (e.g., birds present rarely enter the rotor-swept area). Examples of high concentration areas for birds are wetlands, State or Federal refuges, private duck clubs, staging areas, rookeries, leks, roosts, riparian areas along streams, and landfills. Avoid known daily movement flyways (e.g., between roosting and feeding areas) and areas with a high incidence of fog, mist, low cloud ceilings, and low visibility.	No wetlands occur on the project area. Site-specific surveys indicate that the project area is not located along any of the daily movement flyways used by wetland birds and is consistently a location of high visibility with high cloud ceilings.
Avoid placing turbines near known bat hibernation, breeding, and maternity/nursery colonies, in migration corridors, or in flight paths between colonies and feeding areas.	The project area has shown a very low level of bat activity confined to the northern boundary. It is likely that only a few individuals, if any, use the project area.
Configure turbine locations to avoid areas or features of the landscape known to attract raptors (hawks, falcons, eagles, owls). For example, Golden Eagles, hawks, and falcons use cliff/rim edges extensively; setbacks from these edges may reduce mortality. Other examples include not locating turbines in a dip or pass in a ridge, or in or near prairie dog colonies.	The only likely raptor to be present on site is the Hawaiian short-eared own or pueo, which has only been observed on the site once during the 15 month long survey. All observations thus far have indicated that Kahuku Wind Power is not located at a site that is attractive to raptors.
Configure turbine arrays to avoid potential avian mortality where feasible. For example, group turbines rather than spreading them widely, and orient rows of turbines parallel to known bird movements, thereby decreasing the potential for bird strikes. Implement appropriate storm water management practices that do not create attractions for birds, and maintain contiguous habitat for area-sensitive species (e.g., Sage Grouse).	Turbines have been grouped as closely as feasible, given wind resource and terrain considerations. No water features will be constructed and on-site drainage will be maintained so as not to attract waterbirds.

USFWS Interim Voluntary Guidelines Site Development Recommendations	Proposed Kahuku Wind Power Project
Avoid fragmenting large, contiguous tracts of wildlife habitat. Where practical, place turbines on lands already altered or cultivated, and away from areas of intact and healthy native habitats. If not practical, select fragmented or degraded habitats over relatively intact areas.	The project area has been extensively grazed and cultivated in the past and does not contain any healthy native habitat.
Avoid placing turbines in habitat known to be occupied by prairie grouse or other species that exhibit extreme avoidance of vertical features and/or structural habitat fragmentation. In known prairie grouse habitat, avoid placing turbines within 5 miles of known leks (communal pair formation grounds).	Not applicable as no prairie grouse occur in Hawai'i.
Minimize roads, fences, and other infrastructure. All infrastructure should be capable of withstanding periodic burning of vegetation, as natural fires or controlled burns are necessary for maintaining most prairie habitats.	The proposed access roads and infrastructure are designed to be the minimum necessary to construct and operate the project while observing good engineering and environmental design standards. No periodic burning is necessary at the project area.
Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species. For example, avoid attracting high densities of prey animals (rodents, rabbits, etc.) used by raptors.	Vegetation that will be removed from the site during construction will be replaced with appropriate vegetation to ensure stable cover. Some areas may be planted with native vegetation, providing additional habitat enhancement to a landscape dominated by alien vegetation.
Reduce availability of carrion by practicing responsible animal husbandry (removing carcasses, fencing out cattle, etc.) to avoid attracting Golden Eagles and other raptors.	This recommendation is not applicable to projects on O'ahu.
Use tubular supports with pointed tops rather than lattice supports to minimize bird perching and nesting opportunities. Avoid placing external ladders and platforms on tubular towers to minimize perching and nesting. Avoid use of guy wires for turbine or meteorological tower supports. All existing guy wires should be marked with recommended bird deterrent devices (Avian Power Line Interaction Committee 1994).	Tubular towers will be utilized for the turbine towers. The towers will not have platforms or ladders. The only permanent met tower will be unguyed.

USFWS Interim Voluntary Guidelines Site Development Recommendations	Proposed Kahuku Wind Power Project
If taller turbines (top of the rotor-swept area is >199 feet above ground level) require lights for aviation safety, the minimum amount of pilot warning and obstruction avoidance lighting specified by the FAA should be used (FAA 2000). Unless otherwise requested by the FAA, only white strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. Solid red or pulsating red incandescent lights should not be used, as they appear to attract night-migrating birds at a much higher rate than white strobe lights.	A subset of turbines as determined by FAA will be lit with medium intensity red-flashing lights in accordance with FAA aviation safety guidance. For the clustered arrangement proposed by Kahuku Wind Power, current FAA guidance prescribes a single red pulsing light on turbines located around the outside of the grouping, at a spacing of no more than 2,500 ft between lighted turbines. Kahuku Wind Power will request the maximum flash interval to minimize lighting impact. White strobe lights do not conform to FAA guidance. On-site lighting will be minimal and shielded so as not to attract night-migrating birds.
Where the height of the rotor-swept area produces a high risk for wildlife, adjust tower height where feasible to reduce the risk of strikes.	Roughly 95-100% of the endangered waterbird species observed in the adjacent wetlands fly below the rotor swept zone of the chosen turbine. The risk to seabirds is higher with 64% of all birds expected to fly at turbine height or lower; however, seabird traffic is extremely low over the site.
Where feasible, place electric power lines underground or on the surface as insulated, shielded wire to avoid electrocution of birds. Use recommendations of the Avian Power Line Interaction Committee (1994, 1996) for any required above-ground lines, transformers, or conductors.	This recommendation is being followed; all new power lines will be placed underground where feasible.
High seasonal concentrations of birds may cause problems in some areas. If, however, power generation is critical in these areas, an average of three years monitoring data (e.g., acoustic, radar, infrared, or observational) should be collected and used to determine peak use dates for specific sites. Where feasible, turbines should be shut down during periods when birds are highly concentrated at those sites.	This recommendation is not applicable as there were no observed seasonal concentrations of birds passing over the site. Though seabirds and ducks have been documented to pass through the site, the passage rates are low compared to other locations in Hawai'i. Preliminary results of on-going acoustic bat monitoring indicate low levels of bat activity in the project area.
When upgrading or retrofitting turbines, follow the above guidelines as closely as possible. If studies indicate high mortality at specific older turbines, retrofitting or relocating is highly recommended.	This recommendation is not applicable to the current project as it will be a new facility.

Appendix B.



Firstwind Kahuku Wind Farm Jurisdictional Wetland Determination Study

TMK 56005007
KAHUKU, O‘AHU, HAWAI‘I

Prepared for:

Firstwind
85 Wells Avenue, Suite 305
Newton, MA 02459-3210

Prepared by:

SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, Hawai‘i 96813

October 2008

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

WETLAND DELINEATION SUMMARY

SITE NAME:	Firstwind Kahuku Wind Farm TMK 56005007
SITE LOCATION:	The site is located adjacent to the town of Kahuku on north shore of the Island of O‘ahu, within the state of Hawai‘i.
OWNER:	Firstwind
DATE OF SITE VISITS:	June 4-5, 2008; June 16, 2008; October 6, 2008
PROJECT STAFF:	John Ford, Program Director / Senior Biologist, SWCA Dr. Ling Ong, Senior Scientist Dr. Shahin Ansari, Botanist Maya LeGrande, Botanist Stephen Mosher, Ornithologist Tiffany Thair, Environmental Specialist II, SWCA Ryan Taira, GIS Analyst, SWCA

SUMMARY

SWCA Environmental Consultants (SWCA) was tasked by Firstwind, the developer of the subject property, to identify wetlands subject to Department of the Army jurisdiction under Section 404 of the Clean Water Act. Wetland delineation fieldwork was conducted by SWCA on June 4-5, June 16, and October 6, 2008. SWCA's field studies were conducted utilizing methods prescribed in the US Army Corps of Engineers 1987 Wetlands Delineation Manual, as amended, in accordance with the requirements of US Army Corps of Engineers.

The US Fish and Wildlife Service (USFWS) conducted wetland mapping in Hawai‘i based upon the Cowardin et al. (1979) wetland classification schema in 1981. According to the USFWS definition, three wetlands occur within the project parcel. Each of the following was described by USFWS as being palustrine, forested, broad-leafed evergreen, seasonal (PFO3C) wetlands: Ohia‘ai Gulch/Ki‘i Ditch, Kalaeokahipa Gulch, and an unnamed headwater tributary to James Campbell National Wildlife Refuge (NWR) (paralleling Nudist Camp Road). In addition, the lower reach of Ohia‘ai Gulch/Ki‘i Ditch, outside of the project boundary, is classified as palustrine, emergent, persistent, seasonally flooded, excavated (PEM1Cx).

No wetlands meeting the three established criteria of hydrophilic vegetation, soils, and water regime were found to occur within the project parcel during the survey by SWCA. However, SWCA determined that intermittent Ohia‘ai Gulch and Kalaeokahipa Gulch are likely to be subject to discretionary Department of the Army jurisdiction (in light of the *Rapanos* and *SWANCC* Supreme Court Decisions) because of their significance to the jurisdictional waters at the two units of the James Campbell National Wildlife Refuge (NWR), located immediately downstream of the project property.

1.0 INTRODUCTION TO WETLANDS AND WETLAND DELINEATION

The U.S. Army Corps of Engineers (Corps) derives its regulatory authority over wetlands and waters of the United States from the two Federal laws: Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (33 CFR Part 328 and 329). Waters of the United States subject to Corps jurisdiction include navigable waters and their tributaries, interstate waters and their tributaries, wetlands adjacent to these waters, and impoundments of these waters. The U.S. Army Corps of Engineers, U.S. Environmental Protection Agency (EPA), and Hawai'i Department of Health (HDOH) define wetlands as: *"Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swaps, marshes, bogs and similar areas"* (Erickson and Puttock 2006).

The Cowardin et al. (1979) definition of wetlands developed by the U.S. Fish and Wildlife Service is the standard for the agency and is the national standard for wetland mapping, monitoring and data reporting. As determined by the Federal Geographic Data Committee, wetlands are *"…are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year."*

Wetland jurisdictional boundary determinations involve an assessment of the relationship between indicators of vegetation, soil, and hydrologic regimes. Each is summarized below:

1.1 Vegetation Indicators

The U.S. Fish and Wildlife Service published a *National List of Vascular Plant Species That Occur in Wetlands*. The 1996 National Summary (draft revision) designates a regional wetland indicator status for plant species in Hawai'i which estimates the probability of a species occurring in wetlands versus non-wetlands (USFWS 1997). Plants that are capable of living in anoxic conditions characteristic of inundated or saturated soils are considered hydrophytes if they are classified as OBL, FACW+, FACW, FACW-, FAC+, and FAC (Table 1). If more than 50 percent of the dominant vegetation at a site is hydrophytic, the entire area is considered to have wetland vegetation. The following factors are also listed as supplemental indicators of hydrophytic vegetation: visual observation of plant species growing in areas of prolonged inundation and/or soil saturation; morphological adaptations; technical literature; and physical and reproductive adaptations (Erickson and Puttock 2006).

Table 1. Wetland Plant Indicators published in the Corps' Wetlands Delineation Manual (1987).

PLANT INDICATOR	SYMBOL	DESCRIPTION
Obligate Wetland Species	OBL	>99% found in wetlands
Facultative Wetlands Species	FACW	67-99% found in wetlands
Facultative Species	FAC	33-66% found in wetlands
Facultative Upland Species	FACU	1-33% found in wetlands
Obligate Upland Species	UPL	<1% found in wetlands
No Indicator Status	NI	Ignored in count

(+) = wetter than FAC; (-) = drier than FAC; (*) = tentative assignment/more data needed

1.2 Soil Indicators

Hydric soils are defined as soils that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part (NRCS 2007). Hydric soils are either drained or undrained and are classified as either organic or mineral soils. Soil characteristic are determined in the field by digging 18 inch (45 cm) holes near potential wetland areas and documenting the texture, smell, color, and water level. For sandy soils, the following features are indicative of hydric soils: high organic content in the surface (A) horizon; streaking of subsurface horizons by organic matter; the presence of organic pans (Erickson and Puttock 2006).

The NRCS National List of Hydric Soils (February 2007) for O‘ahu Island includes 13 hydric soils for the island. Soils within TMK 56005007 at Kahuku, O‘ahu are mapped by the Natural Resources Conservation Service (Sato el al. 2001). No hydric soils are mapped by NRCS on the project parcel.

1.3 Hydrologic Indicators

Visual observation of inundation, visual observation of soil saturation, watermarks, drift lines, sediment deposition, and drainage patterns are all primary indicators of wetland hydrology. If a single primary indictor is present, the area can be considered to have wetland hydrology. The *Army Corps of Engineers Wetlands Delineation Manual* (1987, updated online version) states that "an area has wetland hydrology if it is inundated or saturated to the surface continually for at least 5% of the growing season." Erickson and Puttock (2006) note that because the growing season in Hawai‘i is year-round, this equates to at least 18.5 consecutive days of inundation or saturation per year. Furthermore, regional indicators and secondary indicators can also be used to determine hydrological conditions. For example, the presence of tilapia redds (circular fish nests at the bottom of ponds or streams) is considered a regional indicator for wetland hydrology (Erickson and Puttock 2006).

2.0 REGIONAL BACKGROUND

2.1 Location and Vicinity

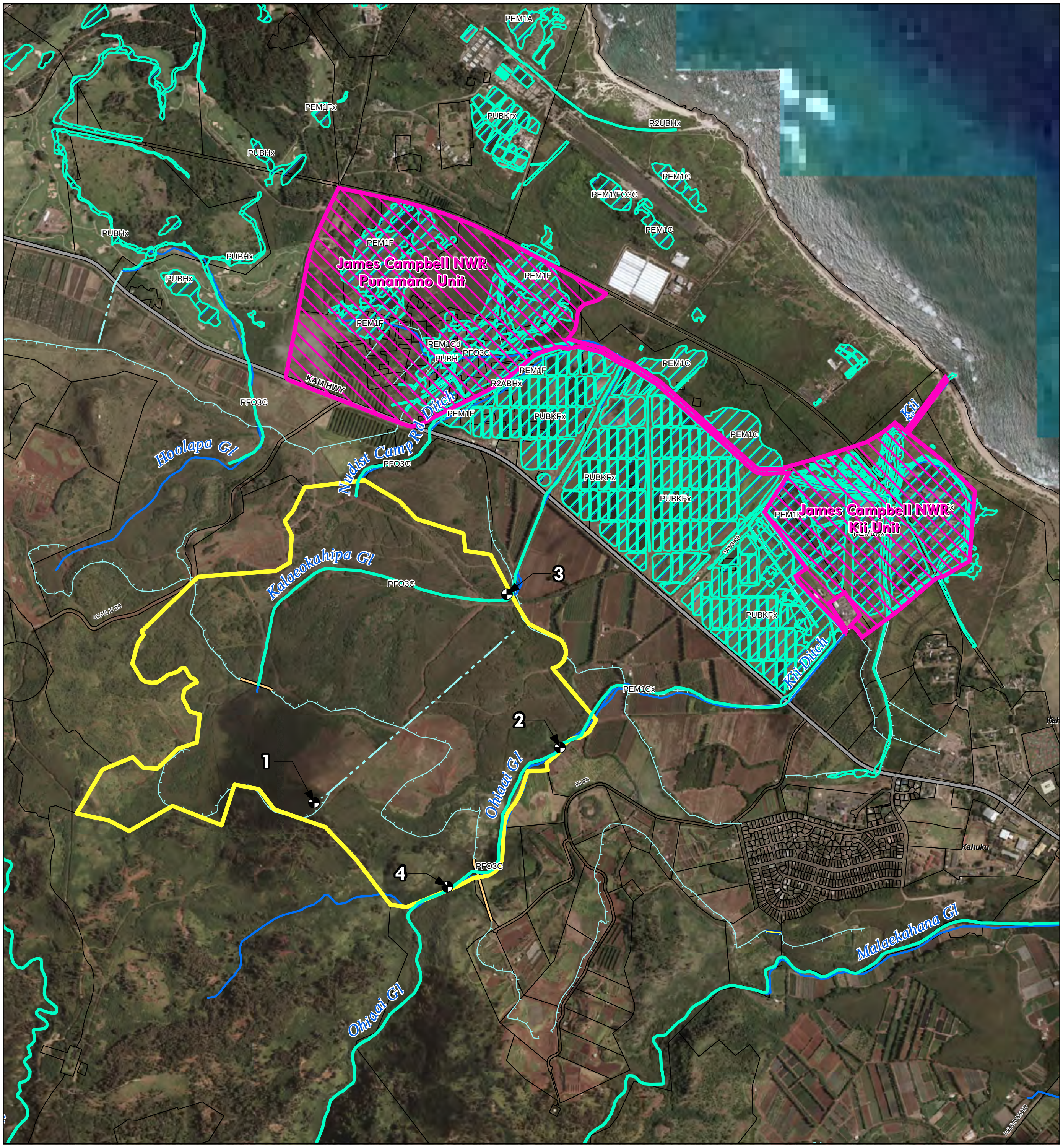
The wetland delineation was conducted in the community of Kahuku on the northeastern portion of the island of O‘ahu, within the state of Hawai‘i. The project area encompasses 506.85 acres (205.11 ha) and ranges from 120 to 535 feet (36.6-163 m) in elevation. The site is accessed by Charlie Road via Kamehameha Highway. It is bounded on the east and south by pasture and agricultural lands along the Kamehameha Highway, on the north by undeveloped military reservation land, and on the west by rough mountainous land (Hobdy 2007). Notable adjacent land uses include the Turtle Bay Resort, located about 0.5 mi (0.8 km) northwest of the site, and the Kuilima Wastewater Treatment Plant, located about 1 mi (1.6 km) northwest of the site. In addition, the James Campbell National Wildlife Refuge (NWR), which consists of two wetland units roughly two miles (3.2 km) apart: the Ki‘i Unit (107.5 acres) and the Punamano Unit (37.5 acres), is located makai (seaward) of the property about a mile away below Kamehameha Highway (Figure 1).

The climate is characteristic of lowland areas on the windward side of O‘ahu, with annual temperatures from 20.5 to 27.1°C (68.9-80.8°F) and annual precipitation between 37.88 and 40.86 inches (96.2 and 103.8 cm) (NOAA 2002, DBEDT 2007). Due to its location on the northern corner of O‘ahu, Kahuku is considered a high wind energy site (Lau and Mink 2006). Prevailing northeasterly trade winds are present nearly 90 percent of the year in Kahuku and the southerly Kona winds are present approximately 10 percent of the year (Smith, Young & Assoc. 1990).

2.2 Geology and Soils

O‘ahu, the third largest island in the Hawaiian archipelago, was created by several geological processes including shield-building volcanism, subsidence, weathering, erosion, sedimentation, and rejuvenated volcanism (Hunt 1996). The island is mostly composed of the heavily eroded remnants of two large Pliocene shield volcanoes - Wai‘anae and Ko‘olau (Juvik and Juvik 1998).

The project site is located at the foot of the Ko‘olau Mountains. This mountain range was created by the Ko‘olau Volcano which formed about 2.2 to 2.5 million years ago (Lau and Mink 2006). Ko‘olau is comprised of shield lavas, referred to as Ko‘olau Basalt, as well as rejuvenated stages, termed the Honolulu Volcanics (Juvik and Juvik 1998). The Kahuku area of O‘ahu has a complex geological history. Eroded shield volcanoes, such as the Ko‘olau Volcano, typically have dike complexes of basaltic material associated with active rift zones. These massive sheets of rock extend vertically into the lava flows, inhibiting normal groundwater flow (Hunt 1996).



Legend

● Wetland Survey Points

🟨 TMK Parcel 56005007

☐ TMK Parcels

▨ USFWS Wetland Inventory/ Cowardin Classification

▨ James Campbell National Wildlife Refuge

Hydrology

AQUEDUCT

DITCH OR CANAL

FLUME

SIPHON

STREAM

STREAM, UNDERPASS

Figure 1
Hydrology and Sampling Points
at the Kahuku Wind Farm Site

N

0 500 1,000 2,000 ft

0 100 200 400 M

ENVIRONMENTAL CONSULTANTS
Sound Science. Creative Solutions.®

Source: State of Hawaii GIS; City and County of Honolulu; USGS; USFWS

The majority of the site is underlain Ko‘olau Basalt lava flows ranging from 1.8 to 3 million year old. Near the makai boundary of the property older dune deposits, as well as lagoon and reef deposits (limestone and mudstone) are present. In addition, a narrow strip of alluvium sand and gravel underlies a portion of the property, roughly bisecting the middle of the parcel. No unique or unusual geologic resources or conditions are known to occur onsite.

Soils on the island of O‘ahu were classified and defined by the U.S. Department of Agriculture (USDA) Soil Conservation Service (Foote et al. 1972) and Natural Resource Conservation Service (NRCS). According to the NRCS National Hydric Soils List, none of the soils on the unit are considered hydric. Soil types and features identified by the USDA on the property are listed in Table 2.

Table 2. Soil types found on the Firstwind property based on classifications from Foote et al. (1972).

Soil Type		**Key Characteristics**	**Percent**
PeC	Paumalu silty clay, 8 to 15 percent slopes	Permeability: moderately rapid; Runoff: slow to medium; Erosion: slight to moderate	19.26%
LaB	Lahaina silty clay, 3 to 7 percent slopes	Permeability: moderate; Runoff: slow; Erosion: slight.	17.43%
LaC	Lahaina silty clay, 7 to 15 percent slopes	Permeability: moderate; Runoff: medium; Erosion: moderate.	16.53%
CR	Coral Outcrop	--	11.46%
PeB	Paumalu silty clay, 3 to 8 percent slopes	Permeability: moderately rapid; Runoff: slow Erosion: slight	10.14%
PZ	Paumalu-badland complex	Permeability: moderately rapid; Runoff: medium to rapid; Erosion: moderate to severe.	5.55%
PeD	Paumalu silty clay, 15 to 25 percent slopes	Permeability: moderately rapid; Runoff: medium; Erosion: moderate.	4.68%
PeE	Paumalu silty clay, 25 to 40 percent slopes	Permeability: moderately rapid; Runoff: medium to rapid; Erosion: moderate to severe.	3.78%
KaC	Kaena clay, 6 to 12 percent slopes	Permeability: slow; Runoff: slow to medium; Erosion: slight to moderate.	3.60%
KPZ	Kemoo-badland complex	Permeability: moderate/moderately rapid; Runoff: medium to rapid; Erosion: moderate to severe.	1.77%
KanE	Kaena very stony clay, 10 to 35 percent slopes	Permeability: slow; Runoff: medium to rapid; Erosion: moderate to severe.	1.30%
KpD	Kemoo silty clay, 12 to 20 percent slopes	Permeability: moderate/moderately rapid; Runoff: medium; Erosion: moderate.	1.24%
HeB	Haleiwa silty clay, 2 to 6 percent slopes	Permeability: moderate; Runoff: slow; Erosion: slight.	0.81%
WkB	Waialua silty clay, 3 to 8 percent slopes	Permeability: moderate; Runoff: slow; Erosion: slight.	0.79%
KaeC	Kaena stony clay, 6 to 12 percent slopes	Permeability: slow; Runoff: slow to medium; Erosion: slight to moderate.	0.60%

W	Water > 40 acres*	--	0.48%
PeF	Paumalu silty clay, 40 to 70 percent slopes	Permeability: moderately rapid; Runoff: rapid; Erosion: severe.	0.31%
WkA	Waialua silty clay, 0 to 3 percent slopes	Permeability: moderate; Runoff: slow; Erosion: slight.	0.21%
KpC	Kemoo silty clay, 6 to 12 percent slopes	Permeability: moderate/moderately rapid; Runoff: medium; Erosion: slight to moderate.	0.06%

2.3 Hydrology and Drainage

Hydrologic processes in Hawai‘i are often highly dependent on the climatic and geological features of the area. For example, stream flow is influenced by rainfall and wind patterns. The majority of the perennial streams (84 percent) on O‘ahu are located in the Ko‘olau Mountains because the prevailing trade wind patterns produce a larger amount of precipitation compared to the leeward side of the island (Polhemus 2007). In addition, permeable underlying rock may cause some streams on O‘ahu to have lengthy dry reaches under natural conditions.

Streams in the Kahuku area are considered to be naturally intermittent (Polhemus et al. 1992) and are typically short and steep, with permeable upland soils creating rapid infiltration into the Ko‘olau aquifer. As a result, streamflow in the lowland areas near the NWR have periods of high peak floods and little base flow (Hunt and De Carlo 2000). Ohia‘ai, Kalaeokahipa, and Hoolapa are intermittent streams in the Kahuku area (Smith, Young & Assoc. 1990). Ohia‘ai Gulch, which is referred to as Ki‘i ditch/stream makai of Kamehameha Highway, has a drainage area of 2.48 mi^2 and enters the western portion of the Ki‘i Unit. Kalaeokahipa Gulch flows east into the Ki‘i Unit of the NWR and has a drainage area of 1.04 mi^2 (Hunt and De Carlo 2000). Nudist Camp Road Ditch drains a 0.022 mi^2 into the Punamano Unit of the refuge. Nearby Hoolapa Gulch drains west into Punahoolapa marsh, located west of the NWR (Hunt and De Carlo 2000) (Figure 1).

In the late 1970s the U.S. Fish and Wildlife Service Division of Ecological Services biologists used orthophoto quadrangle maps and spot field checks to map wetlands in Hawai‘i as a part of the National Wetlands Inventory (NWI) Program according to the Cowardin et al. (1979) classification system. In the generalized wetland maps prepared by the NWI, a single wetland types was identified within the project area: palustrine, forested, broad-leafed evergreen, seasonal (PFO3C) wetlands.

The Flood Insurance Rate Maps (FIRM) prepared by the Federal Emergency Management Agency’s National Flood Insurance Program depicts flood hazard areas through the state. The maps classify land into four zones depending on the expectation of flood inundation. The site is located in Flood Zone D (undetermined); however, the property is known to have a tendency to flood. The applicant is working to alter the current system by establishing drainage ditches (USFWS 2007).

2.4 Flora and Fauna

The majority of the project area (about 80%) is covered with dense brush and trees, with smaller open areas vegetated with grasses and herbaceous species (Hobdy 2007). The abundant and common species are non-native plants and few native plant species exist onsite as a result of topsoil disturbance from sugar production and cattle grazing. Native species are generally located on rocky outcrops and on the exposed ridge tops in the upper portion of the property.

A total of 18 bird species have been recorded within the Kahuku site (SWCA, unpub. data). Several of these birds are protected under the Migratory Bird Treaty Act (MTBA), including the great frigate bird (*Fregata minor*), Pacific golden plover (*Pluviaslis dominica*) and ruddy turnstone (*Arenaria interpres*).

---

* Land uses on the property since the publication of these soils classifications in 1972 likely altered the hydrology of the site; no standing water was observed at these locations during the surveys.

No federally listed endangered, threatened, or candidate species presently occur on the site; however, several endangered and threatened bird species are known to occur on adjacent properties. This includes four species of endangered waterbirds: the Hawaiian duck (*Anas wyvilliana*) or koloa maoli, the Hawaiian coot (*Fulica alai*) or ʽala ekeʽokeʽo, the Hawaiian common moorhen (*Gallinula chloropus sandvicensis*) or ʽalae ʽula, and the Hawaiian stilt (*Himantopus mexicanus knudseni*) or aeʽo.

2.5 Land Use

The project site was used for sugar production during the late 1800's. Since sugar cultivation ended in roughly the late 1900's, the area has primarily been used for cattle grazing (Hobdy 2007).

Under The State Land Use Law (Act 187), Hawaii Revised Statute Chapter 205, all lands and waters in the State are classified into four districts: Agriculture, Rural, Conservation, and Urban. Conservation Districts, under the jurisdiction of DLNR, are further divided into five subzones: Protective, Limited, Resource, General and Special (Hawaii Administration Rules, Title 13, Chapter 5). The State of Hawaiʽi Land Use District Boundaries are governed by the City and County Land Use Ordinance. The area is designated as an Agricultural district by the State of Hawaii Land Use District Boundaries Map.

In addition, land use is dictated by zoning ordinances from the City and County. The City and County of Honolulu zoning ordinance defines the area as AG-1 Restrict Agricultural District. This designation is intended to preserve "important agricultural lands" for agricultural functions such as the production of food, feed, forage, fiber crops and horticultural plants (City and County of Honolulu, Land Use Ordinance, Chapter 21). A wind farm is permitted in this zoning area with a Conditional Use Permit (CUP) (USFWS 2007).

3.0 METHODOLOGY

SWCA employed methods for determining the presence of wetlands and delineating wetland boundaries prescribed by the *Army Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987, updated online version) as required by the Honolulu District, US Army Engineers and the City and County of Honolulu. Wetland delineation fieldwork was conducted by SWCA biologists and staff on June 4-5 and June 16, with supplemental data collected on October 6, 2008. Wetland determination data sheets prepared on these dates appear in Appendix A.

All low lying areas and intermittent streams on the Firstwind project site at Kahuku were walked through on June 4-5 and June 16, 2008 to determine the presence of wetlands based upon the three wetland criteria: a predominance of hydrophilic vegetation, hydric soils, and wetland hydrology (COE 1987). Numbered sampling points and soil cores were established in areas where the NWI had identified wetlands on October 6, 2008 (Figure 1).

3.1 Vegetation

Individual plants species and floral communities were identified throughout the property. In addition, the dominant plant species was recorded at each of the four sampling points. Species cumulatively exceeding 50% of the total cover and those with 20% of the total percent cover were considered dominant. These species were then compared with the regional indicator designated for the state of Hawaiʽi. Plant taxonomy and synonymy follows Wagner et al. (1999).

3.2 Soils

Soils were obtained by digging test pits and taking sediment cores at each of the sampling points. SWCA biologists identified soil samples in the field with standardized color chips (*Munsell Soil Color Charts*, Kollmorgen Corporation, 1998 revised washable edition) of hue, value, and chroma and by texture (sand, silt, clay, loam, muck, and peat). Anaerobic soil conditions and the presence of gleyed soils were of particular interest.

3.3 Hydrology

Both primary and secondary hydrology indicators were evaluated at each sampling site. Biologists searched for inundation, saturation, water marks, drift lines, crust, soil cracks, hydrogen sulfide odor, and drainage patterns.

4.0 FINDINGS

4.1 Vegetation

A list of vegetation noted onsite by SWCA and Hobdy (2007) is included in Appendix B. A total of 50 plant species were observed on site. The vegetation in the upland regions of the surveyed area are mostly comprised of dense koa haole (*Leucaena leucocephala*) trees with a mix of grass and herbaceous plants in the understory. Cocklebur (*Xanthium strumarium*), allspice (*Pimenta dioica*) and kolomona (*Senna surattensis*) were some of the other common tree/ shrub species through the surveyed area (Figure 2). Only a few native species were found, such as ʽalaʽala wai nui (*Peperomia blanda*) and ʽiliee (*Plumbago zeylanica*) on rocky outcrops and ʽakia (*Wikstroemia oahuensis*) and uʽulei (*Osteomeles anthyllidifolia*) on the exposed ridge tops in the upper portion of the property. The upland region also comprised of some large patches of open and eroded areas with no vegetation other than few herbaceous species such as Jamaican vervain (*Stachytarpheta jamaicensis*), ʽuhaloa (*Waltheria indica*) and *Bidens alba*. There was a plateau region in the southern portion of the property that was mostly an ironwood (*Casuarina equisetifolia*) and sisal (*Agave sisalana*) forest with some ʽakia in the understory.

The vegetation in the ditches and canals and the sediment stream beds was dominated by parasol leaf tree (*Macaranga tanarius*) and ficus species (such as *Ficus macrophylla*), especially along the rocky walls and with relatively few species in the shaded understory. Castor bean (*Ricinus communis*), *Pluchea* species, guinea grass (*Panicum maximum*), and kolomona were also common in the gulch areas, ditches and canals. There was a large patch of hau (*Hibiscus tiliaceus*) and Christmas berry (*Schinus terebinthifolius*) thicket in the gulch area near the confluence of the two streams. The rocky stream beds were mostly dominated by guinea grass with rare occurrence of species such as honohono (*Commelina diffusa*) and coral berry (*Rivina humilis*). *Ficus* species, koa haole and Christmas berry trees mostly dominated the banks of the two streams.

None of the 50 plant species recorded onsite are obligate wetland species. Of the 50 species, 32 species did not occur on the regional list for Hawaiʽi – indicating that these are all upland species in Hawaiʽi. Based on the National List of Plant Species that Occur in Wetlands: Hawaiʽi (Reed 1988), of the remaining 18 species are given the following classification on the regional list: nine species are classified as Facultative Upland (FACU); two species are Facultative Upland with lower frequency of occurrence in wetlands in Hawaiʽi (FAC-), two species are Facultative (FAC); two species are Facultative Upland but with tentative assignment due to lack of information (FACU*), 1 Facultative with tentative assignment due to lack of information (FAC*) and 2 species with no information to determine indicator status (NI).

4.2 Soils

None of the soils on the unit are considered hydric and no hydric soil conditions were observed during the surveys.

4.3 Hydrology

Only one small wetted area was found by SWCA during the surveys. The ponded area was located in the upper portion of Ohiaʽai Gulch, just below Sampling Point 4 (Figure 1). On June 4, 2008, this less than 1 sq. meter area bounded by several medium sized boulders had approximately 3 inches of water. On the previous survey dates, no water was present in this depression, although water marks were evident on the boulders (Figure 3). Except in this small area, no flooding or ponding was observed on the parcel in the gulches or in other areas of the parcel.

Figure 2. Typical vegetation on the Firstwind property.

Figure 3. Small wetted area in the upper portion of Ohia‘ai Gulch.

4.4 Sampling points

Four sampling points were studied by SWCA on October 6, 2008 (Figure 1). SWCA assigned a number to each of the areas and documented the three criteria, as explained in section 3.0. Each sampling point is described below and the dominant plant species present at each site are followed by the regional indicator status, as described in Table 1.

Sampling Point 1

Sampling Point 1 is located in the vicinity of the former aqueduct, as indicated on the 1998 USGS Kahuku Quad map. This point is found along the southern boundary of the property. Koa haole (*Leucaena leucocephala*) (UPL), allspice (*Pimenta dioica*) (--),† kolomona (*Senna surattensis*) (UPL), and guinea grass (*Panicum maximum*) (FACU) are the dominate plant species at this site (Figure 4). Although the USDA Soil Conservation Service (Foote et al. 1972) defines this area as water, no water or hydric soils were observed in this location. A test pit dug to a depth of 35.6 cm (14 in) and a soil core to a depth of 20 cm (7.9 in) revealed very fine soil, with a 7.5 YR hue, value of 2.5, and a chroma of 3 (7.5 YR 2.5/3) (Figures 5 and 6). The soil has a high iron content as indicated by its red color. No hydrology indicators were present at the site.

Sampling Point 2

Sampling Point 2 is located in the lower reaches of Ohia‘ai Gulch along the eastern property boundary. A large coral outcrop area lies adjacent to this site. The dominant plants in this area include the following: guinea grass (FACU), hau (*Hibiscus tiliaceus*) (FACW), koa haole (UPL), and Moreton Bay fig (*Ficus macrophylla*) (--) (Figure 7). Soils at 12 cm (4.7 in) and 38 cm (15 in) below the surface were generally found to be 2.5 YR, with both a value and chroma of 3 (2.5 YR 3/3) (Figures 8 and 9). The drainage area is conspicuous due to the de-vegetated stream bed contrasting the raised stream banks lined with dense strands of guinea grass. No water was present in the stream bed and the presence of debris and small koa haole seedlings suggest there has not been a recent flow at this location.

Figure 4. Sampling Point 1.

---

† (--) means that the indicator status was not included in the 1996 National Summary List for Hawai‘i.

Figure 5. Soil core at Sampling Point 1.

Figure 6. Soil pit dug at Sampling Point 1.

Figure 7. Sampling Point 2.

Figure 8. Soil core at Sampling Point 2.

Figure 9. Soil pit dug at Sampling Point 2.

Sampling Point 3

Sampling Point 3 is located at the bottom of Kalaeokahipa Gulch at an elevation of roughly 93 ft. Cocklebur (*Xanthium strumarium*), guinea grass (FACU), Jamaican vervain (*Stachytarpheta jamaicensis*) (FACU), *Sida rhombifolia* (FACU), Bermuda grass (*Cynodon dactylon*) (FACU), and pea aubergine (*Solanum torvum*) (--) are the dominant plant species (Figure 10). According to Foote et al. (1972), the soils at this location are considered Lahaina silty clay, 3 to 7 percent slopes. Coring and pit digging (Figure 11) to a depth of 14 cm (5.5 in) and 28 cm (11 in), respectively, revealed a middle yellow-red hue, with a value of 3 and a chroma of 3 (5 YR 3/3). Similar to Sampling Point 1, the soil at this site contains a large amount of iron oxide. The drainage area is demarcated by the lower lying stream bed compared to the elevated banks. However, it is not likely that this area has flowed recently due to the presence of mature vegetation in the stream bed.

Sampling Point 4

Sampling Point 4 is located with Ohia‘ai Gulch, further upstream from Sampling Point 2, near the southeastern corner of the property. The dominant vegetation at the site is guinea grass (FACU), koa haole (UPL), and Christmas berry (*Schinus terebinthifolius*) (FACU-). The stream bed in this area is mostly lined with large pebbles and small boulders (Figure 12). A soil core and test pit was possible in a clear area of the stream bed (Figures 13 and 14). Soils at 12 cm (4.7 in) and 25.4 cm (10 in) below the surface had a middle yellow-red hue, with a value of 5 and a chroma of 4 (5 YR 5/4). Highly exposed koa haole tree roots were present along the elevated stream banks (Figure 15). The stream bed was largely devoid of vegetation.

5.0 UPLANDS

None of the areas on the parcel meet the criteria for hydrophilic vegetation, hydric soils, and wetland hydrology; therefore, the entire project parcel is considered upland.

Figure 10. Sampling Point 3, showing elevated stream bank on right.

Figure 11. Soil pit dug at Sampling Point 3.

Figure 12. Sampling Point 4.

Figure 13. Soil core at Sampling Point 4.

Figure 14. Soil pit dug at Sampling Point 4.

Figure 15. Exposed koa haole tree roots along the elevated banks of Ohiaʻai Gulch.

6.0 CONCLUSION

Wetlands and waters (streams) of the U.S. are regulated by the U.S. Army Corps of Engineers (Corps) under Section 404 of the Clean Water Act. The following are considered jurisdictional waters and are therefore subject to agency authority:

- Traditional navigable waters (TNW);
- Wetlands adjacent to TNW;
- Non-navigable tributaries of TNW that are relatively permanent where the tributaries typically flow year-round or have continuous flow at least seasonally;
- Wetlands that directly abut such tributaries.

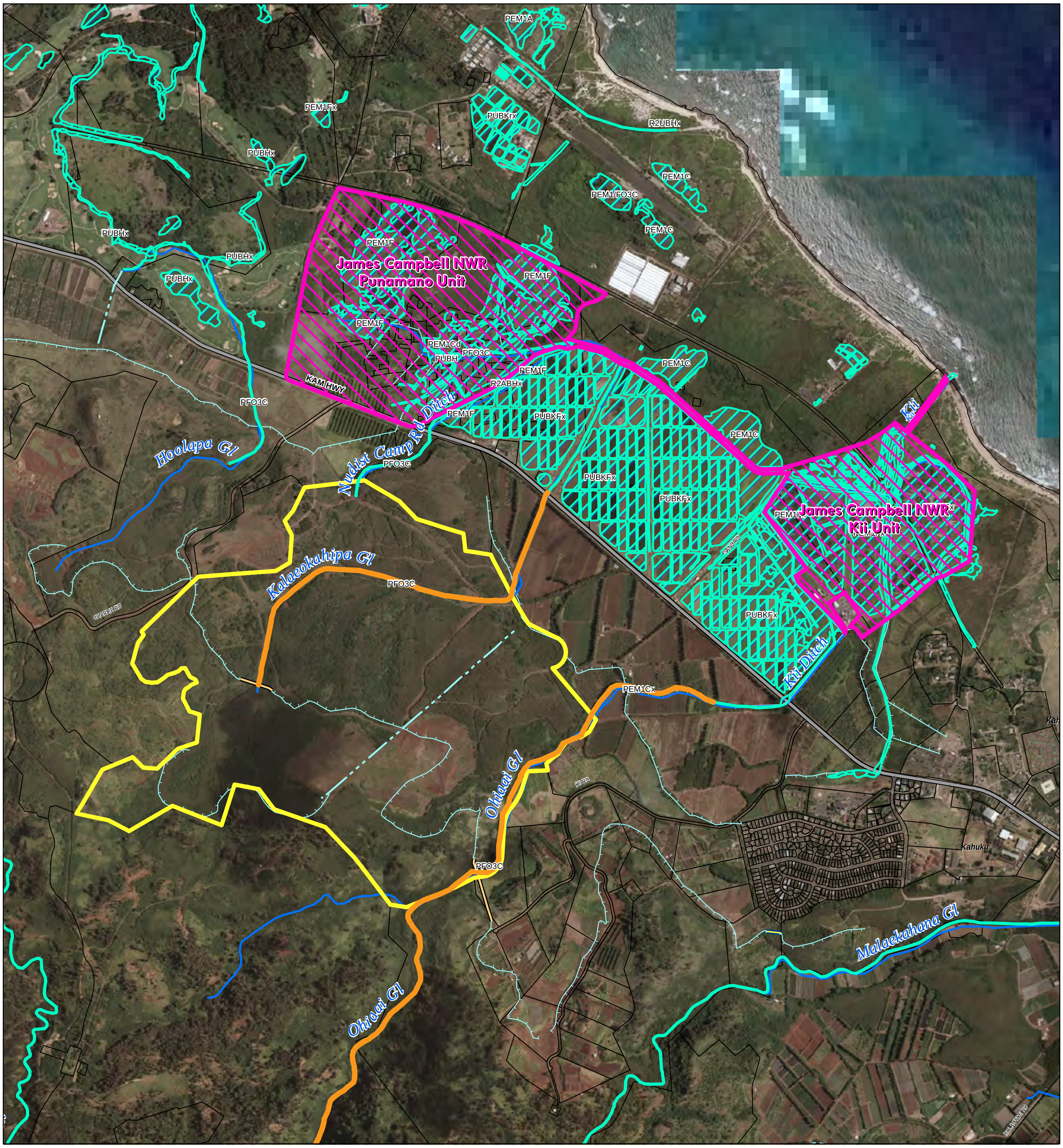
Per the Rapanos v. United States Supreme Court Decision and Solid Waste Agency of Northern Cook County (SWANCC) v. U.S. Army Corps of Engineers Supreme Court Decision, waters are also considered jurisdictional if they have a “significant nexus” with a TNW. A significant nexus is determined by assessing if the flow characteristics and function of the tributary and the functions performed by wetlands adjacent to the tributary significantly affect the chemical, physical, and biological integrity of the downstream TNW.

No wetlands meeting the three established criteria of hydrophilic vegetation, soils, and water regime were found to occur within the project parcel. In addition, streams and tributaries within the property are intermittent and therefore do not have continuous or seasonal flow.

The two intermittent streams, Ohia‘ai Gulch and Kalaeokahipa Gulch, may be subject to discretionary Department of the Army jurisdiction due to their “significant nexus” with the traditional navigable waters of the James Campbell National Wildlife Refuge (Hunt and DeCarlo 2000) (Figure 16). Any proposed impacts jurisdictional wetlands or waters identified in this report will require submittal of a wetland removal/fill permit application and a wetland mitigation plan to the Honolulu District, US Army Engineers.

7.0 LIMITATIONS

The services provided under this contract as described in this report include professional opinions and judgments based on data collected. These services were provided according to generally accepted practices of the environmental profession. The methodology for determining the presence of wetlands and delineating wetland boundaries follows the routine wetland determination methodology and plant community approach of the Army Corps of Engineers Wetlands Delineation Manual (1987, updated online version). The conclusions drawn in this report represent our best professional judgment after examination of the site conditions and background information. SWCA recommend that our report be submitted to Honolulu District, US Army Engineers for certification of our findings.



Legend

- 🟨 TMK Parcel 56005007
- ☐ TMK Parcels
- ▨ USFWS Wetland Inventory/ Cowardin Classification
- ▨ James Campbell National Wildlife Refuge

Hydrology

- AQUEDUCT
- DITCH OR CANAL
- FLUME
- SIPHON
- STREAM
- STREAM, UNDERPASS

Probable jurisdictional wetland based on significant nexus determination by ACOE Honolulu District

Figure 2
Probable Jurisdiction Wetlands at the Kahuku Wind Farm Site

N

0 500 1,000 2,000 ft

0 100 200 400 M

SWCA ENVIRONMENTAL CONSULTANTS
Sound Science. Creative Solutions.®

Source: State of Hawaii GIS; City and County of Honolulu; USGS; USFWS

8.0 REFERENCES

City and County of Honolulu on-line services. Planning and permitting interactive GIS maps & data. Available online at: http://gis.hicentral.com/website/parcelzoning/viewer.htm.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. (Version 04DEC98).

Department of Business, Economic Development, and Tourism (DBEDT). 2007. 2006 State of Hawaii Data Book. Available at: http://www.hawaii.gov/dbedt/info/economic/databook/db2006/. Accessed August 21, 2008.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1. Updated online version. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Erickson, T.A. and C.F. Puttock. 2006. Hawai'i Wetland Field Guide: An ecological and identification guide to wetlands and wetland plants of the Hawaiian Islands. Bess Press Books: Honolulu, HI. 294 pp.

Fletcher III, C.H., E.E. Grossman, B.M. Richmond, and A.E. Gibbs. 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone. U.S. Geological Survey Geologic Investigations Series I-2761.

Foote, D.E., E.L. Hill, S. Nakamura, and F. Stephens. 1972. Soil Survey of the Islands of Kaua'i, O'ahu, Maui, Moloka'i, and Lana'i, State of Hawai'i. U. S. Department of Agriculture, Soil Conservation Service.

Hawai`i Department of Agriculture (HDOA). 1977. Agricultural Lands of Importance to the Islands of Hawaii - Island of Hawaii. Available online at: http://www.hawaii.gov/dbedt/gis/maps/haw_alish_large.pdf.

Hawai`i Land Use Commission. 2005. State of Hawai`i Land Use District Boundaries – Island of Hawaii. Available online at: http://luc.state.hi.us/maps/hawaii_25.pdf.

Hawaiian Ecosystems at Risk (HEAR). Plants of Hawaii database. Available online at: http://www.hear.org/starr/hiplants/.

Hobdy, R.W. 2007. Biological Resources Survey for the North Shore Wind Power Project, Kahuku, Koolauloa, Hawaii. Prepared for North Shore Wind Power, LLC.

Hunt, C.D. 1996. Geohydrology of Oahu, Hawaii: U.S. Geological Survey Professional Paper 1412-B. 54 p.

Hunt, C.D and E.H. De Carlo. 2000. Hydrology and Water and Sediment Quality at James Campbell National Wildlife Refuge near Kahuku, Island of O'ahu, Hawaii. U.S. Geological Survey Water-Resources Investigations Report 99-4171.

Juvik, S.P. and J.O. Juvik. 1998. Atlas of Hawai'i, Third edition. University of Hawai'i Press: Honolulu. 333 pp.

Kollmorgen Instrument Corporation. 1998 revised washable edition. Munsell Soil Color Charts. Baltimore

Lau, L.S. and J.F. Mink. 2006. Hydrology of the Hawaiian Islands. University of Hawai'i Press, Honolulu.

Morden, C.W. and V. Caraway. 2000. Vegetative Key to the Common Grasses of Hawaii. Newsletter of the Hawaiian Botanical Society, Volume 39, Numbers 1 and 2, pages 1-13.

Nance, T. Personal Communication. Tom Nance Water Resource Engineers, Honolulu, HI.

NOAA. 2002. Climatography of the United States No. 81 Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1971 – 2000, 51 Hawaii. National Climatic Data Center Asheville, North Carolina. 21 pp.

Pacific Island Ecosystems at Risk (PIER). Plant Threats to Pacific Ecosystems database. Available online at: http://www.hear.org/pier/.

Palmer, D. 2003. Hawaii’s Ferns and Fern Allies. University of Hawaii Press: Honolulu, HI.

Polhemus, D.A. 2007. Biology Recapitulates Geology: the Distribution of Megalagrion Damselflies on the Ko’olau Volcano of O’ahu, Hawai’i. In N.L. Evenhuis & J.M. Fitzsimons (ed.): Bishop Museum Bulletin in Cultural and Environmental Studies 3:233-246.

Polhemus, D.A., J. Maciolek and J. Ford. 1992. An ecosystem classification of inland waters for the tropical pacific islands. Micronesia 25(2):155-173.

Reed, P.B., Jr. 1988. National List of Plant Species that Occur in Wetlands: Hawaii (Region H). U.S. Fish and Wildlife Service Biological Report No. 88 (26.13).

Sato, H.H, W. Ikeda, R. Paeth, R. Smythe, and M. Takehiro, Jr. 2001. Soil Survey of the Island of Hawaii, State of Hawaii. Prepared by Natural Resources Conservation Service (NRCS). Available online at: http://www.ctahr.hawaii.edu/soilsurvey/Hawaii/hawaii.htm.

Smith, Young & Assoc. 1990. Appendix A. Engineering Studies – The County Courses at Kahuhu, Punamano Site. Final EIS, Volume II, The County Courses at Kahuhu (Punamano), Kahuku, O‘ahu. Prepared for the Estate of James Campbell.

Staples G. W. and D. R. Herbst. 2005. A Tropical Garden Flora: Plants cultivated in the Hawaiian Islands and other tropical places. Bishop Museum Press: Honolulu, HI.

Stemmerman, L. 1981. A Guide to Pacific Wetland Plants. US Army Corps of Engineers, Honolulu District. 116pp.

USDA SCS. 1972. Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Hawaii Agricultural Experiment Station. Available online at: http://www.ctahr.hawaii.edu/soilsurvey/soils.htm

USDA NRCS. 1995. Hydric Soils State Lists, Hydric Soils of Hawaii. Available online at: ftp://ftp-fc.sc.egov.usda.gov/NSSC/Hydric_Soils/Lists/hi.pdf.

U.S. Fish and Wildlife Service (USFWS). No date, aerial photography 1/78 and/or 2/78 at 1:48,000, B-W. National Wetlands Inventory maps: Mokapu, Hawaii, Kaneohe, Hawaii, Koko Head, Hawaii and Honolulu, Hawaii.

USFWS. 1997. National List of Vascular Plant Species that Occur in Wetlands: 1996 National Summary. 209 pp. Available online at: http://www.fws.gov/nwi/bha/list96.html.

USFWS. 2007. City and County of Honolulu Conditional Use Permit Application No. 2007/CUP-141 for UPC Wind Farm, Kahuku, Oahu, Hawaii. Letter to City and County of Honolulu, Department of Planning and Permitting.

U.S. Geological Service (USGS). 1983. 7.5' topographic quadrangles: Mokapu, Hawaii, Kaneohe, Hawaii, Koko Head, Hawaii and Honolulu, Hawaii.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the flowering plants of Hawaii. 2 vols. Bishop Museum Special Publication 83. University of Hawaii Press and Bishop Museum Press: Honolulu, HI.

Wagner, W.L., D.R. Herbst and S.H. Sohmer. 1999. Manual of the flowering plants of Hawai‘i, Volumes I & II. Revised edition. University of Hawai‘i Press: Honolulu, HI.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kahuku Windfarm
Applicant/Owner: Firstwind
Investigator: Thair / Taira

Date: 10-6-2008 @2:40pm
County: Honolulu
State: Hawaii

Do Normal Circumstances exist on the site? [✓ Yes] No
Is the site significantly disturbed (Atypical Situation)? Yes [✓ No]
Is the area a potential Problem Area? Yes [✓ No]
(If needed, explain on reverse.)

Community ID: 1
Transect ID:
Plot ID:

GPS pt. 665

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Leucaena leucocephala		UPL	9.		
2. Senna surattensis		UPL	10.		
3. Pimenta dioica		--	11.		
4. Panicum maximum		FACU	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: mostly bare ground; few understory species

HYDROLOGY

___ Recorded Data (Describe in Remarks):
  ___ Stream, Lake, or Tide Gauge
  ___ Aerial Photographs
  ___ Other
___ No Recorded Data Available

Field Observations

Depth of Surface Water: ________ (in.)
Depth to Free Water in Pit: 0 ________ (in.)
Depth to Saturated Soil: ________ (in.)

Wetland Hydrology Indicators:
Primary Indicators:
  ___ Inundated
  ___ Saturated in Upper 12 Inches
  ___ Water Marks
  ___ Drift Lines
  ___ Sediment Deposits
  ___ Drainage Patterns in Wetlands
Secondary Indicators (2 or more required):
  ___ Oxidized Root Channels in Upper 12 Inches
  ___ Water-Stained Leaves
  ___ Local Soil Survey Data
  ___ FAC-Neutral Test
  ___ Other (Explain in Remarks)

Remarks:
old aqueduct site per USGS map

SOILS

Map Unit Name
(Series and Phase): ______

Drainage Class: ______
Field Observations
Confirm Mapped Type? Yes No

Taxonomy (Subgroup): ______

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/ Size/Contrast	Texture, Concretions, Structure, etc.
20cm	7.5YR 2.5/3				very fine

Hydric Soil Indicators:

___ Histosol
___ Histic Epipedon
___ Sulfidic Odor
___ Aquic Moisture Regime
___ Reducing Conditions
___ Gleyed or Low-Chroma Colors
___ Concretions
___ High Organic Content in Surface Layer in Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks: iron content high
soil pit dug to 14 inches (32.6 cm)

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes [✓ No] (Circle)
Wetland Hydrology Present? Yes [✓ No]
Hydric Soils Present? Yes [✓ No]

(Circle)
Is this Sampling Point Within a Wetland? Yes [✓ No]

Remarks:

Approved by HQUSACE 3/92

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kahuku Windfarm
Applicant/Owner: Firstwind
Investigator: Thaik/Taira

Date: 10-16-2008 @3:06pm
County: Honolulu
State: HI

Do Normal Circumstances exist on the site? [✓ Yes] No
Is the site significantly disturbed (Atypical Situation)? Yes [✓ No]
Is the area a potential Problem Area? Yes [✓ No]
(If needed, explain on reverse.)

Community ID: 2
Transect ID:
Plot ID:

GPS pt. 666

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. Guinea grass		FACU
2. Ficus macrophylla		--
3. Koa haole		UPL
4. Hibiscus tiliaceus		FACW
5.		
6.		
7.		
8.		

Dominant Plant Species	Stratum	Indicator
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks:

HYDROLOGY

☐ Recorded Data (Describe in Remarks):
  ☒ Stream, Lake, or Tide Gauge
  ☐ Aerial Photographs
  ☐ Other
☐ No Recorded Data Available

Field Observations:

Depth of Surface Water: 0 (in.)

Depth to Free Water in Pit: (in.)

Depth to Saturated Soil: (in.)

Wetland Hydrology Indicators:
Primary Indicators:
☐ Inundated
☐ Saturated in Upper 12 Inches
☐ Water Marks
☐ Drift Lines
☐ Sediment Deposits
☐ Drainage Patterns in Wetlands
Secondary Indicators (2 or more required):
☐ Oxidized Root Channels in Upper 12 Inches
☐ Water-Stained Leaves
☐ Local Soil Survey Data
☐ FAC-Neutral Test
☐ Other (Explain in Remarks)

Remarks: within Ohia'ai Gulch

Panicum maximum along banks, but no water

Debris within stream bed; but small seedling showing no recent flow

SOILS

Map Unit Name
(Series and Phase): ______________________

Taxonomy (Subgroup): ______________________

Drainage Class: ______________
Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/ Size/Contrast	Texture, Concretions, Structure, etc.
		25YR 3/3			very fine

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: core to 120mm (4.7in)
pit to 15 inches (38 cm)
+ Iron

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes [✓ No] (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes [✓ No]

(Circle)
Is this Sampling Point Within a Wetland? Yes [✓ No]

Remarks:

Approved by HQUSACE 3/92

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kahuku Windfarm
Applicant/Owner: Firstwind
Investigator: Thair / Taira

Date: 10-6-2008
County: Honolulu
State: Hawaii

Do Normal Circumstances exist on the site? [✓ Yes] No
Is the site significantly disturbed (Atypical Situation)? Yes [✓ No]
Is the area a potential Problem Area? Yes [✓ No]
(If needed, explain on reverse.)

Community ID: 3
Transect ID: ______
Plot ID: ______

GPS pt 667

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Xanthium strumarium		FACU	9.		
2. Sida rhombifolia		FACU	10.		
3. Cynodon dactylon		FACU	11.		
4. Stachytarpheta jamaicensis		FACU	12.		
5. Panicum maximum		FACU	13.		
6. Solanum torvum		- -	14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks:

HYDROLOGY

___ Recorded Data (Describe in Remarks):
  ☒ Stream, Lake, or Tide Gauge
  ___ Aerial Photographs
  ___ Other
___ No Recorded Data Available

Field Observations: very dry

Depth of Surface Water: ______ (in.)
Depth to Free Water in Pit: 0 ______ (in.)
Depth to Saturated Soil: ______ (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- ___ Inundated
- ___ Saturated in Upper 12 Inches
- ___ Water Marks
- ___ Drift Lines
- ___ Sediment Deposits
- ___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
- ___ Oxidized Root Channels in Upper 12 Inches
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ___ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks: @ bottom of Kalaekahipa gulch

SOILS

Map Unit Name
(Saries and Phase): ____________________

Taxonomy (Subgroup): ____________________

Drainage Class: ____________
Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/ Size/Contrast	Texture, Concretions, Structure, etc.
		5YR 3/3			

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: core to 14 cm (5.5)
pit to 11 inches (28 cm)
iron

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes [✓ No] (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes [✓ No]

(Circle)
Is this Sampling Point Within a Wetland? Yes [✓ No]

Remarks:

Approved by HQUSACE 3/92

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kahuku Wind farm
Applicant/Owner: Firstwind
Investigator: Thair / Taira

Date: 10-6-2008
County: Honolulu
State: HI

Do Normal Circumstances exist on the site? [✓ Yes] No
Is the site significantly disturbed (Atypical Situation)? Yes [✓ No]
Is the area a potential Problem Area? Yes [✓ No]
(If needed, explain on reverse.)

Community ID: 4
Transect ID:
Plot ID:

GPS pt. 668

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. Guinea grass		FACU
2. Koa haole		UPL
3. Schinus terebinthifolius		FACU-
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks:

HYDROLOGY

___ Recorded Data (Describe in Remarks):
- X Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- ___ Other

___ No Recorded Data Available

Field Observations:

Depth of Surface Water: ________(in.)

Depth to Free Water in Pit: 0 ________(in.)

Depth to Saturated Soil: ________(in.)

Wetland Hydrology Indicators:
Primary Indicators:
- ___ Inundated
- ___ Saturated in Upper 12 Inches
- ___ Water Marks
- ___ Drift Lines
- ___ Sediment Deposits
- ___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
- ___ Oxidized Root Channels in Upper 12 Inches
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ___ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks: within Ohua'ai Gulch
Tree roots exposed along banks

SOILS

Map Unit Name
(Series and Phase): ______

Drainage Class: ______

Field Observations
Confirm Mapped Type? Yes No

Taxonomy (Subgroup): ______

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/ Size/Contrast	Texture, Concretions, Structure, etc
		5YR 5/4			

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: core to 12cm (4.7in)
pit to 10 inches (25cm)
stream bottom mostly lined with rocks

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes [✓ No] (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes [✓ No]

(Circle)
Is this Sampling Point Within a Wetland? Yes [✓ No]

Remarks:

Approved by HQUSACE 3/92

APPENDIX B: LIST OF VEGETATION

This list is adapted from the report on plant survey conducted by Robert Hobdy at the First Wind project site in April 2007. It lists all the species found during the April 2007. The "X" in the second column indicates the species that were found by SWCA during the survey on June 4, 2008. The "XX" indicates the species that were not listed in the April 2007, but were found during the wetland plant survey on June 4, 2008.

Scientific name	Hawaiian, Common name(s)	Found on 6/4/2008	Wetland indicator	Status	Abundance in 4/2007
FERNS					
LINDSAEACEAE (Lindsaea Family)					
Sphenomeris chinensis (L.) Maxon	pala'ā		FAC*	I	rare
NEPHROLEPIDACEAE (Sword Fern Family)					
Nephrolepis exaltata (L.) Schott subsp. *hawaiiensis* W.H.Wagner	ni'ani'au		FAC*	E	rare
POLYPODIACEAE (Polypody Fern Family)					
Phymatosorus grossus (Langsd. & Fisch.) Brownlie	laua'e	**X**		N	rare
CONIFERS					
PINACEAE (Pine Family)					
Pinus caribaea Morelet	Caribbean pine			N	rare
MONOCOTS					
AGAVACEAE (Agave Family)					
Agave sisalana Perrine	sisal	**X**		N	rare
Cordyline fruticosa (L.) A. Chev.	ki	**X**		P	rare
ARECACEAE (Palm Family)					
Cocos nucifera L.	niu	**X**	FACU	P	rare
Phoenix x dactylifera	hybrid date palm	**X**		N	rare
CYPERACEAE (Sedge Family)					
Cyperus rotundus L.	nut-sedge		FACU	N	rare
POACEAE (Grass Family)					
Andropogon virginicus L.	broomsedge		FACU	N	rare
Brachiaria mutica (Forssk.) Stapf	California grass		FACW	N	rare
Chloris barbata (L.) Sw.	swollen fingergrass			N	rare
Chloris divaricata R.Br.	stargrass			N	uncommon
Chrysopogon aciculatus (Retz.) Trin.	pi'i pi'i			I	uncommon
Cynodon dactylon (L.) Pers.	Bermuda grass		FACU	N	uncommon

Dactyloctenium aegytium (L.) Willd.	beach wiregrass			N	rare
Digitaria ciliaris (Retz.) Koeler	Henry's crabgrass		FAC	N	uncommon
Digitaria insularis (L.) Mez ex Ekman	sourgrass	**X**	FACU	N	abundant
Eleusine indica (L.) Gaertn.	wiregrass		FACU-	N	uncommon
Eragrostis amabilis (L.) Wight & Arnott	Japanese lovegrass			N	rare
Eragrostis pectinacea (Michx.) Nees	Carolina lovegrass			N	rare
Panicum maximum Jacq.	Guinea grass	**X**	FACU	N	uncommon
Paspalum conjugatum Bergius	Hilo grass		FAC+	N	rare
Paspalum dilatatum Poir.	Dallis grass		FACU	N	uncommon
Paspalum fimbriatum Kunth	Panama paspalum		FAC	N	rare
DICOTS					
ACANTHACEAE (Acanthus Family)					
Asystasia gangetica (L.) T.Anderson	Chinese violet	**X**		N	common
AMARANTHACEAE (Amaranth Family)					
Achyranthes aspera L.	chirchita			N	uncommon
Alternanthera pungens Kunth	khaki weed			N	rare
Amaranthus spinosus L.	spiny amaranth	**X**	FACU-	N	uncommon
Amaranthus viridis L.	slender amaranth		FAC	N	rare
ANACARDIACEAE (Mango Family)					
Magnifera indica L.	mango		FACU	N	rare
Schinus terebinthifolius Raddi	Christmas berry	**X**	FACU-	N	common
APIACEAE (Parsley Family)					
Centella asiatica (L.) Urb.	Asiatic pennywort	**X**	FAC	N	rare
Ciclospermum leptophyllum (Pers.) Sprague	fir-leaved celery		NI	N	rare
ASTERACEAE (Sunflower Family)					
Acanthospermum australe (Loefl.) Kuntze	spiny bur			N	rare
Ageratum conyzoides L.	maile hohono		FAC*	N	uncommon
Bidens alba (L.) DC	common beggarticks	**X**		N	common
Calyptocarpus vialis Less.	straggler daisy			N	uncommon

Conyza bonariensis (L.) Cronquist	hairy horseweed	**X**		N	rare
Crassocephalum crepidioides (Benth.)S.Moore	red flower ragleaf		FAC	N	rare
Cyanthillium cinereum (L.) H. Rob.	little ironweed			N	rare
Emilia fosbergii Nicolson	red pualele			N	rare
Pluchea carolinensis (Jacq.) G.Don	sourbush	**X**		N	common
Pluchea indica (L.) Less.	Indian fleabane		FAC*	N	rare
Pluchea x foxbergii T.S. Cooper & M.M. Galang.		**XX**	FAC*	N	uncommon
Synedrella nodiflora (L.) Gaertn.	nodeweed		FAC*	N	rare
Verbesina encelioides (Cav.) Benth.&Hook.	golden crown-beard		FACU-	N	rare
Xanthium strumarium L.	cocklebur	**X**	FACU	N	uncommon
BIGNONIACEAE (Bignonia Family)					
Spathodea campanulata P.Beauv.	African tulip tree			N	rare
BORAGINACEAE (Borage Family)					
Heliotropium procumbens Mill.	clasping heliotrope			N	rare
BRASSICACEAE (Mustard Family)					
Lepidium virginicum L.	peppergrass			N	rare
CARICACEAE (Papaya Family)					
Carica papaya L.	papaya	**X**		N	rare
CASUARINACEAE (She-oak Family)					
Casuarina equisetifolia Stickm.	common ironwood	**X**		N	uncommon
CHENOPODIACEAE (Goosefoot Family)					
Chenopodium murale L.	'aheahea		FACU	N	rare
CONVOLVULACEAE (Morning Glory Family)					
Ipomoea obscura (L.) Ker-Gawl.	---------------			N	rare
COMMELINACEAE					
Commelina diffusa N.L. Burm.,	honohono	**XX**	FACW	N	rare
EUPHORBIACEAE (Spurge Family)					
Aleurites moluccana (L.) Willd.	kukui	**X**		P	rare

Chamaesyce hirta (L.) Millsp.	hairy spurge	**X**		N	rare
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	**X**		N	rare
Chamaesyce prostrata (Aiton.) Small	prostrate spurge			N	rare
Macaranga tanarius (L.) Mull. Arg.	parasol leaf tree	**X**		N	common
Phyllanthus debilis Klein ex Willd.	niruri			N	uncommon
Ricinus communis L.	Castor bean	**X**	FACU	N	rare
FABACEAE (Pea Family)					
Acacia confusa Merr.	Formosa koa			N	rare
Acacia farnesiana (L.) Willd.	klu			N	uncommon
Chamaecrista nictitans (L.) Moench	partridge pea			N	uncommon
Crotalaria incana L.	fuzzy rattlepod			N	rare
Crotalaria pallida Aiton	smooth rattlepod			N	rare
Crotalaria retusa L.	rattleweed			N	rare
Desmanthus pernambucanus (L.) Thellung	slender mimosa			N	uncommon
Desmodium incanum DC.	ka'imi clover			N	uncommon
Desmodium triflorum (L.)	three-flowered beggarweed	**X**	FACU*	N	rare
Erythrina variegata L.	tiger claw			N	rare
Indigofera hendecaphylla Jacq.	creeping indigo			N	rare
Leucaena leucocephala (Lam.) de Wit	koa haole	**X**		N	abundant
Macroptilium lathyroides (L.) Urb.	wild bean			N	rare
Medicago lupulina L.	black medick			N	rare
Mimosa pudica L.	sensitive plant	**X**	FACU	N	uncommon
Neonotonia wightii (Wight&Arnott) Lackey	glycine			N	rare
Samanea saman (Jacq.) Merr.	monkeypod	**X**		N	rare
Senna occidentalis (L.) Link	coffee senna	**X**		N	uncommon
Senna surratensis (N.L.Burm.) H.Irwin&Barneby	kolomona	**X**		N	common
Stylosanthes fruticosa (Retz.) Alston	shrubby pencilflower			N	uncommon
LAMIACEAE (Mint Family)					
Leonotis nepetifolia (L.) R.Br.	lion's ear	**X**	NI	N	uncommon
Ocimum gratissimum L.	wild basil			N	rare

MALVACEAE (Mallow Family)					
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	**X**		N	rare
Malva parviflora L.	cheeseweed			N	rare
Malvastrum coromandelianum (L.) Garcke.	false mallow		FACU	N	uncommon
Sida ciliaris (L.) D.Don	fringed fan petals	**X**		N	uncommon
Sida rhombifolia L.	Cuban jute	**X**	FACU	N	uncommon
Sida spinosa L.	prickly sida		NI	N	uncommon
Hibiscus tiliaceus L.	hau	**XX**	FACW	I	rare
MELASTOMATACEAE (Melastoma Family)					
Clidemia hirta (L.) D.Don	Koster's curse	**X**	FACU	N	rare
MENISPERMACEAE (Moonseed family)					
Cocculus trilobus (Thunb.) DC	Huehue	**XX**		I	
MORACEAE (Fig Family)					
Ficus macrophylla Desf. ex Pers.	Moreton Bay fig	**X**		N	rare
Ficus microcarpa L.fil.	Chinese banyan	**X**		N	rare
Ficus platypoda A.Cunn.ex Miq.	rock fig			N	uncommon
MYRSINACEAE (Myrsine Family)					
Ardisia elliptica Thunb.	shoebutton ardisia		FACU	N	rare
MYRTACEAE (Myrtle Family)					
Pimenta diocia (L.) Merr.	allspice	**X**		N	common
Psidium cattleianum Sabine	strawberry guava	**X**	FACU	N	rare
Psidium guajava L.	guava	**X**	FACU	N	uncommon
Syzygium cumini (L.) Skeels	Java plum	**X**		N	uncommon
NYCTAGINACEAE (Four-o'clock Family)					
Bougainvillea spectabilis Willd.	bougainvillea			N	rare
OXALIDACEAE (Wood Sorrel Family)					
Oxalis corniculata L.	'ihi'ai		FACU	P	uncommon
Oxalis debilis Kunth	pink wood sorrel			N	rare
PASSIFLORACEAE (Passion Flower Family)					

Passiflora edulis Sims	passion fruit	**X**		N	rare
Passiflora suberosa L.	corkystem passion flower			N	uncommon
PHYTOLACCACEAE (Pokeweed Family)					
Rivina humilis L.	coral berry			N	uncommon
PIPERACEAE (Pepper Family)					
Peperomia blanda Kunth var floribunda (Miq.) H.Huber	ala'alawainui	**X**		I	rare
PLANTAGINACEAE (Plantain Family)					
Plantago lanceolata L.	narrow-leaved plantain		FACU	N	uncommon
PLUMBAGINACEAE (Plumbago Family)					
Plumbago zeylanica L.	'ilie'e	**X**		I	rare
POLYGALACEAE (Milkwort Family)					
Polygala paniculata L.	milkwort		FACU*	N	rare
POLYGONACEAE (Buckwheat Family)					
Antigonon leptopus Hook & Arnott	Mexican creeper			N	rare
Rumex obtusifolius L.	bitter dock		FAC	N	rare
PRIMULACEAE (Primrose Family)					
Anagallis arvensis L.	scarlet pimpernel			N	rare
ROSACEAE (Rose Family)					
Osteomeles anthyllidifolia (Sm.) Lindl.	u'ulei	**X**		I	rare
RUBIACEAE (Coffee Family)					
Morinda citrifolia L.	noni	**X**	NI	P	rare
Spermacoce assurgens Ruiz & Pav.	buttonweed			N	rare
RUTACEAE (Rue Family)					
Citrus aurantiifolia (Christm.) Swingle	lime			N	rare
SAPOTACEAE (Sapodilla Family)					
Chrysophyllum oliviforme L.	satin leaf			N	uncommon
SOLANACEAE (Nightshade Family)					
Capsicum frutescens L.	chili pepper			N	rare
Solanum americanum Mill.	popolo			I	rare
Solanum torvum Sw.	pea aubergine			N	common
STERCULIACEAE (Cacao					

Family)					
Waltheria indica L.	'uhaloa	**X**		I	uncommon
THYMELAEACEAE ('Akia Family)					
Wikstroemia oahuensis (A. Gray) Rock	'akia	**X**	FAC	E	uncommon
TILIACEAE (Linden Family)					
Triumfetta rhomboidea Jacq.	diamond burrbark			N	rare
Triumfetta semitriloba Jacq.	Sacramento bur			N	uncommon
VERBENACEAE (Verbena Family)					
Lantana camara L.	lantana	**X**		N	common
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain			N	uncommon
Stachytarpheta jamaicensis (L.) Vahl	Jamaican vervain	**X**	FACU*	N	common
Verbena litoralis Kunth.	ha'u owi	**X**		N	rare

Appendix C.

D. L. ADAMS ASSOCIATES, LTD.
Consultants in Acoustics and Performing Arts Technologies

Environmental Noise Assessment
Kahuku Wind Farm
Kahuku, Oahu, Hawaii

September 15, 2009

DLAA Project No. 08-26

Prepared for:
First Wind Energy, LLC
Honolulu, Hawaii

970 N. KALAHEO AVE. • SUITE A311 • KAILUA, HAWAII 96734
808/254-3318 • FAX 808/254-5295
www.dlaa.com • hawaii@dlaa.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 EXECUTIVE SUMMARY

1.1 The proposed Kahuku Wind Farm project is comprised of 12 wind turbines located on approximately 500 acres near the town of Kahuku, Hawaii, on the north side of Oahu. The proposed site and immediately adjacent properties are currently zoned for agricultural use (AG-1 and AG-2). Other nearby areas that may be affected by the proposed wind farm are zoned as residential (R-5), business (B-1), preservation (P-1 and P-2), and Resort.

1.2 Long term ambient sound measurements were conducted on the proposed Kahuku Wind Farm project site and in the community surrounding the project site. The range of equivalent sound levels, L_{eq}, during the day (7:00 a.m. to 10:00 p.m.) and during the night (10:00 p.m. to 7:00 a.m.) and average calculated day-night level, L_{dn}, were reported for 12 locations. The average calculated L_{dn} ranged from 46 to 60 dBA on the project site and 53 to 68 dBA in the surrounding community. Contributing sound sources included traffic noise from Kamehameha Highway, aircraft flyovers, community noises, landscaping or grading equipment, and environmental sources such as wind and birds.

1.3 To assess potential sound impacts and compliance with associated regulations, a sound propagation model of the proposed wind turbines was developed. The results of the sound propagation model were compared to the State of Hawaii Department of Health maximum permissible limit as well as the existing ambient sound levels.

1.4 The predicted wind turbine sound levels do not exceed the Department of Health maximum permissible nighttime limit at the project property lines or in the community surrounding the proposed Kahuku Wind Farm project site.

1.5 The results of the sound propagation model were compared to the existing ambient sound levels measurements to determine if sound from the future wind turbines will impact the adjacent properties and nearby neighborhoods. A significant impact due to sounds from the proposed Kahuku Wind Farm project on the surrounding community is not expected. The agricultural areas closest to the proposed Kahuku Wind Farm (such as Kii Road) will experience the greatest increase in ambient sound, up to 3 dB, due to the operation of the wind turbines. The ambient sound environment in the communities surrounding the project site is projected to increase by less than 2 dB due to the project. A change in sound level of less than 3 dB is not considered significant.

1.6 On a subjective level, it is expected that the wind turbines will not usually be audible over typical ambient sounds that occur throughout the day and night. On very quiet nights when the wind speed is not sufficient to drive the wind turbine, sound from the turbine is expected to be minimal and not significant. However, a phenomenon is known to occur where local atmospheric and terrain conditions occasionally produce wind speeds sufficient to drive the wind turbines although the surrounding community experiences low wind speeds, and accordingly, low ambient sound levels. On these occasions, the wind turbines may be audible in the neighboring community.

2.0 PROJECT DESCRIPTION

The proposed Kahuku Wind Farm project is comprised of 12 wind turbines located on approximately 500 acres near the town of Kahuku, Hawaii, on the north shore of Oahu. The proposed site and immediately adjacent properties are currently zoned for agricultural use. Other nearby areas that may be affected by the proposed wind farm are zoned as residential, business, preservation, and resort.

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.

3.1 State of Hawaii Department of Health (DOH), Community Noise Control

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* sound 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, air traffic noise, or rail traffic noise. However, the Community Noise Control Rule does regulate noise related to agricultural, construction, and industrial activities, which may not be stationary. The proposed wind turbines are considered stationary sound sources and would be subject to the Community Noise Control Rule.

The maximum permissible sound levels are enforced by the State Department of Health (DOH) for any location at or beyond the First Wind property line and shall not be exceeded for more than 10% 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. Sound levels are typically measured at the property line or on the property of the complainant, and the maximum permissible sound level corresponds with the zoning of the complainant's property.

3.2 U.S. Environmental Protection Agency (EPA)

The U.S. EPA has identified a range of yearly day-night equivalent sound levels, L_{dn}, sufficient to protect public health and welfare from the effects of environmental noise [Reference 2]. The EPA has established a goal to reduce exterior environmental noise to an L_{dn} not exceeding 65 dBA and a future goal to further reduce exterior environmental noise to an L_{dn} not exceeding 55 dBA. Additionally, the EPA states that these goals are not intended as regulations as it has no authority to regulate noise levels, but rather they are intended to be viewed as levels below which the general population will not be at risk from any of the identified effects of noise.

4.0 EXISTING ACOUSTICAL ENVIRONMENT

4.1 Sound Measurement Procedure

Ambient sound level measurements were conducted to assess the existing acoustical environment in two areas which will be referred to as “Community” and “Property Line”. The Community measurements were conducted in six locations in the community surrounding the project site. The Property Line measurements were conducted at six locations on or near the property line of the proposed Kahuku Wind Farm. These 12 measurement locations are shown in Figure 2 and described below.

The ambient sound measurements took place during the months of November and December, 2008. Continuous, hourly, statistical sound levels were recorded for up to 10 days at each location. The measurements were taken using Larson-Davis Laboratories, Model 820, Type-1 Sound Level Meters together with Larson-Davis, Model 2560 Type-1 Microphones. Calibration was checked before and after the measurements with a Larson-Davis Model CAL200 calibrator. Both sound level meters, microphones, and the calibrator have been certified by the manufacturer within the recommended calibration period. The microphones were mounted on a tripod, generally about 5 feet above grade. A windscreen covered the microphone during the entire measurement period. The sound level meter was secured in a weather resistant case.

4.2 Community Measurement Locations and Results

Ambient sound measurements were conducted at six locations in the communities of Kahuku and Kuilima which surround the project site. The existing conditions and ambient sound environment for each location are described below. The results from these long-term sound measurements are graphically presented in Figures 3 through 8, which show the measured equivalent sound level, L_{eq}, and the 90 percent exceedance level, L_{90}, in A-weighted decibels (dBA) as a function of the measurement date and time. The results are also summarized for each location in Table 1 below.

Table 1. Community Sound Measurement Results

ID	Measurement Location	Daily Avg. Day Level $L_{eq\ (Day)}$[1]	Daily Avg. Night Level $L_{eq\ (Night)}$[2]	Daily Avg. Day-Night Level L_{dn}[3]	Daily Avg. L_{90}[4]
C1	Turtle Bay Resort	50 - 58 dBA	44 - 55 dBA	53 - 61 dBA	44 - 52 dBA
C2	Shrimp Trucks	61 - 67 dBA	56 - 61 dBA	64 - 68 dBA	50 - 55 dBA
C3	Kahuku Med Center	48 - 55 dBA	47 - 52 dBA	54 - 59 dBA	44 - 50 dBA
C4	Kahuku HS	46 - 59 dBA	46 - 53 dBA	53 - 60 dBA	43 - 52 dBA
C5	Mauka Village	51 - 58 dBA	44 - 54 dBA	53 - 61 dBA	39 - 49 dBA
C6	Kii Road Farms[5]	46 - 52 dBA	46 - 51 dBA	53 - 57 dBA	37 - 41 dBA

Notes:

1. $L_{eq\ (day)}$ is an average of the hourly equivalent sound levels during the daytime hours only (between 7:00 am and 10:00 pm) within a 24-hour measurement period. The range represents the quietest and noisiest day measured within the measurement period.

2. $L_{eq\ (night)}$ is an average of the hourly equivalent sound levels during the nighttime hours only (between 10:00 pm and 7:00 am) within a 24-hour measurement period. The range represents the quietest and noisiest night measured within the measurement period.
3. The L_{dn} represents the lowest and highest calculated average day-night level from the measurement period.
4. The L_{90} is an average of the 90% exceedance levels within a 24-hour measurement period. The range represents the lowest and highest calculated average over the duration of the measurement period. The ambient sound level is quieter than the L_{90} level only 10% of the time.
5. Peaks caused by overload or environmental conditions were removed from the average sound and day-night levels for the Kii Road location.

4.2.1 Turtle Bay Resort (C1)

The sound level meter was set up adjacent to the Kuilima Estates condominiums along the 17th hole of the George Fazio Golf Course. The surrounding area has been developed into resort, multi-family residential, and commercial (golf course) uses. A graphical representation of the long-term sound measurements results at this location is shown in Figure 3. The graph shows several “overload” conditions. These overload conditions were most likely caused by rainfall, and did not seem to adversely affect the L_{eq} and L_{90} sound measurements. Dominant sound sources at this site include golf carts, wind, and birds. Secondary sound sources include traffic noise from Kamehameha Highway, golfers, occasional landscaping equipment, and other community noises.

4.2.2 Shrimp Trucks (C2)

The sound level meter was set up approximately 100 feet from Kamehameha Highway at the intersection of Sand Road. The site is currently utilized by Romy’s, a commercial shrimp truck vendor. The surrounding area consists of mostly agricultural land. A graphical representation of the results from the long-term sound measurements at this location is shown in Figure 4. The ambient sound levels are dynamic and depend significantly on the vehicular traffic patterns of Kamehameha Highway. However, the graph shows several peaks that were caused by unknown sound sources. The dominant sound source at this site includes noises from the commercial facility and vehicular traffic noise from Kamehameha Highway. Secondary sound sources include wind, birds, and occasional agricultural equipment.

4.2.3 Kahuku Medical Center (C3)

The sound level meter was located on the grounds of the Kahuku Medical Center, approximately 500 feet from Kamehameha Highway. The Medical Center is surrounded by agricultural land and residential homes. A graphical representation of the results from the long-term sound measurements at this location is shown in Figure 5. The ambient sound levels are relatively dynamic and depend somewhat on the vehicular traffic patterns from nearby roadways or use of the medical facility.

Dominant sound sources at this site include wind, birds, and noises from the medical facility. Secondary sound sources include traffic noise from Kamehameha Highway, occasional landscaping equipment and aircraft flyovers.

4.2.4 Kahuku High and Intermediate School (C4)

The sound level meter was located at Building Z of the Kahuku High and Intermediate School, adjacent to the nearby playing fields. Commercial buildings and a residential community flank the school property. A graphical representation of the results from the long-term sound measurements at this location is shown in Figure 6. It is apparent from the graph that the ambient sound environment in the vicinity of the school changes significantly when school is not in session. Dominant sound sources at this site include sounds typical of a school environment, such as children, alarm bells, sports fields, etc. Secondary sound sources include wind, birds, traffic noise from Kamehameha Highway, occasional aircraft flyovers, and other community noises.

4.2.5 Mauka Village (C5)

A residential neighborhood mauka of Kamehameha Highway was chosen for one of the meter locations in the community. The meter was located at a private residence on Pahelehala Loop which is east near of the proposed Kahuku Wind Farm project site. The Mauka Village is surrounded by agricultural land, Kahuku Elementary School, and the Kahuku Medical Center. A graphical representation of the results from the long-term sound measurements at this location is shown in Figure 7. The ambient sound levels are dynamic and depend significantly on environmental and community activities throughout the day. Dominant sound sources at this site include vehicular traffic on Pahelehala Loop, chickens, pedestrians, landscaping equipment, etc. Secondary sound sources include wind, birds, and occasional aircraft flyovers.

4.2.6 Kii Road Farms (C6)

The sound level meter was set up adjacent to the Kii Road, mauka of Kamehameha Highway. This location is primarily agricultural land which flanks the eastern border of the proposed Kahuku Wind Farm project site. A graphical representation of the results from the long-term sound measurements at this location is shown in Figure 8. The graph shows peaks that were caused by overload conditions such as wind gusts, rain, aircraft flyovers or other unknown noise sources. These conditions may have adversely affected the L_{eq} and L_{90} sound measurements and the average day-night level. The dominant sound source at this site includes wind, rain, chickens, and birds. Secondary sound sources include aircraft flyovers, and occasional agricultural equipment.

4.3 Property Line Measurement Locations and Results

Ambient sound measurements were also conducted on the proposed Kahuku Wind Farm project site. Six sound level meters were set up at various locations on or near the property line, as shown in Figure 2. The results from these long-term sound measurements are graphically presented in Figures 9 through 14, which show the measured equivalent sound level, L_{eq}, and the 90 percent exceedance level, L_{90}, in A-weighted decibels (dBA) as a function of the measurement date and time. The results are also summarized for each location and summarized in Table 2 below.

Table 2. Property Line Sound Measurement Results

ID	**Measurement Location**	**Daily Avg. Day Level $L_{eq\,(Day)}$[1]**	**Daily Avg. Night Level $L_{eq\,(Night)}$[2]**	**Daily Avg. Day-Night Level L_{dn}[3]**
P1	North Property Line	45 - 54 dBA	42 - 47 dBA	50 - 56 dBA
P2	North East Property Line	44 - 55 dBA	40 - 53 dBA	47 - 60 dBA
P3	East Property Line	44 - 53 dBA	41 - 44 dBA	48 - 53 dBA
P4	South Property Line	50 - 60 dBA	41 - 48 dBA	50 - 60 dBA
P5	West Property Line	42 - 54 dBA	38 - 44 dBA	47 - 52 dBA
P6	Center of Property	42 - 54 dBA	39 - 43 dBA	46 - 54 dBA

Notes:

1. $L_{eq(day)}$ is an average of the hourly equivalent sound levels during the daytime hours only (between 7:00 am and 10:00 pm) within a 24-hour measurement period. The range represents the quietest and noisiest day measured within the 7 day measurement period.
2. $L_{eq(night)}$ is an average of the hourly equivalent sound levels during the nighttime hours only (between 10:00 pm and 7:00 am) within a 24-hour measurement period. The range represents the quietest and noisiest night measured within the 7 day measurement period.
3. The L_{dn} represents the lowest and highest calculated average day-night level from the 7 day measurement period.

The proposed Kahuku Wind Farm site is approximately 500 acres currently zoned for agricultural uses such as cattle grazing. As shown in the Figures 9 through 14, the ambient sound levels on the project site are dynamic and depend significantly on environmental sound sources. The measurements are fairly consistent for all measurement locations which indicate a uniform ambient sound environment throughout the project site. During the measurement period, grading equipment may have been used on the project site. Dominant sound sources at this site include wind and birds. Secondary sound sources include cattle, farming equipment, occasional aircraft flyovers, and vehicular traffic noise from Kamehameha Highway.

5.0 SOUND PROPAGATION MODEL

A sound propagation model of the site and surrounding areas was developed to predict wind turbine sounds at the property lines of the proposed wind farm and at nine locations in the surrounding community. The following paragraphs provide an overview of the sound propagation model and its development.

5.1 Sound Propagation Model Overview

To evaluate the sound impact of each wind turbine in each direction, the DataKustik CadnaA (version 3.7.123) software program [Reference 3] was used to develop a sound propagation model. The software program uses the calculation procedures of International Standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* [Reference 4].

The Kahuku Wind Farm sound propagation model was developed using the information, site plan, and topographical data provided by First Wind. Zoning maps for the area were obtained from the City and County of Honolulu: Department of Planning and Permitting website [Reference 5].

5.2 Wind Turbine Sound Data

The proposed wind turbines are Clipper Model C96 turbines which have 96 meter diameter three-blade rotors and 80 meter hub heights. The current standard for measuring and reporting the sound power of wind turbines is the International Standard IEC 61400-11:2006 *Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques* [Reference 6]. A complete sound power data report, per IEC 61400 requirements, is currently not available for the Clipper C96 turbines. First Wind has indicated that Clipper is working to provide this data.

The sound propagation model was based on sound data for similar wind turbines and proprietary information provided by First Wind. It is expected that the sound data for the Clipper C96 turbines will be similar to the sound data that was estimated for use in the model. However, it is possible that the actual wind turbine sound data could vary slightly from the estimated sound data.

5.3 Weather and Sound Propagation Assumptions

The sound propagation model assumes that meteorological conditions are favorable to sound propagation. That is, every receiver is assumed to be downwind in the presence of a well developed temperature inversion. In reality, every receiver cannot be downwind simultaneously so this provides a somewhat worst case scenario, which is consistent with ISO 9613-2.

The software program does provide the means to model other meteorological conditions including predominant wind speeds and directions. However, worst-case assumptions were used in the analyses, which means that the actual sound levels due to turbine sound propagation should be equal to or less than the predicted levels.

5.4 Ground Attenuation Coefficient

The ground attenuation coefficient is another condition used in the sound propagation model that can influence the predicted sound levels. A ground attenuation coefficient of 1.0 indicates that the ground is acoustically very absorptive, i.e., dense foliage or fresh powder snow. A coefficient of 0 indicates an acoustically reflective surface such as still water or concrete. A comparison of predicted sound levels using coefficients of 0.0 and 1.0 showed an insignificant difference (+/- 0.5 dB). Consequently, ground attenuation does not appear to be a large factor at the Kahuku Wind Farm site, likely due to the terrain features and the height of the turbines. In our model and reported results, we have used a ground attenuation coefficient of 0 as a worst-case scenario.

5.5 Receiver Height

In the sound propagation model, predicted sound levels at the receiver locations have been calculated at 4 meters (approximately 13 feet) above ground. This height represents a worst case scenario of a listener on a second story balcony or in a second story bedroom with an open window. This also provides a safety factor when considering shadowing due to terrain features, in case there are slight inaccuracies in the topographical data used in the model. Typically, measurements would most often be made at 1.5 meters (approximately 5 feet) above ground if testing for compliance with the Community Noise Control Rule. However, the regulation does allow measurements to be made higher on the vertical plane of the property line, or within the complainant’s property. In almost all cases, predicted sound levels at 1.5 meters would be equal to or slightly less than at 4 meters.

5.6 Predicted Wind Turbine Sound Levels

The predicted sound levels at selected sites that are of specific concern regarding potential sound impacts are shown in Table 3 below. Figures 15 and 16 show the predicted sound level contours and area contours, respectively, for the neighborhoods surrounding the Kahuku Wind Farm project site.

Table 3. Predicted Wind Turbine Sound Levels at Selected Sites

Location	Distance[1]	Predicted Sound Level[2]	DOH Limit[3]
Turtle Bay Resort	3,050m(10,000ft)	< 33 dBA	50 dBA
Turtle Bay Entrance	2,000m (6,500ft)	33 dBA	50 dBA
Shrimp Trucks	650m (2,100ft)	48 dBA	50 dBA
Kahuku Med Center	1,500m (5,000ft)	41 dBA	50 dBA
Kahuku HS	1,950m (6,400ft)	38 dBA	45 dBA
Mauka Village	1,300m (4,300ft)	42 dBA	45 dBA
Kii Road Farms	600m (1,900ft)	46 dBA	70 dBA
Marconi Area	1,500m (4,900ft)	40 dBA	70 dBA
Kupuna Housing	2,300m (7,600ft)	36 dBA	45 dBA
Site Property Lines	Varies	54-58 dBA	70 dBA

Notes:

1. Approximate distance from indicated location to closest wind turbine.
2. The predicted sound levels are based on the conditions indicated in Sections 5.2 – 5.5.
3. The DOH maximum permissible nighttime sound limits are based on the zoning of the indicated location, based on the maps obtained from the City and County of Honolulu: Department of Planning and Permitting website [Reference 5].

6.0 POTENTIAL NOISE IMPACTS

6.1 Compliance with State of Hawaii Community Noise Control Rule

Maximum permissible sound limits are enforced by the State Department of Health (DOH) for any location at or beyond the First Wind property line. The specified sound limits which apply are a function of the zoning and time of day as shown in Figure 1. Sound levels are typically measured at the property line or on the property of a complainant, and the maximum permissible sound level corresponds with the zoning of the complainant's property. However, the ambient sound level is taken into account by the DOH. As stated in Section 11-46-9-g of the State of Hawaii Community Noise Control Rule [Reference 1],

> *"Measurements shall normally not be used for enforcement unless the noise level at a point of measurement is more than three decibels greater than the ambient or background noise level."*

The DOH takes the ambient sound environment into account when enforcing its limits. Therefore, the DOH typically allows for a 3 dB increase in sound level over the ambient sound when the ambient sound is combined with the sound source of interest.

As shown in the table above, the predicted wind turbine sound levels do not exceed the DOH maximum permissible sound limits at the property line or in the community surrounding the proposed Kahuku Wind Farm project site.

6.2 Wind Turbine Noise Impact on Neighboring Properties

As demonstrated by the results of the sound propagation model, sound levels from the proposed Kahuku Wind Farm will increase the ambient sound environment within the project site. However, wind turbine sound levels have been shown to meet the DOH maximum permissible noise limits based on the applicable zoning of the neighboring properties. To determine if sound from the future wind turbines will impact the adjacent properties and nearby neighborhoods, the results of the sound propagation model have been compared to the existing ambient sound levels measured at locations C1 through C6, as shown in Table 4 below.

Table 4: Predicted Wind Turbine and Existing Ambient Sound Levels in the Vicinity of the Kahuku Wind Farm

Location	DOH Limit	Predicted Sound Level[1]	Measured Min. Average $L_{eq(Night)}$[2]	Combined Sound Level[3]	Δ due to New Wind Turbines[4]
Turtle Bay Resort	50 dBA	33 dBA	44 dBA	44 dBA	+ 0 dB
Shrimp Trucks	50 dBA	48 dBA	56 dBA	56 dBA	+ 0 dB
Kahuku Med Center	50 dBA	41 dBA	47 dBA	48 dBA	+ 1 dB
Kahuku HS	45 dBA	38 dBA	46 dBA	47 dBA	+ 1 dB
Mauka Village	45 dBA	42 dBA	44 dBA	46 dBA	+ 2 dB
Kii Road Farms	70 dBA	46 dBA	46 dBA	49 dBA	+ 3 dB

Notes:

1. Sound levels were predicted from the sound propagation model described Section 5.6
2. $L_{eq\ (night)}$ is an average of the hourly equivalent sound levels during the nighttime hours only (between 10:00 pm and 7:00 am) within a 24-hour measurement period. The minimum represents the quietest night measured within the measurement period (refer to the community sound measurement results in Section 4.2) and is a conservative noise descriptor to which the predicted turbine noise can be compared.
3. Combined sound level is the logarithmic addition of the predicted sound level plus the measured ambient sound level.
4. The predicted change (in dB) due to wind turbines is the amount by which the ambient sound environment is expected to increase with the addition of the Kahuku Wind Farm project.

Operation of the wind turbines at the proposed Kahuku Wind Farm are not expected to increase the ambient sound environment in the surrounding community near the project site by a significant amount. A change in sound level of less than 3 dB is not considered a significant noise impact because it is not a perceptible difference to most listeners. In fact, the wind turbine sound levels are predicted to be lower than the measured average minimum nighttime sound levels for locations C1 through C5 and may be masked by existing ambient sound sources such as wind.

The agricultural areas closest to the proposed Kahuku Wind Farm (such as Kii Road) will experience the greatest increase in ambient sound, up to 3 dB, but the total sound level will still be well below the DOH limit. Therefore, a noise impact is not expected based on the use of the land.

Based on the results of the sound propagation model, it is expected that the wind turbines will not be audible over typical ambient sounds that occur throughout the day and night. On very quiet nights when the wind speed is not sufficient to drive the wind turbine, sound from the turbine is expected to be minimal and not significant. As a result, the ambient sound environment is not anticipated to change at all during these periods of low wind. However, a phenomenon is known to occur where local atmospheric and terrain conditions occasionally produce wind speeds that are higher at hub height than predicted from the ground wind speed at the various receiver locations down slope. During these conditions, the wind turbines may be in operation even though the surrounding community experiences low wind, and accordingly, low ambient sound levels. On these occasions, the wind turbines may be audible in the neighboring community.

6.3 Compliance with EPA Noise Guidelines

The EPA has an existing design goal of $L_{dn} \leq 65$ dBA and a future design goal $L_{dn} \leq 55$ dBA for exterior sound levels. It is important to note that the EPA noise guidelines are design goals and not enforceable regulations. However, these guidelines and design goals are useful tools for assessing the sound environment.

The results from the long-term sound measurements conducted in the community surrounding the project site show calculated day-night sound levels ranging from 53 to 61 dBA. The L_{dn} at the Shrimp Truck measurement location (C2) was much higher, 68 dBA, due to its close proximity to Kamehameha Highway.

Once the wind turbines are in operation, nighttime ambient sound levels may increase in the Kii Road area. The L_{dn} at Kii Road is estimated to increase by approximately 3 dB. The L_{dn} in the neighborhoods closest to the wind farm is expected to increase by up to 2 dB. In other areas of the surrounding community, the L_{dn} is expected to increase by less than 1 dB.

6.4 Project Construction Noise

Development of project areas will involve excavation, grading, and other typical construction activities during construction. The various construction phases of the Kahuku Wind Farm will generate significant amounts of noise on-site. The actual sound levels produced during construction will be a function of the methods employed during each stage of the construction process. Typical ranges of construction equipment sound levels are shown in Figure 17. Earth-moving equipment, e.g., bulldozers and diesel-powered trucks, will probably be the loudest equipment used during construction.

7.0 MITIGATION OF NOISE IMPACTS

7.1 Mitigation of Wind Turbine Noise

Wind turbine sound levels from the Kahuku Wind Farm are not expected to significantly impact the adjacent properties or the surrounding area. Therefore, noise mitigation should not be necessary.

7.2 Mitigation of Construction Noise

In cases where construction noise exceeds, or is expected to exceed the State’s maximum permissible property line noise levels [Reference 1], a permit must be obtained from the State DOH to allow the operation of vehicles, cranes, construction equipment, power tools, etc., which emit sound levels in excess of the "maximum permissible" levels.

In order for the State DOH to issue a construction noise permit, the Contractor must submit a noise permit application to the DOH, which describes the construction activities for the project. Prior to issuing the noise permit, the State DOH may require action by the Contractor to incorporate noise mitigation into the construction plan. The DOH may also require the Contractor to conduct noise monitoring or community meetings inviting the neighboring residents and business owners to discuss construction noise. The Contractor should use reasonable and standard practices to mitigate noise, such as using mufflers on diesel and gasoline engines, using properly tuned and balanced machines, etc. However, the State DOH may require additional noise mitigation, such as temporary noise barriers, or time of day usage limits for certain kinds of construction activities.

Specific permit restrictions for construction activities [Reference 1] are:

> *"No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels ... before 7:00 a.m. and after 6:00 p.m. of the same day, Monday through Friday."*
>
> *“No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels... before 9:00 a.m. and after 6:00 p.m. on Saturday."*
>
> *“No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels on Sundays and on holidays."*

The use of hoe rams and jack hammers 25 lbs. or larger, high pressure sprayers, and chain saws are restricted to 9:00 a.m. to 5:30 p.m., Monday through Friday. In addition, construction equipment and on-site vehicles or devices whose operations involve the exhausting of gas or air, excluding pile hammers and pneumatic hand tools weighing less than 15 pounds, must be equipped with mufflers [Reference 1].

REFERENCES

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

2. *Toward a National Strategy for Noise Control*, U.S. Environmental Protection Agency, April 1977.

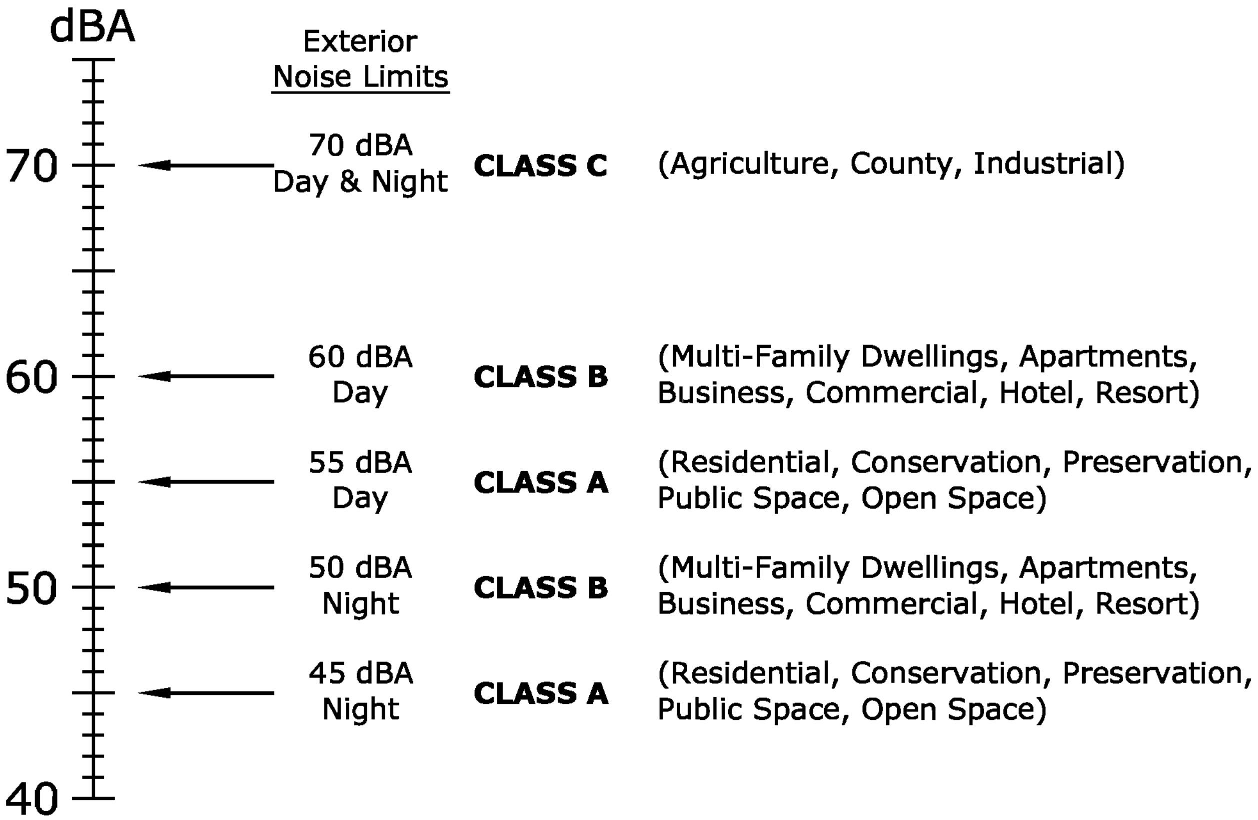
3. *DataKustik CadnaA software program*, Version 3.7; DataKustik GmbH, 2007.

4. International Standard ISO 9613-2:1996, *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of Calculation.*

5. City and County of Honolulu (2008), Interactive GIS Maps and Data, Retrieved November 25, 2008, from http://gis.hicentral.com/.

6. International Electrotechnical Commission (IEC) 61400-11:2006 *Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques, Edition 2.1 2006-11.*

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)



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Hawaii Maximum Permissible Sound Levels for Various Zoning Districts

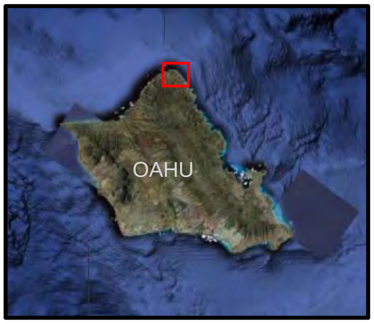
Kahuku Wind Farm

Not to Scale

Date	Project No.	Drawn By	Figure No
Sept 2009	08-26	TRB	1

LEGEND

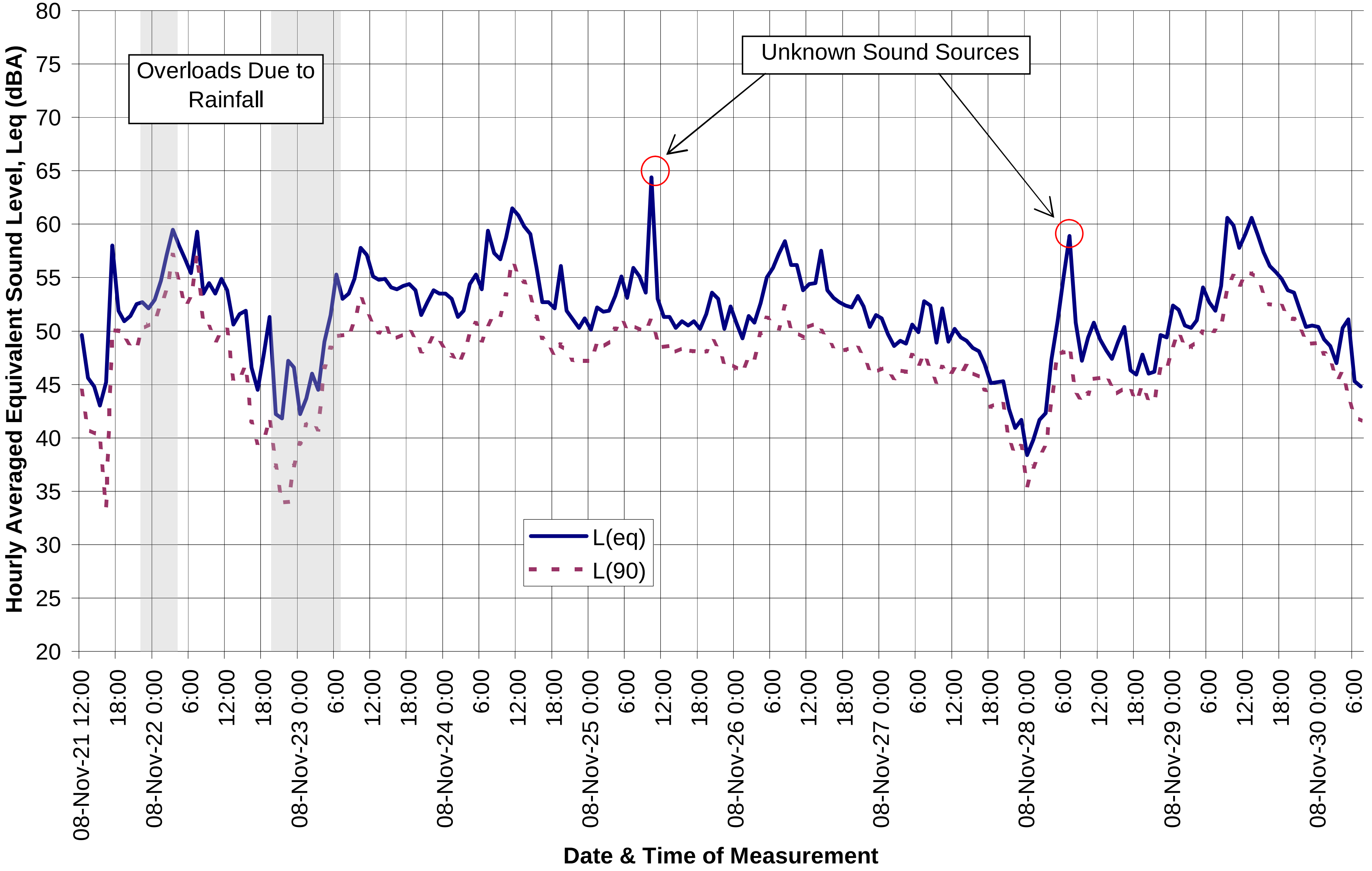
C1	Turtle Bay Resort	P1	North Property Line
C2	Shrimp Trucks	P2	North East Property Line
C3	Kahuku Medical Center	P3	East Property Line
C4	Kahuku High School	P4	South Property Line
C5	Mauka Village	P5	West Property Line
C6	Kii Road Farms	P6	Center of Property



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Sound Measurement Locations

Sept 2009	08-26	DFD	Figure No 2
Date	Project No.	Drawn By	



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

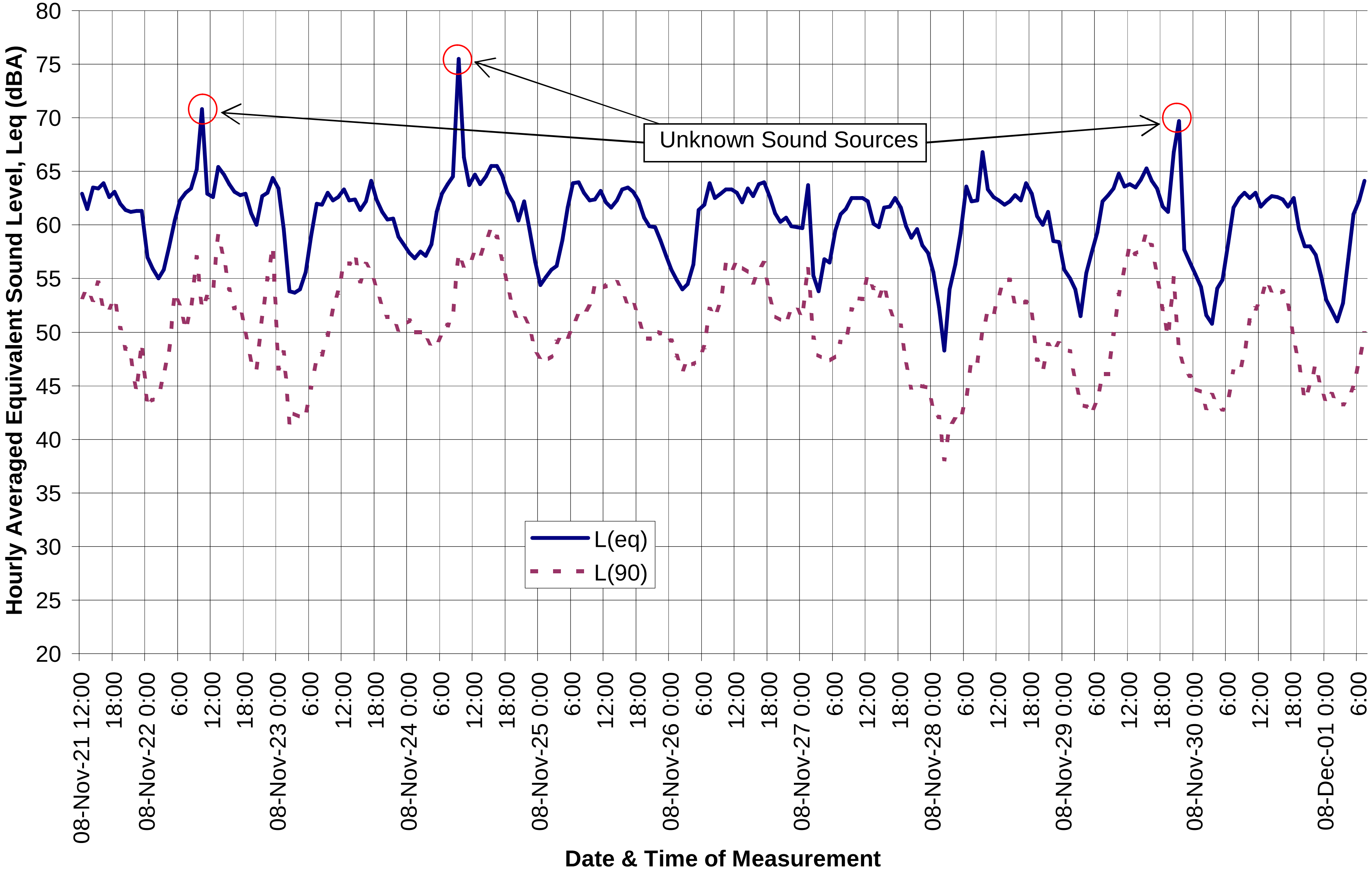
Graph of Long Term Sound Measurements - Turtle Bay Resort (C1)

Sept 2009
Date

08-26
Project No.

KMF
Drawn By

Figure No
3

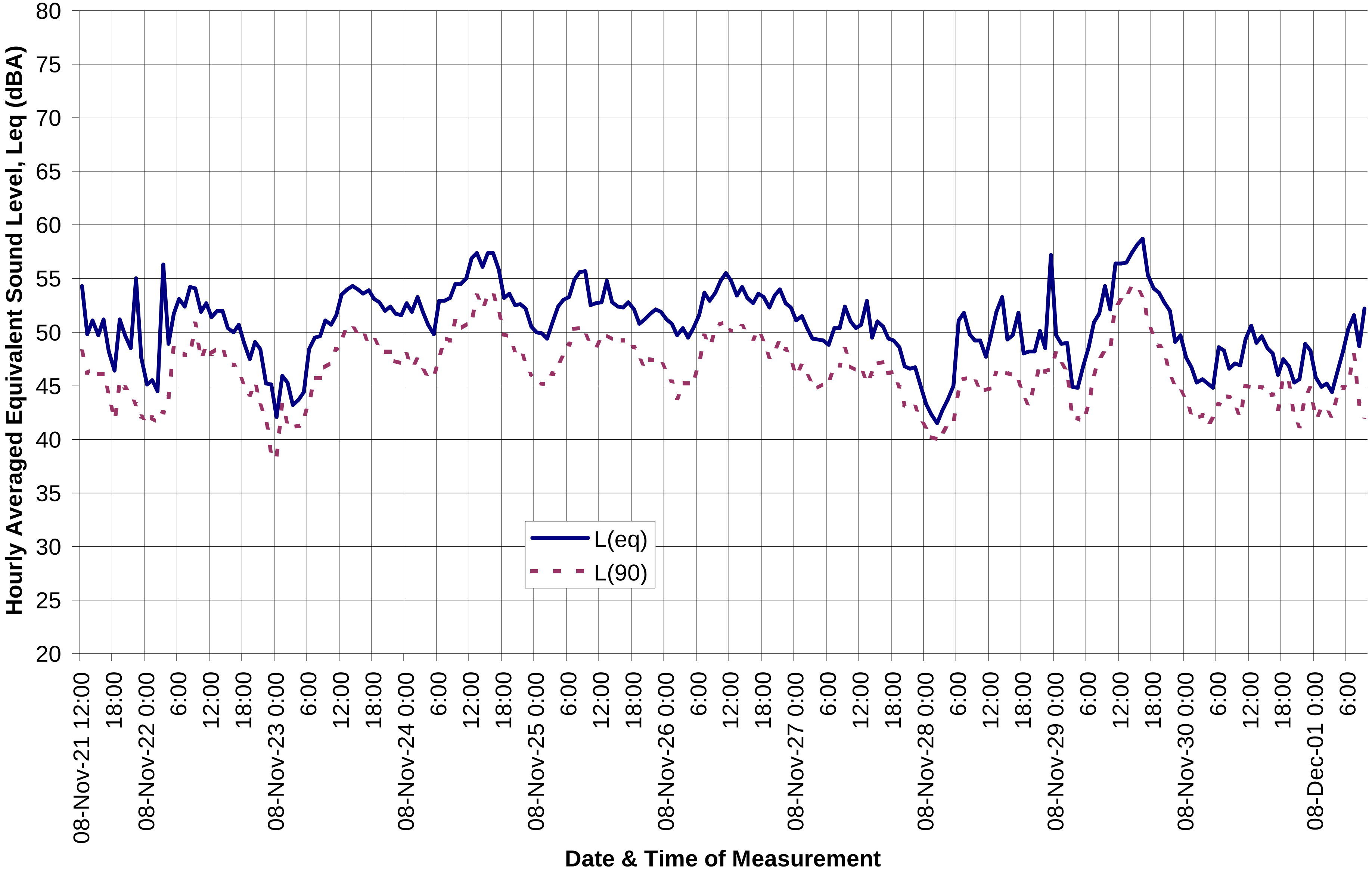


Graph of Long Term Sound Measurements - Shrimp Trucks (C2)

D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Sept 2009	08-26	KMF
Date	Project No.	Drawn By

Figure No
4

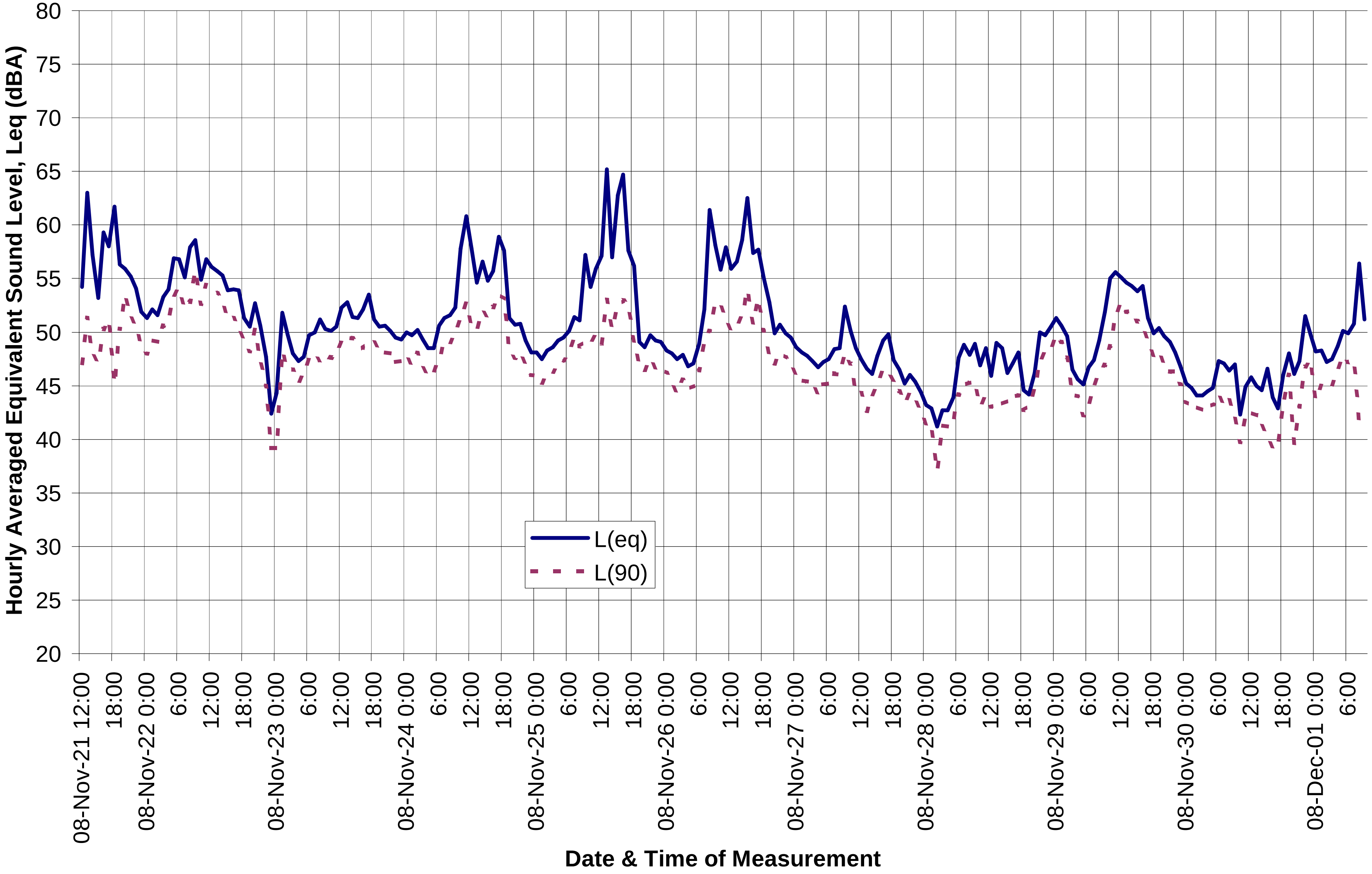


D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3316 FAX 808/254-5295

Graph of Long Term Sound Measurements - Kahuku Medical Center (C3)

Sept 2009	08-26	KMF
Date	Project No.	Drawn By

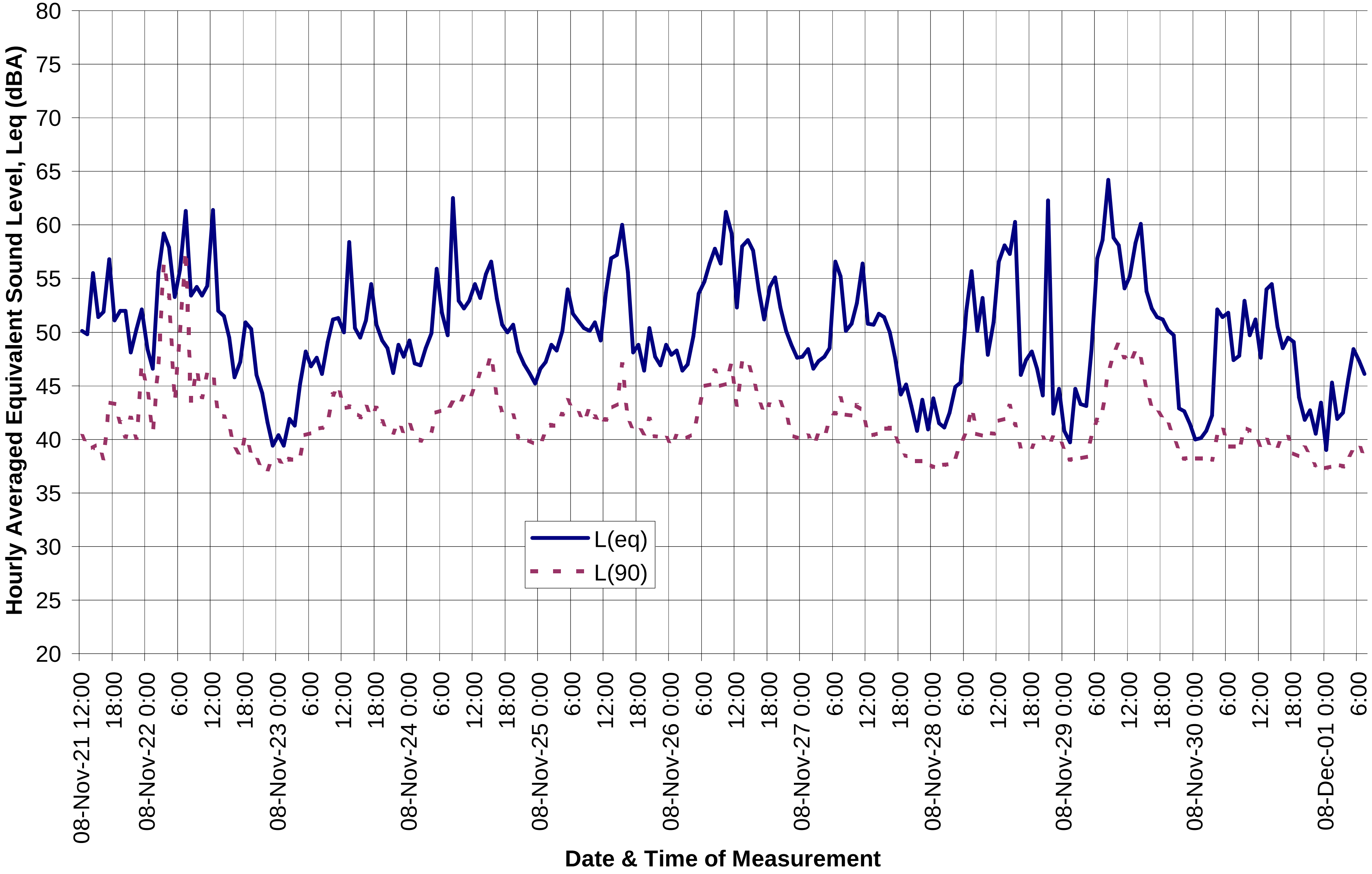
Figure No
5



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - Kahuku High School (C4)

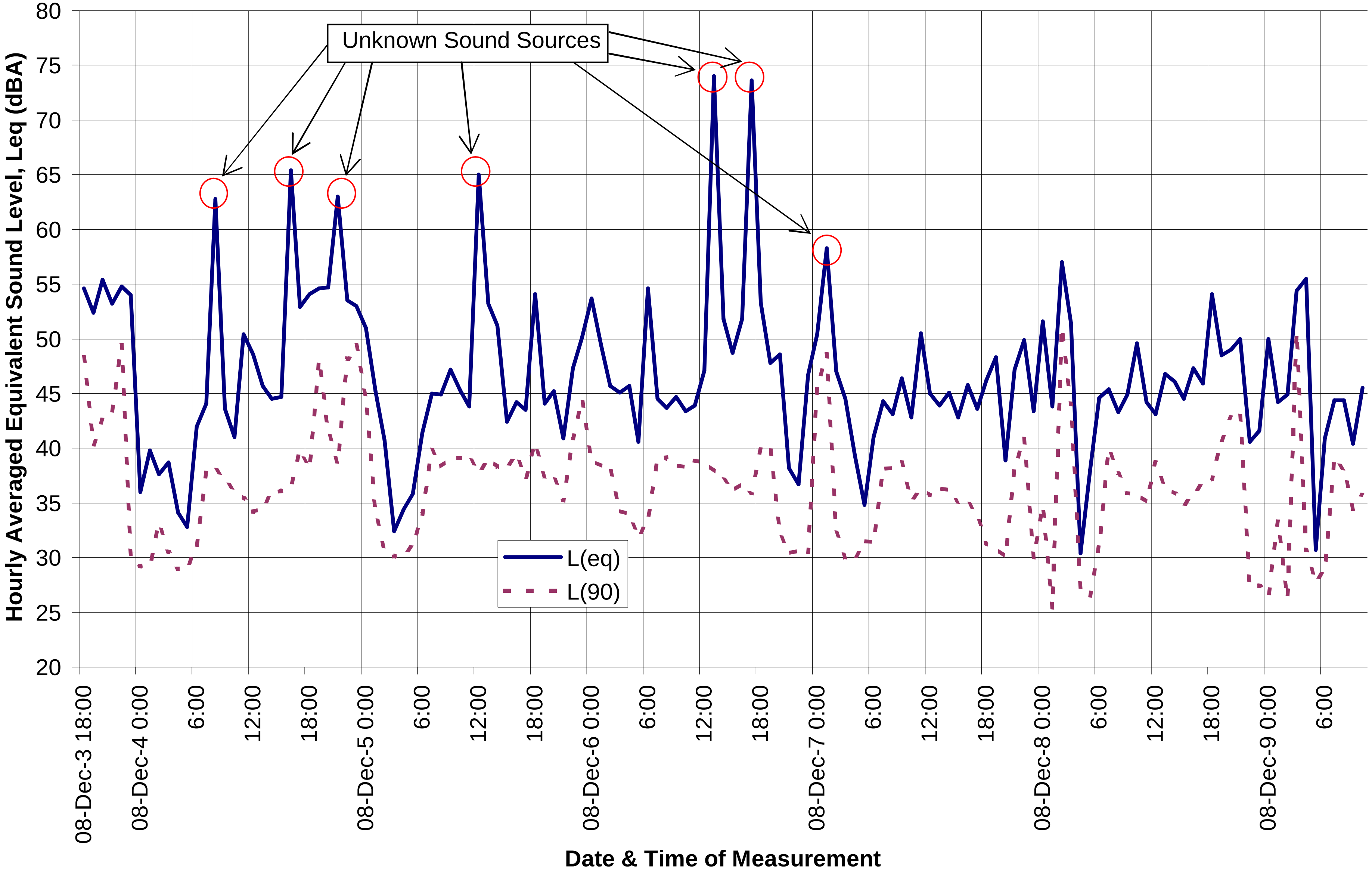
Sept 2009	08-26	KMF	Figure No 6
Date	Project No.	Drawn By	



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - Mauka Village (C5)

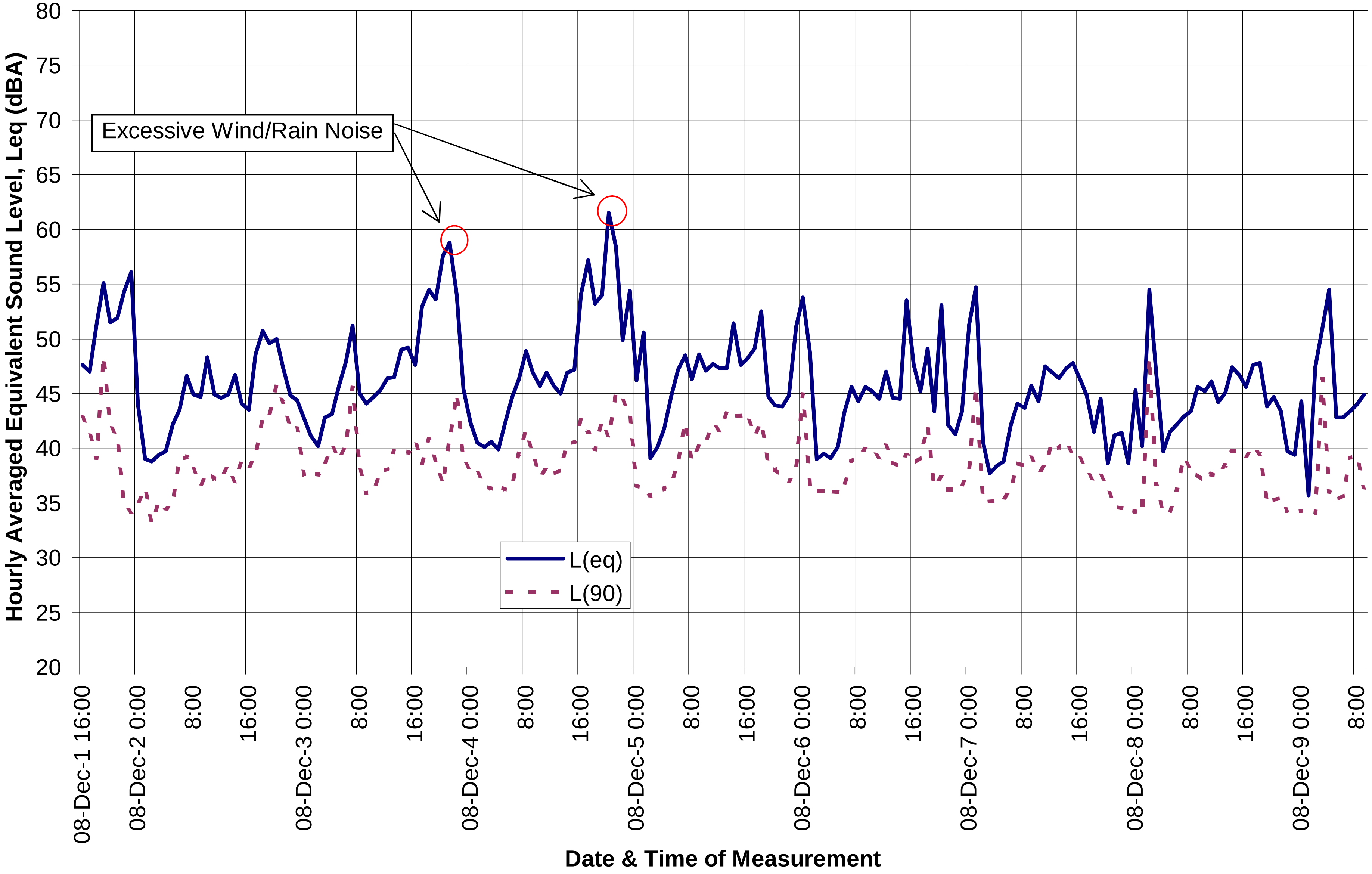
Sept 2009	08-26	KMF	Figure No
Date	Project No.	Drawn By	7



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - Kii Road Farms (C6)

Date	Project No.	Drawn By	Figure No
Sept 2009	08-26	KMF	8

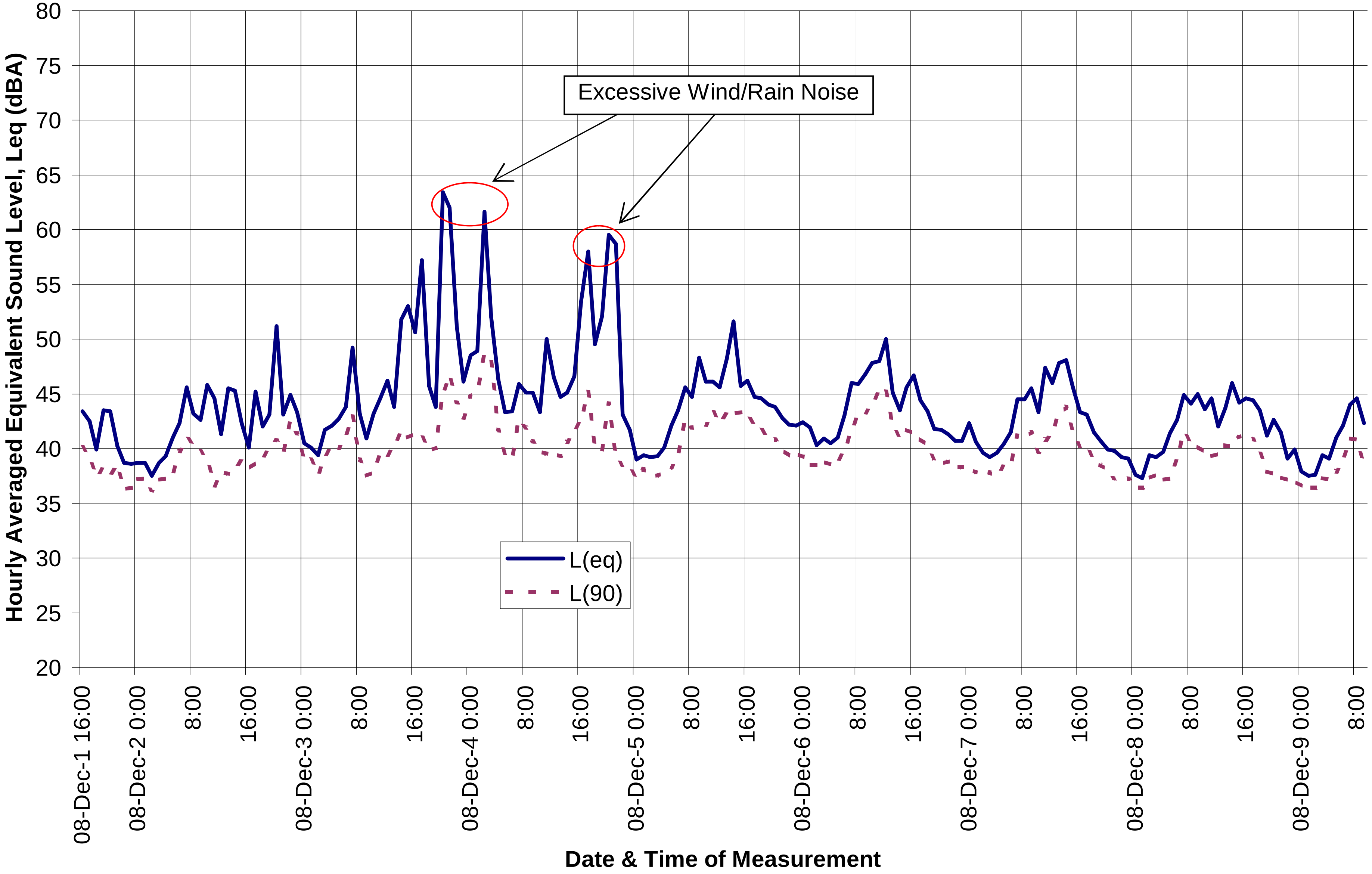


Graph of Long Term Sound Measurements - North Property Line (P1)

D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Sept 2009	08-26	KMF
Date	Project No.	Drawn By

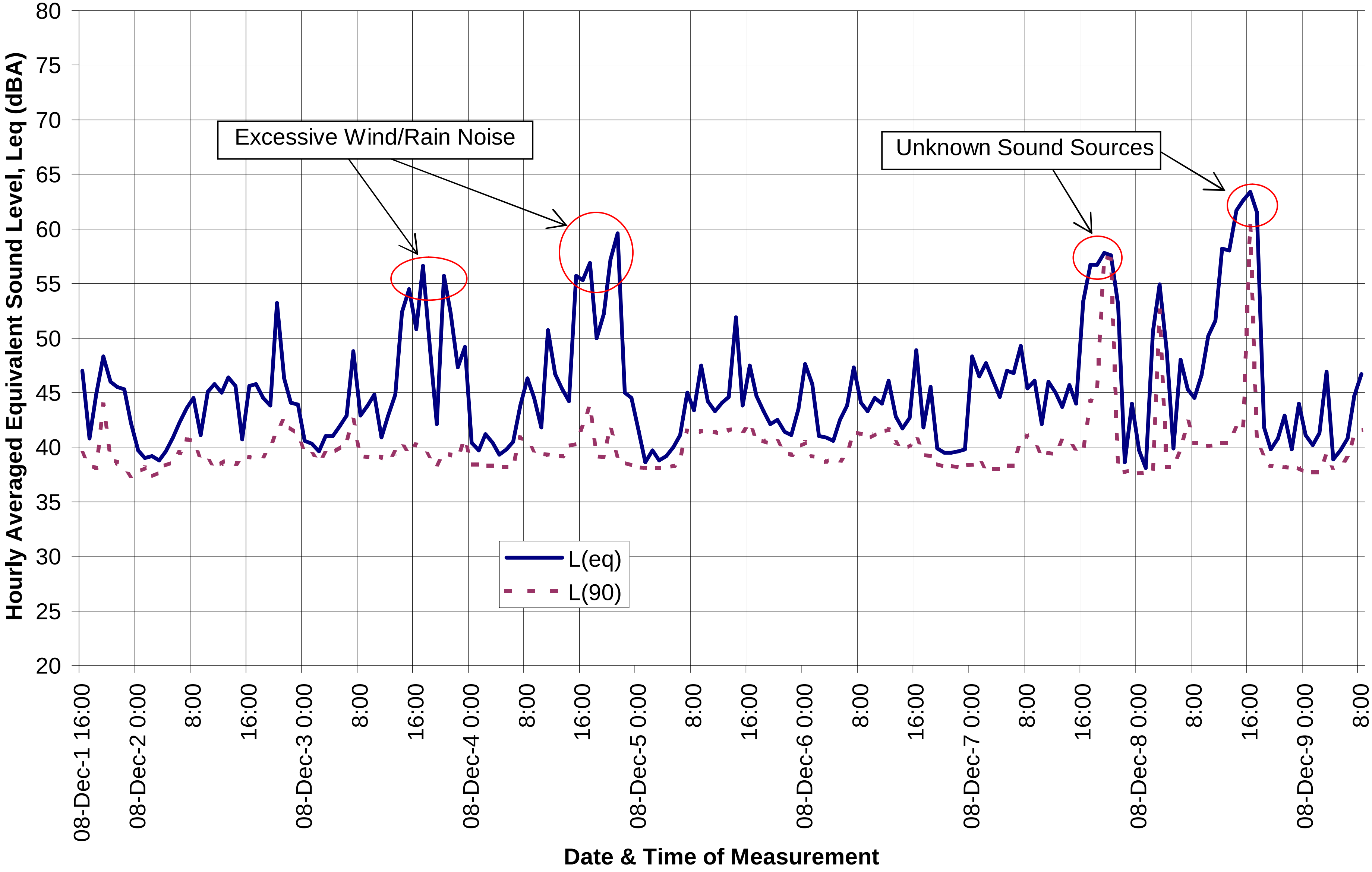
Figure No
9



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - North East Property Line (P2)

Date	Project No.	Drawn By	Figure No
Sept 2009	08-26	KMF	10

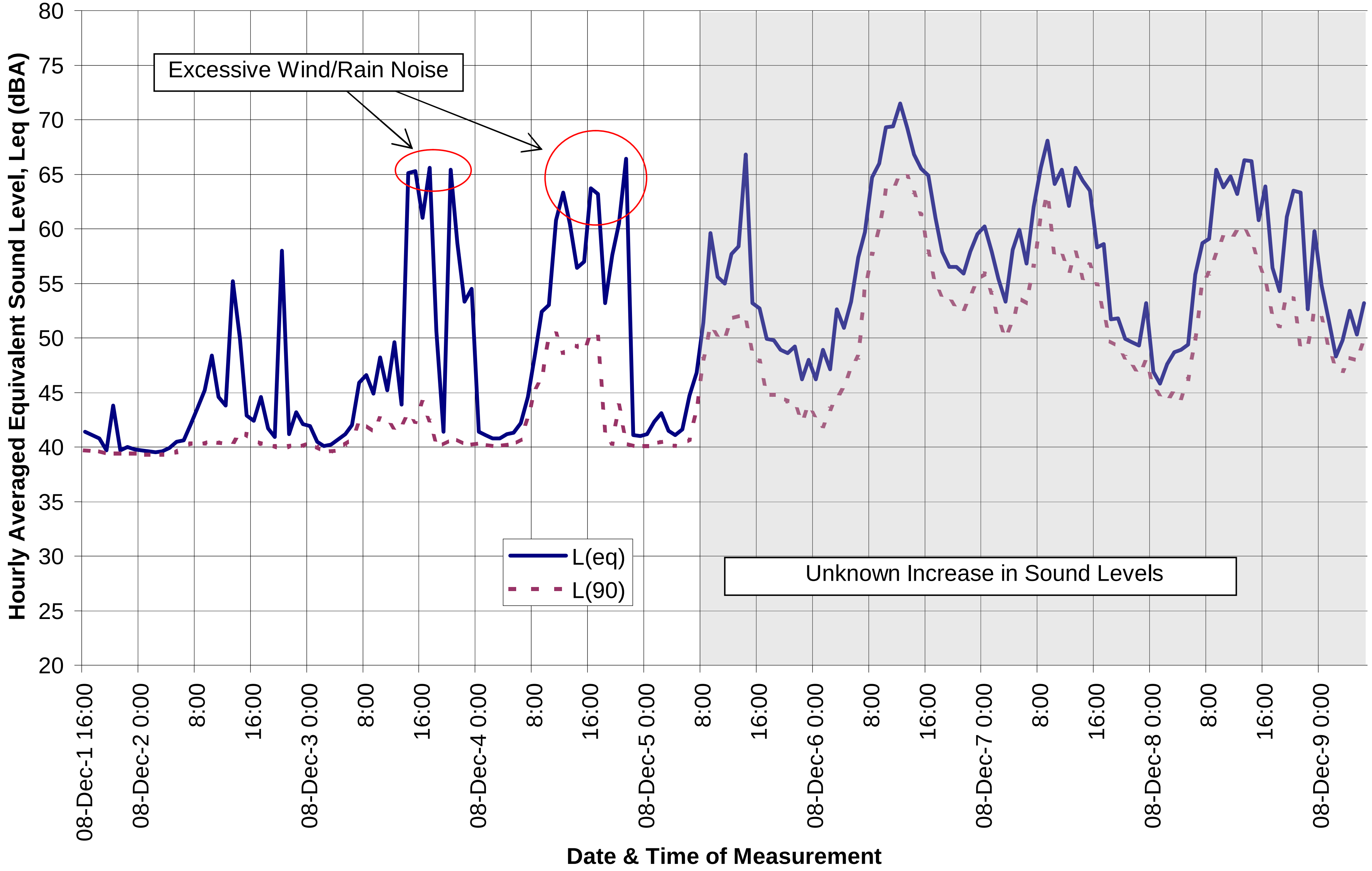


D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - East Property Line (P3)

Sept 2009	08-26	KMF
Date	Project No.	Drawn By

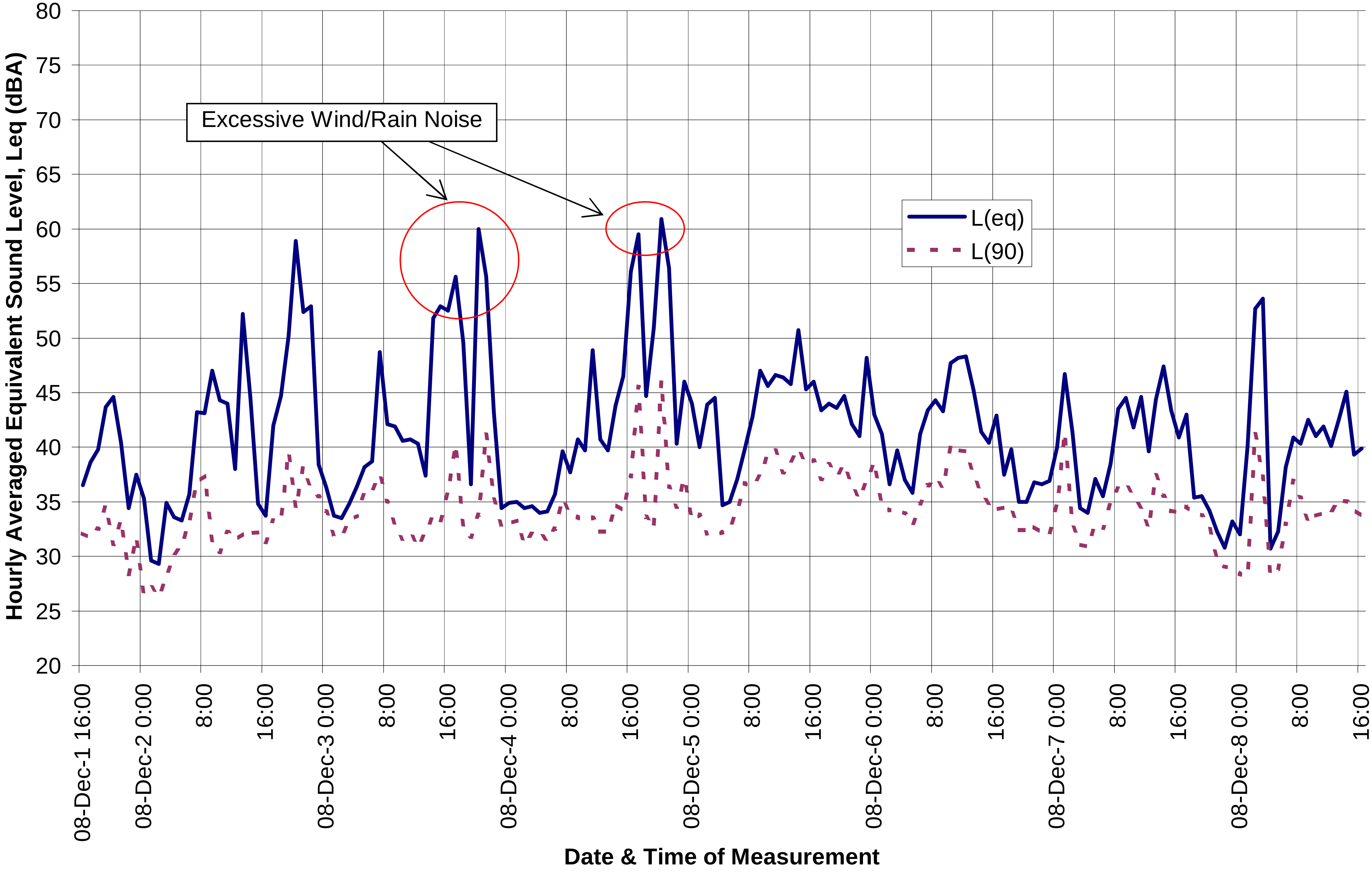
Figure No
11



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - South Property Line (P4)

Date	Project No.	Drawn By	Figure No
Sept 2009	08-26	KMF	12

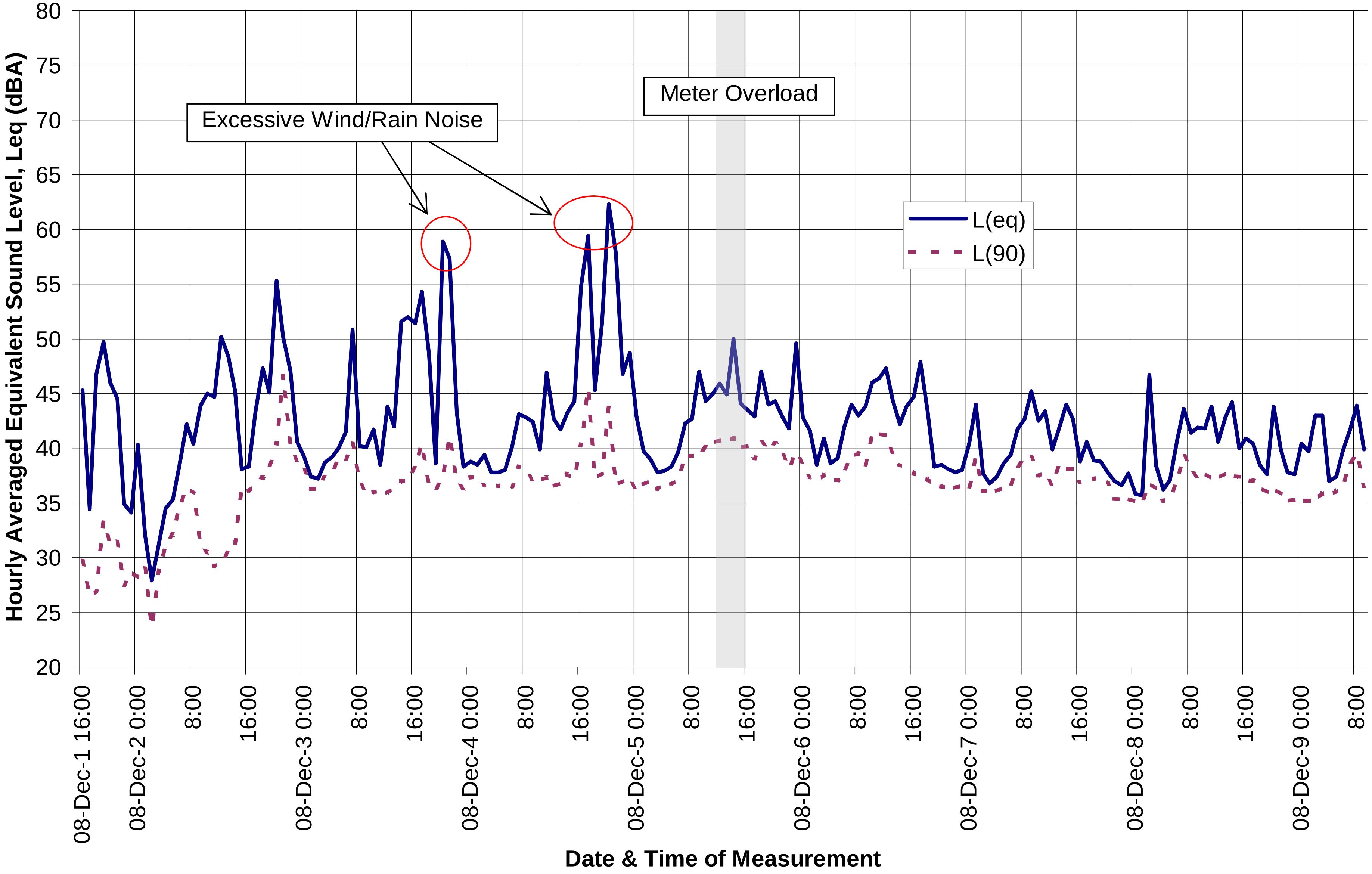


D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - West Property Line (P5)

Sept 2009	08-26	KMF
Date	Project No.	Drawn By

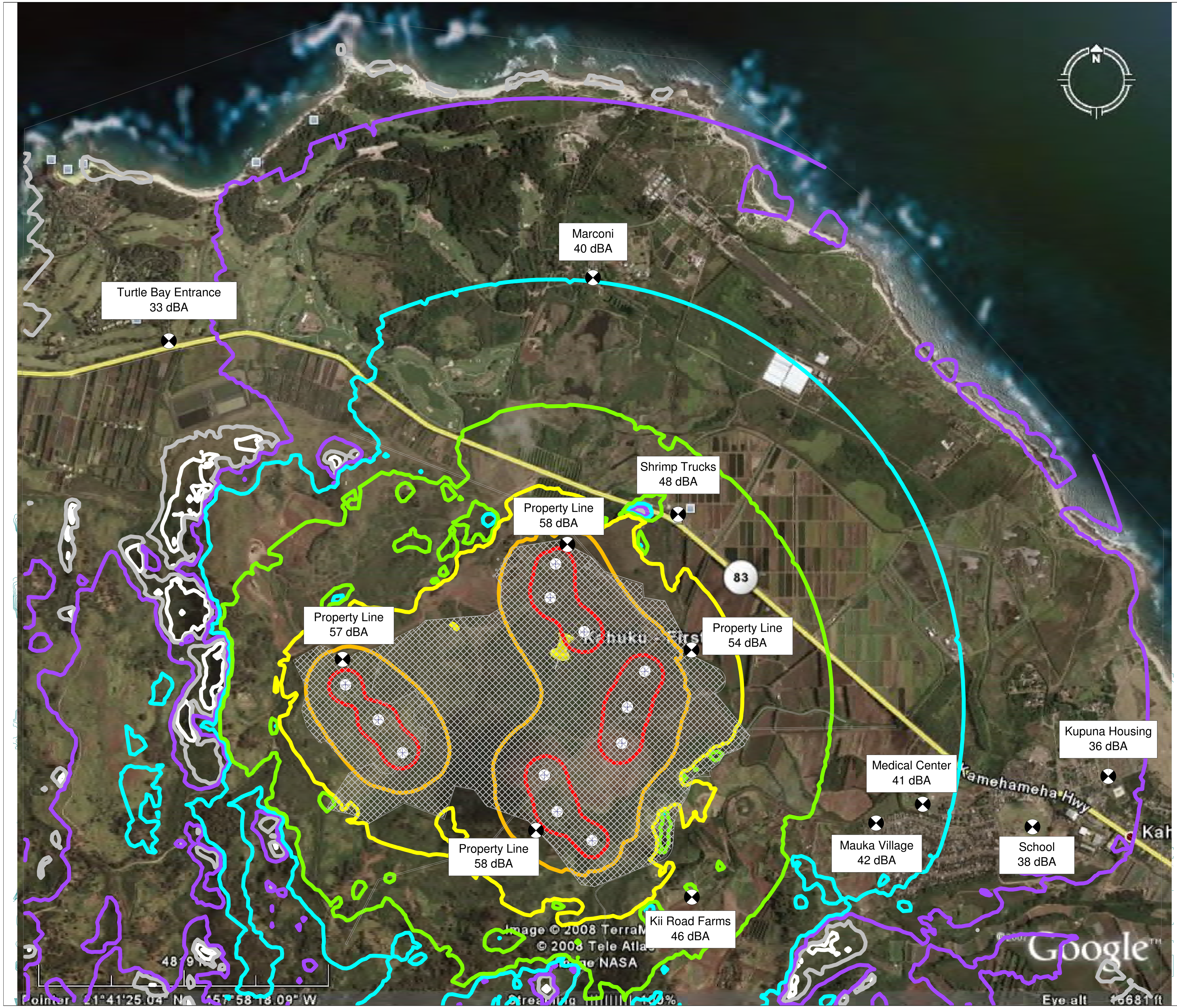
Figure No
13



D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Graph of Long Term Sound Measurements - Center of Property (P6)

Date	Project No.	Drawn By	Figure No
Sept 2009	08-26	KMF	14



Kahuku Wind Farm

Kahuku, Oahu, Hawaii

Prepared for First Wind Energy, LLC

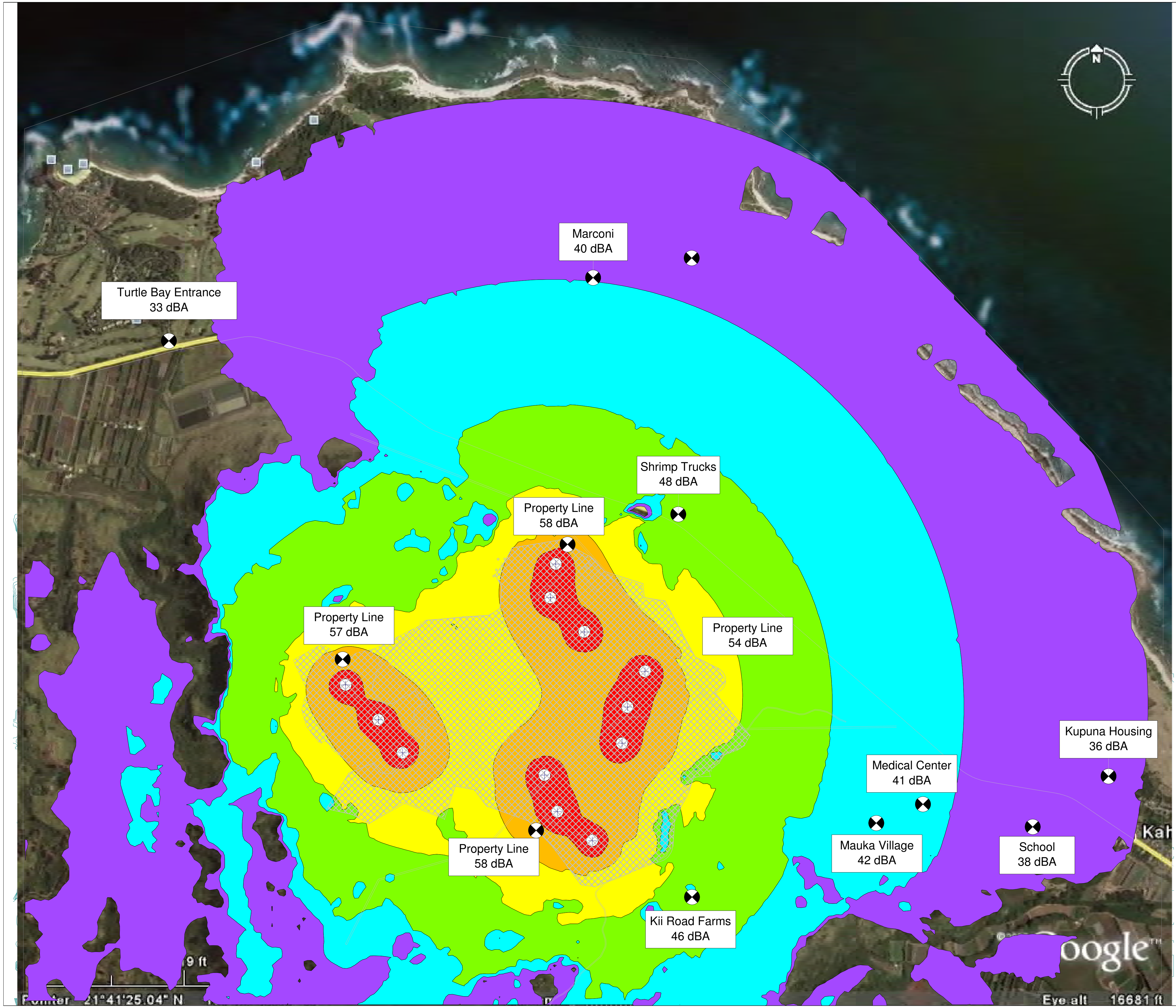
September 2009

Figure 15

Predicted Sound Level Contours Due To Wind Turbine Noise

D. L. ADAMS ASSOCIATES, LTD.
Consultants in Acoustics, Performing Arts and Technologies
970 N. KALAHEO AVE., SUITE A311
KAILUA, HI 96734
P: 808.254.3318 F: 808.254.5295
www.dlaa.com

⬜ = 25 dBA
⬜ = 30 dBA
🟪 = 35 dBA
🟦 = 40 dBA
🟩 = 45 dBA
🟨 = 50 dBA
🟧 = 55 dBA
🟥 = 60 dBA



Kahuku Wind Farm

Kahuku, Oahu, Hawaii

Prepared for First Wind Energy, LLC

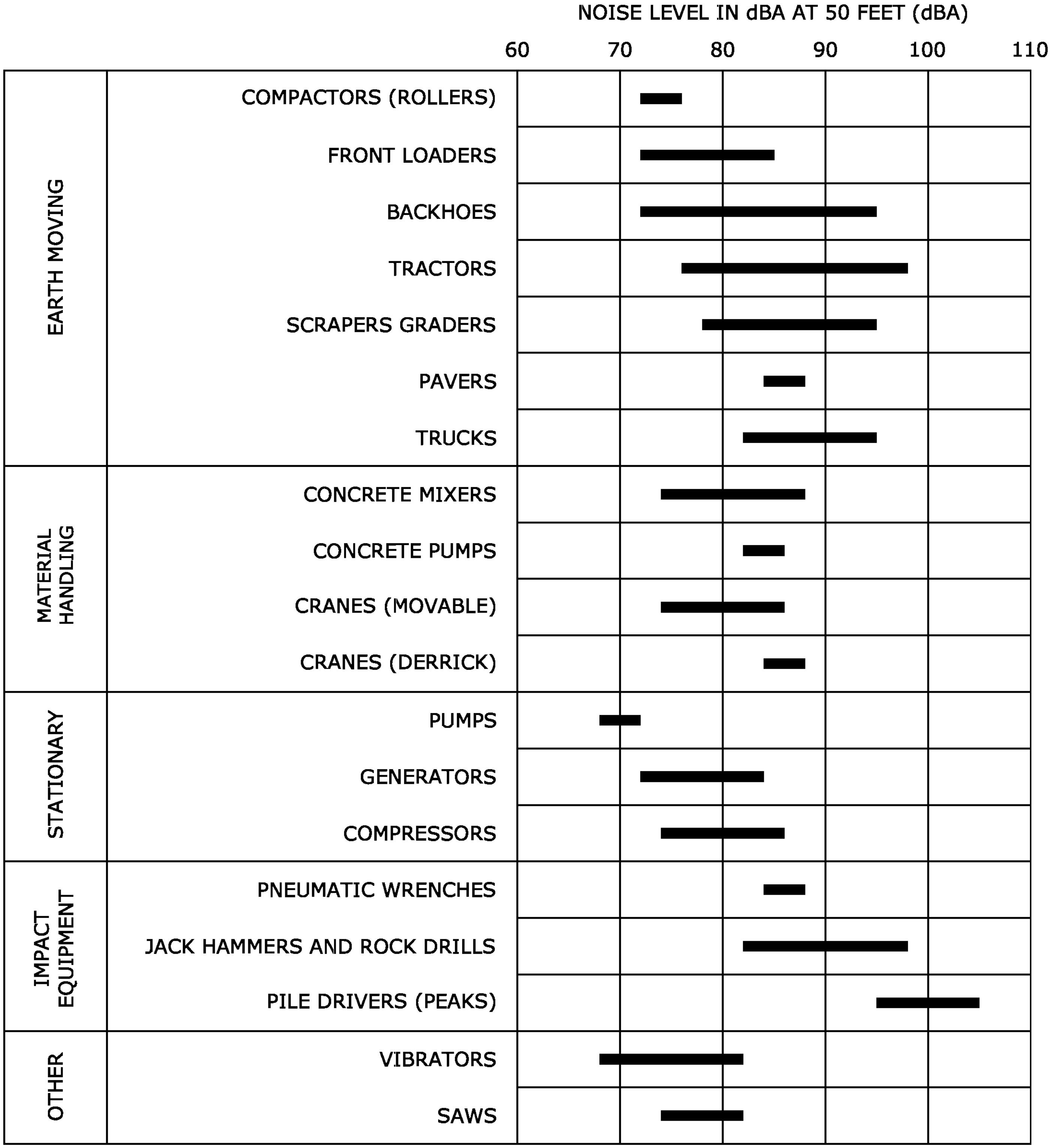
September 2009

Figure 16

Predicted Sound Level Area Contours Due To Wind Turbine Noise

D. L. ADAMS ASSOCIATES, LTD.
Consultants in Acoustics, Performing Arts and Technologies
970 N. KALAHEO AVE., SUITE A311
KAILUA, HI 96734
P: 808.254.3318 F: 808.254.5295
www.dlaa.com

🟪 > 35 dBA
🟦 > 40 dBA
🟩 > 45 dBA
🟨 > 50 dBA
🟧 > 55 dBA
🟥 > 60 dBA



NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES

D. L. ADAMS ASSOCIATES, LTD.
970 N. KALAHEO AVE, A-311
KAILUA, HAWAII 96734
808/254-3318 FAX 808/254-5295

Typical Sound Levels from Construction Equipment

Kahuku Wind Farm

Not to Scale

Date	Project No.	Drawn By
September 2009	08-26	TRB

Figure No
17

APPENDIX A

Acoustic Terminology

Acoustic Terminology

Sound Pressure Level

Sound, or noise, is the term given to variations in air pressure that are capable of being detected by the human ear. Small fluctuations in atmospheric pressure (sound pressure) constitute the physical property measured with a sound pressure level meter. Because the human ear can detect variations in atmospheric pressure over such a large range of magnitudes, sound pressure is expressed on a logarithmic scale in units called decibels (dB). Noise is defined as "unwanted" sound.

Technically, sound pressure level (SPL) is defined as:

$$\text{SPL} = 20 \log (P/P_{ref}) \text{ dB}$$

where P is the sound pressure fluctuation (above or below atmospheric pressure) and P_{ref} is the reference pressure, 20 µPa, which is approximately the lowest sound pressure that can be detected by the human ear. For example:

If P = 20 µPa, then SPL = 0 dB
If P = 200 µPa, then SPL = 20 dB
If P = 2000 µPa, then SPL = 40 dB

The sound pressure level that results from a combination of noise sources is not the arithmetic sum of the individual sound sources, but rather the logarithmic sum. For example, two sound levels of 50 dB produce a combined sound level of 53 dB, not 100 dB. Two sound levels of 40 and 50 dB produce a combined level of 50.4 dB.

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, in general, a change of 1 or 2 dB in the level of sound is difficult for most people to detect. A 3 dB change is commonly taken as the smallest perceptible change and a 6 dB change corresponds to a noticeable change in loudness. A 10 dB increase or decrease in sound level corresponds to an approximate doubling or halving of loudness, respectively.

A-Weighted Sound Level

Studies have shown conclusively that at equal sound pressure levels, people are generally more sensitive to certain higher frequency sounds (such as made by speech, horns, and whistles) than most lower frequency sounds (such as made by motors and engines)[1] at the same level. To address this preferential response to frequency, the A-weighted scale was developed. The A-weighted scale adjusts the sound level in each frequency band in much the same manner that the

---

[1] D.W. Robinson and R.S. Dadson, "A Re-Determination of the Equal-Loudness Relations for Pure Tones," *British Journal of Applied Physics*, vol. 7, pp. 166 - 181, 1956. (Adopted by the International Standards Organization as Recommendation R-226.

human auditory system does. Thus the A-weighted sound level (read as "dBA") becomes a single number that defines the level of a sound and has some correlation with the sensitivity of the human ear to that sound. Different sounds with the same A-weighted sound level are perceived as being equally loud. The A-weighted noise level is commonly used today in environmental noise analysis and in noise regulations. Typical values of the A-weighted sound level of various noise sources are shown in Figure A-1.

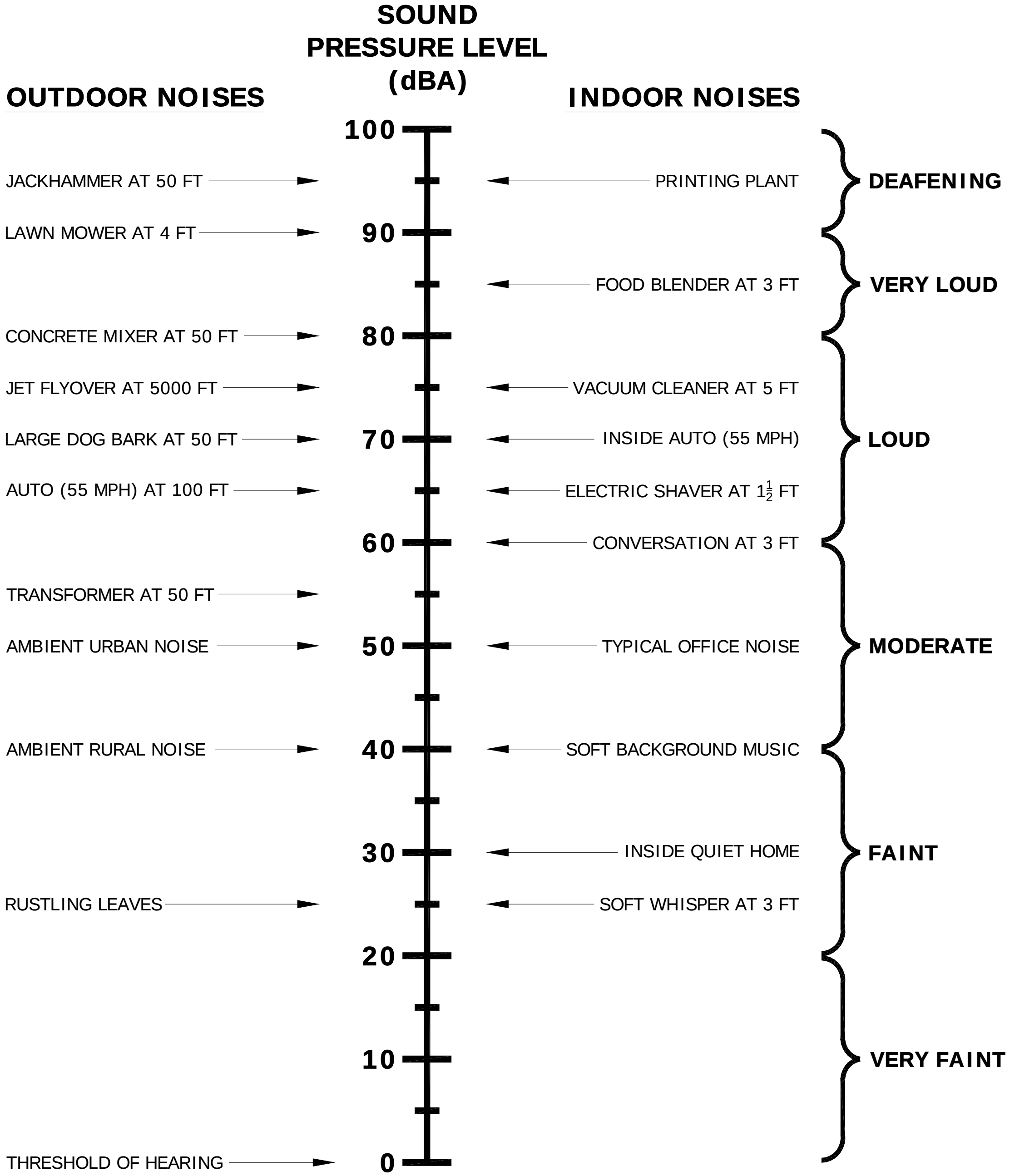


Figure A-1. Common Outdoor/Indoor Sound Levels

Equivalent Sound Level

The Equivalent Sound Level (L_{eq}) is a type of average which represents the steady level that, integrated over a time period, would produce the same energy as the actual signal. The actual *instantaneous* noise levels typically fluctuate above and below the measured L_{eq} during the measurement period. The A-weighted L_{eq} is a common index for measuring environmental noise. A graphical description of the equivalent sound level is shown in Figure A-2.

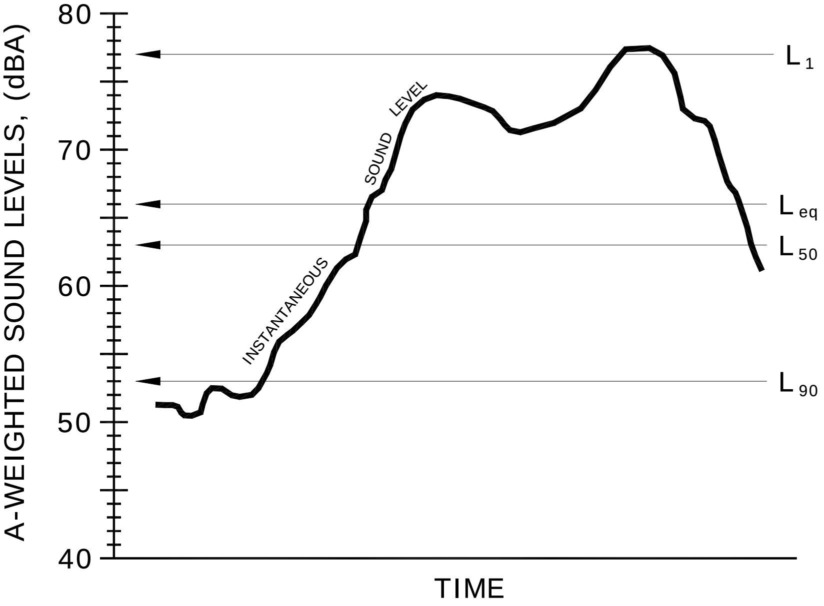


Figure A-2. Example Graph of Equivalent and Statistical Sound Levels

Statistical Sound Level

The sound levels of long-term noise producing activities such as traffic movement, aircraft operations, etc., can vary considerably with time. In order to obtain a single number rating of such a noise source, a statistically-based method of expressing sound or noise levels has been developed. It is known as the Exceedence Level, L_n. The L_n represents the sound level that is exceeded for n% of the measurement time period. For example, L_{10} = 60 dBA indicates that for the duration of the measurement period, the sound level exceeded 60 dBA 10% of the time. Typically, in noise regulations and standards, the specified time period is one hour. Commonly used Exceedence Levels include L_{01}, L_{10}, L_{50}, and L_{90}, which are widely used to assess community and environmental noise. A graphical description of the equivalent sound level is shown in Figure A-2.

Day-Night Equivalent Sound Level

The Day-Night Equivalent Sound Level, L_{dn}, is the Equivalent Sound Level, L_{eq}, measured over a 24-hour period. However, a 10 dB penalty is added to the noise levels recorded between 10 p.m. and 7 a.m. to account for people's higher sensitivity to noise at night when the background noise level is typically lower. The L_{dn} is a commonly used noise descriptor in assessing land use compatibility, and is widely used by federal and local agencies and standards organizations.

APPENDIX D. Applicable Land Use Policies, Plans, and Regulations

Federal, state, and county land use policies, plans, and regulations that are applicable to the Proposed Action are described below. Each section also discusses the extent to which the Proposed Action complies with the objectives of these land use plans, policies, and regulations.

Applicable Federal Land Use Policies, Plans, and Regulations

National Environmental Policy Act (42 U.S.C. 4371 et seq.).

The National Environmental Policy Act (NEPA) of 1969 provides an interdisciplinary framework for federal agencies to analyze and disclose the environmental impacts of their proposed actions and consider reasonable alternatives. The purpose of NEPA is to promote agency analysis and public disclosure of the environmental issues surrounding a proposed federal action in order to reach a decision that reflects NEPA's mandate to strive for harmony between human activity and the natural world.

DOE has prepared this Environmental Assessment (EA) to comply with NEPA (42 USC 4321, et. seq.), Council on Environmental Quality regulations for implementing NEPA (40 CFR Parts 1500-1508), and DOE NEPA regulations (10 CFR Part 1021). The EA examines the potential environmental impacts associated with the proposed action and No Action Alternative and determines whether the proposed action has the potential for significant environmental impacts. The information contained in the EA will enable DOE to fully consider the potential environmental impacts of issuing a loan guarantee for the Kahuku Wind Power project.

Farmland Protection Policy Act (7 USC 4201).

The Farmland Protection Policy Act (FPPA) was established to minimize the impact federal programs have on the unnecessary and irreversible conversion of farmland to non-agricultural uses. Farmland includes land designated as prime farmland, unique farmland, and land of statewide or local importance. Federal actions are subject to FPPA requirements if the actions may irreversibly convert farmland (directly or indirectly) to non-agricultural use.

Approximately 60% (341 ac or 138 ha) of the project area is considered prime farmland. Construction of the proposed facilities would disturb approximately 67 ac of the 578 ac project area (about 11.5%). Roughly 32 ac of the disturbed areas (about 5.6% of the project area) would contain structures, hardened surfaces, and associated setbacks. Therefore, the proposed project would not convert a substantial portion of the project area to non-agricultural uses. As indicated above, Kahuku Wind Power LLC is in the process of evaluating the possibility of allowing complementary agricultural uses in the project area (e.g. community gardens, small plot farming, and grazing of livestock). If this occurs, it would increase the amount of area available for agricultural uses.

A Farmland Conversion Impact Rating form and supporting documentation were completed and submitted to the Natural Resources Conservation Service (NRCS). The rating that resulted from the NRCS evaluation did not exceed 160 points. According to the Farmland Protection Policy Act, sites with a rating less than 160 need no further consideration.

Applicable State Land Use Policies, Plans, and Regulations

Hawaiʻi State Plan.

The Hawaiʻi State Plan is a policy document intended to guide the long-range development of the State of Hawaiʻi by: identifying goals, objectives, and policies for the State of Hawaiʻi and its residents; establishing a basis for determining priorities and allocating resources; and providing a unifying vision to enable coordination between the various counties' plans, programs, policies, projects and regulatory activities to assist them in developing their county plans, programs, and projects and the State's long-range development objectives. The Hawaiʻi State Plan is dependent upon implementing laws and regulations to achieve its goals.

The sections of the Hawaiʻi State Plan that are most relevant to the proposed project are Sections 226-18(a) and (b), which establish objectives and policies for energy facility systems. These sections are reproduced and discussed below.

§226-18 *(a) Planning for the State's facility systems with regard to energy shall be directed toward the achievement of the following objectives, giving due consideration to all:*

> *(1) Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;*

Currently, wind power is the most commercially viable utility-scale renewable energy resource. The Kahuku area in particular has a strong, proven wind resource to ensure that the project would offer a dependable energy source. In addition, the proposed project would result in environmental and economic benefits of reduced air pollutant emissions and enhanced energy independence. Consequently, it is consistent with this objective.

> *(2) Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased;*

Kahuku Wind Power LLC would help to increase the ratio of indigenous to imported energy on Oʻahu by harnessing the naturally occurring wind energy in the area.

> *(3) Greater energy security in the face of threats to Hawaii's energy supplies and systems.*

The proposed facility would reduce Oʻahu's dependence on imported fossil fuels and fluctuating energy costs.

> *(4) Reduction, avoidance, or sequestration of greenhouse gas emissions from energy supply and use.*

The proposed project would reduce the emission of several greenhouse gases, as described in Section 3.2.2. Although very low levels of emissions would be generated from operation and construction of the proposed project, these would be more than offset by the benefits of the proposed project. Therefore, the project is in accordance with this objective.

§226-18 *(b) To achieve the energy objectives, it shall be the policy of this State to ensure the provision of adequate, reasonably priced, and dependable energy services to accommodate demand.*

The proposed facility will provide clean, cost-competitive electricity to O‘ahu’s consumers. The WPMS buffers highly variable wind power and is capable of maintaining grid stability. Consequently, the project is consistent with this objective.

Hawai‘i Revised Statutes, Chapter 195D.

The purpose of Chapter 195D of Hawai‘i Revised Statutes (HRS), is “to insure the continued perpetuation of indigenous aquatic life, wildlife, and land plants, and their habitats for human enjoyment, for scientific purposes, and as members of ecosystems…” (§195D-1). Section 195D-4 states that any endangered or threatened species of fish or wildlife recognized by the Endangered Species Act (ESA) shall be so deemed by State statute. Like the ESA, the unauthorized “take” of such endangered or threatened species is prohibited [§195D-4(e)]. Under Section 195D-4(g), the Board of Land and Natural Resources (BLNR), after consultation with the State’s Endangered Species Recovery Committee (ESRC), may issue a temporary license (subsequently referred to as an “ITL”) to allow a take otherwise prohibited if the take is incidental to the carrying out of an otherwise lawful activity. Kahuku Wind Power LLC is currently seeking an ITL. A Draft Habitat Conservation Plan (HCP) was submitted to the State Department of Land and Natural Resources (DLNR) in August 2009 to support the issuance of the ITL. The final HCP was approved by ESRC in February 2010, and by the Board of Land and Natural Resources on March 11, 2010 (SWCA and First Wind 2010). Acquisition of an ITL is anticipated in May or June of 2010. Therefore, the project is compliant with this statute.

Hawai‘i Revised Statutes, Chapter 343.

Chapter 343 (Environmental Impact Statements) was developed “to establish a system of environmental review which will ensure that environmental concerns are given appropriate consideration in decision making along with economic and technical considerations” (§343-1). This chapter requires the development of an Environmental Assessment (EA) or Environmental Impact Statement (EIS) for certain actions. The approval of an HCP and issuance of an ITL under Chapter 195D, Hawai‘i Revised Statutes (HRS), do not by themselves trigger a requirement for environmental review pursuant to Chapter 343, HRS.

The only component of the Proposed Action that would trigger HRS Chapter 343 is the construction of a fence for predator control at a seabird colony on West Maui at Makamaka‘ole. Because Makamaka‘ole is situated on State land within a Conservation District, a State EA would be prepared prior to construction in accordance with Chapter 343 of HRS.

Hawaiʻi Revised Statutes, Chapter 205.

Under The State Land Use Law (Act 187), HRS Chapter 205, all lands and waters in the State are classified into one of four districts: Agriculture, Rural, Conservation, or Urban. Conservation Districts, under the jurisdiction of DLNR, are further divided into five subzones: Protective, Limited, Resource, General, and Special (Hawaiʻi Administration Rules, Title 13, Chapter 5). State of Hawaiʻi Land Use District Boundaries are governed by the City and County Land Use Ordinance.

The project area and surrounding lands are in an Agricultural District (Figure 3-17). State Conservation District lands exist mauka of the property, including the Kahuku Military Training Area and the Pūpūkea-Paumalū Forest Reserve. The subzone designation for both of these areas is Resource. Land across Kamehameha Highway from the project area, including the James Campbell NWR, is in the General subzone of a State Conservation District. Conservation District lands are not subject to any County zoning or community plan designations or restrictions.

The Waialua Substation is located in an Urban District and Flying R Ranch site is located in an Agricultural District.

Per HRS Chapter 205-4.5, wind energy facilities are a permissible use in State Agricultural Districts. The statute states that these facilities are permitted “provided that the wind energy facilities and appurtenances are compatible with agriculture uses and cause minimal adverse impact on agricultural land.” The proposed facility meets these requirements as it will result in disturbance of only a small percentage of the project area and it compatible with agricultural land use. As indicated, Kahuku Wind Power LLC is in the process of evaluating the possibility of complementary agricultural uses in the project area.

HRS Chapter 205-4.5 also permits “appurtenances associated with the production and transmission of wind generated energy” within State Agricultural Districts. Public and private “utility lines and roadways, transformer stations, communications equipment buildings…” are also permissible uses within Agricultural Districts. Thus, the off-site microwave towers and associated overhead distribution line, which are required to provide secure high-speed communications between Kahuku Wind Power and HECO, would be permitted.

Hawaiʻi Agricultural Land Use Map (ALUM).

Agricultural land use designations have been developed for Hawaiʻi. The State of Hawaiʻi Agricultural Land Use Map (ALUM) does not depict detailed agricultural uses in the project area. However, the Flying R Ranch site is classified as A-1 (Grazing).

University of Hawaiʻi’s Land Study Bureau Detailed Land Classification.

The University of Hawaiʻi’s Land Study Bureau developed a Detailed Land Classification for the Island of Oʻahu that divides the island into a five-class agricultural productivity rating using the letters “A” through “E.” “A” represents the class of highest productivity and “E” the lowest. Roughly 62% of the project area contains Class A&B rated soils and 38% contains non-Class A&B soils.

Although a portion of the project area contains soil classified as Classes A and B, wind energy facilities are permitted uses on these soil classifications, per HRS Chapter 205-4.5.

State Department of Agriculture’s Agricultural Lands of Importance to the State of Hawaiʻi.

The State Department of Agriculture’s Agricultural Lands of Importance to the State of Hawaiʻi (ALISH) system also ranks areas based on soil agricultural suitability. Designed to inventory prime farmlands, the system divides agricultural lands into three classes (Unique, Prime, and Other). Prime agricultural land is defined as land with soil temperature, soil pH, moisture supply, and growing season needed to produce high yields of crops when treated and managed according to modern farming methods. The Other designation refers to land that is important to agriculture, but lacks properties to be Prime or Unique; this land usually has slopes less than 35% and has been used or could be used for grazing.

The ALISH system ranks less than 60% (341 ac or 138 ha) of the agricultural areas on the property as Prime and 23% (134 ac or 54 ha) as Other. Remaining areas are unclassified. The Flying R Ranch site is ranked as Other.

Wind energy facilities are permitted uses on agricultural areas, per HRS Chapter 205-4.5.

Hawaiʻi’s Coastal Zone Management (CZM) Program.

Hawaiʻi’s Coastal Zone Management (CZM) Program (HRS 205A) is a broad management framework designed to protect valuable and vulnerable coastal resources by reducing coastal hazards and improving the review process for activities proposed within the coastal zone. The entire State of Hawaiʻi is within the coastal zone boundary. The CZM Program focuses on ten objectives and associated policies. Federal actions occurring in, or affecting, the state's coastal zone must be in agreement with the CZM Program's objectives and policies.

The ten objectives are repeated below and a brief assessment of the project with respect to these objectives is provided.

1. *Recreational resources: Provide coastal recreational opportunities accessible to the public.*

The project would be constructed on private land that is not located on the shoreline. Therefore, construction and operation of the project would not impact existing public access to coastal recreational opportunities.

2. *Historic resources: Protect, preserve, and, where desirable, restore those natural and manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.*

No adverse impacts to historic or prehistoric resources are expected as a result of construction and operation of the Kahuku Wind Power project.

3. *Scenic and open space resources: Protect, preserve, and, where desirable, restore or improve the quality of coastal scenic and open space resources.*

The proposed project would not affect views of the shoreline from Kamehameha Highway. Although the perception of the project would vary depending on the observer, the proposed project would complement the rural atmosphere and agricultural character of the area and maintain open space.

4. *Coastal ecosystems: Protect valuable coastal ecosystems, including reefs, from disruption and minimize adverse impacts on all coastal ecosystems.*

The proposed project is not expected to have any significant adverse affects on marine resources. BMPs will be employed to prevent and minimize soil erosion during construction and operation and prevent sediment and other pollutants in stormwater runoff from reaching the ocean.

5. *Economic uses: Provide public or private facilities and improvements important to the State's economy in suitable locations.*

The proposed location is considered suitable because wind energy facilities are compatible with some agricultural uses common in the area.

6. *Coastal hazard: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution.*

Due to its distance from the coastline, the project would not increase hazard to life and property from tsunami or storm waves.

The Kahuku Wind Power project area is entirely located in Flood Zone D where analysis of flood hazards has not been conducted and flood hazards are undetermined. Because of topographic relief, potential for flooding at the project area, outside of the immediate vicinity of the gulches, appears to be very low. Kahuku Wind Power LLC intends to grade some low-lying areas during construction to improve drainage and prevent standing water from collecting after heavy rain. Thus, the project would not increase hazard to life and property as a result of flooding.

7. *Managing development: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.*

The proposed project has been review by various state and federal agencies during preparation of the State HCP. The public was able to comment on the project following release of the State HCP and a public meeting regarding the State HCP was held in on November 4, 2009.

8. *Public participation: Stimulate public awareness, education, and participation in coastal management.*

Since early 2007, Kahuku Wind Power LLC has been engaged in community outreach to discuss the Kahuku Wind Power project. Kahuku Wind Power LLC has given presentations and/or held discussions with local community leaders, various community associations, neighborhood boards, organizations, kupuna (elders), residents, and individual stakeholders in the Kahuku and Koʻolau Loa area. Kahuku Wind Power LLC has also met with local school officials in the area to educate students about wind facilities and associated technologies. Other groups that Kahuku Wind Power has met with include the Kahuku Community Association, Lāʻie Community Association, Kahuku Village Association, Defend Oʻahu Coalition, Koʻolau Loa Neighborhood Board, and North Shore Neighborhood.

9. *Beach protection: Protect beaches for public use and recreation.*

The proposed project is not located on the shoreline and therefore would not affect beaches.

10. *Marine resources: Promote the protection, use, and development of marine and coastal resources to assure their sustainability.*

The proposed project is not expected to have any significant adverse affects on marine resources.

Compliance with the CZM objectives and policies is regulated through the Special Management Areas (SMAs) permit system, which is implemented by the City and County of Honolulu DPP. SMAs are designated sensitive environments that should be protected in accordance with the CZM Program. The City and County of Honolulu DPP has designed Oʻahu's entire shoreline, as well as certain inland areas of Oʻahu, as SMAs.

The project area is not located within a SMA, nor are either of the off-site microwave tower locations. Therefore, the proposed project is not subject to the permit requirements of the SMA system.

Applicable County Land Use Policies, Plans, and Regulations

General Plan for the City and County of Honolulu.

The General Plan for the City and County of Honolulu is a comprehensive document with long-range social, economic, environmental, and design objectives, as well as broad policies to facilitate the attainment of those objectives. The General Plan is divided into 11 subject areas including population, economic activity, the natural environment, housing, transportation and utilities, energy, physical development and urban design, public safety, health and education, culture and recreation, and government operations and fiscal management (DPP 2006).

The following section reproduces the policies outlined in different sections of the General Plan that are most relevant to the proposed project and discusses the proposed project's consistency with these policies.

II. Economic Activity

- *Encourage the development in appropriate locations on Oahu of trade, communications, and other industries of a nonpolluting nature.*
- *Take full advantage of Federal programs and grants which will contribute to the economic and social well-being of Oahu's residents.*

The proposed project is generally non-polluting in nature and is appropriately located on the island. Kahuku Wind Power LLC is also attempting to take advantage of a Federal grant to reduce emissions of greenhouse gases and employ new technology in the United States.

III. Natural Environment

- *Protect the natural environment from damaging levels of air, water, and noise pollution.*
- *Protect plants, birds, and other animals that are unique to the State of Hawaii and the Island of Oahu.*
- *Protect Oahu's scenic views, especially those seen from highly developed and heavily traveled areas.*
- *Locate roads, highways, and other public facilities and utilities in areas where they will least obstruct important views of the mountains and the sea.*

The proposed project is expected to have positive, long-term impacts on regional air quality. Although the project has the potential to take unique wildlife species, mitigation measures proposed by Kahuku Wind Power LLC would ultimately result in a net benefit to the species as required by state law. There are no scenic views in the area that would be affected by the project and visual impact of the proposed project was considered during the site and layout selection process.

VI. Energy

- *Develop and maintain a comprehensive plan to guide and coordinate energy conservation and alternative energy development and utilization programs on Oahu.*
- *Establish economic incentives and regulatory measures which will reduce Oahu's dependence on petroleum as its primary source of energy.*
- *Support programs and projects which contribute to the attainment of energy self-sufficiency on Oahu.*
- *Give adequate consideration to environmental, public health, and safety concerns, to resource limitations, and to relative costs when making decisions concerning alternatives for conserving energy and developing natural energy resources.*
- *Support and participate in research, development, demonstration, and commercialization programs aimed at producing new, economical, and environmentally sound energy supplies from: a. solar insolation; b. biomass energy conversion; c. wind energy conversion; d. geothermal energy; and e. ocean thermal energy conversion.*

The Proposed Action is consistent with the above listed policies by supporting the proposed Kahuku Wind Power facility. The proposed facility is designed to reduce O‘ahu’s dependence on imported petroleum. Furthermore, Kahuku Wind Power LLC has considered a wide range of environmental and public concerns in designing the proposed project.

Community Plans.

The county is divided into eight regional areas that are guided by Development Plans or Sustainable Communities Plans (SCP). Kahuku is located in the Koʻolau Loa SCP. The Koʻolau Loa SCP is one of eight geographically oriented plans intended to guide public policy, investment and decision-making through 2020 (DPP 1999). The residential communities located in the plan area include Kahuku, Lāʻie, Hauʻula, Punaluʻu, Kahana and Kaʻaʻawa. In cooperation of the General Plan, this plan provides a policy context for land use, City budgetary actions and decisions made by the private sector. Land use maps within the Koʻolau Loa Sustainable Community Plan depict the area as Agriculture (DPP 1999). An update of the Koʻolau Loa SCP is currently in progress.

Several of the opportunities, objectives, and policies identified in the Koʻolau Loa Sustainable Community Plan (1999) are relevant to the proposed project. The following statements and policies replicated from the plan are compatible with the proposed project:

P.5 BASIS FOR THE KOʻOLAU LOA SUSTAINABLE COMMUNITIES PLANS

- *Energy conservation will be expanded through commercial wind and solar power operations.*

4.4 ELECTRICAL POWER DEVELOPMENT

- *There is the possibility that the wind farm located in Kahuku may be modernized or expanded.*

- *Locate and design system elements such as renewable electrical power facilities, substations, communication sites, and transmission lines, including consideration of underground transmission lines, to mitigate any potential adverse impacts on scenic and natural resources, as well as public safety considerations.*

The Koʻolau Loa Sustainable Community Plan specifically calls out an expanded wind farm in Kahuku. Elements of the proposed project have been located and designed to mitigate potential adverse impacts to natural and scenic resources.

3.2 AGRICULTURAL AREAS

- *Agricultural operations including truck crops, vegetables, taro, indigenous Hawaiian plants, shrubs, trees, and flowers and landscaping plants are currently being pursued on former sugarcane lands and in the mauka valleys throughout the region.*

A portion of the project area may be set aside for subsistence farming by local residents. Thus, the proposed project could support this element of the Koʻolau Loa Sustainable Community Plan (1999).

City and County of Honolulu Zoning.

Land use on Oʻahu is also dictated by zoning ordinances from the City and County. The City and County of Honolulu zoning ordinance defines the project area as AG-1 Restrict Agricultural District. Adjoining land is also zoned AG-1 Restricted or AG-2 General. AG-2 applies to agricultural lands with a minimum lot size of 2 ac (0.8 ha). The AG-1 designation is intended to preserve “important agricultural lands” for agricultural functions such as the production of food, feed, forage, fiber crops and horticultural plants (City and County of Honolulu, Land Use Ordinance, Chapter 21). A wind energy project is permitted in this zoning area with acquisition of a Conditional Use Permit (City and County of Honolulu, Land Use Ordinance, Chapter 21, Section 5.700). Because turbine foundations physically occupy only a small fraction of the project area’s land area, development of wind energy is generally considered compatible with some agricultural uses, such as grazing (Global Energy Concepts LLC 2006).

The proposed project obtained a CUP-M from the City and County of Honolulu’s Department of Planning and Permitting in January 2008. A second CUP-M for the proposed project was approved by the Department of Planning and Permitting in December 2009.

The Waialua Substation site is zoned as R-5 Residential District and the Flying R Ranch site is zoned AG-1 Restricted Agriculture District.

Literature Cited

Department of Planning and Permitting (DPP), City and County of Honolulu. 1999. Ko’olau Loa Sustainable Communities Plan. Honolulu, HI. Available at: http://www.honoluludpp.org/planning/DevSust_Koolauloa.asp. Accessed November 2, 2008.

Department of Planning and Permitting (DPP), City and County of Honolulu. 2006. Oahu General Plan. Available at: http://www.honoluludpp.org/planning/OahuGenPlan.asp. Accessed September 10, 2009.

Global Energy Concepts, LLC. 2006. A Catalog of Potential Sites for Renewable Energy in Hawaii. Prepared for the State of Hawaii Department of Land and Natural Resources and the Department of Business, Economic Development, and Tourism.

SWCA and First Wind. 2010. Kahuku Wind Power Habitat Conservation Plan. Prepared for Kahuku Wind Power LLC for DOFAW.

Appendix E.

BIOLOGICAL RESOURCES SURVEY

for the

NORTH SHORE WIND POWER PROJECT

KAHUKU, KO'OLAULOA, HAWAI'I

by

ROBERT W. HOBDY
ENVIRONMENTAL CONSULTANT
Kokomo, Maui
April 2007

Prepared for:
North Shore Wind Power, LLC

INTRODUCTION

The North Shore Wind Power Project is located on the northern tip of O’ahu on 506 acres of land at Kahuku, Ko’olauloa (TMK (1) 5-6-05:007). It is bounded on the east and south by pasture and agricultural lands along the Kamehameha Highway and bordering the town of Kahuku, on the north by undeveloped military reservation land and on the west by rough mountainous land. This survey was initiated to address environmental requirements of the planning process.

SITE DESCRIPTION

This property is situated on a plateau above the coastal plain. The bluffs on the seaward edge of the plateau which stand at about 120 – 150 feet above sea level are made up of lithified sand from ancient coastal dunes which are now eroded and sculpted by the wind. The plateau itself is made up of soils of the Paumalu, Lahaina and Kaena series which are deep silty clays and clays (Foote et al, 1972). Inland the land slopes upward into hills and gullies to a maximum elevation of 535 feet. The vegetation is mostly dense brush and trees with an abundance of grass in the understory. Rainfall averages 45-50 inches per year with the bulk falling during the winter and spring months (Armstrong, 1983).

BIOLOGICAL HISTORY

The original native vegetation would have been a combination of coastal and lowland windward forests of dense character. Dominating this vegetation would have been such species as ‘a’ali’i (*Dodonaea viscosa*), ‘ohi’a (*Metrosideros polymorpha*), u’ulei (*Osteomeles anthyllidifolia*), hala (*Pandanus tectorius*) and a great variety of other trees, shrubs, vines and ferns.

During several hundred years of Hawaiian occupation, much of the more fertile lands would have been utilized for agriculture with a variety of food and fiber crops. Most of the surrounding areas, however, would have remained essentially native in character all the way to the shoreline.

Late in the 1800’s this area was farmed for sugar production and this use continued for about 100 years. During this period the land was repeatedly plowed, planted, irrigated and harvested. Native plant species were all but eliminated from the area. Since the demise of sugar this area has been used for cattle grazing up until the present. The land is low largely covered with dense brush and trees with grasses and herbaceous weeds in the openings. Only a handful of hardy native plant species persist.

SURVEY OBJECTIVES

This report summarizes the findings of a flora and fauna inventory and assessment of the North Shore Wind Power Project area which was conducted in March 2007. The objectives of the survey were to:

1. Document what plant species occur on the property.
2. Document the status and abundance of each species.
3. Determine the presence or likely occurrence of any native flora and fauna. particularly any that are Federally listed as Endangered or Threatened. If such occur, identify what features of the habitat may be essential for these species.
4. Determine if the project area contains any special habitats which if lost or altered might result in a significant negative impact on the flora and fauna in this part of the island.

FLORA SURVEY REPORT SURVEY METHODS

A walk-through botanical survey method was used following a series of routes to ensure maximum coverage of all parts of this large property. Areas most likely to harbor native or rare plants such as gullies or rocky outcrops were more intensively examined. Notes were made on plant species, distribution and abundance as well as terrain and substrate.

DESCRIPTION OF THE VEGETATION

About 80% of this large property is covered with dense brush and trees. Smaller areas are more open with grasses and herbaceous species. A total of 128 plant species were recorded during the survey. Of these, all 13 of the abundant and common species were non-native plants. These were: sourgrass (*Digitaria insularis*), koa haole (*Leucaena leucocephala*), pitted beardgrass (*Bothriochloa pertusa*), Chinese violet (*Asystasia gangetica*), Christmas berry (*Schinus terebinthifolius*), parasol leaf tree (*Macaranga tanarius*), kolomona (*Senna surratensis*), common beggarticks (*Bidens alba*), sourbush (*Pluchea carolinensis*), allspice (*Pimenta dioeca*), lantana (*Lantana camara*), Jamaica vervain (*Stachytarpheta jamaicensis*) and pea aubergine (*Solanum torvum*).

Two endemic native species were found on the property: ni'ani'au (*Nephrolepis exaltata* subsp. *hawaiiensis*) and 'akia (*Wikstroemia oahuensis*). And additional seven indigenous native species were found on the property as well: pala'ā (*Sphenomeris chinensis*), pi'i pi'i (*Chrysopogon aciculatus*), 'ala'alawainui (*Peperomia blanda* var. *floribunda*), u'ulei, 'ilie'e (*Plumbago zeylanica*), popolo (*Solanum americanum*) and 'uhaloa (*Waltheria indica*). Five Polynesian introductions were found: ki (*Cordyline fruticosa*), niu (*Cocos nucifera*), kukui (*Aleurites moluccana*), 'ihi'ai (*Oxalis corniculata*) and noni (*Morinda citrifolia*). The remaining 114 plant species were non-native pasture grasses, or ornamental or agricultural weeds.

DISCUSSION AND RECOMMENDATIONS

The vegetation on this large property is largely non-native in character. The long history of agriculture and grazing has left little of the original native plants here. A few native species, 'ili'e'e, popolo and 'uhaloa, grow on the coral outcrops on the lower side of the property. A few others, ni'ani'au, 'akia, pala'ā, pi'ipi'i, u'ulei and 'ala'alawainiu, grow on the exposed ridge tops near the top of the property. All of the native species are both widespread and common in Hawai'i due to their ability to withstand disturbance and cattle grazing.

No Threatened or Endangered plant species were found on this property, nor were any found that are candidates for such status. No special habitats or native plant assemblages of significance were found either that would warrant protection.

It is determined that the activities associated with the development of the proposed project would not result in significant negative impacts on the native vegetation in this part of O'ahu.

While not of any special importance it is suggested that some of the hardy native species that already occur on the property, such as the u'ulei, the 'akia and the 'ilie'e, might be considered for propagation and out planting to stabilize bank slopes along any constructed access roads within the project area.

PLANT SPECIES LIST

Following is a checklist of all those vascular plant species inventoried during the field studies. Plant families are arranged alphabetically within each of four groups: Ferns, Conifers, Monocots and Dicots. Taxonomy and nomenclature of the ferns are in accordance with Palmer (2003). The conifers are in accordance with Krussman (1985). The flowering plants (Monocots and Dicots) are in accordance with Wagner et al. (1999).

For each species, the following information is provided:

1. Scientific name with author citation
2. Common English or Hawaiian name.
3. Bio-geographical status. The following symbols are used:
   endemic = native only to the Hawaiian Islands; not naturally occurring anywhere else in the world.
   indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).
   polynesian = those plants brought to the islands by the Hawaiians during their migrations.
   non-native = all those plants brought to the islands intentionally or accidentally after western contact.
4. Abundance of each species within the project area:
   abundant = forming a major part of the vegetation within the project area.
   common = widely scattered throughout the area or locally abundant within a portion of it.
   uncommon = scattered sparsely throughout the area or occurring in a few small patches.
   rare = only a few isolated individuals within the project area.

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
FERNS			
LINDSAEACEAE (Lindsaea Family)			
Sphenomeris chinensis (L.) Maxon	pala'ā	indigenous	rare
NEPHROLEPIDACEAE (Sword Fern Family)			
Nephrolepis exaltata (L.) Schott subsp. hawaiiensis W.H.Wagner	ni'ani'au	endemic	rare
POLYPODIACEAE (Polypody Fern Family)			
Phymatosorus grossus (Langsd. & Fisch.) Brownlie	laua'e	non-native	rare
CONIFERS			
PINACEAE (Pine Family)			
Pinus caribaea Morelet	Caribbean pine	non-native	rare
MONOCOTS			
AGAVACEAE (Agave Family)			
Agave sisalana Perrine	sisal	non-native	rare
Cordyline fruticosa (L.) A. Chev.	ki	polynesian	rare
ARECACEAE (Palm Family)			
Cocos nucifera L.	niu	polynesian	rare
Phoenix x dactylifera	hybrid date palm	non-native	rare
CYPERACEAE (Sedge Family)			
Cyperus rotundus L.	nut-sedge	non-native	rare
POACEAE (Grass Family)			
Andropogon virginicus L.	broomsedge	non-native	rare
Brachiaria mutica (Forssk.) Stapf	California grass	non-native	rare
Chloris barbata (L.) Sw.	swollen fingergrass	non-native	rare
Chloris divaricata R.Br.	stargrass	non-native	uncommon
Chrysopogon aciculatus (Retz.) Trin.	pi'i pi'i	indigenous	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Cynodon dactylon (L.) Pers.	Bermuda grass	non-native	uncommon
Dactyloctenium aegytium (L.) Willd.	beach wiregrass	non-native	rare
Digitaria ciliaris (Retz.) Koeler	Henry's crabgrass	non-native	uncommon
Digitaria insularis (L.) Mez ex Ekman	sourgrass	non-native	abundant
Eleusine indica (L.) Gaertn.	wiregrass	non-native	uncommon
Eragrostis amabilis (L.) Wight & Arnott	Japanese lovegrass	non-native	rare
Eragrostis pectinacea (Michx.) Nees	Carolina lovegrass	non-native	rare
Panicum maximum Jacq.	Guinea grass	non-native	uncommon
Paspalum conjugatum Bergius	Hilo grass	non-native	rare
Paspalum dilatatum Poir.	Dallis grass	non-native	uncommon
Paspalum fimbriatum Kunth	Panama paspalum	non-native	rare
DICOTS			
ACANTHACEAE (Acanthus Family)			
Asystasia gangetica (L.) T.Anderson	Chinese violet	non-native	common
AMARANTHACEAE (Amaranth Family)			
Achyranthes aspera L.	chirchita	non-native	uncommon
Alternanthera pungens Kunth	khaki weed	non-native	rare
Amaranthus spinosus L.	spiny amaranth	non-native	uncommon
Amaranthus viridis L.	slender amaranth	non-native	rare
ANACARDIACEAE (Mango Family)			
Magnifera indica L.	mango	non-native	rare
Schinus terebinthifolius Raddi	Christmas berry	non-native	common
APIACEAE (Parsley Family)			
Centella asiatica (L.) Urb.	Asiatic pennywort	non-native	rare
Ciclospermum leptophyllum (Pers.) Sprague	fir-leaved celery	non-native	rare
ASTERACEAE (Sunflower Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Acanthospermum australe (Loefl.) Kuntze	spiny bur	non-native	rare
Ageratum conyzoides L.	maile hohono	non-native	uncommon
Bidens alba (L.) DC	common beggarticks	non-native	common
Calyptocarpus vialis Less.	straggler daisy	non-native	uncommon
Conyza bonariensis (L.) Cronquist	hairy horseweed	non-native	rare
Crassocephalum crepidioides (Benth.)S.Moore	red flower ragleaf	non-native	rare
Cyanthillium cinereum (L.) H. Rob.	little ironweed	non-native	rare
Emilia fosbergii Nicolson	red pualele	non-native	rare
Pluchea carolinensis (Jacq.) G.Don	sourbush	non-native	common
Pluchea indica (L.) Less.	Indian fleabane	non-native	rare
Synedrella nodiflora (L.) Gaertn.	nodeweed	non-native	rare
Verbesina encelioides (Cav.) Benth.&Hook.	golden crown-beard	non-native	rare
Xanthium strumarium L.	cocklebur	non-native	uncommon
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P.Beauv.	African tulip tree	non-native	rare
BORAGINACEAE (Borage Family)			
Heliotropium procumbens Mill.	clasping heliotrope	non-native	rare
BRASSICACEAE (Mustard Family)			
Lepidium virginicum L.	peppergrass	non-native	rare
CARICACEAE (Papaya Family)			
Carica papaya L.	papaya	non-native	rare
CASUARINACEAE (She-oak Family)			
Casuarina equisetifolia Stickm.	common ironwood	non-native	uncommon
CHENOPODIACEAE (Goosefoot Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Chenopodium murale L.	'aheahea	non-native	rare
CONVOLVULACEAE (Morning Glory Family)			
Ipomoea obscura (L.) Ker-Gawl.	--------------	non-native	rare
EUPHORBIACEAE (Spurge Family)			
Aleurites moluccana (L.) Willd.	kukui	polynesian	rare
Chamaesyce hirta (L.) Millsp.	hairy spurge	non-native	rare
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	non-native	rare
Chamaesyce prostrata (Aiton.) Small	prostrate spurge	non-native	rare
Macaranga tanarius (L.) Mull. Arg.	parasol leaf tree	non-native	common
Phyllanthus debilis Klein ex Willd.	niruri	non-native	uncommon
Ricinus communis L.	Castor bean	non-native	rare
FABACEAE (Pea Family)			
Acacia confusa Merr.	Formosa koa	non-native	rare
Acacia farnesiana (L.) Willd.	klu	non-native	uncommon
Chamaecrista nictitans (L.) Moench	partridge pea	non-native	uncommon
Crotalaria incana L.	fuzzy rattlepod	non-native	rare
Crotalaria pallida Aiton	smooth rattlepod	non-native	rare
Crotalaria retusa L.	rattleweed	non-native	rare
Desmanthus pernambucanus (L.) Thellung	slender mimosa	non-native	uncommon
Desmodium incanum DC.	ka'imi clover	non-native	uncommon
Desmodium triflorum (L.)	three-flowered beggarweed	non-native	rare
Erythrina variegata L.	tiger claw	non-native	rare
Indigofera hendecaphylla Jacq.	creeping indigo	non-native	rare
Leucaena leucocephala (Lam.) de Wit	koa haole	non-native	abundant
Macroptilium lathyroides (L.) Urb.	wild bean	non-native	rare
Medicago lupulina L.	black medick	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Mimosa pudica L.	sensitive plant	non-native	uncommon
Neonotonia wightii (Wight&Arnott) Lackey	glycine	non-native	rare
Samanea saman (Jacq.) Merr.	monkeypod	non-native	rare
Senna occidentalis (L.) Link	coffee senna	non-native	uncommon
Senna surratensis (N.L.Burm.)H.Irwin&Barneby	kolomona	non-native	common
Stylosanthes fruticosa (Retz.) Alston	shrubby pencilflower	non-native	uncommon
LAMIACEAE (Mint Family)			
Leonotis nepetifolia (L.) R.Br.	lion's ear	non-native	uncommon
Ocimum gratissimum L.	wild basil	non-native	rare
MALVACEAE (Mallow Family)			
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	non-native	rare
Malva parviflora L.	cheeseweed	non-native	rare
Malvastrum coromandelianum (L.) Garcke.	false mallow	non-native	uncommon
Sida ciliaris (L.) D.Don	fringed fan petals	non-native	uncommon
Sida rhombifolia L.	Cuban jute	non-native	uncommon
Sida spinosa L.	prickly sida	non-native	uncommon
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D.Don	Koster's curse	non-native	rare
MORACEAE (Fig Family)			
Ficus macrophylla Desf. ex Pers.	Moreton Bay fig	non-native	rare
Ficus microcarpa L.fil.	Chinese banyan	non-native	rare
Ficus platypoda A.Cunn.ex Miq.	rock fig	non-native	uncommon
MYRSINACEAE (Myrsine Family)			
Ardisia elliptica Thunb.	shoebutton ardisia	non-native	rare
MYRTACEAE (Myrtle Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Pimenta diocia (L.) Merr.	allspice	non-native	common
Psidium cattleianum Sabine	strawberry guava	non-native	rare
Psidium guajava L.	guava	non-native	uncommon
Syzygium cumini (L.) Skeels	Java plum	non-native	uncommon
NYCTAGINACEAE (Four-o'clock Family)			
Bougainvillea spectabilis Willd.	bougainvillea	non-native	rare
OXALIDACEAE (Wood Sorrel Family)			
Oxalis corniculata L.	'ihi'ai	polynesian	uncommon
Oxalis debilis Kunth	pink wood sorrel	non-native	rare
PASSIFLORACEAE (Passion Flower Family)			
Passiflora edulis Sims	passion fruit	non-native	rare
Passiflora suberosa L.	corkystem passion flower	non-native	uncommon
PHYTOLACCACEAE (Pokeweed Family)			
Rivina humilis L.	coral berry	non-native	uncommon
PIPERACEAE (Pepper Family)			
Peperomia blanda Kunth *var floribunda* (Miq.) H.Huber	'ala'alawainui	indigenous	rare
PLANTAGINACEAE (Plantain Family)			
Plantago lanceolata L.	narrow-leaved plantain	non-native	uncommon
PLUMBAGINACEAE (Plumbago Family)			
Plumbago zeylanica L.	'ilie'e	indigenous	rare
POLYGALACEAE (Milkwort Family)			
Polygala paniculata L.	milkwort	non-native	rare
POLYGONACEAE (Buckwheat Family)			
Antigonon leptopus Hook & Arnott	Mexican creeper	non-native	rare
Rumex obtusifolius L.	bitter dock	non-native	rare
PRIMULACEAE (Primrose Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Anagallis arvensis L.	scarlet pimpernel	non-native	rare
ROSACEAE (Rose Family)			
Osteomeles anthyllidifolia (Sm.) Lindl.	u'ulei	indigenous	rare
RUBIACEAE (Coffee Family)			
Morinda citrifolia L.	noni	Polynesian	rare
Spermacoce assurgens Ruiz & Pav.	buttonweed	non-native	rare
RUTACEAE (Rue Family)			
Citrus aurantiifolia (Christm.) Swingle	lime	non-native	rare
SAPOTACEAE (Sapodilla Family)			
Chrysophyllum oliviforme L.	satin leaf	non-native	uncommon
SOLANACEAE (Nightshade Family)			
Capsicum frutescens L.	chili pepper	non-native	rare
Solanum americanum Mill.	popolo	indigineous	rare
Solanum torvum Sw.	pea aubergine	non-native	common
STERCULIACEAE (Cacao Family)			
Waltheria indica L.	'uhaloa	indigenous	uncommon
THYMELAEACEAE ('Akia Family)			
Wikstroemia oahuensis (A. Gray) Rock	'akia	endemic	uncommon
TILIACEAE (Linden Family)			
Triumfetta rhomboidea Jacq.	diamond burrbark	non-native	rare
Triumfetta semitriloba Jacq.	Sacramento bur	non-native	uncommon
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	non-native	common
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain	non-native	uncommon
Stachytarpheta jamaicensis (L.) Vahl	Jamaican vervain	non-native	common
Verbena litoralis Kunth.	ha'u owi	non-native	rare

FAUNA SURVEY REPORT

SURVEY METHODS

A walk-through survey method was conducted covering all parts of the project area. Field observations were made using binoculars and by listening to vocalizations. Notes were made on species abundance, activities and locations as well as observations of trails, tracks, scat and signs of feeding. In addition an evening visit was made to record crepuscular activities and vocalizations and to see if there was any evidence of the Endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) in the area.

MAMMALS

Three species of mammals were observed in the project area during three site visits. Taxonomy and nomenclature follow Tomich (1986).

Domestic cattle (*Bos taurus*) – Numerous cattle were being grazed on all parts of the property as part of a ranching operation.

Domestic horse (*Equus caballus*) – A few horses were also being grazed on the property by the ranch.

Feral pig (*Sus scrofa*) – One pig was seen in the dense brush and diggings and scat were widespread across the property.

Others mammals one might expect to be present, but which were not seen, include: mongoose (*Herpestes auropunctatus*), rats (*Rattus rattus)*, mice (*Mus domesticus*) and feral cats (*Felis catus*). Rats and mice feed on seeds, fruits and herbaceous vegetation, and the mongoose and cats hunt for these rodents as well as birds.

A special effort was made to look for the native Hawaiian hoary bat by making an evening survey in the most promising habitat on the property. The limestone bluffs on the lower edge of the property with their adjacent dense forests were reconnoitered during the evening hours for any activity. When present in an area these bats can be easily identified as they forage for insects, their distinctive flight patterns clearly visible in the glow of twilight. No evidence of such activity was observed though visibility was excellent and plenty of flying insects were seen.

Hawaiian hoary bats are extremely rare on O'ahu and no recent sightings have been made in this area.

BIRDS

Birdlife was moderate in both diversity and numbers considering the large size of the property and wide range of habitats. An ample supply of grass and herbaceous plant seeds as well as flying insects and caterpillars were present due to winter rains and spring growth. Sixteen species of birds were recorded during three site visits including fourteen non-native birds and two migratory visitors. Taxonomy and nomenclature follow American Ornithologists' Union (2005).

Zebra dove (*Geopelia striata*) – Small flocks of these doves were found on all parts of the property where they were seen feeding in grassy openings.

Common myna (*Acridotheres tristis*) – Many pairs of mynas were seen in trees or in flight overhead.

Red-vented bulbul (*Pycnonotus cafer*) – Many of these dark birds were seen in trees throughout the property and heard making their warbling calls.

Common waxbill (*Estrilda astrild*) – Several flocks of these tiny birds were seen feeding on grass seeds in forest openings or in flight.

Northern cardinal (*Cardinalis cardinalis*) – Many of these red birds were seen individually or in pairs and more were heard calling from forest trees.

House finch (*Carpodacus mexicanus*) – Small flocks were seen scattered across the property or congregating in ironwood trees.

White-rumped shama (*Copsychus malabaricus*) – Several of these shamas were heard making their prolonged melodic songs from dense forest patches.

Japanese white-eye (*Zosterops japonica*) – Several pairs of these small green birds were seen in forest trees and making their high-pitched calls.

Spotted dove (*Streptopelia chinensis*) – A few of these large doves were seen in flight moving between trees and forest openings.

Cattle egret (*Bubulcus ibis*) – A few of these large white egrets were seen flying over the property especially during the evening when they congregate to roost.

Nutmeg mannikin (*Lonchura punctulata*) – A few flocks of these small brown birds were seen in grassy openings and adjacent trees.

Chestnut manikin (*Lonchura Malacca*) – A few of these small reddish-brown birds were seen in grassy openings and adjacent shrubs.

Red-crested cardinal (*Paroaria coronata*) – Two pairs of these red-headed birds was seen and heard calling from forest trees.

African silverbill (*Lonchura cantans*) – One flock of these small pale silverbills was seen in a grassy opening in the lower part of the property.

Pacific golden-plover, Kolea (*Pluvialis fulva*) – Two of these migratory plovers were seen in an open pasture. They were growing out their breeding plumage in preparation for their flight to the arctic in April.

Ruddy turnstone, 'Akekeke (*Arenaria interpres*) – Two of these migratory turnstones were seen in an open pasture with the plovers. They too are preparing for their summer trip to the arctic breeding grounds.

Five species of native waterbirds, four of which are Endangered species: ae'o or black-necked stilt (Himantopus mexicanus knudseni), 'alae'ula or common moorhen (Gallinula chloropus sandvicensis), 'alae ke'oke'o or Hawaiian coot (Fulica alai) and koloa or Hawaiian duck (Anas wyvilliana) are known to frequent the extensive protected wetlands of the James Campbell National Wildlife Refuge about a mile away below Kamehameha Highway. These species, however, are all wetland obligates for feeding, breeding and nesting. They may periodically fly high over this subject property transiting between other wetland habitats, but there is no such habitat whatsoever that would attract these birds to land here or to utilize this property in any way. The subject property is also not suitable for Hawaii's native forest birds that require native forests at higher elevations.

INSECTS

While insects in general were not tallied, they were common throughout the area and fueled much of the bird activity observed. Although not found in the project site, one native Sphingid moth species, Blackburn's sphinx moth (Manduca blackburni), has been put on the federal Endangered species list and this designation requires special focus (USFWS, 2000). Blackburn's sphinx moth once occurred on Leeward O'ahu although it has not been seen in recent decades. Its native host plants are species of 'aiea (Nothocestrum) in the nightshade family. Some non-native alternative host plants, all also in the nightshade family, include commercial tobacco (Nicotiana tabacum), tree tobacco (Nicotiana glauca), tomato (Solanum

lycopersicum) and eggplant (Solanum melongena). None of the above native or non-native host plants were found on the property and no Blackburn’s sphinx moth or their larvae were seen.

DISCUSSION AND RECOMMENDATIONS

Fauna surveys are seldom comprehensive due to the short windows of observation, the seasonal nature of animal activities and the usually unpredictable nature of their daily movements. This survey would have recorded a few more non-native mammals and birds had the surveys extended longer and at different times of the year, but it is not likely that it would have found anything that was environmentally significant requiring special consideration.

None of the mammals, birds or insects found on the property are Threatened or Endangered species (USFWS,1999) nor are there any that are candidate for such status. The three mammal species and fourteen of the birds are common non-native species, that are of no environmental concern here in Hawaii. The two migrant birds, the kolea and ‘akekeke are seasonally widespread in both the Pacific and the arctic and carry no special federal status. No special fauna habitats were identified on the property either.

There is little of concern regarding the wildlife resources on the property. There is the remote possibility that Endangered waterfowl from the nearby wetlands could be struck by the turbine blades from the proposed windpower project, but as stated earlier there is nothing on the property that would attract these birds to their vicinity. Other than this highly unlikely occurrence, the project plans are not expected to have a significant negative impact on the fauna resources in this part of O’ahu.

COMMON NAME	SCIENTIFIC NAME	STATUS	ABUNDANCE
MAMMALS			
Cattle	*Bos taurus*	non-native	common
Horse	*Equus caballus*	non-native	uncommon
Pig	*Sus scrofa*	non-native	uncommon
BIRDS			
Zebra dove	*Geopelia striata*	non-native	common
Common myna	*Acridotheres tristis*	non-native	common
Red-vented bulbul	*Pycnonotus cafer*	non-native	common
Common waxbill	*Estrilda astrild*	non-native	common
Northern cardinal	*Cardinalis cardinalis*	non-native	common
House finch	*Carpodacus mexicanus*	non-native	uncommon
White-rumped shama	*Copsychus malabarica*	non-native	uncommon
Japanese white-eye	*Zosterops japonica*	non-native	uncommon
Spotted dove	*Streptopelia chinensis*	non-native	uncommon
Cattle egret	*Bubulcus ibis*	non-native	uncommon
Nutmeg mannikin	*Lonchura punctulata*	non-native	rare
Chestnut mannikin	*Lonchura malacca*	non-native	rare
Red-crested cardinal	*Paroaria coronata*	non-native	rare
African silverbill	*Lonchura cantans*	non-native	rare
Kolea, Pacific golden-plover	*Pluvialis fulva*	migratory	rare
'Akekeke, Ruddy turnstone	*Arenaria interpres*	migratory	rare

Literature Cited

American Ornithologists' Union. 2005. FCheck-list of North American Birds. 7th edition. American Ornithologists' Union. Washington D.C.

Armstrong, R. W. (ed.) 1983. Atlas of Hawaii. (2nd. ed.) University of Hawaii Press.

Foote, D.E. , E.L. Hill, S. Nakamura, and F. Stephens. 1972. Soil survey of the islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. U.S. Dept. of Agriculture, Soil Conservation Service. Washington, D.C.

Krussman, G. 1985. Manual of Cultivated Conifers. Timber Press.

Palmer, D.D. 2003. Hawaii's Ferns and Fern Allies. University of Hawaii Press.

Tomich, P.Q. 1986. Mammals in Hawaii (2nd ed.). Bishop Museum Press.

U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and Plants. 50 CFR 17.11 & 17.12

U.S. Fish and Wildlife Service. 2000. Endangered and Threatened Wildlife and Plants: Determination of Endangered Status for Blackburn's Sphinx Moth From Hawaii. Federal Register 65 (21): 4770 – 4779.

Wagner, W. L., D.R. Herbst, and S. H. Sohmer. 1999. Manual of the flowering plants of Hawai'i. Univ. of Hawai'I Press and Bishop Museum Press. Honolulu.

BIOLOGICAL RESOURCES SURVEY

for the

KAHUKU WIND POWER PROJECT

KAHUKU, OAHU, HAWAII

by

Robert W. Hobdy
Environmental Consultant
Kokomo, Maui
July 2009

Prepared for: First Wind Energy, LLC

BIOLOGICAL RESOURCES SURVEY
KAHUKU WIND POWER PROJECT

INTRODUCTION

The Kahuku Wind Power project lies on 68.5 acres of land west of Kahuku Town in the foothills of the northwest Koolau Range. The parcel (Lot 1192 – TMK 5-6-05:14) is surrounded on all sides by undeveloped lands above Kamehameha Highway. This biological study was initiated in fulfillment of environmental requirements of the planning process.

SITE DESCRIPTION

The project area lies on sloping land between elevations of 240 feet and 400 feet above sea level. It borders a military access road on its north edge. Vegetation consists of a broad array of dry grasses, brush and scattered trees. Soils are silty clays of the Kemo'o, Paumalu, and Lahaina series, and used to support sugar cane agriculture. Rainfall averages 45 to 50 inches per year with a winter maximum.

BIOLOGICAL HISTORY

In pre-contact times the lower, more gently sloping lands would have been extensively farmed by a large Hawaiian population that lived in the lower valleys and along the sea shore. The ridges would have been covered by a dense tangle of native shrubs such as 'ülei (*Osteomeles anthyllidifolia*), 'akia (*Wikstroemia oahuensis*), 'iliahi alo'e (*Santalum ellipticum*) and 'uhaloa (*Waltheria indica*).

In the late 1800s much of the area was converted to sugar cane agriculature. The land was cleared, plowed, burned and harvested in continuous cycles for about 100 years. Much of the steeper land was used to pasture plantation horses and mules. This reduced the numbers and diversity of native plants considerably. Sugar was discontinued in the 1980's and the land was put into cattle grazing or left idle. Today the area is a largely non-native shrubland and forest consisting of a diverse array of aggressive weedy species and a few tough and persistent native plants that have been able to compete and survive.

SURVEY OBJECTIVES

This report summarizes the findings of a flora and fauna survey of the proposed Kahuku Windfarm Project which was conducted during July, 2009.
The objectives of the survey were to:

1. Document what plant, bird and mammal species occur on the property or may likely occur in the existing habitat.

2. Document the status and abundance of each species.

3. Determine the presence or likely occurrence of any native flora and fauna, particularly any that are Federally listed as Threatened or Endangered. If such occur, identify what features of the habitat may be essential for these species.

4. Determine if the project area contains any special habitats which if lost or altered might result in a significant negative impact on the flora and fauna in this part of the island.

5. Note which aspects of the proposed development pose significant concerns for plants or for wildlife and recommend measures that would mitigate or avoid these problems.

BOTANICAL SURVEY REPORT

SURVEY METHODS

A walk-through botanical survey method was used following multiple routes to ensure complete coverage of the area. Areas most likely to harbor native plants such as gullies or rock outcrops were more intensively examined. Notes were made on plant species, distribution and abundance as well as terrain and substrate.

DESCRIPTION OF THE VEGETATION

The vegetation on this property is a mixture of aggressive weedy species that have taken over since the abandonment of sugar cane agriculture, but there is also a small complement of native shrubby species scattered across the property. The most abundant plant species encountered during the survey was sourgrass (*Digitaria insularis*) which persists on overgrazed pastures because of its unpalatable nature. Also common were Guinea grass (*Panicum maximum*), Christmas berry (*Schinus terebinthifolius*), kaimi clover (*Desmodium incanum*), koa haole (*Leucaena leucocephala*), shrubby pencil flower (*Stylosanthes fruticosa*), ‘uhaloa (*Waltheria indica*), common guava (*Psidium guajava*), Java plum (*Syzygium cumini*) and lantana (*Lantana camara*).

A total of 99 plant species were recorded during the survey. Of this number 7 were native to Hawaii: ‘akia (*Wikstroemia oahuensis*), kilau (*Pteridium aquilinum var decompositum*), ‘uhaloa, ‘ulei (*Osteomeles anthyllidifolia*), pili grass (*Heteropogon contortus*), huehue (*Cocculus orbiculatus*) and pi’ipi’i (*Chrysopogon aciculatus*). None of these are rare species and all are common on multiple islands.

DISCUSSION AND RECOMMENDATIONS

The vegetation of this parcel is dominated by non-native grasses, shrubs and small trees. A few common native plant species are scattered sparsely among the non-native plants, especially in the upper parts of the property. No federally listed Threatened or Endangered plant species (USFWS, 1999) were found on the property, nor were any found that are proposed for such status. There are no special habitats here either.

Due to the lack of unique or sensitive species or habitats there is little of botanical concern with regard to this property and the proposed project is not expected to have a significant negative impact on the botanical resources in this part of O’ahu.

If, however, there is any re-vegetation planned along road cuts or on the margins of tower pads, it is suggested that some of the native species listed above be selected for propagation and outplanting.

PLANT SPECIES LIST

Following is a checklist of all those vascular plant species inventoried during the field studies. Plant families are arranged alphabetically within each of four groups: Ferns, Conifers, Monocots and Dicots. Taxonomy and nomenclature of the Conifers and of the flowering plants (Monocots and Dicots) are in accordance with Wagner et al. (1999) and Staples and Herbst, 2005). Ferns follow Palmer, (2003).

For each species, the following information is provided:

1. Scientific name with author citation

2. Common English or Hawaiian name.

3. Bio-geographical status. The following symbols are used:

   endemic = native only to the Hawaiian Islands; not naturally occurring anywhere else in the world.
   indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).
   non-native = all those plants brought to the islands intentionally or accidentally after western contact.
   Polynesia = all those plants brought to Hawaii by the Polynesians during the course of their migrations.

4. Abundance of each species within the project area:

   abundant = forming a major part of the vegetation within the project area.
   common = widely scattered throughout the area or locally abundant within a portion of it.
   uncommon = scattered sparsely throughout the area or occurring in a few small patches.
   rare = only a few isolated individuals within the project area.

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
FERNS			
DENNSTAEDTIACEAE (Bracken Fern Family)			
Pteridium aquilinum (L.) Kuhn var. decompositum (Gaud.) R.M.Tryon	kilau, bracken fern	endemic	rare
NEPHROLEPIDACEAE (Sword Fern Family)			
Nephrolepis brownii (Desv.) Hovencamp & Miyam.	Asian sword fern	non-native	uncommon
POLYPODIACEAE (Polypody Fern Family)			
Phymatosorus grossus (Langsdon&Fisch.) Brownlie	laua'e	non-native	uncommon
PTERIDACEAE (Brake Fern Family)			
Cheilanthes viridis (Forssk.) Sw.	green cliff brake	non-native	uncommon
CONIFERS			
PINACEAE (Pine Family)			
Pinus radiata D. Don	Monterey Pine	non-native	rare
MONOCOTS			
ARECACEAE (Palm Family)			
Cocos nucifera L.	coconut, niu	Polynesian	rare
Phoenix x dactylifera	hybrid date palm	non-native	rare
ASPARAGACEAE (Asparagus Family)			
Cordyline fruticosa (L.) A. Chev.	ki, ti leaf	Polynesian	rare
COMMELINACEAE (Spiderwort Family)			
Commelina diffusa N.L. Burm.	honohono	non-native	rare
CYPERACEAE (Sedge Family)			
Cyperus gracilis R. Br.	McCoy grass	non-native	rare
POACEAE (Grass Family)			
Andropogon virginicus L.	broomsedge	non-native	uncommon
Axonopus fissifolius (Raddi) Kuhlm.	narrow-leaved carpetgrass	non-native	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Bothriochloa barbinodis (Lag.) Herter	fuzzy top	non-native	rare
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	non-native	uncommon
Chrysopogon aciculatus (Retz.) Trin.	pi'ipi'i	indigenous	uncommon
Cynodon dactylon (L.) Pers.	Bermuda grass	non-native	uncommon
Digitaria ciliaris (Retz.) Koeler	Henry's crabgrass	non-native	uncommon
Digitaria insularis (L.) Mez ex Ekman.	sourgrass	non-native	abundant
Eleusine indica (L.) Gaertn.	wiregrass	non-native	rare
Heteropogon contortus (L.) Beauv.	pili grass	indigenous	rare
Hyparrhenia rufa (Nees) Stapf	thatching grass	non-native	rare
Melinis repens (Willd.) Zizka	Natal redtop	non-native	uncommon
Panicum maximum Jacq.	Guinea grass	non-native	common
Paspalum conjugatum Bergius	Hilo grass	non-native	rare
Paspalum dilatatum Poir.	Dallis grass	non-native	uncommon
Pennisetum polystachion (L.) Schult.	feathery pennisetum	non-native	rare
Setaria parvilfora (Poir.) Kerguelen	yellow foxtail	non-native	uncommon
Sporobolus africanus (Poir.) Robyns & Tournay	African dropseed	non-native	uncommon
DICOTS			
ACANTHACEAE (Acanthus Family)			
Asystasia gangetica (L.) T.Anderson	Chinese violet	non-native	uncommon
AMARANTHACEAE (Amaranth Family)			
Acyranthes aspera L.	------------------	non-native	rare
Amaranthus spinosus L.	spiny amaranth	non-native	rare
ANACARDIACEAE (Mango Family)			
Mangifera indica L.	mango	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Schinus terebinthifolius Raddi	Christmas berry	non-native	common
APIACEAE (Parsley Family)			
Centella asiatica (L.) Urb.	Asiatic pennywort	non-native	rare
ARALIACEAE (Ginseng Family)			
Shefflera actinophylla (Endl.) Harms	octopus tree	non-native	rare
ASTERACEAE (Sunflower Family)			
Acanthospermum australe (Loefl.) Kuntze	spiny bur	non-native	uncommon
Bidens alba (L.) DC	------------------	non-native	uncommon
Conyza bonariensis (L.) Cronq.	hairy horseweed	non-native	uncommon
Elephantopus mollis Kunth	-----------------	non-native	rare
Emilia fosbergii Nicolson	red pualele	non-native	rare
Emilia sonchifolia (L.) DC.	violet pualele	non-native	rare
Pluchea carolinensis (Jacq.) G.Don	sourbush	non-native	uncommon
Pluchea indica (L.) Less.	Indian fleabane	non-native	rare
Xanthium strumarium L.	kikania	non-native	uncommon
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P.Beauv.	African tulip tree	non-native	rare
CASUARINACEAE (She-oak Family)			
Casuarina equisetifolia Stickm.	common ironwood	non-native	rare
Casuarina glauca Sieber ex Spreng.	longleaf ironwood	non-native	rare
EUPHORBIACEAE (Spurge Family)			
Macaranga tanarius (L.) Mull. Arg.	parasol leaf tree	non-native	rare
Phyllanthus debilis Klein ex Willd.	niruri	non-native	rare
FABACEAE (Pea Family)			
Acacia confusa Merr.	Formosa koa	non-native	uncommon
Acacia farnesiana (L.) Willd.	klu	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Chamaecrista nictitans (L.) Moench	partridge pea	non-native	uncommon
Crotalaria incana L.	fuzzy rattlepod	non-native	rare
Crotalaria retusa L.	rattlepod	non-native	rare
Desmanthus pernambucanus (L.) Thellung	slender mimosa	non-native	uncommon
Desmodium incanum DC.	ka'imi clover	non-native	common
Desmodium triflorum (L.) DC.	three-flowered beggarweed	non-native	rare
Indigofera suffruticosa Mill.	inikö	non-native	rare
Leucaena leucocephala (Lam.) de Wit	koa haole	non-native	common
Mimosa pudica L.	sensitive plant	non-native	uncommon
Neonotonia wightii (Wight & Arnott) Lackey	glycine	non-native	uncommon
Senna occidentalis (L.) Link	coffee senna	non-native	rare
Senna surattensis (N.L. Burm.) H. Irwin & Barneby	kolomona	non-native	uncommon
Stylosanthes fruticosa (Retz.) Alston	shrubby pencil flower	non-native	common
LAMIACEAE (Mint Family)			
Hyptis pectinata (L.) Poit.	comb hyptis	non-native	uncommon
Leonotis nepetifolia (L.) R. Br.	lion's ear	non-native	uncommon
MALVACEAE (Mallow Family)			
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	non-native	uncommon
Malvastrum coromandelianum (L.) Garcke	false mallow	non-native	uncommon
Sida cordifolia L.	--------------------	non-native	rare
Sida rhombifolia L.	Cuban jute	non-native	uncommon
Sida spinosa L.	prickly sida	non-native	uncommon
Triumfetta rhomboidea Jacq.	------------------	non-native	rare
Triumfetta semitriloba Jacq.	Sacramento bur	non-native	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Waltheria indica L.	'uhaloa	indigenous	common
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D.Don	Koster's curse	non-native	uncommon
MENISPERMACEAE (Moonseed Family)			
Cocculus orbiculatus (L.) DC.	huehue	indigenous	uncommon
MORACEAE (Fig Family)			
Ficus platypoda (A. Cunn. ex Miq.) A. Cunn. ex Miq.	rock fig	non-native	rare
MYRSINACEAE (Myrsine Family)			
Ardisia elliptica Thunb.	shoebutton ardisia	non-native	rare
MYRTACEAE (Myrtle Family)			
Pimenta dioica (L.) Merr.	allspice	non-native	uncommon
Psidium cattleianum Sabine	strawberry guava	non-native	uncommon
Psidium guajava L.	common guava	non-native	common
Syzygium cumini (L.) Skeels	Java plum	non-native	common
OXALIDACEAE (Wood Sorrel Family)			
Oxalis corniculata L.	yellow wood sorrel	Polynesian	rare
PASSIFLORACEAE (Passion Flower Family)			
Passiflora edulis Sims	passion fruit	non-native	rare
Passiflora foetida L.	love-in-a-mist	non-native	rare
Passiflora suberosa L.	huehue haole	non-native	rare
PHYTOLACCACEAE (Pokeweed Family)			
Rivina humilis L.	rouge plant	non-native	rare
PLANTAGINACEAE (Plantain Family)			
Plantago lanceolata L.	narrow-leaved plantain	non-native	uncommon
POLYGALACEAE (Milkwort Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Polygala paniculata L.	---------------------	non-native	rare
ROSACEAE (Rose Family)			
Osteomeles anthyllidifolia (Sm.) Lindl.	'ulei	indigneous	uncommon
RUBIACEAE (Coffee Family)			
Morinda citrifolia L.	noni	Polynesian	rare
Spermacoce assurgens Ruiz & Pav.	buttonweed	non-native	rare
SOLANACEAE (Nighshade Family)			
Capsicum frutescens L.	chili pepper	non-native	uncommon
Solanum torvum Sw.	pea aubergine	non-native	uncommon
THYMELAEACEAE ('Akia Family)			
Wikstroemia oahuensis (A. Gray) Rock	'akia	endemic	uncommon
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	non-native	common
Stachytarpheta australis Modenke	owi	non-native	uncommon
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain	non-native	uncommon
Stachytarpheta jamaicensis (L.) Vahl	Jamaican vervain	non-native	uncommon

FAUNA SURVEY REPORT

SURVEY METHODS

A walk-through survey method was conducted in conjunction with the botanical survey. All parts of the project area were covered. Field observations were made with the aid of binoculars and by listening to vocalizations. Notes were made on species, abundance, activities and location as well as observations of trails, tracks scat and signs of feeding. In addition an evening visit was made to the area to record crepuscular activities and vocalizations and to see if there was any evidence of occurrence of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in the area.

RESULTS

MAMMALS

Two species of mammals were observed during three site visits to the property. Taxonomy and nomenclature follow Tomich (1986).

Cattle (*Bos taurus*) – There was quite a bit of old cattle sign scattered about the property. This was from former grazing on this land.

Mongoose (*Herpestes auropunctatus*) – A few mongoose were seen scurrying through the underbrush where they hunt for rodents and birds.

Dense vegetation prevented good visibility of other small mammals. One would expect to find rats (*Rattus spp*.) and mice (*Mus domesticus*) in this type of habitat and one would expect a few feral cats (*Felis catus*) which would hunt for these rodents as well as birds.

BIRDS

Moderate birdlife diversity was observed within the project area during three site visits. Thirteen bird species were recorded including twelve non-native species and one indigenous seabird. Taxonomy and nomenclature follow American Ornithologists' Union (2005).

Red-vented bulbul (*Pycnonotus cafer*) – These dark bulbuls were abundant on all parts of this property, flying between trees and making their warbling calls.

Zebra dove (*Geopelia striata*) – These small doves were scattered throughout the property in small flocks.

Cattle egret (*Bubulcus ibis*) – A few individuals were seen during the day and small flocks were seen flying overhead heading for roosting trees during the evening.

Red-crested cardinal (*Paroaria coronata*) – A couple families of these bright red-headed birds were seen foraging in trees.

Japanese white-eye (*Zosterops japonicus*) – Several pairs of these small green birds were seen foraging for caterpillars in small trees and making their high pitched calls.

Common myna (*Acridotheres tristis*) – A few pairs of mynas were seen flying between trees throughout the property.

Northern cardinal (*Cardinalis cardinalis*) – A few of these red cardinals were seen darting about in dense forest and making their loud distinctive calls.

Red-billed leiothrix *(Leiothrix lutea*) – A few of these colorful birds were seen and heard calling from dense forest in a gully.

Spotted dove (*Streptopelia chinensis*) – Three of these large doves were seen flying between trees across the property.

Northern mockingbird (*Mimus polyglottos*) – Two mockingbirds were seen flying between trees flashing their long tail feathers.

Common waxbill (*Estrilda astrild*) – One flock of these tiny birds was seen feeding in tall grass during the late afternoon.

Red-whiskered bulbul (*Pycnonotus jocosus*) – One of these bulbuls was seen in a small tree during the late afternoon.

‘Iwa, Great frigatebird (*Fregata minor*) – One ‘iwa was seen cruising high over the property during the evening. This bird was looking for incoming seabirds he could rob of their daily catch. The ‘iwa is a widespread and common seabird throughout the tropical Pacific.

This study area is situated about ¾ mile above the substantial wetlands of the James Campbell National Wildlife Refuge that provides habitat for three Endangered Waterbirds, the ‘alae ‘ula or common moorhen (*Gallinula chloropus sandvicensis),* the ‘alae ke’oke’o or Hawaiian coot (*Fulica alai*) and the ae’o or Hawaiian stilt (*Himantopus mexicanus knudseni*) as well as other commoner waterbirds and shorebirds. These birds fly substantial distances and could overlfy the project area enroute to other wetland habitats. This area, however, has no wetland habitat to attract such waterbirds and none were seen.

INSECTS

While insects in general were not tallied, they were common throughout the property. Although not found on the property, one native sphingid moth, Blackburn's sphinx moth (*Manduca blackburni*), has been put on the Federal Endangered species list and this designation requires special focus (USFWS, 2000). Blackburn's sphinx moth was known to occur on O'ahu in the past, although it has not been found here recently. Its native host plants are species of ‘aiea (*Nothocestrum spp.*) and alternative host plants are tobacco (*Nicotiana tabacum*) and tree tobacco (*Nicotiana glauca*). There are no ‘aiea on or near the property, and no tobacco or tree tobacco were found on the property. No Blackburn's sphinx moth or their larvae were found.

DISCUSSION AND RECOMMENDATIONS

Most of the wildlife found on this property is non-native and is of little concern from a conservation standpoint. There are, however, wetlands in the Kahuku area that provide habitat for Endangered waterbirds, and the Endangered Hawaiian hoary bat has been detected about a mile to the southeast in a recent survey. The presence of these Endangered volant birds and bat in the general vicinity of proposed wind turbines raises concerns for their safety that may need to be addressed proactively in consultation with the U.S. Fish and Wildlife Service which exercises jurisdiction over these animals under the authority of the Endangered Species Act.

No other concerns regarding the wildlife of this project area are anticipated and no further recommendations are offered.

ANIMAL SPECIES LIST

Following is a checklist of the animal species inventoried during the field work. Animal species are arranged in descending abundance within two groups: Mammals and Birds. For each species the following information is provided:

1. Common name

2. Scientific name

3. Bio-geographical status. The following symbols are used:

    endemic = native only to Hawaii; not naturally occurring anywhere else in the world.
    indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).
    non-native = all those animals brought to Hawaii intentionally or accidentally after western contact.
    migratory = spending a portion of the year in Hawaii and a portion elsewhere. In Hawaii the migratory birds are usually in the overwintering/non-breeding phase of their life cycle.

4. Abundance of each species within the project area:

    abundant = many flocks or individuals seen throughout the area at all times of day.
    common = a few flocks or well scattered individuals throughout the area.
    uncommon = only one flock or several individuals seen within the project area.
    rare = only one or two seen within the project area.

COMMON NAME	SCIENTIFIC NAME	STATUS	ABUNDANCE
MAMMALS			
Cattle	*Bos taurus*	non-native	uncommon
Mongoose	*Herpestes auropunctatus*	non-native	uncommon
BIRDS			
Red-vented bulbul	*Pycnonotus cafer*	non-native	abundant
Zebra dove	*Geopelia striata*	non-native	uncommon
Cattle egret	*Bubulcus ibis*	non-native	uncommon
Red-crested cardinal	*Paroaria coronata*	non-native	uncommon
Japanese white-eye	*Zosterops japonicus*	non-native	uncommon
Common myna	*Acridotheres tristis*	non-native	uncommon
Northern cardinal	*Cardinalis cardinalis*	non-native	uncommon
Red-billed leiothrix	*Leiothrix lutea*	non-native	uncommon
Spotted dove	*Streptopelia chinensis*	non-native	uncommon
Northern mockingbird	*Mimus polyglottos*	non-native	rare
Common waxbill	*Estrilda astrild*	non-native	rare
Red-whiskered bulbul	*Pycnonotus jocosus*	non-native	rare
'Iwa, Great frigatebird	*Fregata minor palmerstoni*	indigenous	rare

Literature Cited

American Ornithologists' Union 2005. Check-list of North American Birds. 7th edition. American Ornithologists' Union. Washington D.C.

Armstrong, R. W. (ed.) 1983. Atlas of Hawaii. (2nd. ed.) University of Hawaii Press.

Foote, D.E. , E.L. Hill, S. Nakamura, and F. Stephens. 1972. Soil survey of the islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. U.S. Dept. of Agriculture, Soil Conservation Service. Washington, D.C.

Palmer, D.D. 2003. Hawai'is Ferns and Fern Allies. University of Hawaii Press, Honolulu.

Staples, G.W. and D.R. Herbst 2005. A Tropical Garden Flora, Plants Cutivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press.

Tomich, P.Q. 1986. Mammals in Hawaii. Bishop Museum Press, Honolulu.

U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and Plants. 50 CFR 17.11 & 17.12

U.S. Fish and Wildlife Service. 2000. Endangered and threatened wildlife and plants: determination of endangered status for Blackburn's sphinx moth from Hawaii. Federal Register 65(21): 4770-4779.

Wagner, W. L., D.R. Herbst, and S. H. Sohmer. 1999. Manual of the flowering plants of Hawai'i. Univ. of Hawai'i Press and Bishop Museum Press. Honolulu.

Appendix F.

APPENDIX F. List of Plant Species Observed at Flying R Ranch

The following checklist is an inventory of all the plant species observed by SWCA biologists on December 16, 2009 at the Flying R Ranch site, Island of Oʻahu. SWCA staff conducted a walk-through survey method of an approximate 50 x 40 m (164 x 131 ft) area surrounding the proposed microwave tower site and along the dirt trail leading to the site. All plant species were documented and notes were made on plant communities, relative abundances, and substrate types. Plant identifications were made in the field; however, plants which could not be positively identified were collected for later determination in the herbarium, and for comparison with the most recent taxonomic literature.

The plant names are arranged alphabetically by family and then by species into each of two groups: Monocots and Dicots. The taxonomy and nomenclature of the flowering plants are in accordance with Wagner et al. (1990, 1999), Wagner and Herbst (1999), and Staples and Herbst (2005). Recent name changes are those recorded in the Hawaii Biological Survey series (Evenhuis and Eldredge, eds., 1999-2002).

For each species, the following is provided:

1. Scientific name with author citation.

2. Common English and/or Hawaiian name(s), when known.

3. Biogeographic status. The following symbols are used:

    - E= endemic= native only to the Hawaiian Islands.
    - I= indigenous= native to the Hawaiian Islands and elsewhere.
    - P = introduced by Polynesians.
    - X=introduced or alien = all those plants brought to the Hawaiian Islands by humans, intentionally or accidentally, after Western contact (Cook's arrival in the islands in 1778).

4. Relative site abundance. The following categories are used.

    - Abundant = forming a major part of the vegetation within the survey area.
    - Common = widely scattered throughout the area or locally abundant within a portion of it.
    - Uncommon = scattered sparsely throughout the area or occurring in a few small patches.
    - Rare = only a few isolated individuals within the survey area.

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
ANGIOSPERMS- MONOCOTS			
POACEAE			
Melinis repens (Willd.) Zizka	natal red top	X	Rare
Urochloa maxima (Jacq.) R. Webster	Guinea grass	X	Common
ANGIOSPERMS- DICOTS			
ANACARDIACEAE			
Schinus terebinthifolius Raddi	Christmas berry	X	Rare
ASTERACEAE			
Ageratum conyzoides L.	maile honohono	X	Common
EUPHORBIACEAE			
Phyllanthus debilis Klein ex Willd.	niruri	X	Rare
FABACEAE			
Acacia farnesiana (L.) Willd.	klu, aroma, kolu	X	Rare
Desmodium incanum DC.	Spanish clover, ka‘imi	X	Uncommon
Mimosa pudica L.	sensitive plant, sleeping grass	X	Uncommon
Senna surattensis (Burm.f.) H.S.Irwin & Barneby	Kolomona, scrambled egg plant	X	Rare
Stylosanthes sp.	---	X	Rare
MALVACEAE			
Sida acuta N.L. Burm.	---	X	Uncommon
Sida rhombifolia L.	---	X	Uncommon
MYRTACEAE			
Syzygium cumini (L.) Skeels	Java plum	X	Common
OXALIDACEAE			
Oxalis corniculata L.	yellow wood sorrel, ‘ihi ‘ai	X	Rare
PROTEACEAE			
Grevillea robusta A.Cunn. ex R.Br.	silver oak, silk oak	X	Rare
SAPINDACEAE			
Dodonaea viscosa Jacq.	a‘ali‘i	I	Rare
STERCULIACEAE			
Waltheria indica L.	‘uhaloa	I	Uncommon
VERBANACEAE			
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain	X	Common

Appendix G.

Kahuku Wind Power Wildlife Monitoring Report and Fatality Estimates for Waterbirds and Bats (October 2007 – April 2009)

By
SWCA Environmental Consultants and First Wind

SWCA
L. Ong, PhD., T. Thair, B.A., R. Taira, B.A. and S. Mosher, M.S.
201 Merchant Street Suite 2310
Honolulu, HI 96813

First Wind
G. Spencer, R. Roy, I. Bordenave
85 Wells Avenue, Suite 305
Newton, MA 02459-3210

June 19, 2009

1.0 INTRODUCTION

Firstwind (formerly UPC Hawaii Wind Partners, LLC) has proposed to develop a 30 mega-watt wind power facility near the town of Kahuku on the island of Oahu, Hawaii. Kahuku Wind Power is situated one mile from the James Campbell Wildlife Refuge which harbors a significant portion of Hawaii's endangered waterbirds (Fig. 1). Avian and bat surveys were conducted to assess the risk of the proposed wind facility to Federal or state-listed threatened or endangered species that may be found on site or may transit through the site. When the project is completed, Kahuku Wind Power will consist of 12 turbines and one permanent meteorological (met) tower.

The goals of the study were to:

1) quantify the level of bird and bat activity on site using visual surveys and Anabat detectors (for bats) with emphasis on characterizing the flight patterns and activity of threatened and endangered species within these groups;
2) conduct waterbird surveys at nearby wetlands to characterize flight activity and diurnal or seasonal variations in abundance or activity (if any) and
3) estimate fatality rates of threatened and endangered species due to operation of turbines and met towers

2.0 METHODS

2.1 Quantifying Bird Activity

Point count stations (Stations B to K, Fig. 1) were selected to provide maximum survey coverage of the project area. Ten point count stations were established on the site and used during the survey period from October 2007 to December 2008 (Fig. 1). Four to eight point count stations were surveyed during each session and sessions were conducted in the morning (0600 – 1000 h), afternoon (1000 – 1400 h) and evening (1400 – 1800 h). Each point count lasted 20 minutes per station. Two observers using 10 x 50 binoculars with a 6.5 degree field of vision were present at each point count and all passerines, owls (Strigiformes) and doves (Columbiformes) within a 200 m radius of the count location were recorded. Bird species aurally detected within 200 m radius were also recorded. Waterbirds and seabirds, which are larger and more visible were recorded to within a 400 m radius of the count station. Data recorded include time of day, bird species, size of flock, flight direction, flight altitude, distance between bird/s and observer, habitat, location (on site or off site) and sex and age of bird where possible. Weather conditions were also documented. Wind speed and wind direction were recorded with a Kestrel 4500 (Nielsen Kellerman, USA), % cloud cover and visibility were estimated visually and precipitation was categorically documented.

Three additional point count stations were established from June - December 2008 along roads running along wetlands at the north-east of the project site (Stations 77, 78 and 79; Fig. 1). These additional point counts were established to describe the flight activity of endangered Hawaiian waterbirds that may not be adequately surveyed at the established on-site point count locations. Survey methods at these point count stations followed the protocol described above. However, due to the greater number of endangered waterbirds in the surveyed wetlands, point counts were confined to a radius of 200 m for all bird species. In addition, bird flight paths that crossed the road moving from the wetlands to the uplands or from vice versa were also recorded. This behavior was quantified and used as a measure the likelihood of waterbirds flying over the upland Kahuku Wind Power site.

Predominant flight directions were determined for all point counts on site and at the surveyed wetlands. The distribution of flight direction was tested using a Chi-Square Goodness-of-Fit to determine if flight paths were random or directional in nature. Flight activity at each point count station on site at Kahuku Wind Power was tested using a one-way ANOVA with replicates to determine if some stations had higher flight activity than other stations. The data was log-transformed to normalize the data before running the analyses. Post-hoc Tukey's pairwise comparisons were conducted to determine which point count stations had higher rates of flight activity. All analyses were conducted using the statistical software SYSTAT (version 12, Systat Software, Inc.).

2.2 Quantifying bat activity

Nocturnal visual surveys and acoustic monitoring using bat detectors were used to quantify bat activity at the Kahuku Wind Power facility. Nocturnal visual surveys were conducted twice a month from October 2007 to December 2008. Four to eight point counts were surveyed for 20 minutes during each field session using the avian point count stations on the project site. Night vision goggles (Kerif ITT PVS-7 F5001 Series) and infra-red spotlights (Brinkmann Q-beam Max Million III) were used to detect bats to a distance of 30 m.

Three to five Anabat detectors (Titley Electronics, NSW, Australia) were deployed at any one time at various locations at the Kahuku Wind Power site from April 2008 to April 2009 (Fig. 2). Anabat detectors record any ultrasonic sounds emitted up to a radius of approximately 30 m from the device. These sounds are subsequently downloaded and analyzed by examining the sonograms of recorded sound files to confirm the presence of bats by identifying their echolocation (ultrasonic) calls. Anabat detectors were moved to new locations if they did not detect any calls for at least a month. Bat activity was quantified by the number of call sequences recorded (regardless of number of bat calls) and the number of bat passes (a sequence with three or more calls) per detector night. A bat call is one frequency modulated sweep, while a call sequence consists of a continuous recording of one or more bat calls. A call sequence with three of more calls qualifies as a bat pass (Kunz et al. 2007).

2.3 Calculating Fatality Estimates for Koloa Maoli-like Ducks

The koloa maoli-like ducks (or Hawaiian duck hybrids) are not endangered, but are hybrids of the endangered koloa maoli (*Anas wyvilliana* or Hawaiian duck) and the mallard (*Anas platyrhynchos*) and are a waterbird species of interest as they are likely to exhibit similar behaviors to the endangered koloa maoli.

Fatality estimates closely follow the model by Day and Cooper (2008) with modifications. The model includes movement rates (average passage rates over the site), horizontal interaction probabilities (probability of a bird encountering a turbine), exposure indices (the number of birds actually encountering a turbine within a given time frame), and fatality probability (the likelihood of fatality upon striking a structure). Different avoidance rates (probability of flying around the airspace of a structure rather than entering it) were also applied. Fatality estimates were divided into three parts; fatality at heights of the rotor swept zone (RSZ, 32 – 128 m), fatality from colliding with the tubular towers below the RSZ (< 32 m), and fatality upon collision with the met tower.

2.3.1. Passage rates

The average passage rate (flocks/hr/ha) of koloa maoli-like ducks was determined from koloa maoli-like duck flight activity rates at all point count stations on site. As koloa maoli-like ducks are large and visible, a 400 m radius was assumed for each point count. A uniform passage rate was assumed over the entire site encompassing the locations of all turbines and met towers. This enabled one hectare (ha) plots to be centered on each turbine and the passage rate of koloa maoli-like ducks in and around the airspace of each turbine to be calculated.

2.3.2 Calculating Horizontal Interaction Probabilities

The horizontal interaction probability for the RSZ was calculated on the assumption that the volume of the RSZ was a solid sphere with a radius of 47 m (the length of the turbine blades) (Fig. 3). The interaction probability for one RSZ (i.e., probability of encountering one RSZ of a turbine) is the proportion of the volume of one RSZ over the volume of a 1 ha plot from a height of 32 m to 128 m centered on each turbine (Fig. 3).

The interaction probability of one tubular tower (i.e., probability of encountering the tubular tower of the turbine below the RSZ) is the proportion of the volume of the tubular tower over the volume of a 1 ha plot from ground level to 32 m centered on each turbine (Fig. 3).

The interaction probability of one met tower is the proportion of the volume of the tower (80 m high) over the volume of a 1 ha plot centered on the tower at a height less than 80 m. The volume of the met tower consists of the volume of the lattice structure modeled as a solid structure (Fig. 4). The model also over-estimates the volume of the met tower by assuming a straight line taper from the base to the top, rather than a curve.

2.3.3 Exposure indices

Exposure indices estimate the likelihood of collision of a bird when it is in the airspace of the structure and the likelihood of fatality upon collision.

2.3.4 Fatality Probability Factors

Fatality probability factors within the RSZ (i.e., probability of striking a blade on frontal approach and probability of fatality if striking blade) are derived from the model developed by Day and Cooper (2008) for the Clipper C-96 turbine. Similarly, the fatality probability factors for the tubular towers of the turbines and met towers (probability of striking a tower if in airspace and probability of fatality if striking the tower) are also derived from same model (Day and Cooper 2008).

2.3.5 Avoidance Rates

Low mortality of waterbirds has been documented at wind turbines situated coastally (as is the proposed Kahuku Wind Power project), despite the presence of high numbers of waterbirds in the vicinity (e.g., Kingsley and Whittam 2007). Studies at wind energy facilities proximally located to wetlands and coastal areas have shown that waterbirds and shorebirds are among the birds most wary of turbines and that these birds readily "learn" to avoid the turbines over time (Koford et al. 2004, Jain 2005, Carothers 2008). Thus avoidance rates of 90%, 95% and 99% were applied to this project to provide a range of reasonable and prudent fatality estimates.

2.4 Calculating Fatality Estimates for Bats

Extensive monitoring of bat activity at pre-existing wind farms has shown a strong positive relationship between the total number of bat passes per night for each detector on site with estimated fatalities per turbine per year (Kunz et al. 2007). Essentially, the number of bat fatalities per turbine per year is almost equivalent to the number of bat calls per night for each detector on site (see Table 1). However, the data on echolocation passes reported in these studies did not distinguish among species. Moreover, echolocation calls were recorded at different altitudes at some sites and only at ground level at others. In addition, echolocation call data were collected after the wind energy facilities were constructed. Thus, it is unclear whether preconstruction bat pass data, as in the case of Kahuku Wind Power, would have shown a different pattern. Furthermore, the relationship between preconstruction call rates and fatality rates may not exist or may not be as strong if modifications to forested habitats (thereby creating linear landscapes) or the turbines themselves attract bats (Kunz et al. 2007).

Thus, bat fatality estimates per turbine at Kahuku Wind Power was calculated using the following assumptions:

1) the change in landscape or construction of turbines does not attract bats to the area,
2) post-construction bat activity remains the same as pre-construction bat activity, and
3) the number of bat fatalities per turbine per year is equivalent to the number of bat passes per night for each detector on site (as shown by Kunz et al. 2007)

If the level of bat activity recorded at the Kahuku Wind Power site is low, the estimated take of bats per turbine will be based on the number of call sequences per detector night, rather than the number of bat passes (Assumption 3). This will provide a more conservative fatality estimate.

Potential for bats to collide with met tower is considered negligible because these objects are stationary and should be readily detected by the bats. Of 64 wind turbines at Mountaineer Wind Energy Center in the Appalachian plateau in West Virginia, bat fatalities were recorded only at operating turbines and not at a non-operational turbine during the study period (Kerns et al. 2005). This supports the expectation that the presence of stationary structures such as met tower and cranes should not result in bat fatalities.

3.0 RESULTS

3.1 Diurnal Point Count Surveys

3.1.1 On-site Surveys

Avian point count surveys were conducted for 64.9 hours between October 2007 and December 2008. Point count surveys were conducted by First Wind from October 2007 to May 2008, and by SWCA from June 2008 to December 2008. Twenty three bird species (and 6 introduced mammal species were observed during the diurnal point count surveys (Table 2). For ESA "related" listed species, only koloa maoli-like ducks (*Anas* sp) apply, and were seen on three occasions at the northern portion of the Kahuku Wind Power site.

Native resident and migratory birds protected under the Migratory Bird Treaty Act (MBTA) include the greater frigate bird (*Fregata minor*), Pacific golden plover (*Pluvialis fulva*) and ruddy turnstone (*Arenaria interpres*). Migratory shorebirds arrived at Kahuku Wind Power in September and departed in May. Data so far indicates that Pacific golden plover are more frequently observed in flight (0.57 flocks/hr/point count) than the ruddy turnstone (0.02 flocks/hr/point count) at Kahuku Wind Power. The great frigate bird is resident year round in Hawaii and flies over the site occasionally (0.17 flocks/hr/point count, Table 2).

Most flight activity at Kahuku Wind Power was dominated by introduced bird species. Common myna (*Acridotheres tristis*), red-vented bulbuls (*Pycnonotus cafer*), cattle egret (*Bubulcus ibis*), Japanese white-eye (*Zosterops japonicus*), finch species, zebra dove (*Geopelia striata*) and spotted dove (*Streptopelia chinensis*) accounted for 85% of the bird activity observed at Kahuku Wind Power. Seventy-five percent of all flights observed (3rd quartile) were less than 15 m altitude (Fig. 5, see box plot). Ninety three percent of all flights observed were below the RSZ; only 3.4% of all flocks flew within the RSZ and 0.05% above the RSZ. The species most frequently observed flying within the RSZ were cattle egrets (Table 3). The only native species flying within the RSZ were the great frigate bird and koloa maoli-like ducks. Figure 5 also illustrates flight directions (of all bird species combined) at the different point count stations within the Kahuku Wind Power site. Predominant flight directions (> 20% of observed flights) were present for seven of ten point count stations (Table 4) and were mostly perpendicular to the proposed turbine rows (Fig. 5). Bird activity (flights/hr) varied with point count location (range 13.71 – 30.60 flight/hr) but statistical analyses indicate that only point count station D had significantly higher bird activity than one other station (Station J).

3.1.2 Adjacent Wetland Bird Surveys

Observations of endangered Hawaiian waterbirds were conducted at wetlands closest to the project site. The wetlands comprised mostly of active and abandoned shrimp ponds and were surveyed by SWCA biologists between June and December 2008. Hawaiian stilt (*Himanotopus mexicanus knudseni*) and Hawaiian coot (*Fulica alai*) were observed in flight at the adjacent wetlands as well as koloa maoli-like ducks. No Hawaiian moorhen (*Gallinula chloropus sandvicensis*) were observed.

Compared to the flight activity of koloa maoli-like ducks observed in the adjacent wetlands (0.33 flocks/hr/ha, see below), the activity of koloa maoli-like ducks over the Kahuku Wind Power site is low (0.05 flocks/hr/ha). The average flock size for koloa maoli-like ducks as observed in adjacent wetlands was 2.0 birds per flock (range 1 – 9). Only 2.7 % of the observed flight altitudes were within the RSZ; the remainder below the RSZ (Fig. 6). Koloa maoli-like ducks freely moved between the wetlands and uplands. Thirty-three % (n = 45) of all observed flocks (n = 147) in flight were from the wetlands to the uplands or from the uplands to the wetlands. Flight direction was predominantly from the north and west (X^2=51.1., df=7, p=0.000). Most ducks were observed flying between recently harvested cornfields (located below Kahuku Wind Power) and the wetlands. This provides confirmation that koloa maoli-like ducks will occasionally transit past the Kahuku Wind Power site. Flight activity in the adjacent wetlands is highest in the mornings and the evenings and low in the afternoon (X^2=69.9, df=2, p=0.000).

No other state endangered or other ESA-listed or candidate species have been observed at Kahuku Wind Power since the initial surveys began in October 2007. Hawaiian stilt were often seen flying within the adjacent wetlands, but only observed once flying from uplands to wetland (1.3%, 1 of 76 flocks, Fig. 7). This supports the lack of observations of Hawaiian stilt flying over Kahuku Wind Power. The average flock size of Hawaiian stilt was 1.5 birds per flock and predominant flight direction was also from the north and west (X^2=81.9, df=7, p=0.000). As most flights were short between nearby ponds, 75 % of the observed flight altitudes were below 5 m. However, for the few longer-distance flights (100 m or more), the maximum flight height was 30 m, just below the turbine's RSZ. Flight activity in the adjacent wetlands was highest in the mornings and lower in the afternoons and evenings (X^2=21.3., df=2, p=0.000).

Of 31 observations of Hawaiian coot, only one individual was seen in flight between ponds in the adjacent wetlands. No Hawaiian coots were observed flying upland from the wetlands or vice versa. These observations together indicate that Hawaiian coot are highly unlikely to be flying over Kahuku Wind Power at any time and support the absence of observations of Hawaiian coot in flight over Kahuku Wind Power during the 15-month long observations on site.

Hawaiian moorhen were not observed at adjacent wetlands either in flight or on the ground, although they were likely present. This is not surprising considering the species secretive and highly sedentary behavior (USFWS 2005). These factors indicate that Hawaiian moorhen are highly unlikely to be flying over Kahuku Wind Power at any time and also support the absence of observations of Hawaiian moorhen in flight over Kahuku Wind Power during the 15-month long observations on site. Due to the lack of wetlands at Kahuku Wind Power, waterbirds are not expected to be present (either resident or vagrant) on the grounds of Kahuku Wind Power (SWCA 2008).

3.2 Nocturnal Surveys

3.2.1 Visual Surveys

Eighteen hr of nocturnal visual surveys were conducted at Kahuku Wind Power between October 2007 and December 2008. Nocturnal surveys were conducted by First Wind from October 2007 to May 2008, and SWCA from June 2008 to December 2008. No bats were observed during the entire observation period. Only one incidental visual sighting of the Hawaiian hoary bat was recorded in July 2008, during a radar survey for seabirds.

3.2.2 Acoustic Monitoring

Eleven sites at Kahuku Wind Power were acoustically sampled from April 2008 to April 2009 (Figure 2). A total of 1285 detector nights were sampled between April 2008 and April 2009 (Table 6). Hawaiian hoary bat call sequences were recorded on 20 occasions from three locations (Anabat A in late November, D, and E) from April 2008 to April 2009 (Table 6). The limited data suggest that bat activity may increase from June to September and are lowest or absent from December to February. The peak activity is within the period bat numbers are expected to increase in the lowlands because of migration from higher altitudes (Menard 2001). The period of low bat activity coincides with bat migration from lowlands to higher altitudes (Menard 2001). However, due to the very small sample sizes, it is not possible to draw any conclusive patterns herein, and bats may be present on-site year round. Anabat detectors on the site estimate an average hoary bat activity rate of 0.01 bat passes/detector/night or 0.016 call sequences/detector per night. The detection rates at Kahuku Wind Power are 40-fold lower than detection rates at Hakalau National Wildlife Refuge (0.66 passes/detector/night, Bornaccorso, USGS unpublished report). Bat activity at Kahuku Wind Power is also less than half that at the Kaheawa Wind Pastures, which has an activity rate of 0.04 bat call sequences/detector/night (First Wind 2008).

3.3 Estimated Fatality Rates of Koloa Maoli-like Ducks

Three flocks of koloa maoli-like ducks were observed during the 15month avian survey resulting in an average passage rate of 0.001flocks/hr/ha over the project site (Table 7). Incidental sightings include observations of a flock of koloa maoli-like ducks in May 2007, June and December 2008. Using flight altitudes observed in the adjacent wetlands, we estimate that 2.7% of all flights occurring over Kahuku Wind Power occur within the RSZ with the remaining below the RSZ (Table 8).

The estimated fatality rate for koloa maoli-like ducks entering the RSZ ranges between 0.0002and 0.002 koloa maoli-like ducks/RSZ/year assuming 99% and 90% collision avoidance rate respectively (Table 9). Fatality rates due to koloa maoli-like ducks striking the tubular towers of the turbines are even lower at 0.0001 and 0.001 koloa maoli-like ducks /tower/year, assuming a 99% and 90% avoidance rate respectively. Combined, the estimated fatality rate for koloa maoli-like ducks at a turbine at Kahuku Wind Power is between 0.0003 and 0.003 birds/turbine/year or 0.004 to 0.038 birds for twelve turbines per year combined.

Fatality rates due to koloa maoli-like ducks striking the met towers of the turbines are 0.00005 to 0.0005 birds /tower/year, assuming a 99% and 90% avoidance rate respectively).(Table 10).

The total fatality at all turbines and met towers on the site is estimated between 0.004 0.038 koloa maoli-like ducks/year (9% and 90% avoidance rate respectively) (Table 11). This result is not unexpected due to the low passage rates observed on site. Studies of wind energy facilities located in proximity to wetlands and coastal areas have shown that waterbirds and shorebirds are among the birds most wary of turbines and that these birds readily learn to avoid the turbines over time (Carothers 2008). Avoidance behavior has also been documented by nēnē at the existing operating facility on Maui (Kaheawa Wind Power 2008). Thus, the estimated take at 95% avoidance (95% of the birds that approach the turbine successfully avoid it) is used as the basis of the take estimates. The fatality rate at 95% avoidance for koloa maoli-like ducks was estimated at 0.02 birds/year for all 12 turbines and one permanent met tower on site.

3.4 Estimated fatality rates of Hawaiian hoary bat

Based on substantial sampling effort (1285 detector nights between April 2008 and April 2009) the estimated take/turbine/year at Kahuku Wind Power with a bat activity of 0.016 bat call sequences/detector/night is 0.016 bats/turbine/year. This results in a total take of 0.19 bats/year for all twelve turbines on the site.

4.0 CONCLUSION

Kahuku Wind Power avifauna is comprised primarily of introduced birds. Native birds were occasionally observed transiting the site; however no resident native avifauna was recorded. Of the waterbirds, only the koloa maoli-like ducks were observed transiting the site and are at risk of colliding with the turbines. However the estimated fatality rate was small, approximating two ducks every 100 years. No endangered waterbirds were observed flying over the site and the lack of observations is supported by the flight patterns of these species in the adjacent wetlands.

Hawaiian Hoary bats are present at Kahuku Wind Power, but activity rates were very low compared to other sites. The estimated fatality of Hawaiian hoary bats is approximately 2 bats every ten years.

Table 1 Fatality and bat activity indices at 5 wind-energy facilities on the mainland United States (from Kunz et al. 2007).

Study area	Inclusive dates of study*	Bat mortality (no/turbine/ yr)	Bat activity (no./detector/ night)	Total detector nights	Source
Mountaineer, WV	31 Aug-11 Sep 2004	38	38.2	33	E.B. Arnett, Bat Conservation International, unpubl. Data
Buffalo Mountain, TN	1 Sep 2000-30 Sep 2003	20.8	23.7	149	Fieldler 2004
Top of Iowa, IA	15 Mar-15 Dec 2003, 2004	10.2	34.9	42	Jain 2005
Buffalo Ridge, MN	15 Mar-15 Nov 2001, 2002	2.2	2.1	216	Johnson et al. 2004
Foote Creek Rim, WY	1 Nov 1998-31 Dec 2000	1.3	2.2	39	Gruver 2002

* Sample periods and duration of sampling varied among studies, with no fatality assessments conducted or bat activity monitored in winter months.

Table 2. Bird and mammal species observed at Kahuku Wind Power site from October 2007 to December 2008 by First Wind and SWCA.

Common Name	Scientific Name	Bird Activity (flocks/hr/point count)	% of Observed Flight Activity	Rank
Birds				
Common myna	*Acridotheres tristis*	6.37	20.59	1
Red-vented Bulbul	*Pycnonotus cafer*	5.50	17.80	2
Cattle Egret	*Bubulcus ibis*	5.36	17.35	3
Finches and/or white-eyes	-	3.85	12.46	4
Spotted dove	*Streptopelia chinensis*	2.74	8.87	5
Zebra Dove	*Geopelia striata*	2.56	8.28	6
Red-crested Cardinal	*Paroaria coronata*	0.92	2.99	7
Japanese white-eye	*Zosterops japonicus*	0.89	2.89	8
House finch	*Carpodacus mexicanus*	0.62	1.99	9
Pacific golden plover	*Pluvialis fulva*	0.57	1.84	10
Northern Cardinal	*Cardinalis cardinalis*	0.40	1.30	11
House sparrow	*Passer domesticus*	0.35	1.15	12
Great frigate bird	*Fregata minor*	0.17	0.55	13
White-rumped shama	*Copsychus malabaricus*	0.12	0.40	14
Red-whiskered bulbul	*Pycnonotus jocosus*	0.11	0.35	15
Common Waxbill	*Estrilda astrild*	0.09	0.30	16
Nutmeg mannakin	*Lonchura punctulata*	0.06	0.20	17
Koloa maoli-like ducks	*Anas* sp.	0.05	0.15	18
Java sparrow	*Padda oryzivora*	0.05	0.15	18
Chestnut munia	*Lonchura malacca*	0.03	0.10	20
Ring-necked pheasant	*Phasianus colchicus*	0.03	0.10	20
African silverbill	*Lonchura cantans*	0.02	0.05	22
Ruddy turnstone	*Arenaria interpres*	0.02	0.05	22
Unidentified owl	-	0.02	0.05	22
Mammals				
Domestic cattle	*Bos taurus*			
Horse	*Equus caballus*			
Dog	*Canis lupus familiaris*			
Cat	*Felis catus*			
Small Indian mongoose	*Herpestes javanicus*			
Feral pig	*Sus scrofa*			

Table 3. Species composition of birds flying within the RSZ

Bird species	% of species composition within RSZ	Rank
Cattle egret	63.8	1
Common myna	11	2
Great frigate bird	8.7	3
House finch	4.7	4
Red-vented bulbul	4.7	4
Koloa maoli-like ducks	0.8	6
House sparrow	0.8	6
Pacific golden plover	0.8	6
Red-crested cardinal	0.8	6
Spotted dove	0.8	6
Zebra dove	0.8	6

Table 4. Flight activity and predominant flight directions at Kahuku Wind Power point count stations

Stations	Average flight activity (flights/hr)	Predominant flight direction (>20%)	Chi-Square test
B	20.85 (n= 197)	NE	X^2=30.4., df=7, p=0.000
C	29.14 (n= 285)	E	X^2=58.1, df=7, p=0.000
D	44.57 (n= 432)	E	X^2=89.3, df=7, p=0.000
E	17.77 (n= 78)	NE, W	X^2=16.6, df=7, p=0.020
F	22.20 (n= 200)	N, E	X^2=66.2, df=7, p=0.000
G	26.85 (n= 234)	-	X^2=6.0, df=7, p=0.540
H	20.10 (n= 206)	-	X^2=9.3, df=7, p=0.232
I	16.71 (n = 85)	W	X^2=26.3, df=7, p=0.000
J	13.71 (n= 64)	E	X^2= 9, df=7, p=0.253
K	30.60 (n= 131)	E	X^2=18.7, df=7, p=0.009

🟨 statistically significant

Table 5. Analysis of flight activity at point count stations by time of day.

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-ratio	p-value
Point count stations	2.915	9	0.324	2.642	0.007
Error	22.188	181	0.123		

🟨 statistically significant

Table 6. Bat activity at Kahuku Wind Power

Year	Month	Nights per Anabat Detector					Total nights	No. of calls sequences	No. of bat passes (> 2 bat calls)
		A	B	C	D	E			
2008	April	21	21	21	21	21	105	1	1
2008	May	27	1	27	27	27	109	1	0
2008	June	30	0	30	20	30	110	4	1
2008	July	31	0	31	31	31	124	3	3
2008	Aug	31	26	31	31	31	150	3	2
2008	Sept	30	30	30	30	30	150	5	3
2008	Oct	31	6	9	19	31	96	1	1
2008	Nov	30	17	30	11	13	101	1	1
2008	Dec	26	23	31	17		97	0	0
2009	Jan			31			31	0	0
2009	Feb		2	28	2	2	34	0	0
2009	Mar		30	27	31	31	119	1	1
2009	April		2	-	27	30	59	0	0
						Total	**1285**	**20**	**13**

Table 7. Koloa maoli-like duck passage rates over Kahuku Wind Power

		400m radius point counts
A	**Total point counts**	167
B	**No. of birds observed**	8
C	**Birds per point count B/A**	0.048
D	**Birds per hour C*3**	0.144
E	**Area sampled (ha) 0.4*0.4*3.14**	50.265
F	**Passage rate (birds/hr/ha) D/E**	0.003
G	**Total project area (ha)**	233.8
H	**Passage rate (birds/hr/site) F*G**	0.668
I	**Passage per day over site**	8.021

Table 8. Fatality estimate of koloa maoli-like ducks within rotor swept zone

	Variable	
	Movement rate	
A	mean movement rate (birds/hr/ha)	0.002859071
B	daily movement rate (birds/day/ha) A*12	0.03430885
C	fatality domain (days)	365
D	annual movement rate (birds/year) B*C	12.52273025
E	proportion birds flying within rotor swept zone (>30m and < 128m)	0.027210884
F	annual movement rate within rotor swept zone (>30m and <128 m) D*E	0.340754565
	Horizontal interaction probability	
G	Volume occupied by rotor swept zone (m3)	463011.84
H	Vol of 1 ha area from minimum to maximum rotor height (>32 to <128m) (m3)	960000
I	Horizontal interaction probability G/H	0.482304
	Exposure index	
J	daily exposure index (birds/rotor swept zone/day) B*E*I	0.000450267
K	annual exposure index (birds/rotor swept zone/yr) F*I	0.16434729
	Fatality probability	
L	Probability of striking a blade on frontal approach	0.156
M	Probability of fatality if striking blade	0.95
N	Probability of fatality if an interaction on frontal approach L*M	0.1482
	Fatality index	
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/turbine/yr) K*N*0.1	**0.002435627**
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/yr) K*N*0.05	**0.001217813**
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/yr) K*N*0.01	**0.000243563**

Table 9. Fatality estimate of koloa maoli-like ducks striking tubular towers

	Variable	
	Movement rate	
A	mean movement rate (birds/hr/ha)	0.002859071
B	daily movement rate (birds/day/ha) A*12	0.03430885
C	fatality domain (days)	365
D	annual movement rate (birds/year/ha) B*C	12.52273025
E	proportion birds below rotor swept zone (>32m)	0.972789116
F	annual movement rate below rotor swept zone (>30m) D*E	12.18197569
	Horizontal interaction probability	
G	Volume occupied by tubular tower (m^3)	486.3232
H	Vol of 1 ha area below blade height (<32m) (m^3)	320000
I	Horizontal interaction probability G/H	0.00151976
	Exposure index	
J	daily exposure index (birds/tubular tower/day) B*E*I	5.07224E-05
K	annual exposure index (birds/tubular tower/yr) F*I	0.018513679
	Fatality probability	
L	Probability of striking a tubular tower if in airspace	1
M	Probability of fatality if striking tubular tower	0.95
N	Probability of fatality upon interaction L*M	0.95
	Fatality index	
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/yr) K*N*0.1	**0.0017588**
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/yr) K*N*0.05	**0.0008794**
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/yr) K*N*0.01	**0.0001758800**

Table 10. Fatality estimate of koloa maoli-like ducks at met tower

	Variable	
	Movement rate	
A	mean movement rate (birds/hr/ha)	0.002859071
B	daily movement rate (birds/day/ha) A*12	0.03430885
C	fatality domain (days)	365
D	annual movement rate (birds/year) B*C	12.52273025
E	proportion birds below meteorological tower (<60m)	1
F	annual movement rate below meteorological tower (<60m) D*E	12.52273025
	Horizontal interaction probability	
G	Volume occupied by meteorological tower (m3)	420.1840223
H	Vol of 1 ha area meteorological tower (<80m) (m3)	800000
I	Horizontal interaction probability G/H	5.25E-04
	Exposure index	
J	daily exposure index (birds/tower/day) B*E*I	1.80E-05
K	annual exposure index (birds/tower/yr) F*I	6.58E-03
	Fatality probability	
L	Probability of striking a met tower if in airspace	1
M	Probability of fatality if striking tubular tower	1
N	Probability of fatality upon interaction L*M	1
	Fatality index	
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/tubular tower/yr) M*P*0.05	0.000657731
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/tubular tower/yr) M*P*0.05	0.000328866
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/tubular tower/yr) M*P*0.01	0.0000657731

Table 11. Predicted annual fatality rate of koloa maoli-like ducks at Kahuku Wind Power.

	Turbines (x12)	Met tower	Total fatality
Annual fatality rate with 90% exhibiting collision avoidance (birds/yr)	0.050	0.00066	**0.051**
Annual fatality rate with 95% exhibiting collision avoidance (birds/yr)	0.025	0.00033	**0.025**
Annual fatality rate with 99% exhibiting collision avoidance (birds/yr)	0.005	0.00007	**0.005**

References:

Carothers, S. W. 2008. Expert report: Evaluation of risks to avian (birds) and chiropteran (bats) resources. Gulf Wind Project, Kenedy County, TX, USA.

Day, R.H. and B.A. Cooper. 2008. Interim report: Oahu radar and audiovisual studies, Fall 2007 and Summer 2008. ABR, Inc.— Environmental Research & Services.

Fiedler, J. K. 2004. Assessment of bat mortality and activity at Buffalo Mountain windfarm, Eastern Tennessee. Thesis, University of Tennessee, Knoxville, USA.

First Wind. 2008. KWP I and KWP II acoustic monitoring of bat activity

Gruver, J. C. 2002. Assessment of bat community structure and roosting habitat preferences for the hoary bat (*Lasiurus cinereus*) near Foote Creek Rim, Wyoming. Thesis, University of Wyoming, Laramie, WY, USA.

Jain, A. 2005. Bird and bat behavior and mortality at a northern Iowa windfarm. Thesis, Iowa State University, Ames, IA USA.

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat activity, composition, and collision mortality at a large wind plant in Minnesota. Wildlife Society Bulletin 32:1278–1288.

Kaheawa Wind Power, LLC. 2008. Kaheawa Pastures wind energy generation facility habitat Conservation Plan, Year 2 HCP Implementation (July, 2007 – June, 2008).

Kerns, J., W. P. Erickson, and E. B. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. Pages 24–95 In: Arnett, E.B., editor. Relationships between bats and wind turbines in Pennsylvania and West Virginia: An assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas, USA. ,http://www.batcon.org/windliterature. Accessed 1 Sep 2007.

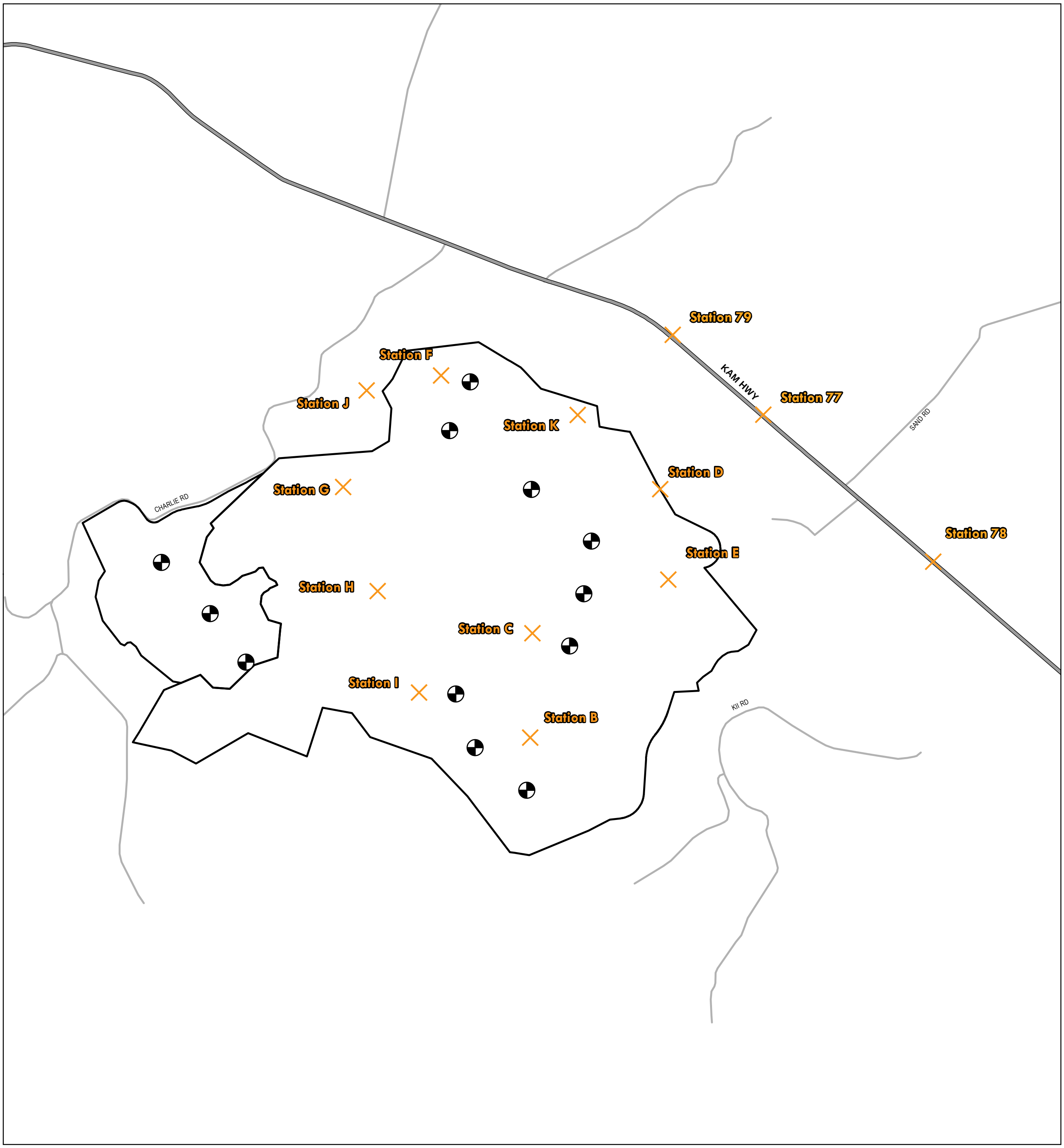
Kingsley, A., and B. Whittam. 2007. Wind turbines and birds: A background review for environmental assessment, draft. Canadian Wildlife Service, Environment Canada, Gatineau, Quebec, Canada.

Koford, R., A. Jain, G. Zenner and A. Hancock. 2004. Avian mortality associated with the top of Iowa Wind Farm: Progress report, calendar year 2003. Iowa Cooperative Fish and Wildlife Research Unit, Iowa State University, Ames, IA, USA.

Kunz, T. H., E. B. Arnett. B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: A guidance document. Journal of Wildlife Management 71: 2449–2486.

SWCA (SWCA Environmental Consultants). 2008. First Wind Kahuku wind farm jurisdictional wetland determination study. Honolulu, HI, USA.

USFWS. 2005. Draft revised recovery plan for Hawaiian waterbirds, second draft of second revision. U.S. Fish and Wildlife Service, Portland, OR, USA.



Legend

⊕ Turbine/Tower Locations

× Point Count Locations

▭ Project Parcel

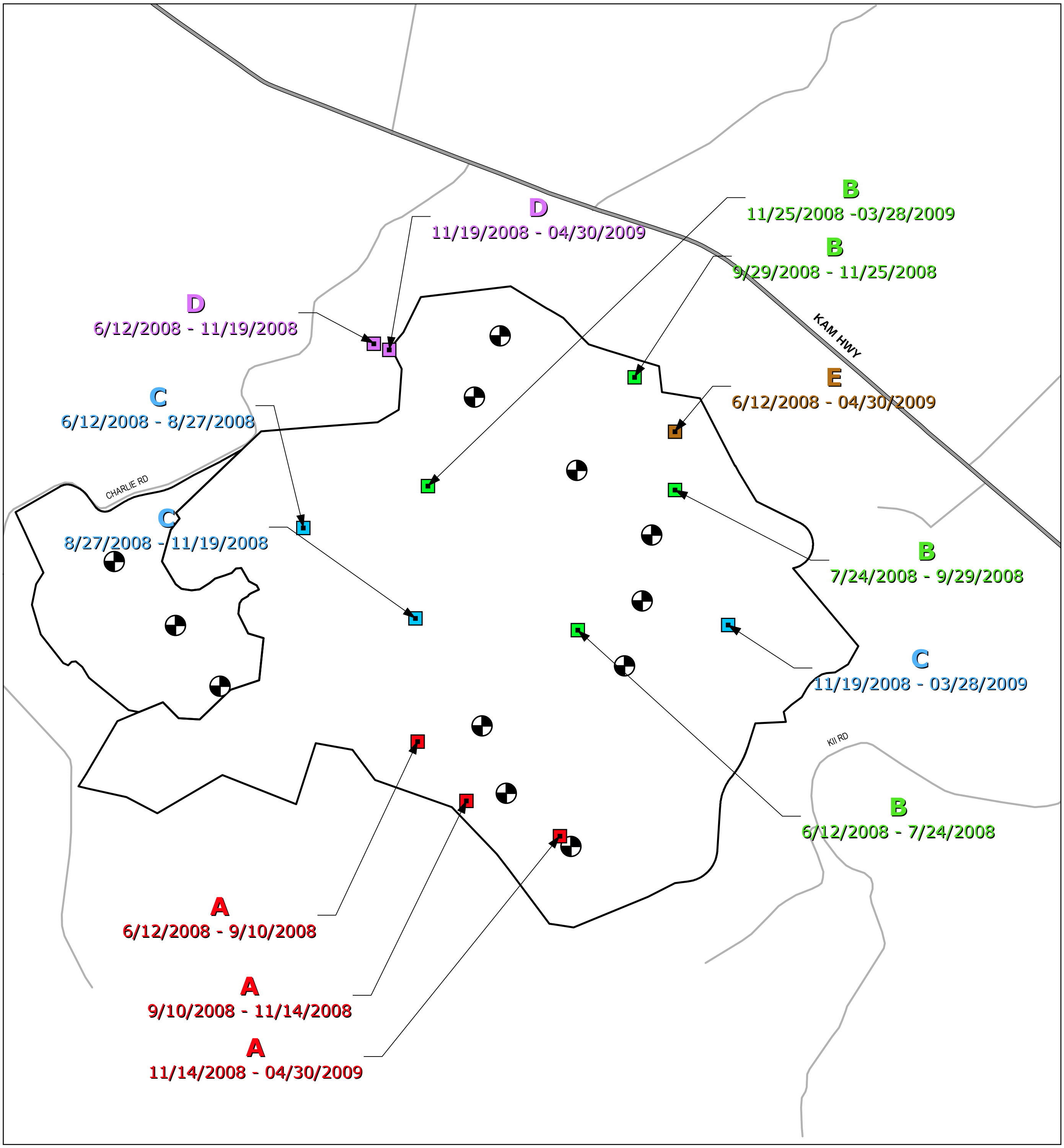
Figure 1
Station Locations

N

0 250500 1,000 ft

0 100 200 400 M

SWCA ENVIRONMENTAL CONSULTANTS



Legend

Anabat Sensors

- 🟥 A
- 🟩 B
- 🟦 C
- 🟪 D
- 🟫 E
- ▭ Project Parcel

Figure 2
Anabat Sensor Locations and Dates of Deployment

N

0 250 500 1,000 ft

0 100 200 400 M

SWCA ENVIRONMENTAL CONSULTANTS

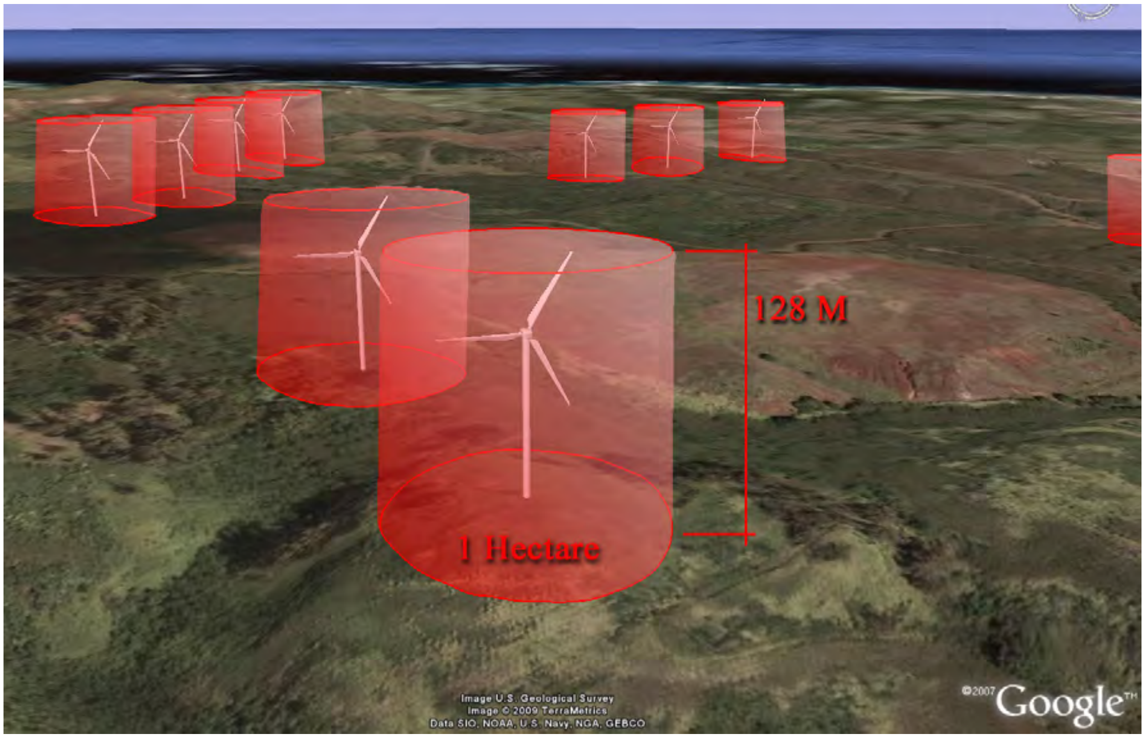
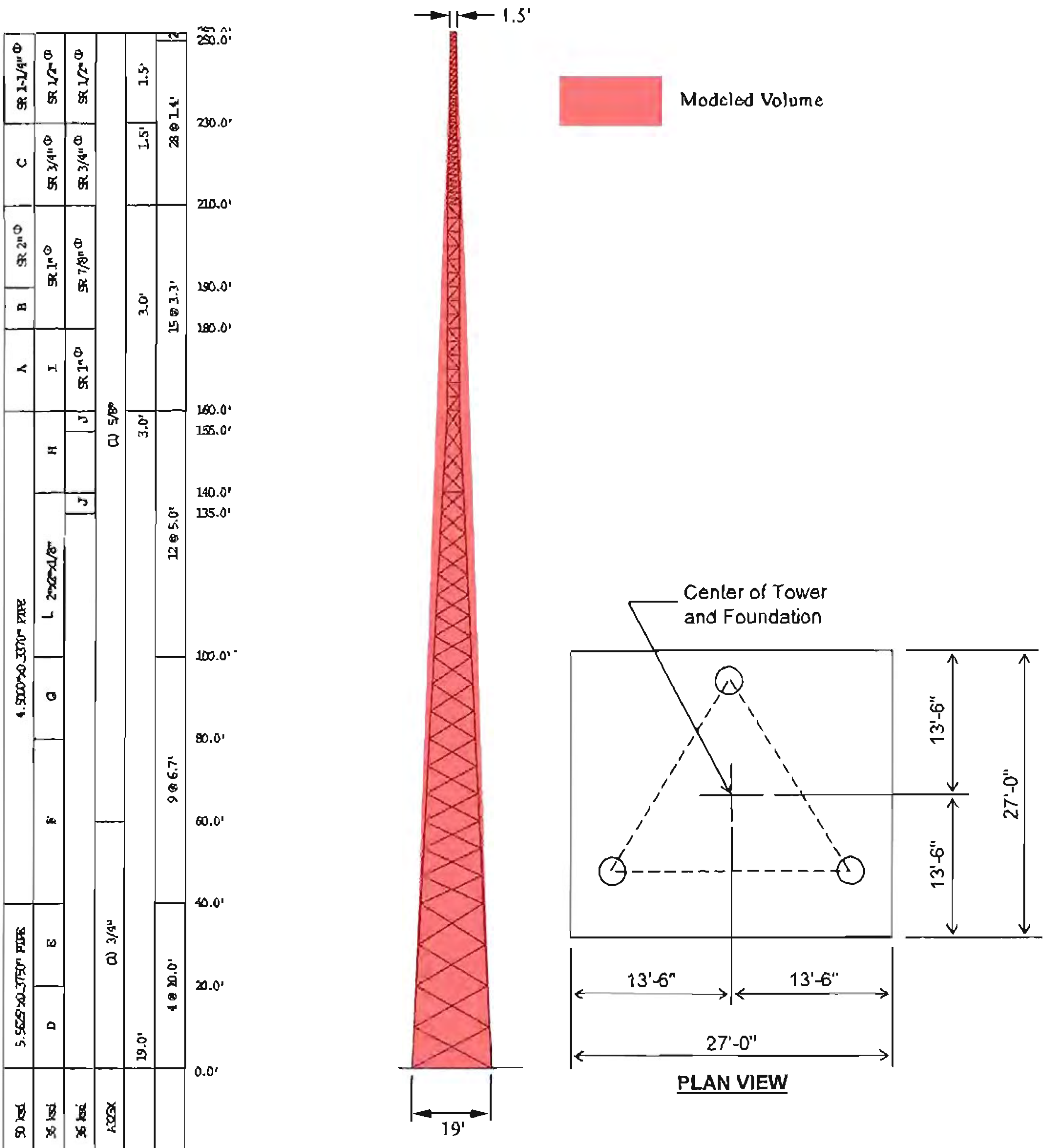


Figure 3. Volume of Turbine to Volume of 1 ha Area.



PLAN VIEW

GUYMAST Version 3.2 + A (c) Guymast Inc. 2007 Phone: (416) 736-7453

Sabre Towers And Poles

2101 Murray Street (P.O. Box 658), Sioux City, IA 51111

Phone: (712) 258-6690 Fax: (712) 258-8250

Client: --

Location:

Job No: 09-8316

Date: 19 mar 2009

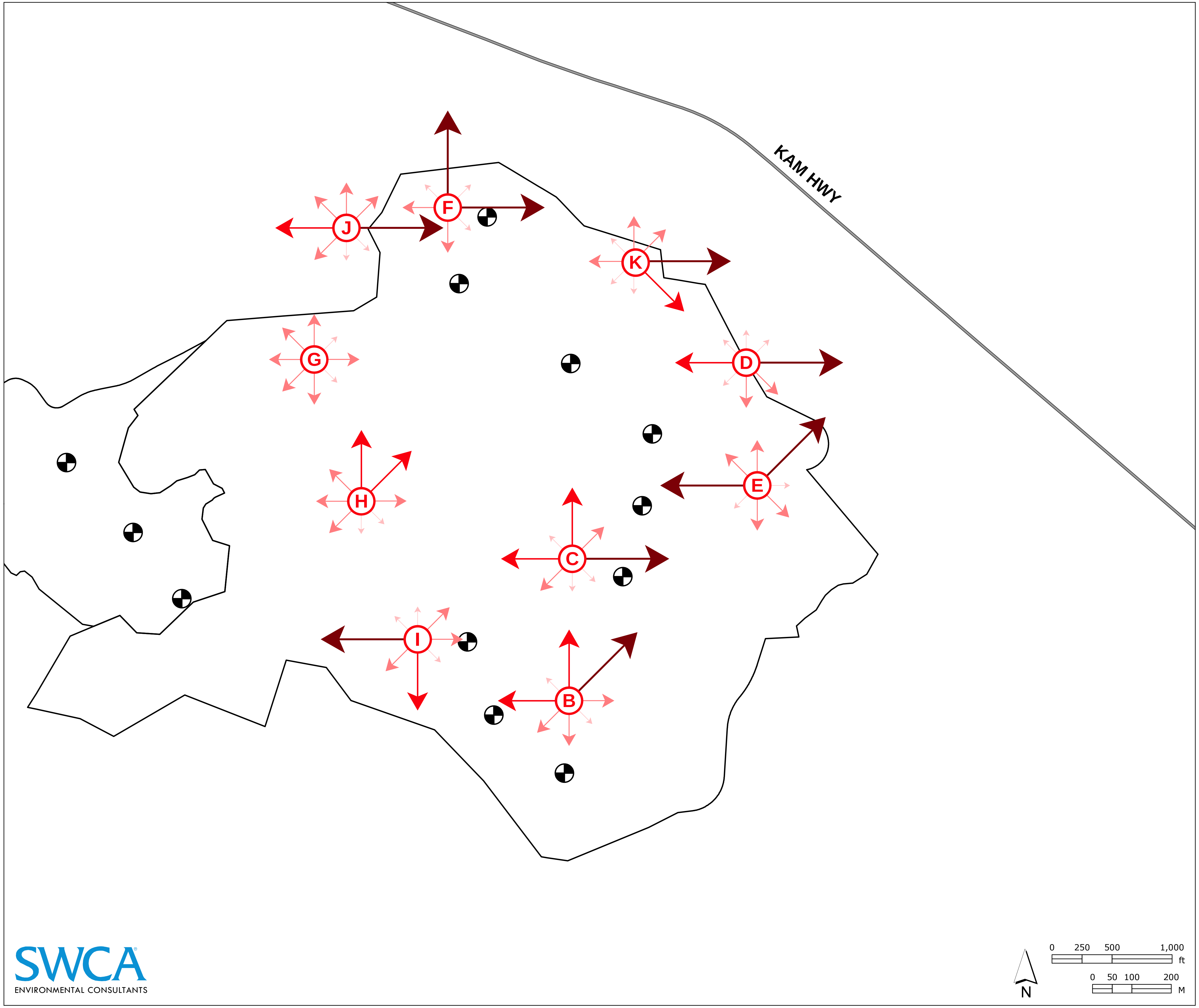
Total Height: 252.00'

Tower Height: 252.00'

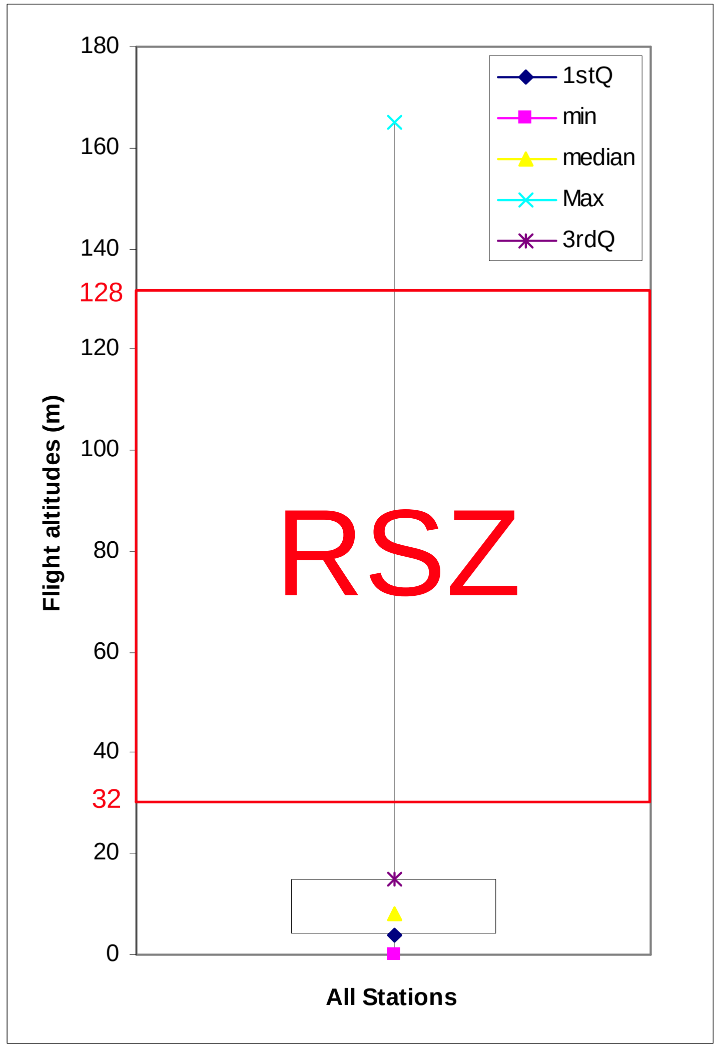
Standard: TIA 222-G-2005

Design Wind & Ice: 90mph 0" ice & 60mph 0.5" ice

Project: C:\GUYMAST DESK\-09-8316M LOD



SWCA
ENVIRONMENTAL CONSULTANTS



Legend

◐ Turbine/Tower Locations

Bird Point Count Data Oct 07 - Dec 08

↑ 1% - 10%

↑ 10.1% - 15%

↑ 15.1% - 20%

↑ 20.1% - 30%

Figure 5
STATION DATA

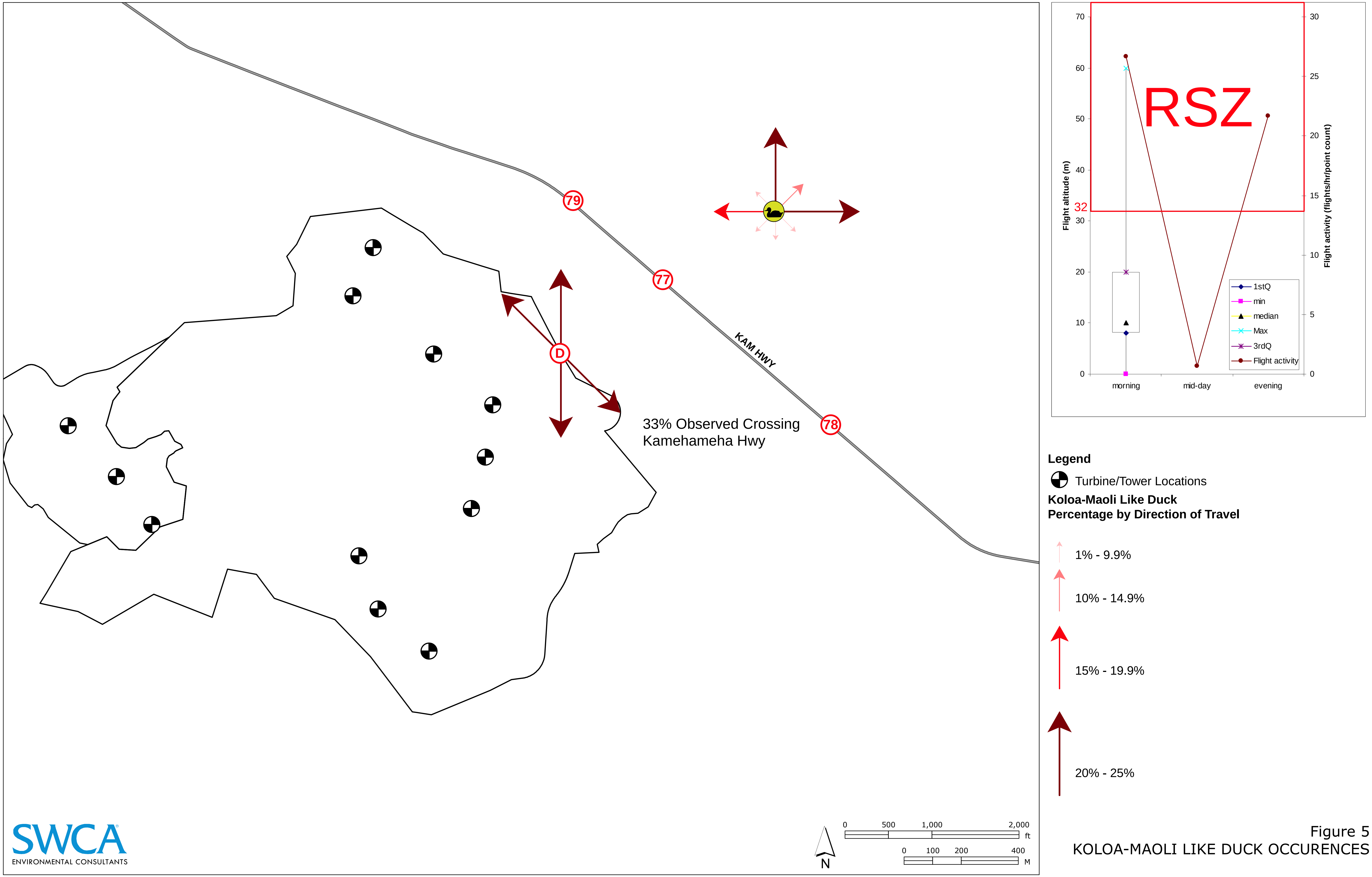
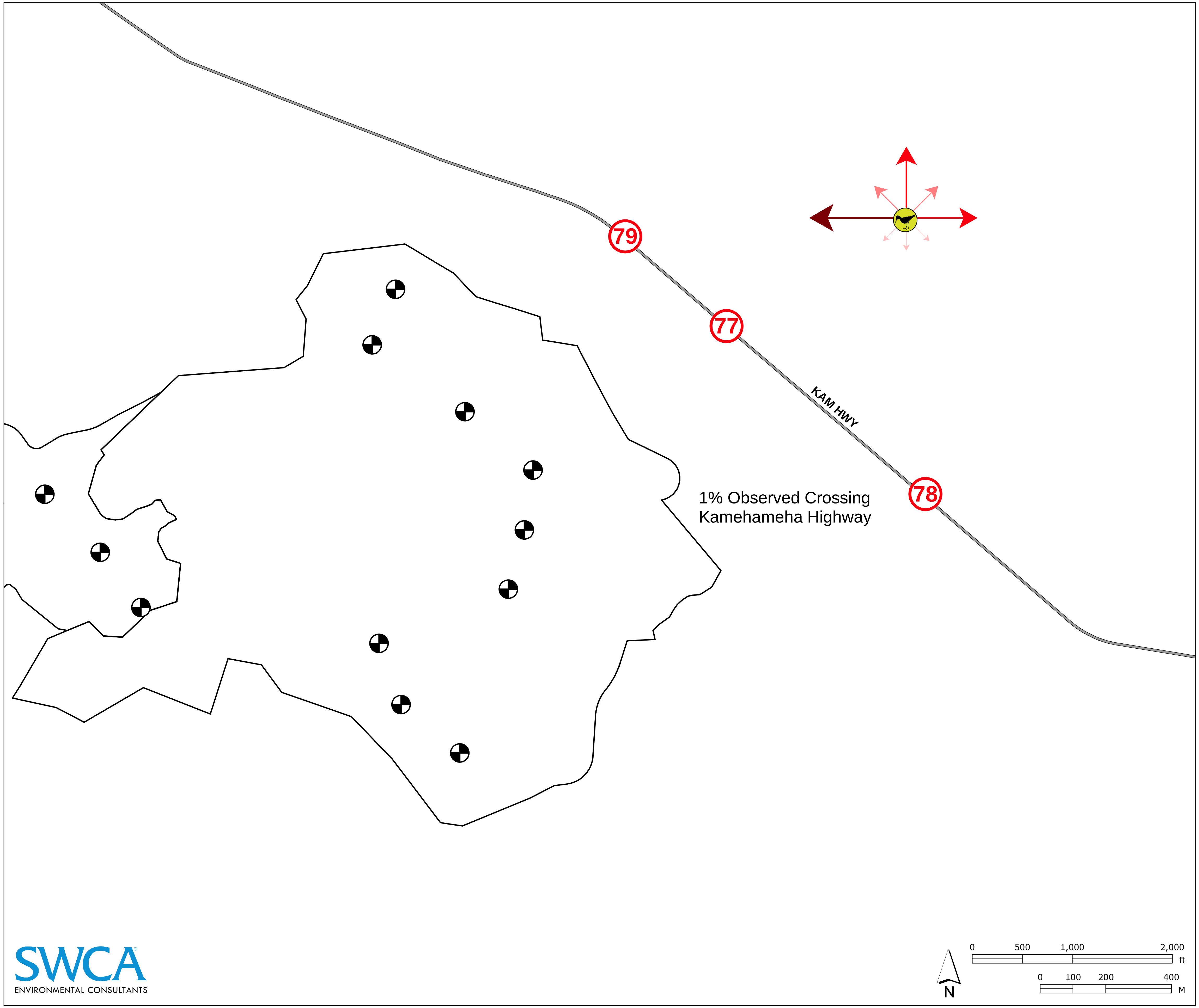
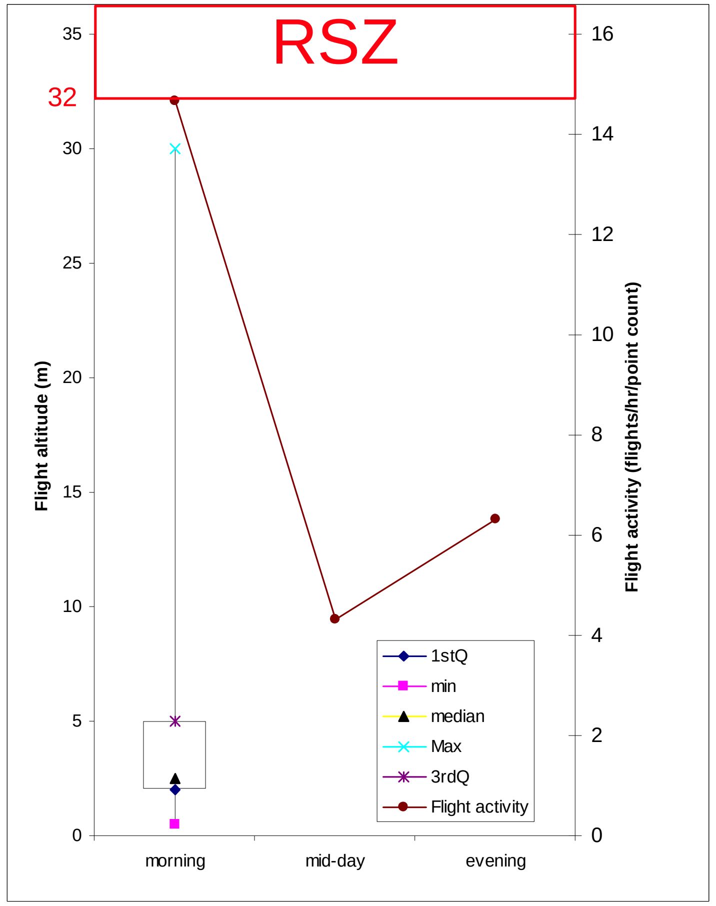


Figure 5
KOLOA-MAOLI LIKE DUCK OCCURENCES





Legend

◐ Turbine/Tower Locations

Stilt Occurences
Percentage by Direction of Travel

↑ 1% - 9.9%

↑ 10% - 14.9%

↑ 15% - 19.9%

↑ 20% - 25%

Figure 6
STILT OCCURENCES

Appendix H.

FINAL REPORT

RESULTS OF ENDANGERED SEABIRD AND HAWAIIAN HOARY BAT SURVEYS ON NORTHERN OAHU ISLAND, HAWAII, OCTOBER 2007 AND JULY 2008

ROBERT H. DAY AND BRIAN A. COOPER

PREPARED FOR
FIRSTWIND, LLC
NEWTON, MASSACHUSETTS

PREPARED BY
ABR, INC.–ENVIRONMENTAL RESEARCH & SERVICES
FAIRBANKS, ALASKA ◆ FOREST GROVE, OREGON

RESULTS OF ENDANGERED SEABIRD AND HAWAIIAN HOARY BAT SURVEYS ON NORTHERN OAHU ISLAND, HAWAII, OCTOBER 2007 AND JULY 2008

FINAL REPORT

Prepared for

FIRSTWIND, LLC
85 Wells Avenue, Suite 305
Newton, MA 02459–3210

Prepared by

Robert H. Day
ABR, Inc.—Environmental Research & Services
P.O. Box 80410
Fairbanks, AK 99708–0410

and

Brian A. Cooper
ABR, Inc.—Environmental Research & Services
P.O. Box 249
Forest Grove, OR 97116–0249

October 2008

Printed on recycled paper.

EXECUTIVE SUMMARY

- FirstWind, LLC, is interested in developing a windfarm on northern Oahu Island, Hawaii. This report summarizes the results of a radar and audio-visual study of seabirds and bats conducted there in fall 2007 and summer 2008. The objectives of this study were to: (1) conduct surveys of endangered seabirds (Hawaiian Petrels *Pterodroma sandwichensis* and Newell's Shearwaters *Puffinus auricularis newelli*) and Hawaiian Hoary Bats (*Lasiurus cinereus semotus*); (2) obtain preliminary information to help assess use of the area by these species; and (3) assess possible fatality rates of these species at this proposed windfarm.
- Two observers monitored movements of seabirds and bats at the Kahuku Study Site, following standard ornithological radar and audio-visual techniques used in previous studies, for 5 nights in October 2007 and for 7 nights and mornings in July 2008.
- Seabird passage rates were extremely low (0.2 targets/h in the summer and 0.3 targets/h in the fall), both overall and relative to other locations in the Hawaiian Islands.
- Flight directions of petrel/shearwater targets were extremely consistent and oriented along a southeast–northwest axis of ~145–325°; only one of nine targets was flying in a direction other than this axis. Nearly all targets that were heading seaward crossed the proposed windfarm site itself, with only one skirting the northeastern boundary of the site.
- The timing of movements suggested that all of the radar targets were those of Newell's Shearwaters.
- We did not see any petrels or shearwaters during the audiovisual sampling, so we were unable to collect data on flight altitude of birds in the study area. In modeling analyses, we assumed that shearwaters in the study area flew at altitudes similar to those on the other Hawaiian Islands.
- We recorded Hawaiian Hoary Bats during the audiovisual sampling, but their movement rates were extremely low (0.0004 bats/h).
- The consistency of flight directions and the presence of safe (so steep that it provides some protection from ground-based predators) and appropriate (uluhe ferns) nesting habitat for Newell's Shearwaters in the area where the radar targets were flying into and out of suggest that there is at least one small colony of Newell's Shearwaters in the northeastern Koolau Range between Kahuku and Laie. There also are numerous records of Newell's Shearwaters in the Koolau Range in the past 30 years, again suggesting persistent nesting colonies in that area.
- We calculated exposure rates and estimated that 1.46 Newell's Shearwaters will fly within the space occupied by a guyed met tower in an average year and that 0.39–3.81 Newell's Shearwaters will fly within the space occupied by a proposed wind turbine in an average year.
- We made some calculations to explore what level of collision-caused fatalities might occur at each of the three met towers at the Kahuku site. By using a range of assumptions for avoidance rates in our fatality models (i.e., 50%, 95%, and 99% avoidance), we estimate fatality of 0.014–0.692 Newell's Shearwaters/met tower/yr and 0.004–0.273 Newell's Shearwaters/wind turbine/yr, depending on the collision-avoidance rate.
- We caution that these assumptions are not based on empirical data. Currently, the limited avoidance data available for these and other bird species suggest that the proportion of petrels that see and avoid the met towers will be substantial and will be enhanced by marking, but we emphasize that, until data are available on petrel and shearwater avoidance behavior at met towers with marked guy wires, the exact proportion will remain unknown.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

We thank FirstWind, LLC, for funding this study. We especially thank Gregory Spencer and Ian Bordenave, both of FirstWind, who helped with all of the field work. We also thank Dave Cowan and Gregory Spencer of FirstWind for their help with logistical matters. At ABR, we thank Allison Zusi-Cobb, Julie Parrett, and Will Lentz for GIS work; Thomas DeLong for fiscal assistance; and Pam Odom for report preparation. This report has been improved by the reviews of David Cowan and Gregory Spencer.

INTRODUCTION

FirstWind, LLC, is interested in developing a wind-energy facility (hereafter, windfarm) near Kahuku, on northern Oahu Island, Hawaii. As part of the siting process, FirstWind wanted to obtain information on endangered seabirds and bats in the vicinity of this proposed windfarm. Because ornithological radar and night-vision techniques have been shown to be successful in studying these species on Kauai (Cooper and Day 1995, 1998; Day and Cooper 1995, Day et al. 2003b), Maui (Cooper and Day 2003), Molokai (Day and Cooper 2002), and Hawaii (Reynolds et al. 1997, Day et al. 2003a), we used them to survey seabirds in the vicinity of the proposed Oahu windfarm. This report summarizes the results of a radar and visual study of seabirds and bats conducted in this area in October (fall) 2007 and early July (summer) 2008. The objectives of this study were to: (1) conduct surveys of endangered seabirds and bats in the vicinity of the proposed windfarm; (2) summarize available information to help assess use of the area by these species; and (3) assess possible fatality rates of these species at this proposed windfarm.

BACKGROUND

Two seabird species that are protected under the Endangered Species Act are likely to occur in the Oahu study area: the endangered Hawaiian Petrel (*Pterodroma sandwichensis*; 'Ua'u) and the threatened Newell’s (Townsend's) Shearwater (*Puffinus auricularis newelli*; 'A'o). Both of these species are forms of tropical Pacific species that nest only on the Hawaiian Islands (AOU 1998), and both are Hawaiian endemics whose populations have declined significantly in historical times: they formerly nested widely over all of the Main Islands but now are restricted in most cases to scattered colonies in more inaccessible locations (Ainley et al. 1997b, Simons and Hodges 1998). The main exception is Kauai Island, which has no introduced Indian Mongooses (*Herpestes auropunctatus*); there, colonies still are widespread and populations are substantial in size.

The Hawaiian Petrel nests on several of the Main Hawaiian Islands (Harrison et al. 1984, Harrison 1990) but is known to nest primarily on Maui (Richardson and Woodside 1954, Banko 1980a; Simons 1984, 1985; Simons and Hodges 1998, Cooper and Day 2003) and Lanai (Shallenberger 1974; Hirai 1978a, 1978b; Conant 1980; J. Penniman, State of Hawaii, DOFAW, pers. comm.) and, to a lesser extent, on Kauai (Telfer et al. 1987, Gon 1988; Ainley et al. 1995, 1997a, 1997b; Day and Cooper 1995, Day et al. 2003a) and Hawaii (Banko 1980a, Conant 1980, Hu et al. 2001, Day et al. 2003a). Recent information from Molokai (Simons and Hodges 1998, Day and Cooper 2002) also suggests breeding.

The Newell's Shearwater nests on several of the Main Hawaiian Islands (Harrison et al. 1984, Harrison 1990), with the largest numbers clearly occurring on Kauai (Telfer et al. 1987, Day and Cooper 1995, Ainley et al. 1995, 1997b, Day et al. 2003b). These birds also nest on Hawaii (Reynolds and Richotte 1997, Reynolds et al. 1997, Day et al. 2003a), almost certainly nest on Molokai (Pratt 1988, Day and Cooper 2002), and may still nest on Oahu (Sincock and Swedberg 1969, Banko 1980b, Conant 1980, Pyle 1983; but see Ainley et al. 1997b). On Kauai, this species is known to nest at several inland locations, often on steep slopes vegetated by uluhe fern (*Dicranopteris linearis*) undergrowth and scattered ohia trees (*Metrosideros polymorpha*).

This study occurred during the incubation period (summer 2008) and the fledging period (fall 2007) of both species of interest (Telfer et al. 1987, Ainley et al. 1997b, Simons and Hodges 1998). There is interest in studying these species because of concerns about collisions with met towers and wind turbines. To date, however, there is a documented mortality of one Hawaiian Petrel and zero Newell's Shearwaters at wind turbines and none of either species at met towers (G. Spencer, FirstWind, Maui, HI, pers. comm.). (Note, however, that fatality studies for these species in the Hawaiian Islands have been conducted for only ~2.75 yr at one windfarm and six met towers.) In contrast, there has been a long history of petrel and shearwater mortality due to collisions with other human-made objects (e.g., powerlines) on Kauai (Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998) and Maui (Hodges 1992).

HAWAIIAN HOARY BATS

The Hawaiian Hoary Bat (*Lasiurus cinereus semotus*; 'Ope'ape'a) is the only terrestrial mammal native to Hawaii. It apparently is classified as endangered primarily because so little is known about its status and population trends. It is a nocturnal species that roosts solitarily during the daytime and occupies a wide variety of habitats, from sea level to >13,000 ft (Baldwin 1950, Fujioka and Gon 1988, Fullard 1989, David 2002). It occurs on all of the Main Hawaiian Islands (Baldwin 1950, van Riper and van Riper 1982, Tomich 1986, Fullard 1989, Kepler and Scott 1990, Hawaii Heritage Program 1991, David 2002; Day and Cooper, unpubl. data), although there is recent speculation that the species has disappeared from both Oahu and Molokai (State of Hawaii 2005).

Recent studies on mountaintops in the eastern US and on the prairies in both the US and Canada indicate that substantial kills of bats, including Hoary Bats, sometimes occur at windfarms (Arnett 2005, Erickson 2004, Kerns 2004, Barclay et al. 2007, Kunz et al. 2007b, Arnett et al. 2008). These fatalities have prompted researchers to develop standardized methods for assessing the use of proposed wind-energy projects by bats (Reynolds 2006, Kunz et al. 2007a). Most of the bat fatalities documented at wind farms have been of migratory tree-roosting species, including Hoary (*Lasiurus cinereus*), Eastern red (*Lasiurus borealis*), Big brown (*Eptesicus fuscus*), and Silver-haired (*Lasionycteris noctivagans*) bats, during seasonal periods of dispersal and migration in late summer and fall. Several hypotheses have been posited to explain these turbine interactions (e.g., Arnett 2005, Barclay et al. 2007, Cryan and Brown 2007, Kunz et al. 2007b, Cryan 2008), although none have been tested yet. Larkin (2006) suggested that bats may be killed when flying straight into objects without reacting, so their fatality rates may be correlated with their movement rates or foraging activity near windfarms; however, recent research by Baerwald et al. (2008) indicates that barotrauma (high-pressure damage to mammalian lungs) is a major cause of the fatalities. Because of these recent fatalities of migratory Hoary Bats at windfarms on the US mainland, there was interest in having us collect visual data on Hawaiian Hoary Bats during this study, even though the Hawaiian subspecies is non-migratory.

STUDY AREA

The proposed windfarm is located near the town of Kahuku, which is located near the northern tip of Oahu Island (Figures 1 and 2). Subsequent to our fall 2007 surveys, three 60-m-high meteorological (met) towers that are anchored by six guy wires in each of four directions were installed at the proposed windfarm. All guy wires are marked by bird flight-diverters (BFDs) with an orange aircraft-marker ball near the top of the uppermost guy wire and 17 spiral vibration dampers (Preformed Products, Cleveland, OH) total per anchor point. In addition, the current development plan for this site is to install 12 Clipper C-96 (“Clipper Liberty”) wind turbines. Each turbine would have a generating capacity of ~2.5 MW, for a total installed capacity of ~30 MW for the windfarm as a whole. The currently-proposed monopole towers would be ~80 m in height, and each turbine would have 3 rotor blades ~48 m long; hence, the total maximal height of a turbine would be ~128 m with a blade in the top-vertical position.

The proposed windfarm will be located on a low ridge that is oriented in a roughly east–west axis and that lies north of the northern end of the Koolau Range, which in turn lies just inland from the eastern shore of Oahu. The study site has an elevation varying from ~30 m to ~100 m above sea level and is extremely disturbed, being covered with old pasturelands and introduced species such as haole koa (*Leucaena leucocephala*), kiawe (*Prosopis pallida*), and christmasberry (*Schinus terebinthefolius*). Native vegetation such as ohia lehua trees (*Metrosideros polymorpha*) and uluhe (*Dicranopterus linearis*) ferns, which are the preferred nesting habitat for Newell's Shearwaters (Sincock and Swedberg 1969, Ainley et al. 1997b), occurs inland on the steeper slopes of the nearby Koolau Range (Day, photographs taken July 2008).

We conducted standard radar and audiovisual sampling at a site just northwest of the proposed windfarm and where there was a good view over the entire windfarm study area. This site was located on a rise in a pasture near an old WWII

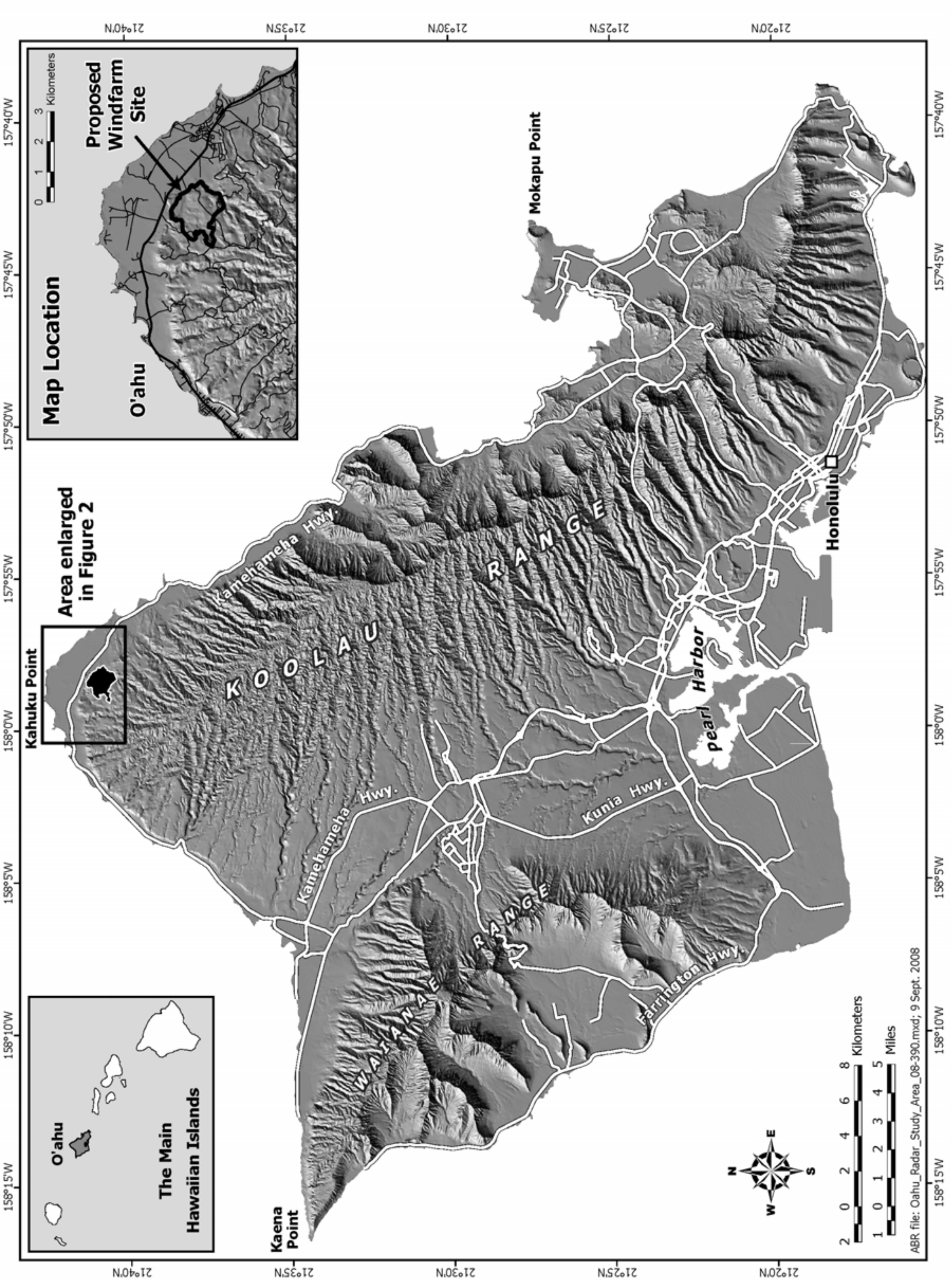


Figure 1. Oahu Island, Hawaii, showing the approximate location of the proposed windfarm study site.

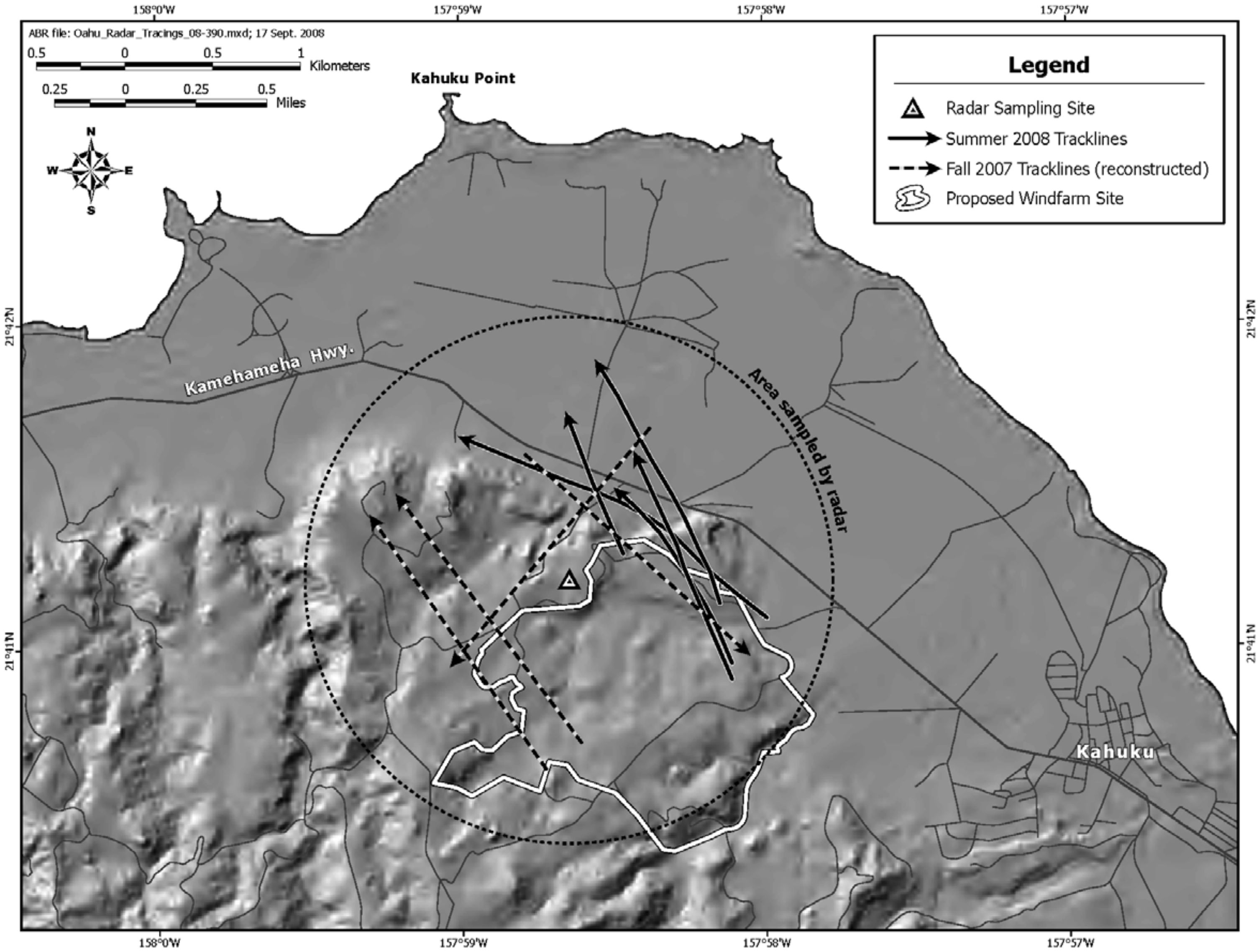


Figure 2. Location of proposed windfarm site and flight tracklines of probable petrel/shearwater targets recorded on radar, fall 2007 and summer 2008. Arrowheads indicate flight directions. Fall 2007 tracklines had to be reconstructed because the original tracings were lost.

gun-emplacement (21.68695°N 157.97745°W; WGS84 datum), provided good radar coverage with essentially no radar-shadow zones or extensive areas of ground-clutter within the study area, and was an excellent site for audiovisual sampling. The radar site was located at ~70 m elevation.

METHODS

DATA COLLECTION

Two observers monitored movements of birds and bats during 16–20 October 2007 and 1–8 July 2008 (Table 1) by following standard ornithological radar and audiovisual techniques used in previous studies (e.g., Cooper and Day 1995, 2003; Day and Cooper 1995, Day et al. 2003b). We collected data on five evenings (1800–2100) in the fall of 2007 and on 7 evenings (1900–2200) and mornings (0400–0600) over 8 days in the summer of 2008. One observer operated the radar, while the second observer conducted audiovisual sampling. For the purposes of this study, an evening and the following morning (i.e., from sunset to sunrise) were considered as occurring on the same date to simplify analytical results for each period of darkness.

Before each radar and audiovisual sampling period, we recorded standardized weather and environmental data: wind direction (to the nearest 5°, plus variable winds and no wind), wind speed (to the nearest 1 m/sec), percent cloud cover (to the nearest 5%), cloud ceiling height above ground level (agl; in several height categories), visibility (maximal distance we could see, in categories), light condition (daylight, crepuscular, or nocturnal, and with or without precipitation), precipitation type, and moon phase/position (lunar phase and whether the moon was above or below the horizon in the night sky).

RADAR SAMPLING

Our radar laboratory consisted of a marine radar that was mounted on the roof of an SUV vehicle. During all sampling, the antenna was positioned in the horizontal position (i.e., in surveillance mode), so the radar scanned the area surrounding the vehicle for movement rates, flight directions, flight behaviors, and groundspeeds of targets. A description of a similar radar laboratory can be found in Gauthreaux (1985a, 1985b), Cooper et al. (1991), and Mabee et al. (2006).

The radar used for this study was a Furuno Model 1510 X-band radar transmitting at 9.410 GHz through a slotted wave guide with a peak power output of 12 kW. We operated the radar at a 1.5-km range setting and a pulse-length of 0.07 μsec. The surveillance radar's antenna face was tilted upward by ~10–15°. Figure 3 shows the approximate sampling airspace for the Furuno FR–1510 marine radar at a 1.5-km range setting, as determined by field trials with Rock Pigeons (*Columba livia*).

Whenever energy is reflected from the ground, surrounding vegetation, and other objects that surround the radar unit, a ground-clutter echo appears on the radar's display screen. Because ground clutter can obscure targets of interest (i.e., birds and bats), we attempted to minimize it by picking optimal sampling locations. Ground clutter was minor at the study site and, in our opinion, did not cause us to miss any targets. Radar coverage also can be affected by shadow zones, which are areas of the screen where birds were likely to be flying at an altitude that would put them behind a hill or row of vegetation, so that they could not be detected. Shadow zones were minimal at the Kahuku site, and we do not believe that petrels or shearwaters could have crossed the radar screen without being detected by the radar.

We sampled during the evening and morning peaks of movement, which is when petrels and shearwaters fly inland toward the nesting colonies and seaward from the nesting colonies (Day and Cooper 1995). Thus, we conducted six 25-min counts of birds during the period 1800–2100 each night in the fall of 2007 and the periods 1900–2200 h and 0400–0600 in the summer of 2008 (Table 1). Each 25-min sampling period was separated by a 5-min break for collecting data on weather between sampling periods. To eliminate species other than those of interest (e.g., slowly-flying birds, insects), we recorded data only for those targets flying with an airspeed ≥30 mi/h (≥50 km/h). For each radar target, we recorded the time, number of radar targets, transect crossed (the four cardinal points—000°, 090°, 180°, or 270°; used in reconstructing flight paths), flight direction (to the nearest 1°), tangential range (the minimal distance

Table 1. Radar and audiovisual sampling effort at the proposed wind-energy site on Oahu Island, Hawaii, during fall 2007 and summer 2008.

	Sampling type	
Season/date	Surveillance radar	Audiovisual
FALL		
16 October	1800–2100	1800–2100
17 October	1800–2100	1800–2100
18 October	1800–2100	1800–2100
19 October	1800–2100	1800–2100
20 October	1800–1930 [a]	1800–1930 [a]
SUMMER		
1 July	–	1900–2200, 0400–0600
2 July	1900–2200, 0400–0600	1900–2200, 0400–0600
3 July	1900–2200, 0400–0600 [b]	1900–2200, 0400–0600
4 July	1900–2200 [b], 0400–0600 [b]	1900–2200, 0400–0600
5 July	1900–2200, 0400–0600	1900–2200, 0400–0600
6 July	1900–2200, 0400–0600	1900–2200, 0400–0600
7 July	1900–2200, 0400–0600	1900–2200, 0400–0600
8 July	1900–2200, 0400–0600	–

[a] Sampling stopped early because of battery problems.
[b] Some sampling time was lost because of rain.

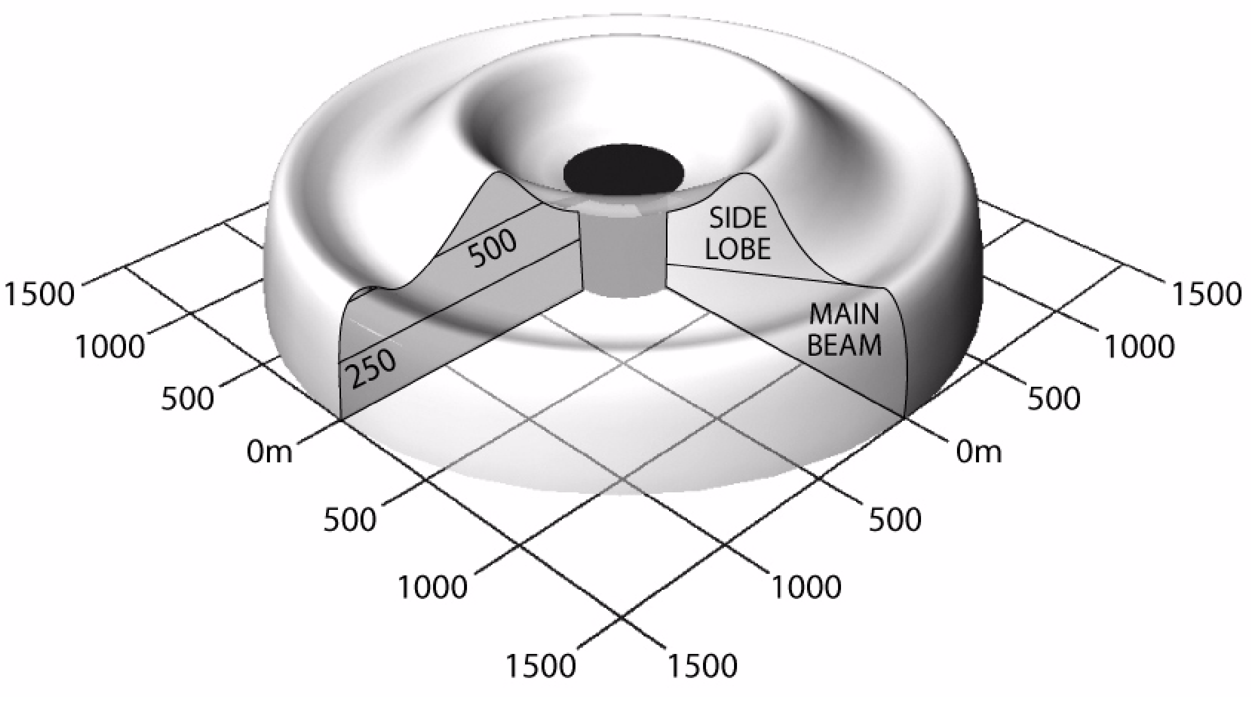


Figure 3. Approximate sampling airspace for the Furuno FR–1510 marine radar at the 1.5-km range setting, as determined by field trials with Rock Pigeons. Note that the configuration of the radar beam within 250 m of the origin was not determined.

to the target when it passed closest to the lab; also used in reconstructing actual flight paths, if necessary), flight behavior (straight, erratic, circling), velocity (to the nearest 5 mi/h [8 km/h]) species (if known), and number of birds or bats (if known).

AUDIOVISUAL SAMPLING

We also conducted audiovisual sampling for birds and bats concurrently with the radar sampling, to help identify targets observed on radar and to obtain flight-altitude information. During this sampling, we used 10× binoculars during crepuscular periods and used PVS-7 night-vision goggles during nocturnal periods to look for targets that were detected on the radar. The magnification of these Generation-3 goggles was 1×, and their performance was enhanced with the use of a 3-million-Cp floodlight that was fitted with an IR filter to avoid blinding and/or attracting these nocturnal birds. For each bird or bat seen during night-vision sampling, we recorded the time, species (to the lowest practical taxonomic unit—e.g., Newell's Shearwater, unidentified shearwater/petrel), number of birds or bats in the target, flight direction (the eight ordinal points), flight behavior (as above), flight altitude (m above ground level), and cardinal transect crossed (as above).

DATA ANALYSIS

RADAR DATA

We entered all data into a Microsoft Excel database. Data files were checked visually for errors after each night's sampling and were checked again electronically for errors prior to data analyses. All data summaries and analyses were conducted with the statistical software available in Microsoft Excel. For quality assurance, we cross-checked results of the Excel analyses with hand-tabulations of small subsets of data whenever possible.

Prior to analyses, radar data were filtered to remove non-target species. Only known petrel/shearwater targets or unknown targets with appropriate characteristics (i.e., with appropriate target size, flight characteristics, and airspeeds ≥30 mi/h) were included in data analyses of movement rates, flight directions, and flight behavior; all other species were excluded from those analyses. Following Mabee et al. (2006), we computed the airspeed (i.e., groundspeed corrected for wind speed and relative direction) of surveillance-radar targets with the formula:

$$V_a = \sqrt{V_g{}^2 + V_w{}^2 - 2V_g V_w \cos\theta},$$

where V_a = airspeed, V_g = target groundspeed (as determined from the radar's flight trackline), V_w = wind velocity, and θ is the angular difference between the observed flight direction and the direction of the wind vector.

We tallied counts of targets recorded during each sampling session, then converted the counts to estimates of movement rates (targets/h), based on the number of minutes sampled in each session. Battery problems can prevent sampling, and rain showers sometimes can obscure significant portions of the screen for several minutes at a time. Hence, periods when we were unable to sample for the full session were subtracted from the standardized 25-min sampling period, with the resulting number of minutes being used to calculate movement rates. We lost 11 min in 2 sampling sessions, plus 3 entire sampling sessions (all on the same evening), in the fall of 2007 because of battery problems and lost 16 min in 3 sampling sessions (all on different nights) because of rain in the summer of 2008 (Table 1).

We used the estimated movement rates on radar for each sampling period to calculate the mean ± 1 standard error (SE) movement rate at each site on each evening, morning, and overall for each date. Only known petrel/shearwater targets or unknown targets with appropriate sizes, flight characteristics, and groundspeeds (i.e., ≥30 mi/h) were included in data analyses of movement rates, flight direction, and flight behavior; all other species were excluded from these analyses.

We calculated the mean ± circular standard deviation (S') and the vector length (r) of the flight direction for all targets seen on radar. (The circular standard deviation is a statistical equivalent of the standard deviation that is used for directional data, and the vector length is a measure of how consistently the targets are moving in one direction.) We also classified general flight directions of each radar target as inland, seaward, or “other” and summarized these directional categories by site and by night. Because the shoreline in this area goes to a point at the northern tip of the island, we were unable to use normal methods to determine whether a target was flying inland or seaward. Instead, we defined an inland flight direction as 120–239°, a seaward flight direction as 300–059°, and an "other" flight direction as 060–119° or 240–299°. Finally, we plotted all tracklines on a map of the study area.

EXPOSURE AND FATALITY RATES

The risk-assessment technique that we have developed uses the radar data on seasonal movement rates to estimate numbers of birds flying over the area of interest (sampling site) across the portion of the year when birds are present on land. The model then uses information on the physical characteristics of the met towers and wind turbines to estimate horizontal-interaction probabilities, uses flight-altitude data and information on the height of the met towers and wind turbines to estimate vertical-interaction probabilities, and combines these interaction probabilities with the movement rates to generate annual exposure rates. These exposure rates represent the estimated numbers of petrels or shearwaters that pass within the airspace occupied by a met tower and its associated guy wires (or a wind turbine) each year. We then combine these exposure rates with (1) the probability that an exposure results in a fatality; and (2) the probability that birds detect structures and avoid interacting with them, to estimate fatality rates at each of the met towers in an average year.

Exposure Rates

We calculate an exposure rate by multiplying the annual movement rate by horizontal- and vertical-interaction probabilities. The movement rate is an estimate of the average number of birds passing in the vicinity of the proposed towers in a year, as indicated by the number of targets crossing the radar screen and the mean flock size/target. It is generated from the radar data by: (1) multiplying the average movement rates for summer and fall seasons by 5.5 h to estimate the number of targets moving over the radar site during those periods; (2) adjusting the sum of those counts to account for the estimated percentage of movement that occurs during the middle of the night (12.6%; Cooper and Day, unpubl. data); (3) multiplying that total number of targets/night by the mean number of Newell's Shearwaters/target (1.03 ± SE 0.01 Newell's Shearwaters/flock; *n* = 722 flocks; Day and Cooper, unpubl. data) to generate an estimate of the number of shearwaters passing in the vicinity of the proposed tower during an average night; and (4) multiplying those numbers by the number of days that these birds were exposed to risk in each season (150 days in the spring/summer and 60 days in the fall; Ainley et al. 1997b). (We believe that all of the targets we recorded were those of Newell's Shearwaters; see Results and Discussion.)

Interaction probabilities consist of both horizontal and vertical components. Please note that our horizontal and vertical interaction “probabilities” actually are just fractions of sampled airspace occupied by structures, rather than usual statistical probabilities. Hence, we assume that the probability of exposure is equal to the fraction of sampled air space that was occupied by a met tower or wind turbine and that there is a uniform distribution of birds in the sampled airspace.

The horizontal-interaction probability is the probability that a bird seen on radar will pass over the two-dimensional space (as viewed from the side) occupied by a met tower or wind turbine located somewhere on the radar screen. This probability is calculated from information on the two-dimensional area (side view) of the met tower or wind turbine and the two-dimensional area sampled by the radar screen. The met-tower system has a central tower with four sets of guy wires attached at six heights; hence, from a side view, the met-tower/guy-wire system appears from the side to be an isosceles triangle 60 m high with a base of 100 m and a side-view area of 3,000 m^2. The wind-turbine system will have a maximal height of 128 m, a radius of 48 m, and minimal (side-view) and maximal (front-view) areas of 768 m^2 and 7, 430 m^2, respectively. The ensuing ratio of the cross-sectional area of the met tower or wind turbine to the cross-sectional area sampled by the radar (3-km diameter times the height of the structure) indicates the probability of interacting with (i.e., flying over the airspace occupied by) the met tower or wind turbine.

The vertical-interaction probability is the probability that a bird seen on radar will be flying at an altitude low enough that it actually might pass through the airspace occupied by a met tower or wind turbine located somewhere on the radar screen. This probability is calculated from data on flight altitudes and from information on the towers' and proposed turbines' heights. We calculated the percentage of shearwaters with flight altitudes ≤60 m agl (maximal height of the met towers) and the percentage of shearwaters with flight altitudes ≤130 m agl (maximal height of the rotor-swept area on a proposed turbine). We used data on flight altitudes of Newell's Shearwaters from throughout the Hawaiian Islands (*n* = 688 birds; Day and Cooper, unpubl. data) to calculate the percentage of shearwaters with flight altitudes at or below the maximal height of the met towers (28.5%) or turbines (64.1%). We would have preferred to use flight-altitude data from Oahu for the flight-altitude percentage calculation, but we did not have any data from that island.

Fatality Rates

The annual fatality rate is calculated as the product of: (1) the exposure rate (i.e., the number of birds that might fly in the airspace occupied by a met tower or wind turbine); (2) the fatality probability (i.e., the probability of a fatal collision with a portion of the structure while in that airspace); and (3) the probability that a bird actually will detect and avoid entering the airspace containing the structure. The annual fatality rate is generated as an estimate of the number of birds killed/year as a result of collisions with the tower/turbine, based on a 210-d breeding season for Newell's Shearwaters (Ainley et al. 1997b). Because collision-avoidance probabilities are largely unknown, we present fatality estimates for a range of probabilities by these birds by assuming that 50%, 95%, or 99% of all shearwaters flying near a met tower or wind turbine will see and avoid it.

The estimate of the fatality-probability portion of the fatality-rate formula is derived as the product of: (1) the probability of colliding with the tower/guy wires or the proposed wind turbine if the bird enters the airspace occupied by either of these structures (i.e., are there gaps big enough for birds to fly through the structure without hitting any part of it?); and (2) the probability of dying if it collides with the met-tower frame/guy wires or the wind-turbine structure (including blades). The former probability is needed because the estimates of horizontal-interaction probability are calculated as if the met tower/guy wires and the wind turbine are solid structures. Because a bird hitting the met-tower frame/guy wires or wind turbine will have a high probability of actually dying unless it just brushes the structure with a wingtip, we used an estimate of 95% for the first fatality-probability parameter. The second probability (i.e., that of striking the structure) needs to be calculated differently for met towers and wind turbines. In the met-tower design, the tower frame is a solid monopole tower, and the four sets of guy wires at six heights each occupy a substantial proportion of the total cone of airspace enclosed by the tower and guy wires, making it a low probability that a bird could fly though the space occupied by this tower/guy wires without hitting some part of it. Hence, we conservatively estimated the probability of hitting a met tower or guy wires if the bird enters the airspace at 100%. Similarly, a bird approaching a wind turbine from the side has essentially a 100% probability of hitting the tower or a turbine blade. In contrast, a bird approaching from the back or front of a turbine may pass through the rotor-swept area without colliding with a blade, depending on the bird's size and speed of flight and the maximal rate of rotation of the turbine blades. We calculated the probability of collision for the “frontal” bird approach based upon the length of a shearwater (33 cm; Pratt et al. 1987); the average groundspeed of Newell's Shearwaters on the Hawaiian Islands (mean velocity = 36.4 mi/h [58.6 km/h]; *n* = 28 identified shearwater targets; Day and Cooper, unpubl. data) and the time that it would take a 33-cm-long shearwater to travel completely through a 2-m-wide turbine blade spinning at its maximal rotor speed (15.5 revolutions/min for this model); also see Tucker (1996). These calculations indicated that up to 15.6% of the disk of the rotor-swept area would be occupied by a blade sometime during the length of time (0.14 sec) that it would take a shearwater to fly completely past a rotor blade (i.e., to fly 2.33 m).

RESULTS

SURVEILLANCE-RADAR OBSERVATIONS

We recorded 3 targets on radar that fit our criteria for petrel/shearwater targets during the 5 nights of surveillance radar sampling in fall 2007 and recorded 5 targets on radar that fit our criteria for petrel/shearwater targets during the 8 nights of surveillance radar sampling in summer 2008 (Table 2). In addition, we recorded 1 target off-survey in fall 2007 that we discuss whenever possible here, to help increase our understanding of movements through the area. Movement rates of shearwater and petrel targets varied between 0 and 0.8 targets/h for individual sampling sessions and averaged 0.3 ± 0.2 targets/h overall in fall 2007 and 0.2 ± 0.1 targets/h overall in summer 2008 (Table 2). Mean movement rates generally were similar among nights, ranging from 0 to 0.8 targets/h among nights in fall 2007 and from 0 to 0.5 targets/h in summer 2008.

We recorded similar numbers of landward- and seaward-flying targets in fall 2007 (includes the 1 seaward-flying target seen off-survey on the evening of 18 October) but recorded only seaward-flying targets during both the evening and the morning in summer 2008 (Table 2). Overall 77.8% (including the target seen off-survey) of all targets were flying seaward, whereas 22.2% were flying landward.

Mean overall flight directions (± *S'*) were 323 ± 57° (*r* = 0.610; *n* = 9 targets, including one seaward-flying target seen off-survey on the evening of 18 October.) Mean evening flight directions were 316 ± 67° (*r* = 0.509; *n* = 7 targets). Six of the seven evening targets were strongly aligned along a southeast–northwest axis (142°, 301°, 322°, 335°, 343°, and 346°), whereas the remaining target was flying inland toward the southwest (220°); consequently, the vector length (*r*) was only moderate. Mean morning flight directions were 336 ± 1° (*r* = 0.999; *n* = 2 targets), with both targets being strongly aligned along the same southeast–northwest axis (335°, 337°); the extremely high *r* reflects this strong consistency of flight directions. Mean inland flight directions were 181 ± 41° (*r* = 0.777; *n* = 2 targets), with the moderate *S'* and *r* reflecting the almost-perfect balance of targets flying toward the southeast and the southwest. In contrast, mean seaward flight directions were 331 ± 14° (*r* = 0.970; *n* = 7 targets), with the small *S'* and the large *r* reflecting the great consistency of flight directions between 301° and 346°.

A qualitative assessment of flight paths and trajectories suggested that there was one pattern of movement in the area: a southeast–northwest axis of ~145–325° between the ocean and the northeastern end of the Koolau Range (8 targets). In addition, there was an outlier data point represented by a southwesterly flight toward the northern extremity of the Koolau Range or the valley between the Koolau and Waianae ranges (1 target; Figure 2). Nearly all targets that were heading seaward crossed the proposed windfarm site itself, with only one skirting the northeastern boundary of the site. One of the two targets that were heading inland did not cross the site.

Mean evening flight velocities (corrected to airspeeds; ± SE) were 42.3 ± 3.3 mi/h (*n* = 7 targets) and ranged from 33 to 57 mi/h. Mean morning flight velocities were 46.0 ± 2.0 (*n* = 2 targets) and ranged from 44 to 48 mi/h. Mean inland flight velocities were 38.0 ± 1.0 (*n* = 2 targets) and ranged from 37 to 39 mi/h, whereas mean seaward flight velocities were 44.6 ± 3.2 (*n* = 7 targets) and ranged from 33 to 57 mi/h. Mean overall flight velocities were 43.1 ± 2.6 (*n* = 9 targets) and ranged from 33 to 57 mi/h.

The timing of movement of targets suggested that all of the targets were those of Newell's Shearwaters (Table 3). No evening targets were recorded during the first sampling session, which is when only Hawaiian Petrels fly, and only one was recorded during the second session, which is when Hawaiian Petrel numbers are tapering off and Newell's Shearwater numbers are increasing; all other targets were flying after the point of complete darkness (Day and Cooper 1995, Cooper and Day 2003). This latter target, however, was flying after it was completely dark (i.e., after the point of complete darkness), suggesting that it was a Newell's Shearwater and not a Hawaiian Petrel. In the morning, the two targets also were recorded while it was completely dark out. Hence, we believe that all of the targets recorded on radar were those of Newell's Shearwaters (Table 3).

No targets that we believed were petrels or shearwaters were observed flying in an erratic or

Table 2. Daily and overall counts and movement rates of seabirds detected on surveillance radar at the proposed wind-energy site on Oahu Island, Hawaii, during fall 2007 and summer 2008. Overall rates are presented as mean ± SE (*n* number of sampling sessions except for totals for a season, when they are number of nights).

		Number of targets			Movement rate (targets/h)		
Season/date	Time period	Landward	Seaward	Total	Landward	Seaward	Total
FALL							
16 October	Evening	1	1	2	0.4 ± 0.4 (6)	0.4 ± 0.4 (6)	0.8 ± 0.5 (6)
17 October	Evening	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
18 October [a]	Evening	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
19 October	Evening	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
20 October	Evening	1	0	1	0.8 ± 0.8 (3)	0.0 ± 0.0 (3)	0.8 ± 0.8 (3)
Total fall	Evening	2	1	3	0.2 ± 0.2 (5)	0.1 ± 0.1 (5)	0.3 ± 0.2 (5)
	Total	2	1	3	0.2 ± 0.2 (5)	0.1 ± 0.1 (5)	0.3 ± 0.2 (5)
SUMMER							
1 July	Morning	0	0	0	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)
	Total	0	0	0	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)
2 July	Evening	0	1	1	0.0 ± 0.0 (6)	0.4 ± 0.4 (6)	0.4 ± 0.4 (6)
	Morning	0	0	0	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)
	Total	0	1	1	0.0 ± 0.0 (10)	0.2 ± 0.2 (10)	0.2 ± 0.2 (10)
3 July	Evening	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
	Morning	0	0	0	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)
	Total	0	0	0	0.0 ± 0.0 (10)	0.0 ± 0.0 (10)	0.0 ± 0.0 (10)
4 July	Evening	0	1	1	0.0 ± 0.0 (6)	0.4 ± 0.4 (6)	0.4 ± 0.4 (6)
	Morning	0	1	1	0.0 ± 0.0 (4)	0.6 ± 0.6 (4)	0.6 ± 0.6 (4)
	Total	0	2	2	0.0 ± 0.0 (10)	0.5 ± 0.3 (10)	0.5 ± 0.3 (10)
5 July	Evening	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
	Morning	0	0	0	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)
	Total	0	0	0	0.0 ± 0.0 (10)	0.0 ± 0.0 (10)	0.0 ± 0.0 (10)
6 July	Evening	0	1	1	0.0 ± 0.0 (6)	0.4 ± 0.4 (6)	0.4 ± 0.4 (6)
	Morning	0	1	1	0.0 ± 0.0 (4)	0.6 ± 0.6 (4)	0.6 ± 0.6 (4)
	Total	0	2	2	0.0 ± 0.0 (10)	0.5 ± 0.3 (10)	0.5 ± 0.3 (10)

Table 2. Continued.

		Number of targets			Movement rate (targets/h)		
Season/date	Time period	Landward	Seaward	Total	Landward	Seaward	Total
7 July	Evening	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
	Morning	0	0	0	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)	0.0 ± 0.0 (4)
	Total	0	0	0	0.0 ± 0.0 (10)	0.0 ± 0.0 (10)	0.0 ± 0.0 (10)
8 July	Evening	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
	Total	0	0	0	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)	0.0 ± 0.0 (6)
Total summer	Evening	0	3	3	0.0 ± 0.0 (7)	0.2 ± 0.1 (7)	0.2 ± 0.1 (7)
	Morning	0	2	2	0.0 ± 0.0 (7)	0.2 ± 0.1 (7)	0.2 ± 0.1 (7)
	Total	0	5	5	0.0 ± 0.0 (7)	0.2 ± 0.1 (7)	0.2 ± 0.1 (7)

[a] In addition, a petrel/shearwater-like target was recorded flying seaward at 1930 during a break between sampling sessions (i.e., off-sampling).

Table 3. Evening timing of movement of bird targets on ornithological radar, with mean movement rates and percentages of nightly movements observed by half-hour period at the proposed wind-energy site on Oahu Island, Hawaii, during fall 2007 and summer 2008.

Time period/time	Number of targets	Percent
EVENING		
1800–1829	0	0
1830–1859	1	16.7
1900–1929	1	16.7
1930–1959	2	33.3
2000–2029	0	0
2030–2059	2	33.3
MORNING		
0400–0429	0	0
0430–0459	0	0
0500–0529	2	100.0
0530–0559	0	0

circling manner. Straight-line flights composed 100% of all flights.

AUDIOVISUAL OBSERVATIONS

We visually recorded no Hawaiian Petrels, no Newell's Shearwaters, no unidentified shearwaters/petrels, and no Hoary Bats during our 5 nights of audiovisual sampling in fall 2007 (Table 4). We visually recorded no Hawaiian Petrels, no Newell's Shearwaters, no unidentified shearwaters/petrels, and 1 Hoary Bat during our 7 nights and 7 mornings of audiovisual sampling in summer 2008. Other species of interest that we recorded audiovisually included Pacific Golden-Plovers, Short-eared Owls, Barn Owls, "Koloa-like" Ducks (i.e., Koloa Ducks that may or may not have hybridized with Mallards), unidentified ducks, and Cattle Egrets. Cattle Egrets, in particular, were common in the area and moved *en masse* toward nocturnal roosting grounds every evening between sunset and darkness and from roosting grounds to feed in the study area in the morning; they only were diurnal in activity.

We recorded 1 Hoary Bat during audiovisual surveys, on the evening of 6 July 2008 (Table 4), translating to an estimated occurrence rate of 1 bat in 97 25-min observation sessions (0.0004 bats/h). It was flying slowly in a seaward direction from farther inland at an altitude of ~35 m agl. Many moths were active that night, although the reason why was unclear: winds were from a similar direction (~100°, or just south of east) and at a wind speed (~4 mi/h [~6 km/h]) similar to wind conditions on other nights. Although we did not record them audiovisually, we also recorded bat-like targets on radar on several nights over the marshy flats to the north of us.

EXPOSURE RATES

The exposure rate is calculated as the product of three variables: annual movement rate, horizontal-interaction probability, and vertical-interaction probability (Tables 5 and 6). As such, it is an estimate of the number of birds flying in the vicinity of a met tower or a wind turbine (i.e., crossing the radar screen) that could fly in a horizontal location and at a low-enough altitude that they could interact with a tower nor turbine. In this modeling exercise, we used the radar-based movement data collected during October 2007 and July 2008 as model inputs; data on the timing of movements at the study site to determine proportions of Hawaiian Petrels and Newell's Shearwaters; data on the timing of movements from Day and Cooper (1995) to determine the proportion of birds flying during the off-peak hours in the middle of the night that we did not sample in this study; information on the mean flock size of targets of each species (Day and Cooper, unpubl.

Table 4. Number of Hawaiian Petrels (HAPE), Newell’s Shearwater (NESH), unidentified shearwater/petrels (UNSP), and Hawaiian Hoary Bats (HOBA) recorded during audiovisual surveys at the proposed wind-energy site on Oahu Island, Hawaii, during fall 2007 and summer 2008. *n* number of sampling sessions.

	Number				
Season/date (*n*)	HAPE	NESH	UNSP	HOBA	Other species [a]
FALL					
16 October (6)	0	0	0	0	1 BAOW; 10^+ CAEG
17 October (6)	0	0	0	0	10^+ CAEG
18 October (6)	0	0	0	0	10^+ CAEG
19 October (6)	0	0	0	0	1 BAOW; 10^+ CAEG
20 October (3)	0	0	0	0	10^+ CAEG
Total fall (27)	0	0	0	0	
SUMMER					
1 July (4)	0	0	0	0	2 PAGP; 10^+ CAEG
2 July (10)	0	0	0	0	1 SEOW; 1 KODU; 3 UNDU; 10^+ CAEG
3 July (10)	0	0	0	0	10^+ CAEG
4 July (10)	0	0	0	0	10^+ CAEG
5 July (10)	0	0	0	0	10^+ CAEG
6 July (10)	0	0	0	1	10^+ CAEG
7 July (10)	0	0	0	0	10^+ CAEG
8 July (6)	0	0	0	0	10^+ CAEG
Total summer (70)	0	0	0	1	
Total (97)	0	0	0	1	

[a] PGPL = Pacific Golden-Plover (*Pluvialis fulva*); SEOW = Short-eared Owl (*Asio flammeus*); BAOW = Barn Owl (*Tyto alba*); KODU = "Koloa-like" Duck (*Anas wyvilliana* or Koloa hybrid with Mallard *Anas platyrhynchos*); UNDU = unidentified duck CAEG = Cattle Egret (*Bubulcus ibis*).

data); and information on the dimensions of the met towers and proposed wind turbines to calculate annual movement rates of these birds through the study area. By using these parameters, we estimate that 0 Hawaiian Petrels and 307 Newell's Shearwaters pass over the 1.5-km-radius radar sampling area (Figure 2) during an average year (Tables 5 and 6).

To generate annual exposure rates of birds exposed to each met tower (birds/tower/yr) or wind turbine (birds/turbine/yr), we then multiplied the annual movement rate by the horizontal-interaction probability and the vertical-interaction probability. For the horizontal-interaction probability, we estimated that it was 0.01667 at a 60-m met tower (Table 5) and that it ranged between 0.00200 and 0.01935, depending on whether the bird was approaching the wind turbine from the side or the front, respectively (Table 6). We were unable to detect any petrels or shearwaters visually in this study, so, for the purposes of vertical-interaction probabilities in the model, we used flight-altitude data for Newell's Shearwaters from elsewhere in the Hawaiian Islands (*n* = 688 birds) to estimate that 28.5% of all birds passing through this area would be flying at or below met-tower height (Table 5) and that 64.1% of all birds passing through this area would be flying at or below turbine height (Table 6).

The annual exposure rate then is calculated by multiplying the annual movement rate by the horizontal-interaction probability and the vertical-interaction probability. By applying these proportions to our data, we estimate that 1.46 Newell's Shearwaters will fly within the space occupied by a met tower during an average year (Table 5) and that 0.39–3.81 Newell's Shearwaters will fly within the space occupied by a proposed

Table 5. Estimated average exposure rates and fatality rates of Newell’s Shearwaters at guyed 60-m monopole met towers at the proposed wind-energy site on Oahu Island, Hawaii, based on radar data collected in October 2007 and July 2008. Values of particular importance are in boxes.

Variable/parameter for 60-m monopole met tower	Estimate
MOVEMENT RATE (MVR)	
A) Mean movement rate (targets/h)	
A1) Mean rate during nightly peak movement periods in spring/summer based on July 2008 data (targets/h)	0.2
A2) Mean rate during nightly peak movement periods in fall based on July 2008 data (targets/h)	0.3
B) Number of hours of evening and morning peak period sampling	5.5
C) Mean number of targets during evening and morning peak movement periods	
C1) Spring/summer (A1 * B)	1.100
C2) Fall (A2 * B)	1.650
D) Mean proportion of birds moving during off-peak hours of night	0.126
E) Seasonal movement rate (targets/night) = ((C * D) + C)	
E1) Spring/summer	1.24
E2) Fall	1.86
F) Mean number of birds/target	1.03
G) Estimated proportion that is Newell's Shearwaters	1.00
H) Daily movement rate (birds/day =E * F * G)	
H1) Spring/summer	1.28
H2) Fall	1.91
I) Fatality domain (days/year)	
I1) Spring/summer	150
I2) Fall	60
J) Annual movement rate (birds/year; = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	307
HORIZONTAL-INTERACTION PROBABILITY (IPH)	
K) Maximal cross-sectional area of tower and guys (side view = ((50 m * 60 m)/2) *2 = 3,000 m^2	3,000
L) Cross-sectional sampling area of radar at or below 60 m tower height (= 3,000 m * 60 m = 180,000 m^2)	180,000
M) Horizontal-interaction probability (= K/L, rounded to 8 decimal places)	0.01666667
VERTICAL-INTERACTION PROBABILITY (IPV)	
N) Proportion of Newell's Shearwaters flying ≤ tower height in Hawaiian Islands (*n* = 688)	0.285
EXPOSURE RATE (ER = MVR*IPH*IPV)	
O) Daily exposure rate (birds/tower/day = H * M * N, rounded to 8 decimal places)	
O1) Spring/summer	0.00605738
O2) Fall	0.00908607
P) Annual exposure rate (birds/tower/year = J * M * N, rounded to 8 decimal places)	1.45765504
FATALITY PROBABILITY (MP)	
Q) Probability of striking tower or guys if in airspace	1.00
R) Probability of fatality if striking tower or guys	0.95
S) Probability of fatality if an interaction (= Q * R)	0.95000
FATALITY RATE (= ER*MP)	
T) Annual fatality rate with 50% exhibiting collision avoidance (birds/tower/year = P * S * 0.50)	0.69239
U) Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year = P * S* 0.05)	0.06924
V) Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year = P * S * 0.01)	0.01385

Table 6. Estimated average exposure rates and fatality rates of Newell’s Shearwaters at Clipper C-96 wind turbines at the proposed wind-energy site on Oahu Island, Hawaii, based on radar data collected in October 2007 and July 2008. Values of particular importance are in boxes.

	Estimate	
Variable/parameter for Clipper C-96 turbine	Minimum	Maximum
MOVEMENT RATE (MVR)		
A) Mean movement rate (targets/h)		
A1) Mean rate during nightly peak movement periods in spring/summer based on July 2008 data (targets/h)	0.2	0.2
A2) Mean rate during nightly peak movement periods in fall based on October 2007 data (targets/h)	0.3	0.3
B) Number of hours of evening and morning peak period of movement	5.5	5.5
C) Mean number of targets during evening and morning peak movement periods		
C1) Spring/summer (A1 * B)	1.100	1.100
C2) Fall (A2 * B)	1.650	1.650
D) Mean proportion of birds moving during off-peak hours of night	0.126	0.126
E) Seasonal movement rate (targets/night) = ((C * D) + C)		
E1) Spring/summer	1.24	1.24
E2) Fall	1.86	1.86
F) Mean number of birds/target	1.03	1.03
G) Estimated proportion that is Newell's Shearwaters	1.00	1.00
H) Daily movement rate (birds/day =E * F * G)		
H1) Spring/summer	1.28	1.28
H2) Fall	1.91	1.91
I) Fatality domain (days/year)		
I1) Spring/summer	150	150
I2) Fall	60	60
J) Annual movement rate (birds/year; = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	307	307
HORIZONTAL-INTERACTION PROBABILITY (IPH)		
K) Turbine height (m)	128	128
L) Blade radius (m)	48	48
M) Height below blade (m)	32	32
N) Front to back width (m)	6	6
O) Min side profile area (m^2) = (K * N)	768	
P) Max front profile area (m^2) = (M * N) + (π x L^2)		7,430
Q) Cross-sectional sampling area of radar at or below 128-m turbine height (= 3,000 m * 128 m = 384,000 m^2)	384,000	384,000
R) Minimal horizontal-interaction probability (= O/Q, rounded to 8 decimal places)	0.00200000	
S) Maximal horizontal-interaction probability (= P/Q, rounded to 8 decimal places)		0.01934960
VERTICAL-INTERACTION PROBABILITY (IPV)		
T) Proportion of Newell's Shearwaters flying ≤ turbine height in Hawaiian Islands (*n* = 688)	0.641	0.641
EXPOSURE RATE (ER = MVR*IPH*IPV)		
U) Daily exposure rate (birds/turbine/day = H * (R or S) * T, rounded to 8 decimal places)		
O1) Spring/summer	0.00163549	0.01582306
O2) Fall	0.00245324	0.02373459
V) Annual exposure rate (birds/turbine/year = J * (R or S) * T, rounded to 8 decimal places	0.39356686	3.80768066
FATALITY PROBABILITY (MP)		
W) Probability of striking turbine if in airspace on a side approach	1.00	1.00
X) Probability of striking turbine if in airspace on frontal approach	0.151	0.151
Y) Probability of fatality if striking turbine	0.95	0.95
Z1) Probability of fatality if an interaction on side approach (= W * Y)	0.95000	
Z2) Probability of fatality if an interaction on frontal approach (= X * Y)		0.14345
FATALITY RATE (= ER*MP)		
Annual fatality rate with 50% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.50)	0.18694	0.27311
Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.05)	0.01869	0.02731
Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.01)	0.00374	0.00546

wind turbine during an average year (Table 6). Note that these numbers are exposure rates and, thus, include an unknown proportion of birds that would detect and avoid the met towers or wind turbines. Hence, exposure rates estimate how many shearwaters/year would be exposed to met towers or wind turbines and do not necessarily estimate how many birds actually would collide with these structures.

FATALITY MODELING

Fatality estimates use two parameters to correct estimates of exposure rates to estimates of fatality rates. The first parameter involves the fatality probability that a bird flying through the airspace occupied by one of these structures will be fatally injured; for this exercise, we estimate it to be 95% for met towers and 14.8% and 95% for frontal approaches and side approaches to wind turbines, respectively. The second parameter involves correcting the subsequent number by the collision-avoidance probability, which is the proportion of these birds that do not collide with these structures because they detect and avoid them by flying around or over them.

Once collision-avoidance information is known, one may be able to assess the likelihood of avian fatalities at this proposed windfarm project with greater certainty. We speculate that the proportion of birds that detect and avoid met towers and wind turbines is substantial (see Discussion), but there are no shearwater-specific data available to use for an estimate of these factors for either marked-guyed met towers or wind turbines. Because it is necessary to calculate the annual fatality of shearwaters for the proposed project, however, we made some calculations to explore what level of magnitude the annual fatality rate might be. For the model, we assumed that 50%, 95%, or 99% of all birds will be able to detect and avoid the met towers and turbines. If we use those scenarios, the estimates of annual fatality would be 0.014–0.692 Newell's Shearwaters/met tower/year (Table 5) and 0.004–0.273 Newell's Shearwaters/wind turbine/year (Table 6). Fatality rates are higher for the met tower than the wind turbine because the extensive set of guy wires causes the met tower to have a larger three-dimensional size than the wind turbine; in addition, the fact that the turbine's rotor-swept area is not solid also allows birds to pass through it without colliding, again reducing fatality rates. We caution again, however, that these avoidance assumptions are not based on empirical data.

DISCUSSION

PETRELS AND SHEARWATERS

SPECIES COMPOSITION

Our radar data suggest that the radar targets that we recorded in 2007–2008 were those of Newell's Shearwaters, rather than Hawaiian Petrels or other species. The timing of movements entirely when it was completely dark and the inland–seaward directions of flight are similar to those for this species elsewhere in the Hawaiian Islands (Day and Cooper 1995, Cooper and Day 2003, Reynolds et al. 1997, Day et al. 2003a). In addition, we can find no records of Hawaiian Petrels on Oahu in the past 50–100 yr.

Other information suggesting that these targets were only of Newell's Shearwaters is that only Newell's Shearwaters have been recorded on Oahu in the past 50–100 yr, with a high probability of nesting in the Koolau Range. There are multiple records of Newell's Shearwaters in the Aiea area on 27 May 1954 (Richardson 1955) and 26 May and 2 and 5 June 1990 (Pyle 1990), and there are multiple records at the Honolulu Airport and in Honolulu itself on 7 August 1959 (Hatch 1959, cited in Banko 1980a); on 3 July 1961 (King and Gould 1967; Carpenter et al. 1962, cited in Banko 1980a); somewhere between 1973 and 1975 (Banko 1980a); and on 19 July 1985 (Pyle 1986). In addition, records of Newell's Shearwaters heard calling in the Waianae Mountains during the summer have been reported in recent years (G. Spencer, pers. comm.).

Importantly, there are numerous records of Newell's Shearwaters in the Koolau Range. For example, Newell's Shearwaters have been found dead at the tunnel on the Pali Highway on 4 August, 9 September, and 19, 25, and 27 November 1967 (Sincock and Swedberg 1969); on 26 May 1971 (Banko 1980a); on 4 September 1972 (Banko 1980a); on 18 July 1975 (Conant 1980); and on 9 August 2008 (2 birds <100 m from the tunnel entrance; Yukie and Tim Ohashi, Volcano, HI, in litt.). Shallenberger (1976, cited in Conant 1980) also reported seeing these birds flying at night over the Pali Highway in the 1970s, again suggesting nesting somewhere in the Koolau Mountains. In addition, a dead Newell's Shearwater was found on the beach near Laie Point on 8 June 1987 (Pyle 1987). The occurrence of these birds inland during both the summer breeding season and the fall fledging period suggests nesting somewhere in the Koolau Range.

An additional piece of information suggesting nesting by Newell's Shearwaters in the Koolau Range comes from the data collected in this study. All targets except one were heading into or out of the northeastern side of the Koolau Range, especially inland from the area between Kahuku and Laie. In this area, the mountains are steep (providing some protection from ground-based predators), and there are several patches of uluhe ferns on the steeper hillside in this area that are large enough to be visible from 1–2 mi (2–3 km) away. The consistent orientation of movements toward this area and the presence of both safe habitat (steep hillsides) and appropriate nesting habitat (uluhe ferns) suggest that at least one small Newell's Shearwater colony exists in this area.

MOVEMENT RATES

Our sampling dates occurred during the late-incubation period (summer) and the fledging period (fall) of Newell's Shearwaters (Ainley et al. 1997b). During the summer period, breeding adults, nonbreeding adults, and subadults are visiting the colonies; during the fall period, the activity is that of breeding adults and fledging young (Telfer et al. 1987; Ainley et al. 1997b). The average incubation shift is 10 days for Newell's Shearwaters (B. Zaun, USFWS Kauai National Wildlife Refuge Complex, Kilauea, HI, in litt.), so a breeding adult does not visit the nesting colony every night during incubation.

The overall mean evening movement rate of shearwaters at the proposed windfarm site was 0.2–0.3 targets/h for the two seasons. These data suggest that extremely low numbers of shearwaters are flying in the vicinity of this proposed windfarm site. Unfortunately, we have no other radar data from Oahu for comparison; however, data from almost all sampling sites on all other islands (e.g., Day and Cooper 1995, 2002; Cooper and Day 2003, Day et al. 2003a) are larger, and often much larger, than these movement rates.

The only data set from Oahu that is available for comparison is from Denis and Verschuyl (2007), who sampled 2–4 mi (3–6 km) inland from our sampling site in May 2007. During that 7-day study, they recorded 16 targets that they believed were those of Hawaiian Petrels or Newell's Shearwaters, resulting in an overall estimated mean movement rate of ~0.5 targets/h. There are several methodological differences between their study and ours, so we are unable to make a direct comparison between our results and the results of their study. First, they sampled during May, which is the period when Newell's Shearwaters make an egg-laying exodus from the colonies (Ainley et al. 1997b). As a result, one would have expected extremely low numbers of (if any) Newell's Shearwaters to have been visiting the colonies at that time. In addition, they used a minimal-cutoff flight speed (airspeed) of 40 mi/h (64 km/h), which we believe is too high for these species (Day and Cooper 1995, unpubl. data), resulting in an underestimation of the true movement rate. In addition, their mean flight directions (264° and 276° in the evening and morning, respectively) bear no resemblance to those recorded nearby in this study; and those flight directions suggest that their targets primarily were of birds of an unidentified species crossing over the northern side of the island, rather than entering and leaving colonies in an inbound/seaward pattern like Newell's Shearwaters would be expected to do. All of these factors lead us to suspect that they may have had significant contamination of their sample by Sooty Terns, tropicbirds, or other nocturnal seabirds.

FLIGHT ALTITUDES

We were unable to collect flight-altitude data on Newell's Shearwaters at the Kahuku study site. Consequently, for the modeling exercise, we used data from other locations in the Hawaiian Islands to estimate the percentage of birds that were flying low enough to be at risk of colliding with either a met tower or a wind turbine. The only data on flight altitudes of shearwater or petrel targets available from Oahu are those from Denis and Verschuyl (2007), who estimated a mean flight altitude (measured on vertical radar) of either 228 m agl (Executive Summary) or 260 m agl (Results); however, it was unclear how many targets this estimate incorporated. In addition, we have reservations about the movement-rate data in this study (see above) that also should be applied to the identity of targets in the flight-altitude data.

EXPOSURE AND FATALITY RATES

We estimate that 1.46 Newell's Shearwaters will fly within the space occupied by a met tower in an average year and that 0.39–3.81 Newell's Shearwaters will fly within the space occupied by a proposed wind turbine in an average year. We used these estimated exposure rates as a starting point for developing a complete avian risk assessment; however, we emphasize that it currently is not known whether bird use and fatality rates at windfarms are strongly correlated. For example, Cooper and Day (1998) found no relationship between movement rates and fatality rates of Hawaiian Petrels and Newell's Shearwaters at powerlines on Kauai. Hence, other factors (e.g., weather) could be more highly correlated with fatality rates than is bird abundance (as expressed through movement rates). To determine which factors are most relevant, future studies should collect concurrent data on movement rates, weather, and fatality rates to begin to determine whether movement rates and/or weather conditions can be used to predict the likelihood of shearwater fatalities at proposed met towers and windfarms.

COLLISION AVOIDANCE

In addition to these questions about the unknown relationships among abundance, weather, and fatality, few data are available on the proportion of shearwaters that do not collide with met towers or wind turbines because of collision-avoidance behavior (i.e., birds completely alter their flight paths horizontally and/or vertically to avoid flying through the space occupied by a wind turbine or met tower). Clearly, the detection of met towers, wind turbines, or other structures could result in collision-avoidance behavior by these birds and reduce the likelihood of collision. Unfortunately, Cooper and Day (1998) indicated that Newell's Shearwaters are not very maneuverable and fly only during nocturnal periods, suggesting that they may not have a good ability to avoid met towers or turbines.

Some collision-avoidance information is available on petrels and shearwaters from earlier work conducted on Kauai (Cooper and Day 1998; Day and Cooper, unpubl. data). Those data suggest that the behavioral-avoidance rate of Newell's Shearwaters near powerlines is high. For example, although we were unable to calculate an avoidance rate *per se* for the Kauai data, none (0%) of the 392 Newell's Shearwaters that passed within 150 m (vertical distance) of a powerline collided with it. These numbers probably include a substantial proportion of shearwaters that had flight paths that did not require a course correction to avoid the powerline; however, even when one examines only those shearwaters that flew within 25 m of a powerline (i.e., those at greatest risk of collision), 0 (0%) of 113 collided with the lines. Further, all 34 shearwaters that were observed reacting to the lines were able to avoid collision (i.e., a 100% collision-avoidance rate for that subset of birds if one assumes that, without avoidance, all of those birds would have collided with the lines).

Additional data that might provide some insight on collision-avoidance behavior of petrels and shearwaters are available from studies associated with the KWP I windfarm (20 turbines, 3 met towers) on Maui Island. One Hawaiian Petrel fatality and 0 Newell's Shearwater fatalities were recorded at that windfarm in the first 2.75 yr of operation (G. Spencer, pers. comm.). After correcting these apparent-fatality values with data for scavenging bias and searcher efficiency collected in the first year of study, UPC Wind Management (2007, 2008, unpubl. data) has calculated that the 1 observed fatality as of October 2008 equates to a corrected direct fatality of ~1.2 Hawaiian Petrels/yr and 0.0 Newell's Shearwaters/yr. Cooper and Day (2004b) also modeled seabird fatality rates for the KWP I windfarm, based on movement rates from radar studies there (Day and Cooper 1999; Cooper and Day 2004a, 2004b), and estimated that the combined annual fatality of Hawaiian Petrels and Newell's Shearwaters at the KWP I site would be ~3–18 birds/yr with a 50% avoidance rate, ~1–2 birds/yr with a 95% avoidance rate, and <1 bird/yr with a 99% avoidance rate. Thus, the fatality model using a 95% avoidance rate has been a much closer fit with the measured fatality rates than was the fatality model using a 50% avoidance rate or a 99% avoidance rate.

Comparable avoidance data are not available for the met towers, but the fact that no birds have been found killed at the 3 guyed met towers at the KWP I windfarm (i.e., at the 1 30-m tower and the 2 55-m towers) during the first 2.75 yr of operation also suggests that petrels and shearwaters have been avoiding those structures. In addition to the recent KWP information, a fatality study conducted at two ~40-m-high guyed met towers and four ~25-m-high guyed met towers at the KWP I site in May–July 1996 found no downed petrels or shearwaters on any of the 26 searches (Nishibayashi 1997), again suggesting avoidance of met towers.

In summary, the currently available data on Hawaiian Petrels and Newell's Shearwaters suggest that the avoidance rate of these birds at transmission lines and tall structures is high. Data from the fatality searches at met towers and wind turbines on Maui are more difficult to interpret because they suggest high avoidance—but they are not a direct measure of avoidance; however, those data suggest that the avoidance of those structures must be high because the estimated fatality rate is so low. Thus, the overall body of evidence, while incomplete, is consistent with the notion that the average avoidance rate of met towers and wind turbines is greater than 50% and is as high as 95% or more. The ability of Hawaiian Petrels and Newell's Shearwater to detect and avoid most objects under low-light conditions makes sense from a life-history standpoint, in that they forage extensively at night and are adept at flying through forests near their nests during the night.

In addition to the limited data available for Hawaiian Petrels and Newell's Shearwaters, there is evidence that many other species of birds detect and avoid wind turbines during low-light conditions (Winkelman 1995, Dirksen et al. 1998, Desholm and Kahlert 2005, Desholm et al. 2006). For example, seaducks in Europe have been found to detect and avoid wind turbines >95% of the time (Desholm 2006). Further, natural anti-collision behavior (especially alteration of flight directions) is seen in night-migrating Common and King eiders (*Somateria mollissima* and *S. fischeri*) approaching human-made structures in the Beaufort Sea off of Alaska (Day et al. 2005) and in diving ducks approaching offshore windfarms in Europe (Dirksen et al. 1998). Collision-avoidance rates around wind turbines are high for Common Eiders in the daytime (Desholm and Kahlert 2005), gulls (*Larus* spp.) in the daytime (>99%; Painter et al. 1999, cited in Chamberlain et al. 2006), Golden Eagles (*Aquila chrysaetos*) in the daytime (>99%; Madders 2004, cited in Chamberlain et al. 2006), American Kestrels (*Falco sparverius*) in the daytime (87%, Whitfield and Band in prep., cited in Chamberlain et al. 2005), and passerines during both the day and night (>99%; Winkelman 1992, cited in Chamberlain et al. 2006). Further, the proportion of nocturnal migrants that detect and avoid turbines must be very high because the average annual fatality rates of nocturnal migrants of a few birds/MW generally are far lower than average annual exposure rates of nocturnally-migrating birds as measured by radar (Cooper, unpubl data).

We agree with others (Chamberlain et al. 2006, Fox et al. 2006) that species-specific, weather-specific, and site-specific avoidance data are needed in models to estimate fatality rates accurately. However, the currently-available avoidance data from Kauai and Lanai for Hawaiian Petrels and Newell's Shearwaters and the petrel and shearwater fatality data at KWP I met towers and wind turbines, while incomplete, are consistent with the hypothesis that a substantial proportion of petrels detect and avoid wind turbines, marked met towers, communication towers, and powerlines under normal ranges of weather conditions and visibility (but note that avoidance rates could be lower under inclement conditions). Until further petrel- and shearwater-specific data on the relationship between exposure and fatality rates are available for met towers and wind turbines, we will provide a standard range of assumptions for avoidance rates in our fatality models (i.e., 50%, 95%, and 99% avoidance), along with a discussion of the body of evidence that is consistent with the hypothesis that the average avoidance-rate value is greater than 50% and around 95%. With a 95%-avoidance assumption, the estimated average annual fatality rate at the proposed Kahuku windfarm would be <0.07 Newell's Shearwater/met tower/yr and <0.03 Newell's Shearwaters/wind turbine/yr.

Additional factors could affect our estimates of fatality rates in either positive or negative directions. One factor that would have created a positive bias was the inclusion of targets that were not petrels or shearwaters. Our visual observations (especially during crepuscular periods, when we could use binoculars) probably helped to minimize the inclusion of non-target species, but it is possible that some of our nocturnal radar targets were other fast-flying species that were active during the sampling period (e.g., Sooty Terns, tropicbirds at times, Greater Frigatebirds at times). A second positive bias is our simplistic assumption in the modeling that movement rates of seabirds did not fall as individual fatalities occurred (i.e., we assumed sampling with replacement after fatalities). Given the extremely low movement rates observed in this study, it is likely that the fatality of just a single bird would substantially reduce the average nightly movement rates.

There also are factors that could create a negative bias in our fatality estimates. One example would be if targets were missed because they flew within radar shadows. Because the sampling station provided excellent coverage of the surrounding area, however, we believe that the number of targets that was missed because they passed through the entire area of coverage of the study area within a radar shadow was zero.

At least three factors could affect our fatality estimates in either direction. The first factor is interannual variation in numbers of seabirds visiting nesting colonies. The average hourly movement rate for the current study (~0.3 targets/h in the fall of 2007 and ~0.2 targets/h in the summer of 2008) suggest that rates are consistently very low at this site and that interannual variation is minimal. Some caution in extrapolation of movement rates across years is warranted, however, because there are examples of other sites with high interannual variation in movement rates. For example, mean movement rates on Kauai in fall 1992 were 25% of those in fall 1993, with the lower counts in 1992 being attributed to the devastating effects of Hurricane Iniki on the island just prior to the fledging of chicks (Day and Cooper 1995). Oceanographic factors (e.g., El Niño–Southern Oscillation events) also vary among years and are known to affect the distribution, abundance, and reproduction of seabirds (e.g., Ainley et al. 1994, Oedekoven et al. 2001). Another factor that could cause interannual variation in counts in either direction is overall population increases or declines. For example, a ~60% decline in radar counts of petrels and shearwaters on Kauai between 1993 and 1999–2001 was attributed primarily to population declines of Newell's Shearwaters (Day et al. 2003b).

HAWAIIAN HOARY BATS

Recent data from Appalachian ridge tops in the eastern and from prairie locations in both the US and Canada have indicated that substantial kills of bats, including Hoary Bats, sometimes occur at wind turbines (Kunz et al. 2007b, Arnett et al. 2008). In contrast, while some bats also have been killed by communication towers (Zinn and Baker 1979, Crawford and Baker 1981, Erickson et al. 2002), powerlines (Dedon et al. 1989, cited in Erickson et al. 2002), and fences (Denys 1972, Wisely 1978), the annual fatality rate at those structures has been small (Erickson et al. 2002). We were unable to find any references on bat kills at met towers in the published or unpublished literature. Because of recent fatalities of migratory Hoary Bats at wind turbines on the US mainland (Kunz et al. 2007a), there was interest in having us collect audiovisual data on Hawaiian Hoary Bats during this study, even though the Hawaiian subspecies is non-migratory. Our data indicate that Hawaiian Hoary Bats are present in the Kahuku study area but appear to occur there in very low numbers: only 1 bat was recorded during the 13 nights of this study (i.e., 1 bat in 97 25-min observation sessions, or 0.0004 bats/h). These bats have been recorded on Oahu (Baldwin 1950, Tomich 1986), where their densities are described as "sparse" (van Riper and van Riper 1982), and it is speculated that they formerly were much more abundant on Oahu than they are now (Kepler and Scott (1990). In fact, there is recent speculation that the species has disappeared from Oahu and Molokai (State of Hawaii 2005), although this study indicates persistence on this island and the work of Day and Cooper (2002) does the same for Molokai. More extensive visual and/or acoustic work could be done in the study area to provide better seasonal information on the distribution and abundance of bats there, but it appears that they are rare in the vicinity of the proposed windfarm.

CONCLUSIONS

This study focused on the movement patterns and flight behavior of Hawaiian Petrels and Newell's Shearwaters near the proposed Kahuku windfarm in fall 2007 and summer 2008. The key results of our study were: (1) seabird movement rates were extremely low (0.2–0.3 targets/h) relative to other locations in the Hawaiian Islands; (2) the timing of movements suggested that all of the radar targets that we observed were those of Newell's Shearwaters; (3) Hawaiian Hoary Bats were recorded in the vicinity of the proposed windfarm, but bat movement rates were extremely low (~0.0004 bats/h); (4) an estimated 1.46 Newell's Shearwaters flew within the space occupied by a met tower in an average year and an estimated 0.39–3.81 flew within the space occupied by a wind turbine an average year; and (5) by using a range of assumptions for avoidance rates in our fatality models (i.e., 50%, 95%, and 99% avoidance), we estimated a collision-caused fatality rate of 0.014–0.692 Newell's Shearwaters/met tower/yr and 0.004–0.273 Newell's Shearwaters/wind turbine/yr. The limited avoidance data available for these and other bird species suggest that the proportion of birds that see and avoid the met towers and wind turbines will be substantial and will be enhanced by marking; however, we emphasize that, until data are available on petrel and shearwater collision-avoidance behavior at met towers with marked guy wires and at wind turbines, the exact proportion will remain unknown. We provide a discussion of the body of evidence that, while incomplete at this time, is consistent with the hypothesis that the average avoidance-rate value is greater than 50%.

LITERATURE CITED

Ainley, D. G., R. Podolsky, L. DeForest, and G. Spencer. 1997a. New insights into the status of the Hawaiian Petrel on Kauai. Colonial Waterbirds 20: 24–30.

Ainley, D. G., R. Podolsky, L. DeForest, G. Spencer, and N. Nur. 1995. Kauai Endangered Seabird Study, Vol. 2: The ecology of Dark-rumped Petrels and Newell's Shearwaters on Kauai, Hawaii. Electric Power Research Institute, Palo Alto, CA, Final Report No. TR–105847–V2. 74 pp.

Ainley, D. G., W. J. Sydeman, S. A. Hatch, and U. W. Wilson. 1994. Seabird population trends along the west coast of North America: causes and extent of regional concordance. Studies in Avian Biology 15:119–133.

Ainley, D. G., T. C. Telfer, and M. H. Reynolds. 1997b. Townsend's and Newell's Shearwater (*Puffinus auricularis*). *In* A. Poole and F. Gill, eds. The birds of North America, No. 297. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, DC. 20 pp.

AOU (American Ornithologists' Union). 1998. Check-list of North American birds. 7th ed. American Ornithologists' Union, Washington, DC. 829 pp.

Arnett, E. B., technical ed. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Unpublished report prepared for Bats and Wind Energy Cooperative. Bat Conservation International, Austin, TX. 187 pp.

Arnett, E. B., W. K. Brown, W. P. Erickson, J. K. Fielder, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. J. O'Connell, M. D. Piorkowski, and R. D. Tankersly. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72: 61–78.

Baerwald, E. F., G. H. D'Amours, B. J. Klug, and R. M. R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18: 695–696.

Baldwin, P. H. 1950. Occurrence and behavior of the Hawaiian Bat. Journal of Mammalogy 31: 455–456.

Banko, W. E. 1980a. Part I. Population histories—species accounts. Sea birds: Hawaiian Dark-rumped Petrel ('Ua'u). Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa, Honolulu, HI. CPSU/UH Avian History Report 5B: History of Endemic Hawaiian Birds. 42 pp.

Banko, W. E. 1980b. Part I. Population histories—species accounts. Sea birds: Newell Shearwater ('A'o). Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa, Honolulu, HI. CPSU/UH Avian History Report 5B: History of Endemic Hawaiian Birds. 35 pp.

Barclay, M. R., E. F. Baerwald, and J. C. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Canadian Journal of Zoology. 85: 381–387.

Chamberlain, D. E., S. Freeman, M. R. Rehfisch, A. D. Fox, and M. Desholm. 2005. Appraisal of Scottish Natural Heritage's wind farm collision risk model and its application. British Trust for Ornithology, Norfolk, United Kingdom. Report No. 401. 51 pp.

Chamberlain, D. E., M. R. Rehfisch, A. D. Fox, M. Desholm, and S. J. Anthony. 2006. The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models. Ibis 148: 198–202.

Conant, S. 1980. Recent records of the 'Ua'u (Dark-rumped Petrel) and the 'A'o (Newell's Shearwater) in Hawaii. 'Elepaio 41: 11–13.

Cooper, B. A., and R. H. Day. 1995. Kauai Endangered Seabird Study, Vol. 1: Interactions of Dark-rumped Petrels and Newell's Shearwaters with utility structures on Kauai, Hawaii. Electric Power Research Institute, Palo Alto, CA, Final Report No. TR–105847–V1. 170 pp.

Cooper, B. A., and R. H. Day. 1998. Summer behavior and mortality of Dark-rumped Petrels and Newell's Shearwaters at power lines on Kauai. Colonial Waterbirds 21: 11–19.

Cooper, B. A., and R. H. Day. 2003. Movement of Hawaiian Petrels to inland breeding sites on Maui Island, Hawaii. Waterbirds 26: 62–71.

Cooper, B. A., and R. H. Day. 2004a. Results of endangered bird and bat surveys at the proposed Kaheawa Pastures Wind Energy Facility, Maui Island, Hawaii, fall 2004. Unpublished report prepared for Kaheawa Windpower LLC, Makawao, HI, and UPC Wind Management LLC, Newton, MA, by ABR, Inc., Forest Grove, OR, and Fairbanks, AK. 16 pp.

Cooper, B. A., and R. H. Day. 2004b. Modeling annual seabird use and fatality at the proposed Kaheawa Pastures Wind Energy Facility, Maui Island, Hawaii, fall 2004. Unpublished report prepared for Kaheawa Windpower LLC, Makawao, HI, and UPC Wind Management LLC, Newton, MA, by ABR, Inc., Forest Grove, OR, and Fairbanks, AK. 7 pp.

Cooper, B. A., R. H. Day, R. J. Ritchie, and C. L. Cranor. 1991. An improved marine radar system for studies of bird migration. Journal of Field Ornithology 62: 367–377.

Crawford, R. L., and W. W. Baker. 1981. Bats killed at a north Florida television tower: a 25-year record. Journal of Mammalogy 62: 651–652.

Cryan, P. M. 2008. Mating behavior as a possible cause of bat fatalities at wind turbines. Journal of Wildlife Management 72: 845–849.

Cryan, P. M., and A. C. Brown. 2007. Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. Biological Conservation 139: 1–11.

David, R. E. 2002. An analysis of endangered terrestrial vertebrate species management issues for the proposed Koa Timber Project, South Hilo District, Island of Hawai'i, Hawai'i. Unpublished report prepared for Koa Timber, Inc., Kapolei, HI, by Rana Productions, Ltd., Kailua–Kona, HI. 15 pp.

Day, R. H., and B. A. Cooper. 1995. Patterns of movement of Dark-rumped Petrels and Newell's Shearwaters on Kauai. Condor 97: 1011–1027.

Day, R. H., and B. A. Cooper. 1999. Results of endangered bird and bat surveys at the proposed Kaheawa Pastures Windfarm on Maui Island, Hawaii, summer 1999. Unpublished report prepared for Zond Pacific, Wailuku, HI, by ABR, Inc., Fairbanks, AK, and Forest Grove, OR. 26 pp.

Day, R. H., and B. A. Cooper. 2002. Petrel and shearwater surveys near Kalaupapa, Molokai Island, June 2002. Unpublished report prepared for National Park Service, Hawaii National Park, HI, by ABR, Inc.—Environmental Research & Services, Fairbanks, AK, and Forest Grove, OR. 17 pp.

Day, R. H., B. A. Cooper, and R. J. Blaha. 2003a. Movement patterns of Hawaiian Petrels and Newell's Shearwaters on the island of Hawai'i. Pacific Science 57: 147–159.

Day, R. H., B. A. Cooper, and T. C. Telfer. 2003b. Decline of Newell's Shearwaters on Kauai, Hawaii. Auk 120: 669–679.

Day, R. H., A. K. Prichard, and J. R. Rose. 2005. Migration and collision avoidance of eiders and other birds at Northstar Island, Alaska, 2001–2004. Unpublished final report prepared for BP Exploration (Alaska), Inc., Anchorage, AK, by ABR, Inc.—Environmental Research and Services, Fairbanks, AK. 142 pp.

Denis, N., and J. Verschuyl. 2007. Endangered bird and bat surveys at the proposed Kahuku Wind Resource Area on O'ahu, Hawai'i. Unpublished report submitted to Planning Solutions, Inc., Honolulu, HI, by Hamer Environmental, Mount Vernon, WA. 29 pp.

Denys, G. A. 1972. Hoary bat impaled on barbed wire. Jack-Pine Warbler 50: 63.

Desholm, M., A. D. Fox, P. D. L. Beasley, and J. Kahlert. 2006. Remote techniques for counting and estimating the number of bird-wind turbine collisions at sea: a review. Ibis:148: 76–89.

Desholm, M. and J. Kahlert. 2005. Avian collision risk at an offshore windfarm. Biology Letters 1: 296–298.

Dirksen, S. E., A. L. Spaans, and J. Winden. 1998. Nocturnal collision risks with wind turbines in tidal and semi-offshore areas. Pp. 99–108 *In* Proceedings of International Workshop on Wind Energy and Landscape, Genua, 26–27 July 1997. Balkema, Rotterdam, The Netherlands.

Erickson, W. 2004. Patterns of daily mortality searches at Meyersdale, Pennsylvania. Talk presented at the National Wind Coordinating Committee meeting, “Onshore wildlife interactions with wind developments: Research Meeting V”, 3–4 November 2004, Lansdowne, VA.

Erickson, W., D. Johnson, D. P. Young, M. D. Strickland, R. E. Good, M. Bourassa, K. Bay, and K. Sernka. 2002. Synthesis and comparison of baseline avian and bat use, raptor nesting, and mortality information from proposed and existing wind developments. Unpublished report for Bonneville Power Administration, Portland, OR, by WEST, Inc., Cheyenne, WY. 124 pp.

Fox, A. D., M. Desholm, J. Kahlert, T. K. Christensen, and I. K. Petersen. 2006. Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. Ibis 148: 129–144.

Fujioka, K. K., and S. M. Gon III. 1988. Observations of the Hawaiian Bat (*Lasiurus cinereus semotus*) in the districts of Ka'u and South Kona, island of Hawai'i. Journal of Mammalogy 69: 369–371.

Fullard, J. H. 1989. Echolocation survey of the distribution of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) on the Island of Kaua'i. Journal of Mammalogy 70: 424–426.

Gauthreaux, S. A., Jr. 1985a. Radar, electro-optical, and visual methods of studying bird flight near transmission lines. Unpublished final report prepared for Electric Power Research Institute, Palo Alto, CA, by Clemson University, Clemson, SC. 76 pp.

Gauthreaux, S. A., Jr. 1985b. An avian mobile research laboratory: hawk migration studies. Pages 339–346 *in* M. Harwood, ed. Proceedings of Hawk Migration Conference IV. Hawk Migration Association of North America, Washington, CT.

Gon, S. M., III. 1988. Observations of the 'Ua'u (Hawaiian Petrel) in the Hono O Pali Natural Area Reserve, Island of Kauai. 'Elepaio 48: 113.

Harrison, C. S. 1990. Seabirds of Hawaii: natural history and conservation. Cornell University Press, Ithaca, NY. 249 pp.

Harrison, C. S., M. B. Naughton, and S. I. Fefer. 1984. The status and conservation of seabirds in the Hawaiian Archipelago and Johnston Atoll. Pages 513–526 in J. P. Croxall, P. G. H. Evans, and R. W. Schreiber, eds. Status and conservation of the world's seabirds. ICBP Technical Publication No. 2, International Council for Bird Preservation, Cambridge, United Kingdom.

Hawaii Heritage Program. 1991. Distributional maps of *Lasiurus cinereus semotus* ('Ope'ape'a or Hawaiian Hoary Bat). Data from Hawaii Heritage Program database. 4 pp.

Hirai, L. T. 1978a. Native birds of Lanai, Hawaii. Western Birds 9: 71–77.

Hirai, L. T. 1978b. Possible Dark-rumped Petrel colony on Lanai, Hawaii. 'Elepaio 38:71–72.

Hodges, C. S. N. 1992. 'Ua'u observation at proposed site for antenna farm. Unpublished memorandum by Haleakala National Park, Makawao, HI. 2 pp.

Hu, D., C. Glidden, J. S. Lippert, L. Schnell, J. S. MacIvor, and J. Meisler. 2001. Habitat use and limiting factors in a population of Hawaiian Dark-rumped Petrels on Mauna Loa, Hawai'i. *In* J. M. Scott, S. Conant, and C. van Riper III, eds. Evolution, ecology, conservation, and management of Hawaiian birds: a vanishing avifauna. Studies in Avian Biology 22: 234–242.

Kerns, J. 2004. Patterns from daily mortality searches at Backbone Mountain, West Virginia. Talk presented at the National Wind Coordinating Committee meeting, “Onshore wildlife interactions with wind developments: Research Meeting V”, 3–4 November 2004, Lansdowne, VA.

Kepler, C. B., and J. M. Scott. 1990. Notes on distribution and behavior of the endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), 1964–1983. 'Elepaio 50: 59–64.

King, W. B., and P. J. Gould. 1967. The status of Newell's race of the Manx Shearwater. Living Bird 6: 163–186.

Kunz, T. H., E. B. Arnett, B. A. Cooper, W. P. Erickson, R. P. Larkin, T. J. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewzak. 2007a. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. Journal of Wildlife Management 71: 2449–2486.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007b. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5: 315–324.

Larkin, R. P. 2006. Migrating bats interacting with wind turbines: what birds can tell us. Bat Research News 47: 23–32.

Mabee, T. J., B. A. Cooper, J. H. Plissner, and D. P. Young. 2006. Nocturnal bird migration over an Appalachian ridge at a proposed wind power project. Wildlife Society Bulletin 34: 682–690.

Nishibayashi, E. 1997. Downed wildlife surveys at six leeward West Maui monitoring towers. Unpublished report prepared for Zond Pacific, Wailuku, HI, by Eric Nishibayashi Biological Consulting, Kahului, HI. 10 pp.

Oedekoven, C. S., D. G. Ainley, and L. B. Spear. 2001. Variable responses of seabirds to change in marine climate: California Current, 1985–1994. Marine Ecology Progress Series 212: 265–281.

Podolsky, R., D. G. Ainley, G. Spencer, L. DeForest, and N. Nur. 1998. Mortality of Newell's Shearwaters caused by collisions with urban structures on Kauai. Colonial Waterbirds 21: 20–34.

Pratt, H. D., P. L. Bruner, and D. G. Berrett. 1987. A field guide to the birds of Hawaii and the tropical Pacific. Princeton University Press, Princeton, NJ. 409 pp. + plates.

Pyle, R. L. 1983. Hawaiian Islands Region (1 June–31 July 1983). American Birds 37: 1028–1029.

Pyle, R. L. 1986. Recent observations, March–June 1986. 'Elepaio 46: 156–157.

Pyle, R. L. 1987. Hawaiian Islands Region (1 June–31 July 1987). American Birds 41: 1489–1490.

Pyle, R. L. 1990. Hawaiian Islands Region (1 June–31 July 1990). American Birds 44: 1189–1190.

Pratt, T. K. 1988. Recent observations, March–May 1988. 'Elepaio 48: 65–66.

Reynolds, D. S. 2006. Monitoring the potential impact of a wind development site on bats in the Northeast. Journal of Wildlife Management 70: 1219–1227.

Reynolds, M. H., B. A. Cooper, and R. H. Day. 1997. Radar study of seabirds and bats on windward Hawaii. Pacific Science 51: 97–106.

Reynolds, M. H., and G. L. Richotte. 1997. Evidence of Newell's Shearwater breeding in Puna District, Hawaii. Journal of Field Ornithology 68: 26–32.

Richardson, F. 1955. Reappearance of Newell's Shearwater in Hawaii. Auk 72: 412.

Richardson, F., and D. H. Woodside. 1954. Rediscovery of the nesting of the Dark-rumped Petrel in the Hawaiian Islands. Condor 56: 323–327.

Shallenberger, R. J. 1974. Field notes. 'Elepaio 35: 18–20.

Simons, T. R. 1984. A population model of the endangered Hawaiian Dark-rumped Petrel. Journal of Wildlife Management 48: 1065–1076.

Simons, T. R. 1985. Biology and behavior of the endangered Hawaiian Dark-rumped Petrel. Condor 87: 229–245.

Simons, T. R., and C. N. Hodges. 1998. Dark-rumped Petrel (*Pterodroma phaeopygia*). *In* A. Poole and F. Gill, eds. The birds of North America, No. 345. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, DC. 24 pp.

Sincock, J. L., and G. E. Swedberg. 1969. Rediscovery of the nesting grounds of Newell's Manx Shearwater (*Puffinus puffinus newelli*), with initial observations. Condor 71: 69–71.

State of Hawaii. 2005. 'Ope'ape'a or Hawaiian Hoary Bat. *In* Hawaii's Comprehensive Wildlife Conservation Strategy. State of Hawaii, Honolulu, HI. 3 pp.

Telfer, T. C., J. L. Sincock, G. V. Byrd, and J. R. Reed. 1987. Attraction of Hawaiian seabirds to lights: conservation efforts and effects of moon phase. Wildlife Society Bulletin 15: 406–413.

Tomich, P. Q. 1986. Mammals in Hawaii: a synopsis and notational bibliography. 2nd ed. Bishop Museum Press, Honolulu. HI. Bishop Museum Special Publication 76. 375 pp.

Tucker, V. A. 1996. A mathematical model of bird collisions with wind turbine rotors. ASME Journal of Solar Energy Engineering 118: 253–262.

UPC Wind Management LLC. 2007. Kaheawa Pastures wind general facility Habitat Conservation Plan 2006 Annual Report. Unpubl. report by UPC Wind Management LLC, Newton, MA, and Kaheawa Wind Power, Wailuku, HI. 25 pp. + appendices.

UPC Wind Management LLC. 2008. Kaheawa Pastures wind general facility Habitat Conservation Plan: Year 1 HCP Implementation (Part II), January–June 2007. Unpubl. report by UPC Wind Management LLC, Newton, MA, and Kaheawa Wind Power, Wailuku, HI. 23 pp. + appendices.

van Riper, S. G., and C. van Riper II. 1982. A field guide to the mammals in Hawaii. Oriental Publishing Co., Honolulu, HI. 68 pp.

Winkelman, J. E. 1995. Bird/wind turbine investigations in Europe. Pages 43–47 and 110–140 *in* LGL Ltd., ed. Proceedings of National Avian–Wind Power Planning Meeting I, Lakewood, CO. (Available at http://www.nationalwind.org/pubs/avian94/default.htm.)

Wisely, A. N. 1978. Bat dies on barbed wire fence. Blue Jay 36: 53.

Zinn, T. L., and W. W. Baker. 1979. Seasonal migration of the Hoary Bat, *Lasiurus cinereus*, through Florida. Journal of Mammalogy 60: 634–635.

Appendix I.

Wildlife Education and Observation Program

Purpose	To educate project employees and other on-site personnel in the observation, identification and treatment of wildlife
Approach	In conjunction with regular assigned duties, all personnel will: - attend wildlife education briefings conducted in cooperation with DOFAW and USFWS; - monitor wildlife activity while on the site; - identify key species when possible (Hawaiian Petrel, Newell’s Shearwater, Hawaiian duck, Hawaiian stilt, Hawaiian coot, Hawaiian moorhen and Hawaiian Hoary Bat); - document specific observations with the filing of a Wildlife Observation Form; - identify, report and handle any downed wildlife in accordance with the Downed Wildlife Protocol, including filing a Downed Wildlife Monitoring Form – Incidence Report; - respond and treat wildlife appropriately under all circumstances.
Notes	All personnel will avoid approaching any wildlife other than downed wildlife; avoid any behavior that would startle or harass any wildlife; and not feed any wildlife.

Descriptions and Photographs
Follow

Hawaiian Petrel	
Description	16 inches, 36-inch wingspan. Head, wings and tail are sooty-colored, contrasting with slightly paler back. Forehead and underparts are white; tail is short. Feet are bi-colored pink and black. Downy chicks are charcoal gray.
Voice	Distinctive call heard at breeding colonies is a repeated moaning "ooh-ah-ooh." At their burrows, birds also produce a variety of yaps, barks and squeals.
Habits	The Hawaiian Petrel is generally seen close to the main Hawaiian islands during breeding season; otherwise, it is a pelagic species. The flight is characterized by high, steeply-banked arcs and glides; the wings are long and narrow. Breeding extends from March to October. One white egg is laid within deep burrows or under rocks. Adults arrive in colonies well after dark. As the chicks develop, parental care becomes less frequent and adults leave the colony each year two to three weeks before the chicks. Adults feed on squid, fish and crustaceans, and pass food to chicks by regurgitation. Predation by introduced rats, cats and mongooses is a serious threat to this species.

HNP/C. Hodges

HVNP/W Banko

source: http://pacificislands.fws.gov/wesa/uau.html

source: http://www.birdinghawaii.co.uk/xHawaiianPetrel2.htm

Newell's Shearwater	
Description	12 – 14 inches, 30 – 35-inch wingspan. Black above and white below. The white extends from the throat to the black undertail coverts. Sharp contrast of dorsal/ventral color is more distinct than in larger, more common Wedge-tailed Shearwater. Bill, legs and toes are dark; webbing between toes is pink.
Voice	Around nesting colony, a variable, jackass-like braying and crow-like calling.
Habits	The flight of the Newell's Shearwater is characterized by rapid, stiff wingbeats and short glides. This species occurs in Hawaiian waters during the breeding season (April to November); it flies to nesting colonies only after dark, departing before dawn. Birds are highly vulnerable to predation by rats and cats. Many fledglings departing the colonies in late fall are attracted to urban lights and fall on highways or other brightly-lit areas.

Painting by Sheryl Ives Boynton

source: http://pacificislands.fws.gov/wesa/ao.html

source: http://audubon2.org/webapp/watchlist/viewSpecies.jsp?id=141

source: http://www.birdinghawaii.co.uk/XNewells2.htm

<table>
<tr><th colspan="2">Hawaiian Stilt</th></tr>
<tr><td>Description</td><td>16 inches, both sexes are visually similar; extension of black around eyes and head, traveling down sides of neck. Long, pink legs; black bill. Males have a glossy black back while female backs are tinged with brown. Chicks are downy and tan with black speckling. Immature stilts have similar coloring as the North American breed, with a brownish back and a white cheek patch.</td></tr>
<tr><td>Voice</td><td>When disturbed in flight or on the ground, a loud, sharp “kik-kik-kik” call is heard. While resting, stilts may voice a soft, muted call. Immature birds give a distinct peeping call.</td></tr>
<tr><td>Habits</td><td>The Black-Necked Stilt can be found singly, in pairs or groups in wetland habitat, usually marshy areas, mudflats, and ponds. They nest in loose colonies close to the water on mudflats. Shallow depressions lined with twigs, stones, and other debris are used as nesting areas. Stilts consume fish, worms, aquatic insects, and crabs. The standard clutch is four eggs. Hatchlings will leave the nest to feed with the adults. Aggressive defenders of their territories, adults often feign injury as a distraction for predators that are near nesting sites and offspring.</td></tr>
<tr><td colspan="2"> 
<i>source: http://en.wikipedia.org/wiki/Image:Black-necked_Stilt.jpg</i> <i>source: http://en.wikipedia.org/wiki/Image:Bnstiltpair.jpg</i></td></tr>
</table>

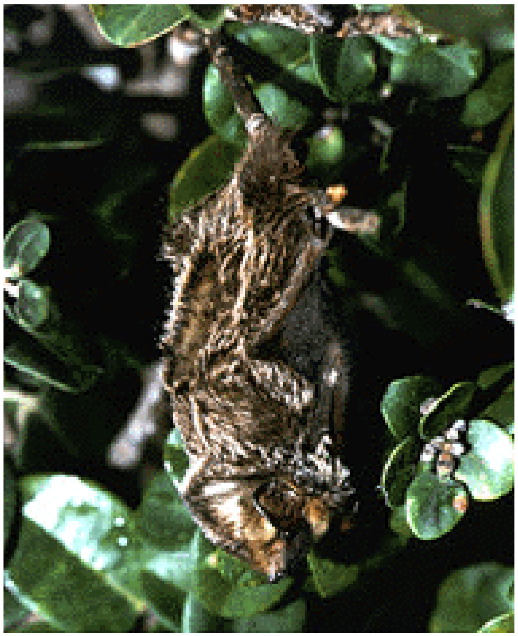
<table>
<tr><th colspan="2">Hawaiian Duck or Koloa Maoli</th></tr>
<tr><td>Description</td><td>Males are 19-20” in length while females are slightly smaller at 16-17”. Although both sexes have a mottled brown coloring, males have darker heads and necks with bright orange feet and olive colored bills. Females have bills that are more orange and their feet are a dull orange. The secondary wing feathers of the koloa maoli are greenish-blue, with white borders.</td></tr>
<tr><td>Voice</td><td>The koloa has a quack like a mallard, but are quieter and less vocal.</td></tr>
<tr><td>Habits</td><td>Generally found in wetland habitats such as river valleys and mountain streams, the Hawaiian duck are usually seen in pairs. Clutches are from two to ten eggs with in incubation period of less than 30 days. Nests are commonly on the ground and near water.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2"><i>Source: http://en.wikipedia.org/wiki/File:Hawaiian_duck.jpg</i></td></tr>
</table>

Hawaiian Coot or ‘Alae Ke’oke’o	
Description	This small waterbird measures 14” in length for both male and female. Other similarities between sexes include a pointed white bill and bulbous frontal shield. The body color of adult birds are slate gray with white undertail feathers; feet are lobed instead of webbed and are greenish-gray.
Voice	Calls are scratchy clucking noises and include a variety of short, harsh croaks.
Habits	Their environment consists of brackish and freshwater marshes and ponds. Hawaiian coots feed on tadpoles, insects, fish as well as the seeds and leaves of aquatic plants. Nesting usually occurs between March and September with the construction of a floating nest on wetland vegetation using aquatic plants. Four to ten eggs are laid. Chicks are capable of swimming shortly after hatching.

Source: http://en.wikipedia.org/wiki/File:Fulica_alai.jpg

Common Moorhen or ‘Alae ‘Ula	
Description	Endemic to the islands of Oahu, Kauai and Molokai, both sexes measure 13” in length and are slate-gray in color and darker gray on the head and neck. This waterbird has a white streak on its’ flanks, a white undertail and the frontal shield and base of bill are red with yellow at the tip of the bill. Adolescent moorhens are olive brown to grayish brown in color with a brown or pale yellow bill.
Voice	The ‘alae ‘ula emit cackling calls and croaks similar to that of a chicken and higher in pitch than the coot.
Habits	The common moorhen can be found in freshwater marshes, wet pastures, wetland agricultural areas, reservoirs, and reedy margins of water courses. This species are able to sustain themselves on aquatic insects, mollusks, grasses, water plants, and algae. Six to nine eggs are found in the nest which is often built on folded reeds.
	
source: http://upload.wikimedia.org/wikipedia/commons/2/2b/Kokoszka%28Grzecho_Lukasik%29.jpg	

Short-Eared Owl	
Description	Buffy brown plumage with dark streaks on the chest, abdomen, and back. Females are darker in color than males. 13-17 inches in length; female wingspan is 107cm while male wingspan is105cm. Eyes are yellow and circled with black and set in buffy white facial disks which are surrounded with a brown ring. Their feet and legs are feathered.
Voice	Generally quiet creatures; their call is similar to a muffled bark. During courtship, low hoots will be accompanied by loud yapping and wing clapping. If excited near the nest, both sexes squeal, bark, hiss, and squawk.
Habits	At dawn and dusk, the Short-Eared Owl is active. They hunt mainly at night and during the morning and late afternoon searching for insects, rodents, and other birds. Nests are built on the ground; normally a clutch of three to six white eggs are laid. Prey is usually carried in their talons as opposed to their beak.
 *source: http://en.wikipedia.org/wiki/File:Asio-flammeus-001.jpg*	

<table>
<tr><th colspan="2">Hawaiian Hoary Bat</th></tr>
<tr><td>Description</td><td>Weighs 5 to 8 ounces, has a 10.5 – 13.5-inch wingspan. Females are larger than males. It has a heavy fur coat that is brown and gray, and ears tinged with white, giving it a frosted or "hoary" look.</td></tr>
<tr><td>Voice</td><td>Like most insectivorous bats, this bat emits high frequency (ultrasonic) echolocation calls that detect its flying prey. These calls generally range from 15 – 30 KHz. Their lower frequency social calls may be audible to humans. The low frequency “chirps” are used to warn other bats away from their feeding territory.</td></tr>
<tr><td>Habits</td><td>The Hawaiian Hoary Bat is nocturnal to crepuscular and eats insects. Little is known about its biology, distribution, or habitat use on the Hawaiian islands, though it is thought to be most abundant on the Big Island. It occurs primarily below 4,000 feet elevation, although it commonly is seen at 7,000 to 8,000 feet on Hawai`i and at 10,000 feet on Haleakala.
On Maui, this bat is believed to primarily occur in moist, forested areas. In spite of this preference, though, it has been seen in Lahaina and near Mopua, both of which are dry, and on the dry, treeless crest of Haleakala. During the day, this bat roosts in a variety of tree species and occasionally in rock crevices and buildings; it even has been recorded hanging from wire fences on Kaua`i and has been seen leaving and entering caves and lava tubes on Hawai`i.</td></tr>
<tr><td>
©Jack Jeffrey
<i>source:
http://pacificislands.fws.gov/wesa/hrybatindex.html</i></td><td>
<i>source:
http://www.honoluluzoo.org/hawaiian_bat.htm</i></td></tr>
</table>

Wildlife Education and Observation Program
Kahuku Wind Power
Observation Form

<table>
<tr><td colspan="3">Observer’s Name:</td><td colspan="2">Date:</td></tr>
<tr><td>Temperature:</td><td>Wind Direction:</td><td>Wind Speed:</td><td>Precipitation:</td><td>Cloud Cover:</td></tr>
</table>

Species Observed	
Location	
Proximity to Turbine	
Approximate Altitude	
Direction Traveling	
Other Species in Area	
Comments	

Appendix J.

Kahuku Wind Power Post-Construction Monitoring Protocol

Sampling to estimate the mortality occurring at a wind energy facility must consider spatial and temporal factors at different scales. At the scale of the individual turbine, the area searched should encompass the majority of where expected mortalities will fall; in addition, the search interval has to be of a frequency where most carcasses will be discovered before they are scavenged. When spatial and temporal variation within a site are considered, individual turbines within a site should be sampled sufficiently to account for the spatial variation that exists among turbines, as well as across seasons of the year when species of interest are at the greatest risk of turbine collision.

The accuracy of a mortality estimate itself depends on several factors. The probability of finding a carcass depends on the search interval and scavenging rates at the site. Scavenging rates are typically estimated by conducting trials to yield representative carcass retention times and search intervals are then adjusted accordingly. Another factor that determines the probability of finding a carcass is searcher efficiency. Searcher efficiency will account for individuals that may be killed by collision with project components but that are not found by searchers for various reasons, such as vegetation cover.

This monitoring protocol outlines the scavenger and searcher efficiency trials that Kahuku Wind Power will conduct as well as the search methods that will be used to locate carcasses impacted by the operation of the wind facility.

EARLY POST-CONSTRUCTION STUDIES

The field methods proposed below are based primarily on a refinement of the methods that have been used at Kaheawa Wind Power (KWP) on Maui since operations began in June 2006 (Kaheawa Wind Power 2006). Other recent studies of bird and bat fatalities at wind power projects in the U.S. and Europe were also reviewed to develop and refine previously-approved methods and search techniques (e.g., Kerns and Kerlinger 2004, Pennsylvania Game Commission 2007, Stantec 2008, Stantec 2009, Arnett 2005, Jain et al. 2007, Fiedler et al. 2007).

The initial period of fatality monitoring at Kahuku Wind Power will entail frequent, systematic searches of the area beneath each turbine by trained technicians. Carcass removal and searcher efficiency trials will be conducted within this period. Subsequently, systematic sampling at a pre-determined reduced effort will be conducted for one year at 5-year intervals with attendant SEEF trials and carcass removal trials. A regular rapid assessment technique will be developed for the interim years to determine direct take occurring between years of systematic monitoring.

Factors Considered for Scavenger and Searcher Efficiency (SEEF) Trials

Factors that may affect the results of scavenger and SEEF trials include seasonal differences, vegetation types and carcass sizes. All scavenger and SEEF trials will be conducted in accordance with DOFAW monitoring guidelines.

Seasonal differences are presumed to affect the outcome of carcass removal trials. The rate of carcass retention may vary due to seasonal changes in density of predators on site, or seasonal changes in predator behavior. For the monitoring protocol at Kahuku Wind Power, the year is divided into two seasons, the winter/spring season (December – May) and summer/fall (June – November). Results from carcass removal trials may vary with season, as they are known to at KWP (Kaheawa Wind Power 2008) but the outcome of SEEF trials are not expected to vary with season.

Search plots will be mowed monthly and maintained throughout the life of the project. For this reason, scavenger and SEEF trials are not expected to vary with vegetation type.

Carcass sizes will also likely affect the outcome of both scavenger and SEEF trials. Three size classes have been established to reflect the size classes of the Covered Species: bat size, medium birds (waterbirds) and large birds (seabirds, owl). Based on studies conducted at KWP and elsewhere, it is expected that as size increases, both carcass retention times and searcher efficiency will increase.

Placement of Carcasses for Searcher Efficiency and Carcass Removal Trials

Each carcass used in searcher efficiency or carcass removal trials will be placed randomly within the search plots. These points will be generated within each identified vegetation zone using ArcView 9x with the Generate Random Points tool in Hawth's Analysis Tools 3.27. Parameters that will be specified for each randomly chosen location will include the minimum distance between random points. Minimum distances between random points will ensure that carcasses are not placed too close together. This will maintain the independence of the samples and prevent predator swamping. These points will subsequently be loaded into a GPS as waypoints to allow the accurate placement of the carcasses.

Carcass Removal Trials

The objective of performing carcass removal studies at Kahuku Wind Power will be to determine the average amount of time an avian or bat carcass remains visible to searchers before being removed by scavengers or otherwise rendered undetectable. Trials will be conducted at Kahuku Wind Power with the purpose of maintaining an ongoing record of scavenging rates at different times of year, that will best reflect site-specific conditions in the event that a take does occur. Eight to twelve carcass removal trials will be conducted during the initial survey year, designed to enable four to six trials within a corresponding season (summer/fall and winter/spring). These trials will be used to adjust the number of estimated direct takes of Covered Species observed by correcting for carcass removal bias.

Each carcass removal trial will consist of placing a pre-determined number of carcasses (up to a maximum of seven specimens) of varying size classes on the ground at random locations within search plots. The carcass will be placed such that it approximates what would be expected if a bird/bat came to rest on the ground after having collided with an overhead structure. The intent will be to distribute trials within the project area to represent a range of habitat conditions and seasonal variability. Fresh carcasses will be used whenever available, if frozen carcasses are used, all carcasses will be thawed before being deployed. An example of a possible sampling design is presented in Table 1.

All carcasses will be checked daily for up to 30 days, or until all evidence of the carcass is absent. On day 30, all remaining materials, feathers or parts will be retrieved and properly discarded. Results of trials provide a basis for determining the search frequency necessary to ensure that birds and bats are not scavenged before they can be detected by searchers (see Barrios and Rodriguez 2004 and Kaheawa Wind Power 2008). In some instances, carcasses may be monitored beyond the 30 day survey duration if the information being gathered substantially informs the conclusions of the monitoring exercise. Data will be analyzed by season, and carcass size classifications.

Table 1. Possible Sampling Scheme for Kahuku Wind Power Carcass removal trials for One Season

Size class	Season	Vegetation	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total sample size
Bats	Winter / Spring	Mowed grass	4		4		4		12
Medium Birds	Winter / Spring	Mowed grass	3		3		3		9
Large Birds	Winter / Spring	Mowed grass		3		3		3	9
		Total	7	3	7	3	7	3	30

Searcher Efficiency Trials (SEEF)

As with SEEF trials at KWP, trials will be conducted in association with the regular search effort to estimate the percentage of avian/bat fatalities that are found by searchers. Searcher efficiency will be evaluated according to differences in carcass detection rates for different sized birds and for bats. Estimates of searcher efficiency will be used to adjust estimates of direct take by accounting for carcass detection bias.

Personnel conducting carcass searches will not be told when or where trials will be conducted. Trials will be administered during the monitoring period but dates will be chosen randomly. Each trial will consist of 3 - 7 bird carcasses and/or bats or bat surrogates. Prior to a search commencing that same day, each carcass will be placed at randomly selected locations. Each trial carcass will be discreetly marked and located by GPS so it can be relocated and identified when found. If carcasses of the Covered Species are not available, carcasses of surrogate species will be used as previously described. Data will be analyzed according to carcass size classifications. If the results between trials is highly variable, more trials will be conducted to increase statistical confidence in the resultant values and enable mean searcher detection probabilities to be ascertained for the project site.

Procurement of Carcasses for Trials

If using state or federally protected species as surrogates for trials, all state and federal laws pertaining to transport, possession, and permitted use of these species along with appropriate animal use protocols will be followed. A scientific permit will be obtained for all species that may be used in trials. The Applicant will cover all costs and responsibilities for acquiring carcasses for trials. Carcasses used in the trials will be selected to best represent the size, mass, coloration, and if possible should be closely related to or roughly the same proportions as the Covered Species. For example, Wedge-tailed shearwaters, a close taxonomic relative of the Hawaiian Petrel and Newell's Shearwater, exhibit a close resemblance to both these covered seabird species, and have been used successfully at KWP and elsewhere in carcass removal trials. All carcasses used for the trials will be fresh or freshly thawed. Dark colored mammals (e.g., small rats, mice) and small passerines (e.g. house finch, house sparrow) may be used as surrogates for bats. Other types of avian carcasses that may prove useful for trials include locally-obtained road kills, downed seabirds, owls, and waterbirds, or species not protected under the MBTA such as pheasant (*Phasianus colchicus*) and rock dove (*Columba livia*). Use of species protected under ESA or MBTA will require permission from DLNR and USFWS.

Search Intervals

Consultation with the Endangered Species Recovery Committee (ESRC) and DLNR has indicated a preference for search intervals that are equal to approximately 50% of the mean carcass removal rate. Studies at the KWP facility indicate a mean carcass removal time of 9.2 days (n = 17). While Kahuku Wind Power will be conducting its own carcass removal trials, due to an expected higher density of mongoose at Kahuku Wind Power than at KWP, an average carcass retention time of one week (seven days) is assumed for the time being. Therefore, in order to comply with the request of ESRC and DLNR and account for variability in these removal rates, search intervals of three or four days were chosen. Thus, searches will be carried out twice a week at the Kahuku Wind Power turbines. These search intervals may be adjusted to more accurately reflect seasonal carcass removal rates as carcass removal trials are conducted and data indicate appropriateness of sampling design modifications.

Should SEEF trials indicate that carcass retention times are less than 7 days, trapping may be conducted to depress scavenger populations and increase carcass retention times. All applicable permits will be obtained.

Search Areas Beneath Meteorological Towers

The search area beneath the temporary met towers will be circular and extend 10 m beyond the supporting guy wires. The search area beneath the permanent unguyed met tower (80 m) will also be circular and be half the height of the tower at 40 m search radius.

Search Areas Beneath Individual Turbines

Several studies of small-bodied animals (songbirds and bats), with adequate sample sizes (n = 69 – 466), have shown that the majority of carcasses are found within a search area of less than 50% of the maximum turbine height (Arnett 2005, Jain et al. 2007, Fiedler et al. 2007; see Fig. 1a, b, 2a, b, c, d, e). Most of the carcass distributions (% fatalities vs. distance from turbine) appear to be well described by 2nd degree polynomials, with most fatalities found at approximately 25% of the distance of turbine height, then decreasing with few fatalities occurring beyond 50% of the maximum turbine height (Fig 2a, b, c).

These data are also supported by the distribution of carcasses that have been found at the operating KWP facility. To date, after more than 3000 turbine plot searches conducted during the three years operation at KWP, only eight carcasses have been found that are clearly attributable to collisions with the turbines. The carcasses consist of one Hawaiian hoary bat, one Hawaiian petrel, three nēnē, one barn owl, one ring-necked pheasant, and one white-tailed tropicbird with distances from the turbine ranging from 2 – 73 m (2 – 81 % of maximum turbine height at 90 m). Search plots for KWP are of 90 m radius (100% turbine height) and no intact carcasses were found beyond a distance of 50% turbine height, with the exception of the white-tailed tropicbird which was found in two locations (56% and 81% maximum turbine height) in which a portion of the carcass was discovered at 81% maximum turbine height. It should not be ruled out that the material recovered in this case may have been moved by a scavenger.

Most studies have concentrated on the fatality distributions of small birds and bats. However, these fatality distributions are also expected to apply to larger bodied birds, though because of their greater weight, they will likely be found closer to the base of the turbines.

Given the considerations detailed above, it is proposed that search areas beneath individual turbines for Kahuku Wind Power will consist of a combination of sample areas including 50% and 75% maximum turbine height (64 m and 96 m, radii, respectively).

Spatial and Temporal Sampling Scheme During the First Year of Intensive Sampling

Frequency of Sampling

Sampling at Kahuku Wind Power will initially consist of twice weekly carcass searches. The actual search intervals will be adjusted based on the results of the seasonal carcass removal trials as they become available. The search intervals will be determined in consultation with DLNR and USFWS.

Temporal Sampling Scheme

The first weekly search will consist of sampling all 12 turbines with a search area radius of 50% maximum turbine height (Figure 3A). The second search of the week will consist of sampling a randomly selected subset of six turbines (Fig 3B) with a search area radius of 75% of maximum turbine height. Turbines are randomly chosen to reduce possible bias. The subsequent week, the other set of six turbines will be searched to 75% maximum turbine height (Fig. 3C). The random selection of turbines will only be done once, prior to searches commencing at the project. The same subset of turbines will then be alternated each week for the remaining duration of the intensive sampling. In essence, each turbine will be searched to 75% turbine height at 2 week intervals. As the rate of mortality for all Covered Species at Kahuku Wind Power is expected to be low, sampling all turbines twice weekly at the 50% maximum turbine height and a subsample of six with a search area radius of 75% of turbine height will ensure a high probability that most of the mortality will fall within the search areas. The short search interval at 50% maximum turbine height will also increase the probability that any carcasses will be found before they are removed by scavengers.

Plot Maintenance

All search plots will be mowed monthly out to 75% turbine height and maintained throughout the life of the project.

Determining Spatial and Temporal Variation on Site

The twice weekly search frequency is anticipated to accurately describe variation in mortality rates at different turbines within the site, as well as identify periods when Covered Species that potentially occur year round on site (e.g., Hawaiian short-eared owl, Hawaiian hoary bat) are at greater risk of collision. Each turbine will be sampled 108 times a year, resulting in a total of 1296 turbine searches per year for the entire facility.

Intensive Sampling During the Second Year

Sampling intervals after the first year will be adjusted to reflect seasonal carcass retention rates measured by the carcass removal trials. In addition, if sufficient data is collected and a reliable correction factor is obtained for the search area between 50 -75% maximum turbine height, all search plots may be reduced to 50% radius. The change in sampling regime will be determined by Kahuku Wind Power in consultation with DLNR, USFWS and members of the ESRC .

However, the same sampling regime as Year 1 will be continued if data indicates that more sampling is needed before any change can be made.

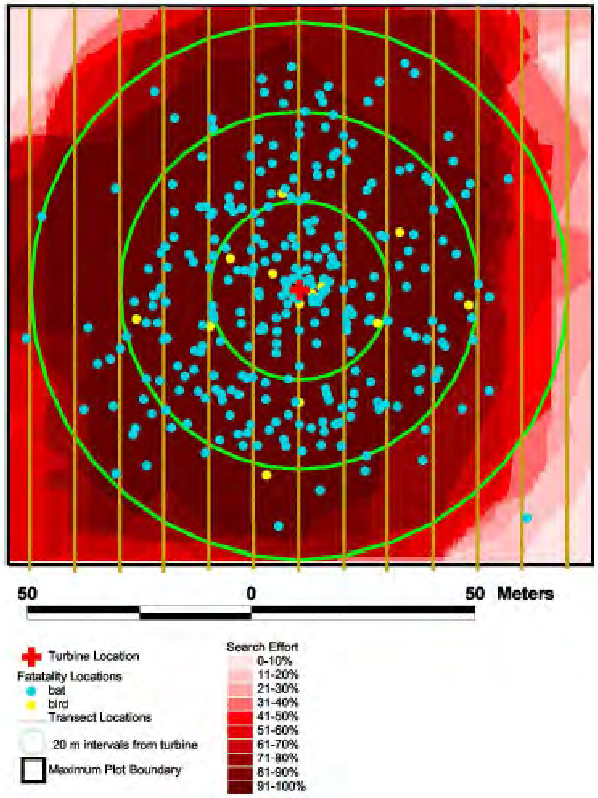


Figure 1a. Bat and bird fatalities (n=466 bats) at all turbines combined at Meyersdale Wind Energy Center in Pennsylvania, 2 August to 13 September 2004 (Arnett 2005). The maximum turbine height was 115 m.

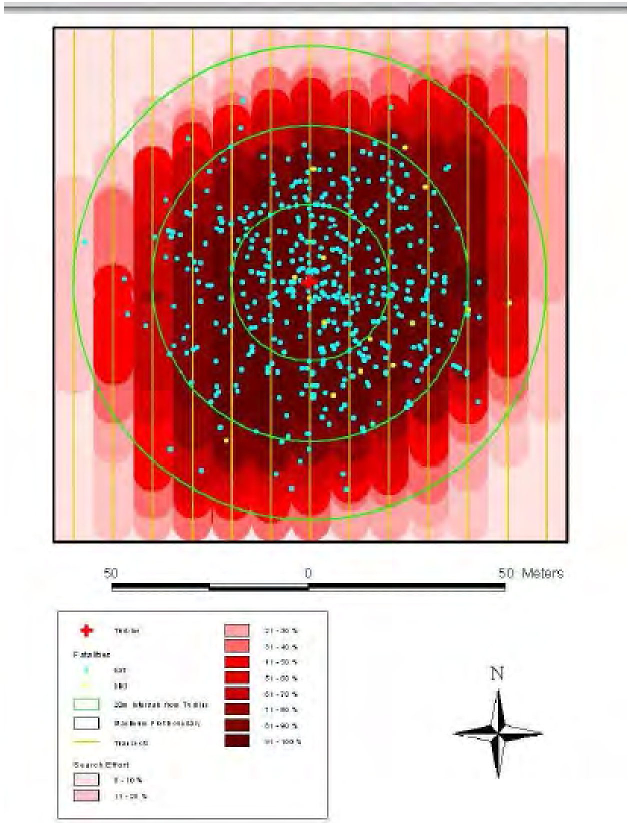
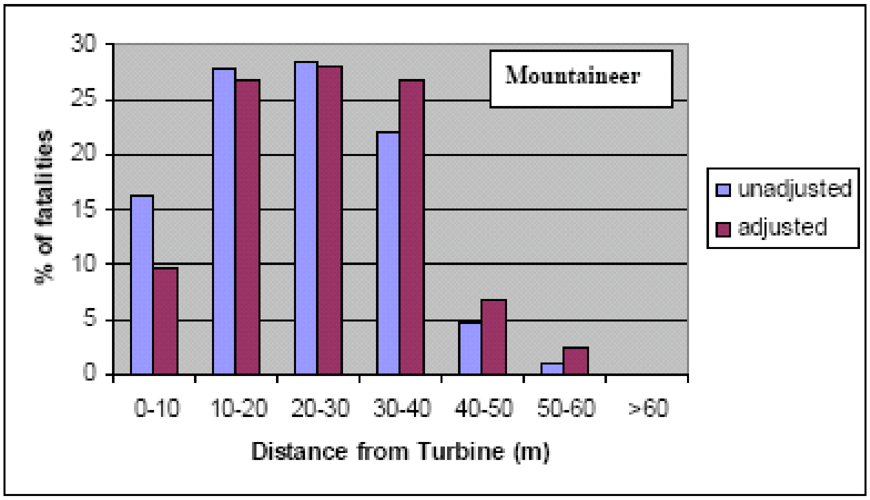
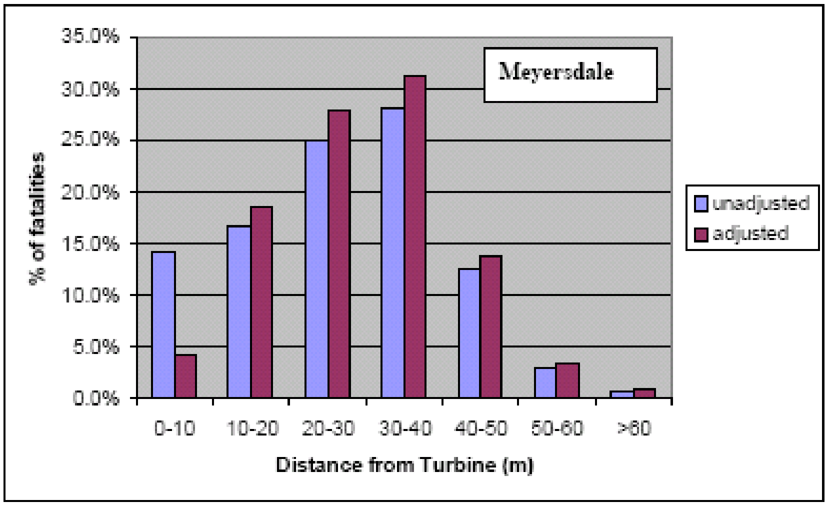


Figure 1b. Bat and bird fatalities (n=499 bats) at all turbines combined at Mountaineer Wind Energy Center in West Virginia, 31 August to 11 September 2004 (Arnett 2005). The maximum turbine height was 104.5m.

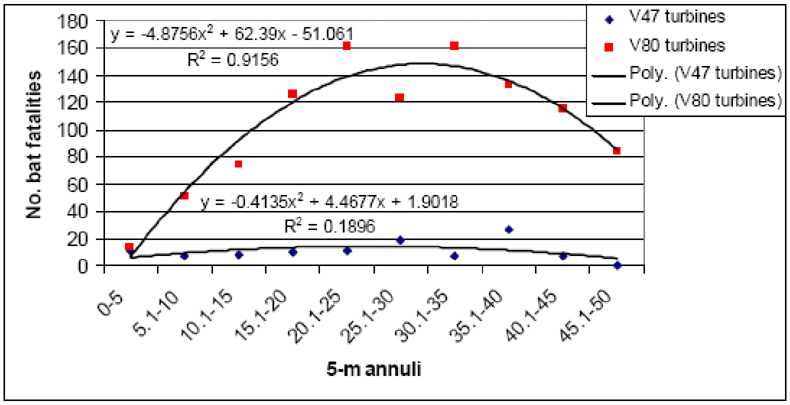


a

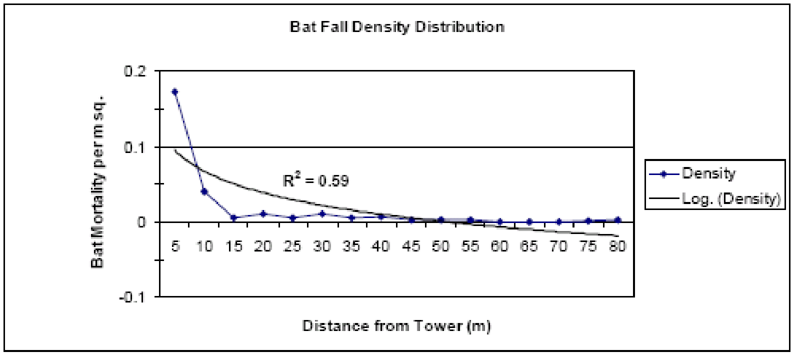


b

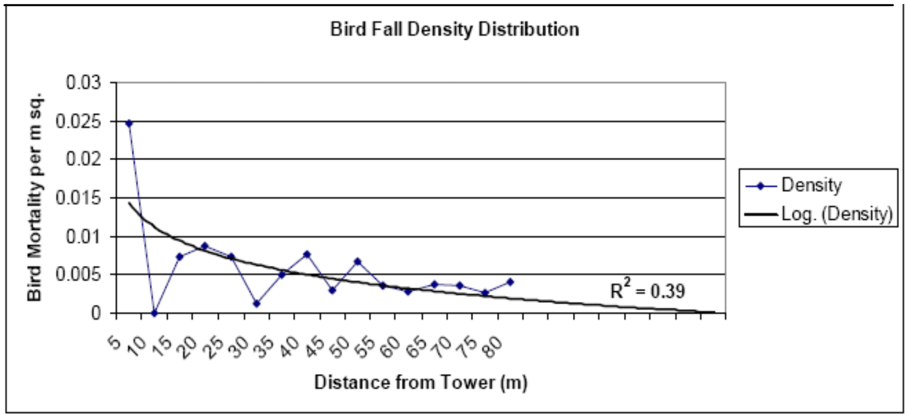
Figure 2a, b. Distribution of fatalities (birds and bats) as a function of distance from a turbine for Mountaineer and Meyersdale sites based on unadjusted counts, and counts adjusted for searcher detection and sampling effort (figures from Arnett 2005). The maximum turbine height was 104.5 m.



c



d



e

Figure 2c. Number of bats found within 5m annuli around V47 turbines (n = 20) and V80 turbine (n=243) from 5 April to 20 December 2005 and associated trend line for Buffalo Mountain, Tennessee (figure from Fielder et al 2007). The trend line for the V80 predicts that bat fatalities would reach zero at 59.6 m from the turbine (maximum turbine height is 120m). Data from the V47 is not considered in this report due to small sample sizes.

Figure 2d,e. Maple Ridge Wind Power, New York bat and bird fatality density distributions from September 1 to November 15, 2006, in relation to distance from towers with associated trend lines. The maximum turbine heights were 122 m (figures from Jain et al 2007). The trend lines predict that bird carcass densities approximate zero at 110m and at 45m for bats. The maximum turbine height was 122 m.

Fig 3 Search areas

Post Two-Year Intensive Sampling Period

Spatial and temporal trends on site should also be well understood at the end of the two-year intensive sampling period, enabling correction factors to be appropriately applied. Depending on findings, the correction factors may enable a decrease or modification of sampling effort (e.g. increase in search intervals or decrease in the number of turbines searched), identify specific turbines or times of the year when sampling effort should be concentrated, and inform adaptive management considerations. Discussion with ESRC, USFWS and DLNR has indicated a preference for the reallocation of effort whereby mitigation efforts are increased in exchange for a reduction in fatality monitoring. It is expected that the systematic monitoring effort will be scaled back by about 50%. It is also proposed that systematic fatality monitoring after the post two-year intensive sampling period be conducted at the beginning of 5-year bins; years 6, 11 and 16, resulting in a total of 5 years of systematic monitoring during the life of the project (Table 2). SEEF trials and carcass removal trials will be repeated during these years to determine if any of the variables have changed over time (Table 2). All adjustments to direct take will use the most recent estimates from the SEEF and carcass removal trials.

In addition to this reduced monitoring effort, regular rapid assessment (RRA) of each search plot will be conducted in the interim years. This may consist of personnel searching each plot to 75% turbine height on an ATV (all terrain vehicle). The frequency at which the surveys take place will be determined at the conclusion of the carcass removal trials for that 5-year period. SEEF trials will also be conducted to determine the searcher efficiency of the chosen RRA method. All adjustments to direct take found in the interim years will use the estimates from the SEEF and carcass removal trials for that 5-year time period.

The systematic monitoring during the first year of the 5-year period and the subsequent 4-year rapid assessment is designed to inform the Applicant if the take is still occurring at Baseline levels or whether take has moved to a Higher or Lower tier based on 5-year and 20-year take limits outlined in the HCP. Five-year total direct take levels will be determined for each 5-year bin while 20-year total direct take levels will be a cumulative total from the start of project operation.

This long-term sampling regime will be refined by Kahuku Wind Power in consultation with ESRC, USFWS, statisticians and wind energy experts after the initial 2-year intensive sampling period.

Years

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IM1	IM2	RRA	RRA	RRA	SM	RRA	RRA	RRA	RRA	SM	RRA	RRA	RRA	RRA	SM	RRA	RRA	RRA	RRA
SEEF trials	SEEF trials	SEEF trials			SEEF trials	SEEF trials				SEEF trials	SEEF trials				SEEF trials	SEEF trials			
CRT					CRT					CRT					CRT				
1st 5-year bin					2nd 5-year bin					3rd 5-year bin					4th 5-year bin				

IM1 = intensive monitoring for year 1; IM2 = intensive monitoring for year 2; RRA = regular rapid assessment; SM= systematic montoring
CRT= carcass removal trials

Total direct take for 1st 5-year bin = total direct take for IM1 + total direct take for IM2 + total direct take for RRA years

Total direct take for subsequent 5-year bins = total direct take for SM + total direct take for RRA years

Table 2. Timetable for SEEF and scavenger removal trials and search techniques

REFERENCES

Arnett E. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Barrios, L. and A. Rodriguez. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. Journal of Applied Ecology 41:72-81.

Fiedler, J.K., T.H. Henry, R.D. Tankersley, and C.P. Nicholson. 2007. Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Wind Farm, 2005. 36 pp.

Jain A. P. Kerlinger, R. Curry, L. Slobodnik. 2007. Maple Ridge Wind Power Avian and Bat Fatality Study Year One Report FINAL REPORT. Prepared for PPM Energy and Horizon Energy and Technical Advisory Committee (TAC) for the Maple Ridge Project Study

Kerns, J. and P. Kerlinger. 2004. A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003.

Kaheawa Wind Power. 2008b. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 2 Annual Report. First Wind, LLC, Environmental Affairs, Newton, MA. 26 pp.

Osborn, R. G., K. F. Higgins, R., E. R. Usgaard, C. D. Dieter, and R. D. Neiger. 2000. Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota. American Midland Naturalist 143:41-52.

Pennsylvania Game Commission. 2007. Protocols to Monitor Bird and Bat Mortality at Industrial Wind Turbines. Exhibit C Used in Conjunction with the Wind Energy Cooperative Agreement.

Stantec Consulting. 2008. 2007 Spring, Summer, and Fall Post-Construction Bird and Bat Mortality Study at the Mars Hill Wind Farm, Maine. Report prepared for UPC Wind Management, LLC. January 2008. 31 pp.

Stantec Consulting. 2009. Post-construction Monitoring at the Mars Hill Wind Farm, Maine – Year 2. Report prepared for First Wind, LLC. January 2009. 33 pp.

Appendix K.

Thomas, Sharon (CF)

From: Thomas, Sharon (CF)
Sent: Tuesday, April 27, 2010 4:38 PM
To: 'James_Kwon@fws.gov'
Cc: oeqc@doh.hawaii.gov
Subject: RE: Comments on DOE/EA-1726 Federal Loan Guarantee to Kahuku Wind Power LLC, Oahu, Hawaii

James,

Thank you for submitting comments on behalf of the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, on the draft Environmental Assessment for the Department of Energy Loan Guarantee to Kahuku Wind Power, LLC for Construction of the Kahuku Wind Power Facility in Kahuku, O‘ahu, Hawai‘i (DOE/EA-1726). I also appreciate your willingness to meet with me on April 1st to discuss these comments. DOE has made several revisions to the EA to address your comments, as described below:

FWS recommended the title include mention of both "construction and operation" associated with the proposed wind energy facility. The Final Rule governing the Loan Guarantee Program (10 CFR Part 609) outlines eligible project costs in Section 609.12. Operating costs are not eligible; therefore, the title of the document and any related text that states what the loan guarantee is “for” does not include operation. DOE does state in the EA that impacts from both construction and operation are analyzed and included in the EA.

FWS commented that in addition to construction equipment, construction materials may originate from outside the State of Hawai‘i and have the potential to introduce non-native or invasive species. FWS requested that the EA discuss measures to prevent such occurrences and recommended inspection of all such construction materials. Section 3.11.2.1 of the draft EA discusses the unintentional introduction or transport of invasive species and states that all construction equipment and vehicles arriving from outside of the Island of O‘ahu would be washed prior to entering the project area. This text has been supplemented and revised to include additional information on visual inspection and/or washing (as appropriate) of construction materials.

FWS requested that in Section 3.12.4.1, DOE briefly describe each mitigation effort and how it will benefit each covered species. FWS also recommended that the EA analyze the potential impacts of each mitigation effort. Table 3.16 briefly summarizes each mitigation measure and subsequent text refers the reader to the Habitat Conservation Plan for more details. The mitigation measures are also discussed in the EA for each covered species starting on page 99. DOE has added text to describe how each mitigation measure would benefit each covered species in Table 3.16 and throughout the text of Section 3.12.4.1. This text includes the removal of koloa hybrids as proposed at Hamakua Marsh for the Hawaiian duck or duck hybrids, as requested. DOE also added a discussion of the potential impacts of each mitigation measure throughout the text of Section 3.12.4.1. (Draft versions of this text were shared with you and agreed upon vie e-mail correspondence in April 2010).

Thank you for your continued cooperation! Please contact me if you would like to discuss the EA revisions in more detail.

Sharon Thomas
Environmental Protection Specialist
DOE

From: James_Kwon@fws.gov [mailto:James_Kwon@fws.gov]
Sent: Monday, March 22, 2010 3:27 PM

To: Thomas, Sharon (CF)
Cc: oeqc@doh.hawaii.gov
Subject: Comments on DOE/EA-1726 Federal Loan Guarantee to Kahuku Wind Power LLC, Oahu, Hawaii

March 22, 2010

Dear Ms. Thomas:

On behalf of the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, I would like to offer the following comments on the draft Environmental Assessment for the Department of Energy Loan Guarantee to Kahuku Wind Power, LLC for Construction of the Kahuku Wind Power Facility in Kahuku, Oahu, Hawaii (DOE/EA-1726):

1. Title, Purpose and Need Page 1, Section 1.1. We recommend the title as well the project description include mention of both "construction and operation" associated with the proposed wind energy facility.

2. Page 74, Section 3.11.2.1. In addition to construction equipment, construction materials may originate from outside the State of Hawaii. Please address the potential for the introduction of non-native or invasive species via construction materials and any measures to prevent such occurrences. We recommend inspection of all such construction materials.

3. Page 95 to 108, Section 3.12.4.1. In general, please briefly describe each mitigation effort and how it will benefit each covered species. For seabirds, for example, predation by feral cats and mongoose has been documented as a major threat to listed seabirds, therefore, fencing and predator control are expected to increase adult survival and overall productivity creating the net benefit to the species.

4. Seabird baseline mitigation Alternative 1 (Section 7.3.1.1), the preferred alternative for seabird mitigation, proposes construction of a cat-proof fence [(length 1.6 to 2.0 miles (2.6 to 3.2 km)] which equates to an area approximately 100 to 160 acres in size. The seabird colony at the Makamakaole site occurs in West Maui Forest Reserve and may extend into the Kahakuloa Natural Area Reserve (Kaheawa Wind Power Seabird Mitigation Plan 2009). Because the Kahuku HCP includes the goal to achieve baseline mitigation actions at this site, with benefits of predator control and social attraction studies contingent upon fencing , we believe this analysis is required. Therefore, we recommend the EA analyze impacts of each mitigation alternative, as appropriate.

5. For the Hawaiian duck or duck hybrids, please include removal of koloa hybrids as proposed at Hamakua Marsh (HCP Section 7.4.1).

Please feel free to contact us if you or the preparers of the EA have any questions or concerns regarding these comments.

Sincerely,

James

===
James Kwon
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
300 Ala Moana Blvd, Room 3-122
Honolulu, Hawaii 96850
ph: (808) 792-9433 fax: (808) 792-9580
===

APPENDIX K. EXPANDED DISCUSSION OF IMPACTS TO LISTED WILDLIFE

FEDERAL AND STATE LISTED SPECIES

No federally listed endangered, threatened, or candidate species are known to reside on the Kahuku Wind Power project area and no portion of the project area has been designated as critical habitat for any listed species. The endangered Hawaiian hoary bat or ʻopeʻapeʻa has been documented flying over the project area and low bat activity has been recorded on the acoustic bat detectors. Several federally listed endangered and threatened bird species occur regularly on nearby properties and individuals some or all of these species may occasionally transit through the airspace of the proposed Kahuku Wind Power facility. Presumed Newell's shearwaters were detected flying over the Kahuku Wind Power site during nocturnal radar surveys. No birds believed to be Hawaiian petrels, which also may fly inland at night, were detected during the radar surveys. One state listed endangered species, the Hawaiian short-eared owl or pueo, was heard in the Kahuku Wind Power project area by the radar technicians and is believed to occur at least infrequently.

The proposed WTGs, on-site and off-site microwave towers, met tower, overhead collection lines and relocated distribution line associated with the Kahuku Wind Power project would create collision hazards for seven federally listed threatened or endangered species: the Hawaiian stilt or aeʻo, Hawaiian coot or ʻalae keʻokeʻo, Hawaiian duck or koloa maoli, Hawaiian moorhen or ʻalae ʻula, Newell's shearwater or ʻaʻo, Hawaiian petrel or uaʻu, and Hawaiian hoary bat. These facilities would also create a collision hazard for the state listed Hawaiian short-eared owl or pueo. These eight species are also collectively referred to as the "Covered Species" because Kahuku Wind Power LLC is seeking to have incidental take of these eight species covered by a State of Hawaiʻi Incidental Take License (ITL). Table 1 lists the federally and state-listed species with potential to be adversely impacted by operation of the Kahuku Wind Power project. Lighting structures associated with the facility, pursuant to Federal Aviation Administration (FAA) regulations, may increase the risk of avian collisions (USFWS 2007).

Table 1. Federally or state listed species with potential to be impacted by the Kahuku Wind Power project.

Scientific Name	Common, Hawaiian Name(s)	Date Listed	Status[1]
Birds			
Puffinus auricularis newelli	Newell's shearwater, ʻaʻo	10/28/1975	T
Pterodroma sandwichensis	Hawaiian petrel, uaʻu	3/11/1967	E
Anas wyvilliana	Hawaiian duck, koloa maoli	3/11/1967	E
Himantopus mexicanus knudseni	Hawaiian stilt, aeʻo	10/13/1970	E
Fulica alai	Hawaiian coot, ʻala ekeʻokeʻo	10/13/1970	E
Gallinula chloropus sandvicensis	Hawaiian moorhen, ʻalae ʻula	3/11/1967	E
Asio flammeus sandwichensis	Hawaiian short-eared owl, pueo	--	SE
Mammals			
Lasiurus cinereus semotus	Hawaiian hoary bat, ʻopeʻapeʻa	10/13/1970	E

1) E = federally endangered; T = federally threatened; SE = state endangered

It is expected that Newell's shearwater and Hawaiian petrels could occasionally transit over the off-site microwave tower sites. No waterbirds are expected at either site due to unsuitable habitat. The Hawaiian short-eared owl is not expected at the HECO Wailua substation due to unsuitable habitat, but may be present at the Flying R Ranch site. Hawaiian hoary bats may potentially forage at either microwave site. Information on this is discussed further below.

Information on each of the eight Covered Species and current threats to their populations is provided below. More detailed information on these species is provided in the State HCP prepared as part of the ITL application for the proposed project (SWCA and First Wind 2010).

Newell's Shearwater

Population, Biology, and Distribution of the Newell's Shearwater

The Newell's shearwater is an endemic Hawaiian sub-species of the nominate species, Townsend's shearwater (*Puffinus a. auricularis*) of the eastern Pacific. The Newell's shearwater is considered "Highly Imperiled" in the *Regional Seabird Conservation Plan* (USFWS 2005b) and the *North American Waterbird Conservation Plan* (Kushlan et al. 2002). Species identified as "Highly Imperiled" have suffered significant population declines and have either low populations or some other high risk factor.

The most recent population estimate of Newell's shearwater was approximately 84,000 birds, with a possible range of 57,000 to 115,000 birds (Ainley et al. 1997). The largest breeding population of Newell's shearwater occurs on Kauaʻi (Telfer et al. 1987, Day and Cooper 1995, Ainley et al. 1995, 1997, Day et al. 2003). Breeding also occurs on Hawaiʻi Island (Reynolds and Richotte 1997, Reynolds et al. 1997, Day et al. 2003a) and almost certainly occurs on Molokaʻi (Pratt 1988, Day and Cooper 2002). Recent radar studies suggest the species may also nest on Oʻahu (Day and Cooper 2008). On Maui, radar studies and visual and auditory surveys conducted over the past decade suggest that one or more small breeding colonies are present in the West Maui Mountains in the upper portions of Kahakuloa Valley (G. Spencer/First Wind, pers. comm.).

Newell's shearwaters typically nest on steep slopes vegetated by uluhe fern (*Dicranopteris linearis*) undergrowth and scattered ʻōhiʻa (*Metrosideros polymorpha*) trees. Currently, most Newell's shearwater colonies are found from 525 to 3,900 ft (160 to 1,200 m) above mean sea level, often in isolated locations and/or on slopes greater than 65 degrees (Ainley et al. 1997). The birds nest in short burrows excavated into crumbly volcanic rock and ground, usually under dense vegetation and at the base of trees. A single egg is laid in the burrow and one adult bird incubates the egg while the second adult goes to sea to feed. Once the chick has hatched and is large enough to withstand the cool temperatures of the mountains, both parents go to sea and return daily to feed the chick. Newell's shearwaters arrive at and leave their burrows during darkness and birds are seldom seen near land during daylight hours. During the day, adults remain either in their burrows or at sea.

The Newell's shearwater breeding season begins in April, when birds return to prospect for nest sites. A pre-laying exodus follows in late April and possibly May; egg-laying begins in the first two weeks of June and likely continues through the early part of July. Pairs produce one egg, and the average incubation period is thought to be approximately 51 days (Telfer 1986). The fledging period is approximately 90 days, and most fledging takes place in October and November, with a few birds still fledging into December (SOS Data).

The flight of the Newell's shearwater is characterized by rapid beats interspersed with glides, although beats tend to be fewer in high winds. The birds avoid flying with tailwinds because it decreases control. Over land, ground speed of the species has been measured to average 38 mph or 61 kph (Ainley et al. 1997). The wing beat pattern of Newell's shearwater is somewhat similar to that of Hawaiian petrel.

Current Threats to the Newell's Shearwater

Declines in Newell's shearwater populations are attributed to loss of nesting habitat, predation by introduced mammals (mongoose, feral cats, rats, and feral pigs) at nesting sites, and fallout of juvenile birds associated with disorientation from urban lighting (Ainley et al. 1997, Mitchell et al. 2005, Hays and Conant 2007).

No Newell's shearwater fatalities have been recorded at KWP in the time since the Federal Incidental Take Permit (ITP) and State ITL were issued in January 2006 (Kaheawa Wind Power LLC 2008a, 2008b).

Occurrence of Newell's Shearwater in the Project Area and Off-site Microwave Towers

Day and Cooper (2008) conducted surveillance radar and audiovisual sampling at the Kahuku Wind Power project area in fall 2007 and summer 2008. These surveys found an extremely low number of targets exhibiting flight speeds and flight patterns that fit the "shearwater/petrel" category. Based on surveys conducted on other islands, Newell's shearwaters move to the interior portions of the islands starting about 30 min after sunset, while Hawaiian petrel movements begin at sunset to about 60 min after sunset (Day et al. 2003b). Over five nights of sampling in fall 2007, two petrels or shearwaters were detected flying inland over the Kahuku Wind Power project area toward the Koʻolau Range and two were detected flying seaward over the site from the Koʻolau Range. No petrels or shearwaters were detected flying inland during seven nights of sampling in summer 2008, while seven petrels and/or shearwater-like targets were recorded flying seaward.

No visual identification of these birds was possible, but Day and Cooper (2008) suggested that the individuals were likely Newell's shearwaters and not Hawaiian petrels since all targets were recorded after complete darkness. While the uppermost elevation of the site reaches the lower elevation limit for known nesting by this shearwater, no evidence was obtained to suggest that these birds could be nesting on-site.

As indicated, Newell's shearwater has not been confirmed as a nesting species on Oʻahu. Assuming the detected birds were Newell's shearwaters, then their observed behavior of flying to and from the Koʻolau Range suggests strongly that at least a small number of these birds are breeding or prospecting in these mountains. Because of the few detections obtained during the Day and Cooper study and lack of radar studies from adjacent lands, it is not known whether the Kahuku Wind Power project area lies within a corridor used regularly by these few birds as they move between their nesting areas and the ocean. Observations of Newell's shearwaters in the Hawaiian Islands indicate that approximately 65% of shearwaters will fly at or below turbine height (Day and Cooper 2008).

No radar studies were conducted at the off-site microwave tower sites because the low heights of the towers (60 ft or less) and their small profiles would present minimal collision risk to shearwaters. It is expected that Newell's shearwater individuals could occasionally transit over the off-site microwave tower sites, but at much higher altitudes than the towers themselves (average flight height estimated at 627 ± 82 ft or 191 ± 25 m).

Hawaiian Petrel

Population, Biology, and Distribution of the Hawaiian Petrel

The Hawaiian petrel was once abundant on all main Hawaiian Islands except Niʻihau (Mitchell et al. 2005). The population was most recently estimated to be approximately 20,000, with 4,000 to 5,000 breeding pairs (Mitchell et al. 2005). Today, Hawaiian petrels breed in high-elevation colonies on Maui, Hawaiʻi, Kauaʻi and Lānaʻi (Richardson and Woodside 1954, Simons and Hodges 1998, Telfer et al. 1987, DOFAW unpublished data 2006, 2007). Radar studies conducted in 2002 also suggest that breeding may occur on Molokaʻi (Day and Cooper 2002). Breeding is no longer thought to occur on Oʻahu (Harrison 1990).

Survey work at a recently re-discovered Hawaiian petrel colony on Lānaʻi, that had been previously thought to be extirpated, indicates that thousands of birds are present, rather than hundreds of birds as first surmised, and that the size of the breeding colony approaches that at Haleakalā, Maui, where as many as 1,000 pairs have been thought to nest annually (Mitchell et al. 2005, Tetra Tech EC, Inc., June 2008). Radar counts of petrels on the perimeter of Maui and recent colony detections by Kaheawa Wind Power (KWP) researchers suggest that the Maui population may be much higher than the 1,000 pairs previously estimated (Cooper and Day 2003).

Hawaiian petrels are nocturnal and subsist primarily on squid, fish, and crustaceans caught near the sea surface. On Kauaʻi, Hawaiian petrels move from the sea to the interior portions of the island between sunset and about 60 min after sunset (Day et al. 2003b).

Hawaiian petrels are active in their nesting colonies for about eight months each year. The birds are long-lived (ca. 30 years) and return to the same nesting burrows each year between March and April. Present-day Hawaiian petrel colonies are typically located at high elevations above 8,200 ft (2,500 m). The types of habitats used for nesting are very diverse and range from xeric habitats with little or no vegetation, such as at Haleakalā National Park on Maui, to wet forests dominated by ʻōhiʻa with uluhe understory as those found on Kauaʻi (Mitchell et al. 2005). Females lay only one egg per year, which is incubated alternately by both parents for approximately 55 days. Eggs hatch in June or July, after which both adults fly to sea to feed and return to feed the nestling. The fledged young depart for sea in October and November. Adult birds do not breed until age six and may not breed every year, but pre-breeding and non-breeding birds nevertheless return to the colony each year to socialize (SWCA and First Wind 2010).

Current Threats to the Hawaiian Petrel

The most serious land-based threat to the species is predation of eggs and young in the breeding colonies by introduced mammalian predators such as small Indian mongoose, feral cats, pigs, dogs, and rats. Owls have also been documented as predators of fledglings (Hodges and Nagata 2001). Population modeling by Simons (1984) suggested that this species could face extinction in a few decades if predation was not controlled. Intensive trapping and habitat protection has helped to improve nesting and fledging success (Ainley et al. 1997). Hodges and Nagata (2001) found that nesting activity (signs of burrow activity) in sites protected from predators on Haleakala ranged from 37.25 to 78.13% while nesting activity in unprotected sites ranged from 23.08 to 88.17%. Nesting success (proportion of active burrows that showed signs of fledging chicks) in protected sites ranged from 16.97 to 50.00%, while nesting success in unprotected sites ranged from 0.00 to 44.00% (Hodges and Nagata 2001).

Ungulates can indirectly affect nesting seabirds by overgrazing and trampling vegetation, as well as facilitating erosion. Climatic events such as El Niño can also impact the reproductive success of seabirds (Hodges and Nagata 2001). Other threats include occasional mortality from collisions with power lines, fences, and other structures near breeding sites or attraction to bright lights. In addition, juvenile birds are sometimes grounded when they become disoriented by lights on their nocturnal first flight from inland breeding sites to the ocean. The problem is much smaller than the one involving Newell's shearwaters (see previous section), and Simons and Hodges (1998) conclude that it is probably not a threat to remaining populations. Hawaiian petrels are known to occasionally collide with tall buildings, towers, powerlines, and other structures while flying at night between their nesting colonies and the ocean (Federal Register 2004).

Occurrence of the Hawaiian Petrel in the Project Area and Off-site Microwave Towers

As discussed in the previous section, several birds that were either Newell's shearwaters or Hawaiian petrels were detected by radar flying over the Kahuku Wind Power project area. No visual identification of these birds was possible, but Day and Cooper (2008) suggested that the individuals were likely Newell's shearwaters and not Hawaiian petrels since all targets were recorded after complete darkness. However, because of a lack of definitive identification of these birds, it is considered possible that a small number of Hawaiian petrels could occasionally fly over the Kahuku Wind Power project area during their nesting season (March through September). Hawaiian petrels fly at higher altitudes than Newell's shearwater on average (191 ± 25 m vs 125 ± 4 m; Cooper and Day 2003) and would be less likely to collide with the wind turbines and blades than Newell's shearwater.

No radar studies were conducted at the off-site microwave tower sites because the low heights of the towers (60 ft or less) and their small profiles would present minimal collision risk to petrels. It is expected that Hawaiian petrel individuals could occasionally transit over the off-site microwave tower sites, but at much higher altitudes than the towers themselves (average flight height estimated at 410 ± 13 ft or 125± 4 m, Cooper and Day 2003).

Waterbirds (Hawaiian Duck, Hawaiian Stilt, Hawaiian Coot, Hawaiian Moorhen)

The Hawaiian duck, Hawaiian stilt, Hawaiian coot, and Hawaiian moorhen require wetlands for their survival (USFWS 2005a). The loss and degradation of coastal wetlands, as a result of coastal development and runoff, has been a significant factor in the decline of these birds in Hawai‘i. Between 1780 and 1980, the area of coastal wetland habitat in the main Hawaiian Islands declined by 31% (Evans et al. 1994). Coastal wetlands were filled for commercial, residential, and resort developments and drained for agriculture. Predation by introduced animals, disease, and environmental contaminants have also contributed to the population decline of Hawai‘i’s endangered waterbirds. Furthermore, invasive plants, such as mangroves and grasses, have encroached on wetlands and altered natural processes (Evans et al. 1994, USFWS 2005a).

No critical habitat has been designated for any of Hawai‘i’s endangered waterbirds (USFWS 2005a). The general recovery objectives for the endangered waterbirds, as described in the *Second Draft Recovery Plan for Hawaiian Waterbirds* (2005a), are the following: stabilize or increase populations to greater than 2,000 individuals per species; establish multiple self-sustaining breeding populations throughout their historic ranges; protect and manage core and supporting wetlands statewide; eliminate or control the threat of introduced predators, diseases, and contaminants; and remove the island-wide threat of the Hawaiian duck hybridizing with feral mallards.

All four of these waterbirds are known to occur regularly in the Ki‘i Unit of the James Campbell NWR, which lies near the proposed Kahuku Wind Power facility.[1] Of these four species, only possible Hawaiian ducks have been observed flying over the Kahuku Wind Power project area during avian surveys conducted by First Wind and SWCA. All “Hawaiian ducks” observed during the surveys were flying over the project area; a pair of ducks was also observed on one occasion incidental to the surveys following a period of prolonged rain in an ephemeral area of standing water. Individual information on the four species of waterbirds is provided below.

Hawaiian Duck

<u>Population, Biology, and Distribution of the Hawaiian Duck</u>

The Hawaiian duck is a non-migratory species endemic to the Hawaiian Islands, and the only endemic duck extant in the main Hawaiian Islands (Uyehara et al. 2008). The known historical range of the Hawaiian duck includes all the main Hawaiian Islands except for the Islands of Lāna‘i and Kaho‘olawe. Hawaiian duck are strong flyers and usually fly at low altitudes. Intra-island movement has been recorded, where they may move between ephemeral wetlands or disperse to montane areas during the breeding season (Engilis et al. 2002). Hawaiian ducks also fly inter-island and have been documented to fly regularly between Ni‘ihau and Kaua‘i in response to above-normal precipitation and the flooding and drying of Ni‘ihau’s ephemeral wetlands (USFWS 2005a). Hawaiian ducks occur in aquatic habitats up to an altitude of 10,000 ft (3,048 m) in elevation (Uyehara et al. 2007). The only naturally occurring population of Hawaiian duck exists on Kaua‘i, with reintroduced populations on O‘ahu, Hawai‘i, and Maui (Pratt et al. 1987, Engilis et al. 2002, Hawaii Audubon Society 2005).

Hawaiian ducks are closely related to mallards (Browne et al. 1993). Due to this close genetic relationship, Hawaiian ducks will readily hybridize with mallards and allozyme data indicate there has been extensive hybridization between Hawaiian duck and feral mallards on O‘ahu, with the near disappearance of koloa maoli alleles from the population on the island (Browne et al. 1993, A. Engilis/ UC Davis, pers. comm.). Uyehara et al. (2007) found a predominance of hybrids on O‘ahu and samples collected by Browne et al. (1993) from ducks and eggs at the Ki‘i Unit of the James Campbell NWR found mallard genotypes. In 2005, a peak count of 141 Hawaiian duck x mallard hybrids were recorded on the Ki‘i Unit of the James Campbell NWR (USFWS, unpubl). Populations on Maui are also suspected to largely consist of Hawaiian duck x mallard hybrids. Estimated Hawaiian duck hybrid counts on these islands are 300 and 50 birds, respectively (Engilis et al. 2002, USFWS 2005a). The current wild population of pure Hawaiian ducks is estimated at approximately 2,200 birds. Roughly 200 pure individuals occur on the Island of Hawai‘i and the remainder reside on Kaua‘i. Because of similarities between the species, it can be difficult to distinguish between pure Hawaiian ducks, feral hen mallards, and hybrids during field studies.

---

[1] “Hawaiian ducks” occurring at James Campbell NWR and elsewhere on O‘ahu are all believed to be Hawaiian duck x mallard hybrids.

Habitat types utilized by the Hawaiian duck include natural and man-made lowland wetlands, flooded grasslands, river valleys, mountain streams, montane pools, forest swamplands, aquaculture ponds, and agricultural areas (Engilis et al. 2002, Hawaii Audubon Society 2005, USFWS 2005a). The James Campbell NWR provides suitable habitat for foraging, resting, pair formation, and breeding (Engilis et al. 2002). Hawaiian ducks occasionally transit the Kahuku Wind Power area and have been observed using the ephemeral ponds found on site after heavy rains. These ponds disappear rapidly following the cessation of rainfall, leaving the project area devoid of suitable habitat for the duck.

Breeding occurs year-round, although the majority of nesting occurs from March through June. The peak breeding season on Kaua‘i Island occurs between December and May and the peak on Hawai‘i Island occurs from April to June (Uyehara et al. 2008). Nests are placed in dense shoreline vegetation of small ponds, streams, ditches, and reservoirs (Engilis et al. 2002). Types of vegetation associated with nesting sites of Hawaiian duck include grasses, rhizominous ferns, and shrubs (Engilis et al. 2002). The diet of Hawaiian ducks consists of aquatic invertebrates, aquatic plants, seeds, grains, green algae, aquatic mollusks, crustaceans, and tadpoles (Engilis et al. 2002, USFWS 2005a).

Current Threats to the Hawaiian Duck

Hybridization with mallards is the largest threat to the Hawaiian duck. Reintroduction of pure Hawaiian ducks to O‘ahu is being contemplated, although in order for pure Hawaiian ducks to persist on O‘ahu following reintroduction, the removal of all hybrids and the elimination of all sources of feral mallard ducks will need to occur (Engilis et al. 2002). James Campbell NWR in Kahuku is expected to play a key role in any future reintroduction of pure Hawaiian ducks to O‘ahu (USFWS 2005a, Kwon/USFWS, pers. comm.). At present it is uncertain when and if reintroduction would occur, but it is possible that reintroduction could occur during the 20-year life of the proposed project.

Hawaiian ducks are preyed upon by mongoose, feral cats, feral dogs, and possibly rats (Engilis et al. 2002). Black-crowned night-herons, largemouth bass (*Micropterus salmoides*), and bullfrogs (*Lithobates catesbeianus*) have been observed to take ducklings (Engilis et al. 2002), and it is presumed here that cattle egrets could do the same. Avian diseases are another threat to Hawaiian ducks, with outbreaks of avian botulism (*Clostridium botulinum*) occurring annually throughout the state. In 1983, cases of adult and duckling mortality on O‘ahu were attributed to Aspergillosis and Salmonella (Engilis et al. 2002). As stated previously, the loss and degradation of coastal wetlands have been a significant factor in the decline of these birds in Hawai‘i.

Little is known about the interaction of Hawaiian ducks with wind turbines. Studies of wind energy facilities located in proximity to wetlands and coastal areas in other parts of the United States and the world have shown that waterfowl and shorebirds have some of the lowest collision mortality rates at these types of facilities, suggesting that these types of birds are among the best at recognizing and avoiding wind turbines (e.g., Koford et al. 2004, Jain 2005, Carothers 2008). In support of these findings, systematic and ancillary observations of nēnē or Hawaiian goose (*Branta sandvicensis*) in flight at the KWP facility on Maui indicate this species is capable of exhibiting deliberate avoidance of wind turbines under prevailing conditions (Kaheawa Wind Power 2008).

Occurrence of the Hawaiian Duck in the Project Area and Off-site Microwave Towers

Ducks resembling Hawaiian ducks (but likely to be hybrids) have been seen flying over the lower elevation eastern portion of the Kahuku Wind Power project area on three occasions during point count surveys and one incidental observation (SWCA and First Wind 2010). These individuals were not observed landing on the site. More recently, a pair of ducks that resembled Hawaiian ducks was observed on-site following a period of heavy rain in a flooded depression in the area where topsoil had been excavated historically (L. Ong/SWCA pers. obs.). Hawaiian duck-like ducks flying over the nearby wetlands have been observed up to heights of approximately 200 ft (60 m). Thus, while flying over the Kahuku Wind Power project area, ducks may be vulnerable to colliding with the WTGs, turbine blades, and met towers. The estimated passage rate of Hawaiian duck-like ducks over the Kahuku Wind Power project area is 0.003 birds/ha/hr or 8.0 birds/day for the entire site (SWCA and First Wind 2010).

Due to the residential nature of the environment at the HECO Waialua substation microwave tower (asphalt roads, traffic, close proximity to houses), no waterbirds are expected to utilize the site. No habitat suitable for waterbirds occurs at the microwave tower site at Flying R Ranch as well, which consists of non-native forest with no nearby water features. Thus no Hawaiian ducks are expected to be near the vicinity of either off-site microwave tower.

Because of hybridization with feral mallards, it is questionable whether the Hawaiian duck-like ducks present on O‘ahu are protected under Section 9 of the ESA. However, at the request of the USFWS, the Applicant has agreed to consider the Hawaiian duck-like ducks present in the general project vicinity as if they were pure Hawaiian ducks. Consequently, the Applicant is offering to provide mitigation to compensate for the loss of any Hawaiian duck-like ducks resulting from construction and operation of the Kahuku Wind Power project.

Hawaiian Stilt

Population, Biology, and Distribution of the Hawaiian Stilt

The Hawaiian stilt is a non-migratory endemic subspecies of the black-necked stilt (*Himantopus mexicanus mexicanus*). The black-necked stilt occurs in the western and southern portions of North America, southward through Central America and the West Indies to southern South America and also the Hawaiian Archipelago (Robinson et al 1999). The *U.S. Pacific Islands Regional Shorebird Conservation Plan* considers the Hawaiian stilt as highly imperiled because of its low population level (Engilis and Naughton 2004). Over the past 25 years, the Hawaiian stilt population has shown a general upward trend statewide. Annual summer and winter counts have shown variability from year to year. This fluctuation can be attributed to variation in winter rainfall and reproductive success (Engilis and Pratt 1993, USFWS 2005a). The state population size has recently fluctuated between 1,200 to 1,500 individuals with a five-year average of 1,350 birds (USFWS 2005a). Adult and juvenile dispersal has been observed both intra- and inter-island within the state (Reed et al. 1998).

O‘ahu supports the largest number of stilts in the state, with an estimated 35 to 50% of the population residing on the island. Some of the largest concentrations can be found at the James Campbell NWR, Kahuku aquaculture ponds, Pearl Harbor NWR, and Nu‘upia Ponds in Kane‘ohe (USFWS 2005a). The Ki‘i Unit of the James Campbell NWR, and the Waiawa Unit and Pond 2 of the Honouliuli Unit of the Pearl Harbor NWR are the most productive stilt habitats, with birds numbering near 100 or above during survey counts (USFWS 2002, USFWS unpubl. data). Hatching success of stilt nests has been greater than 80% in the Ki‘i Unit, but chick mortality rates are high (USFWS 2002).

Hawaiian stilts favor open wetland habitats with minimal vegetative cover and water depths of less than 9.4 inches (24 cm), as well as tidal mudflats (Robinson et al. 1999). Stilts feed on small fish, crabs, polychaete worms, terrestrial and aquatic insects, and tadpoles (Robinson et al. 1999, Rauzon and Drigot 2002). Hawaiian stilts tend to be opportunistic users of ephemeral wetlands to exploit the seasonal abundance of food (Berger 1972, USFWS 2005a). Hawaiian stilts nest from mid-February through late August with variable peak nesting from year to year (Robinson et al. 1999). Nesting sites for stilts consist of simple scrapes on low relief islands within and/or adjacent to ponds. Clutch size averages four eggs (Hawaii Audubon Society 2005, USFWS 2005a).

Current Threats to the Hawaiian Stilt

The most important causes of decline of the Hawaiian stilt and other Hawaiian waterbirds is the loss of wetland habitat and predation by introduced animals. Barn owls and the endemic Hawaiian short-eared owl are known predators of adult stilts and possibly their young (Robinson et al. 1999, USFWS 2005a). Known predators of eggs, nestlings, and/or young stilts include small Indian mongoose, feral cat, rats, feral and domestic dogs, black-crowned night-heron, cattle egret, common mynah, ruddy turnstone, laughing gull (*Larus atricilla*), American bullfrog (*Rana catesbeiana*), and large fish (Robinson et al. 1999, USFWS 2005a). A study conducted at the Ki‘i Unit of the James Campbell NWR between 2004 and 2005 attributed 45% of stilt chick losses to bullfrog predation over the two breeding periods (USFWS, unpubl. data). The Ki‘i Unit has on-going control programs for mongoose, feral cats, rats, cane toads (*Bufo marinus*), and bullfrogs (M. Silbernagle/USFWS, pers. comm.).

Other factors that have contributed to population declines in Hawaiian stilts include altered hydrology, alteration of habitat by invasive non-native plants, disease, and possibly environmental contaminants (USFWS 2005a). Although the Hawaiian stilt is considered imperiled, it is believed to have high recovery potential with a moderate degree of threat.

Little is known about the interaction of black-necked stilt with turbines in the United States. One black-necked stilt was reported at the Altamont Pass Wind Resource Area from 2005-2007 (Altamont Pass Avian Monitoring Team 2008). The annual adjusted fatality per turbine was 0.00193 stilt per turbine. In general, low mortality of waterbirds has been documented at wind turbines situated coastally, like the proposed Kahuku Wind Power project, despite the presence of high numbers of waterbirds in the vicinity (Kingsley and Whittam 2007, Carothers 2008). Many studies of coastal-wind energy facilities have shown that waterbirds and shorebirds are among the birds most wary of turbines and that these birds readily learn to avoid the turbines over time (Carothers 2008).

Occurrence of the Hawaiian Stilt in the Project Area and Off-site Microwave Towers

No suitable habitat for Hawaiian stilt occurs on the Kahuku Wind Power project area. No Hawaiian stilts were seen flying over the proposed Kahuku Wind Power facility during the avian point count surveys conducted by Kahuku Wind Power LLC and SWCA, although one downed individual was found incidentally on the site next to a temporary met tower. Post-mortem results by USFWS veterinarians indicated that the bird was emaciated and carried a heavy parasite load. As there were no broken bones or abrasions to indicate a collision with the met tower or guy wires, the bird was determined to likely have died of natural causes. However, since the carcass was found at the base of the met tower, the final cause of death was declared indeterminate and not attributed to the met tower (K. Swindle/USFWS, pers. comm.). Because of the known dispersal capabilities of these birds and their regular occurrence at the nearby Ki‘i Unit of James Campbell NWR, it is expected that individual stilts can fly over the Kahuku Wind Power project area on a very irregular basis while moving between wetlands or islands.

Due to the residential nature of the environment at the HECO Wailua substation microwave tower (asphalt roads, traffic, close proximity to houses), no waterbirds are expected to utilize or fly over the site. No habitat suitable for waterbirds occurs at the microwave tower site at Flying R Ranch as well, which consists of non-native forest with no nearby water features. Thus, no Hawaiian stilts are expected to be near the vicinity of either off-site microwave tower.

Hawaiian Coot

Population, Biology, and Distribution of the Hawaiian Coot

The Hawaiian coot is an endangered species endemic to the main Hawaiian Islands, except Kaho‘olawe. The Hawaiian coot is non-migratory and believed to have originated from migrant American coots (*Fulica americana*) that strayed from North America. The species is an occasional vagrant to the northwestern Hawaiian Islands west to Kure Atoll (Pratt et al. 1987, Brisbin et al 2002).

The population of Hawaiian coot has fluctuated between 2,000 and 4,000 birds. Of this total, roughly 80% occur on O‘ahu, Maui, and Kaua‘i (Engilis and Pratt 1993, USFWS 2005a). The O‘ahu population fluctuates between approximately 500 to 1,000 birds. Hawaiian coots occur regularly in the Ki‘i Unit of the James Campbell NWR, with peak counts in 2005 and 2006 reaching nearly 350 birds (USFWS 2002, USFWS 2005a, USFWS unpubl. data). Population fluctuations in these areas are attributed to variations in seasonal rainfall and reproductive success. Inter-island dispersal has been noted and is presumably influenced by seasonal rainfall patterns and food abundance (USFWS 2005a).

Coots are usually found on the coastal plain of islands and prefer freshwater ponds or wetlands, brackish wetlands, and man-made impoundments. They prefer open water that is less than 12 inches (30 cm) deep for foraging. Preferred nesting habitat has open water with emergent aquatic vegetation or heavy stands of grass (Schwartz and Schwartz 1949, Brisbin et al. 2002, USFWS 2005a). Nesting occurs mostly from March through September, with opportunistic nesting occurring at other times of year depending on rainfall. Hawaiian coots construct floating nests of aquatic vegetation, semi-floating nests attached to emergent vegetation or nests in clumps of wetland vegetation (Brisbin et al. 2002, USFWS 2005a). False nests are also sometimes constructed and used for resting or as brooding platforms (USFWS 2005a). Coots feed on seeds, roots, and leaves of aquatic and terrestrial plants, freshwater snails, crustaceans, tadpoles, small fish, and aquatic and terrestrial insects (Schwartz and Schwartz 1949, Brisbin et al. 2002).

Current Threats to the Hawaiian Coot

The USFWS *Second Draft Recovery Plan for Hawaiian Waterbirds* (2005a) lists the Hawaiian coot as having high potential for recovery and a low degree of threats (USFWS 2005a). Introduced feral cats, feral and domestic dogs, and mongoose are the main predators of adult and young Hawaiian coots (Brisbin et al. 2002, Winter 2003). Other predators of young coots include black-crowned night-heron, cattle egret, and large fish. Coots are susceptible to avian botulism outbreaks in the Hawaiian Islands (Brisbin et al. 2002). Wetland loss and degradation has also been noted as contributing to the decline of this species, as stated previously. Low numbers of American coot fatalities have been reported at two wind facilities in California and Minnesota, where standing or ponded water within the project area was an attractant (Erickson et al. 2001).

Occurrence of the Hawaiian Coot in the Project Area and Off-site Microwave Towers

No Hawaiian coots were observed in flight at the Kahuku Wind Power project area during the year-long avian point count survey. However, Hawaiian coots are known to disperse between islands, so there is potential for coots to occasionally fly over the lower elevations of Kahuku Wind Power project area if moving between wetlands or islands. No suitable habitat for Hawaiian coot occurs on the Kahuku Wind Power project area.

Due to the residential nature of the environment at the HECO Waialua substation microwave tower (asphalt roads, traffic, close proximity to houses), no waterbirds are expected to utilize the site. No habitat suitable for waterbirds occurs at the microwave tower site at Flying R Ranch as well, which consists of non-native forest with no nearby water features. Thus, no Hawaiian coots are expected to be near the vicinity of either off-site microwave tower.

Hawaiian Moorhen

Population, Biology, and Distribution of the Hawaiian Moorhen

The Hawaiian moorhen is an endangered, endemic, non-migratory sub-species of the cosmopolitan common moorhen (*Gallinula chloropus*). It is believed that the sub-species originated through colonization of Hawaiʻi by stray North American migrants (USFWS 2005a). Originally occurring on all the main Hawaiian Islands (excluding Lānaʻi and Kahoʻolawe), Hawaiian moorhen is currently limited to regular occurrence on the Islands of Kauaʻi and Oʻahu (Hawaii Audubon Society 2005, USFWS 2005a). A population was reintroduced to Molokaʻi in 1983, but no individuals remain on the island today.

Hawaiian moorhens are very secretive; thus, population estimates and long-term population trends are difficult to approximate (Engilis and Pratt 1993, Hawaii Audubon Society 2005, USFWS 2005a). The population of Hawaiian moorhen appears to be stable, with an average annual total of 314 birds estimated between 1977 and 2002. Approximately half of this population occurs on Oʻahu. Seasonal fluctuations in population have been recorded, although this is believed to be an artifact of sparser vegetation allowing greater visibility in fields in winter than in summer (USFWS 2005a). In 2006, a peak of over 90 moorhens was recorded at the Kiʻi Unit of the James Campbell NWR (USFWS unpubl. data).

In Hawaiʻi, moorhens largely depend on agricultural and aquaculture habitats. They prefer freshwater marshes, taro patches, reservoirs, wet pastures, lotus fields, and reedy margins of water courses. The habitats in which they occur are generally below 410 ft (125 m) in elevation (Pratt et al. 1987, Engilis and Pratt 1993, Hawaii Audubon Society 2005, USFWS 2005a). According to the *Second Draft Recovery Plan for Hawaiian Waterbirds* (2005a), the key components of moorhen habitat are: 1) dense stands of emergent vegetation near open water; 2) slightly emergent vegetation mats; and 3) shallow, freshwater areas. No such habitat is present in the Kahuku Wind Power project area.

Hawaiian moorhens will nest on open ground and wet meadows, as well as on banks of waterways and in emergent vegetation over water (Bannor and Kiviat 2002). Typically, nesting areas have standing water less than 24 in (60 cm) deep. Nesting occurs year-round with the majority of nesting activity occurring from March through August (Bannor and Kiviat 2002, USFWS 2002). Timing of nesting by the Hawaiian moorhen is dependent on water levels and growth of suitable emergent vegetation (USFWS 2002).

Although the specific diet of the Hawaiian moorhen is not known, it is presumed the birds are opportunistic feeders (USFWS 2005a). Moorhens are very closely related to coots, and it is presumed that the diet of Hawaiian moorhens is generally similar to that described above for Hawaiian coot.

Current Threats to the Hawaiian Moorhen

As previously stated, coastal wetland loss and degradation as a result of commercial, residential, and resort developments have been identified as a key threat to the Hawaiian moorhen (Evans et al. 1994, USFWS 2005a). Feral cats, feral and domestic dogs, mongoose, and bullfrogs are known predators of Hawaiian moorhen. Black-crowned night-herons and rats are possible predators (Byrd and Zeillemaker 1981, Bannor and Kiviat 2002, USFWS 2005a). The Hawaiian moorhen is highly susceptible to disturbance by humans and introduced predators (Bannor and Kiviat 2002). The moorhen is considered to have a high potential for recovery with a moderate degree of threats (USFWS 2005a).

Hawaiian moorhens are considered to be at low risk from wind farms because there have only been a few published reports of the closely related common moorhen colliding with turbines in Europe (Ireland, Percival 2003) and Netherlands (Hotker et. al 2006) and none in the United States. This is despite the fact that common moorhens are frequently found around wind turbines located near wetlands. However, one study in Spain lists the common moorhen at “some” collision risk with power lines due to their flight performance and also records one instance of mortality due to collision (Janss 2000).

Occurrence of the Hawaiian Moorhen in the Project Area and Off-site Microwave Tower

No Hawaiian moorhens were detected during the year of avian point count surveys on the Kahuku Wind Power project area or on adjacent wetlands, although the birds are known to occur regularly at the Ki‘i Unit of James Campbell NWR. This lack of detection is likely because moorhens rarely fly, but typically remain within or close to dense vegetation. However, as colonization of Hawai‘i by moorhens does attest, members of the species are able to fly considerable distances when they so desire. It is very unlikely that Hawaiian moorhens regularly fly over the Kahuku Wind Power project area; however, given their ability to fly and their regular occurrence at the nearby Ki‘i Unit of James Campbell NWR, it is possible that individual Hawaiian moorhens will very occasionally fly over the site, especially the lower elevation eastern portion nearest the adjacent wetlands.

Due to the residential nature of the environment at the HECO Wailua substation microwave tower (asphalt roads, traffic, close proximity to houses), no waterbirds are expected to utilize or fly over the site. No habitat suitable for waterbirds occurs at the microwave tower site at Flying R Ranch as well, which consists of non-native forest with no nearby water features. Thus no Hawaiian moorhen are expected to be near the vicinity of either off-site microwave tower.

Hawaiian Short-eared Owl

Population, Biology, and Distribution of the Hawaiian Short-eared Owl

The Hawaiian short-eared owl is an endemic subspecies of the nearly cosmopolitan short-eared owl (*Asio flammeus*). This is the only owl native to Hawai‘i and it is found on all the main islands from sea level to 8,000 ft (2,450 m). The Hawaiian short-eared owl is listed by the State of Hawai‘i as endangered only on the Island of O‘ahu.

Unlike most owls, Hawaiian short-eared owls are active during the day (Mostello 1996, Mitchell et al. 2005), though nocturnal or crepuscular activity has also been documented (Mostello 1996). Hawaiian short-eared owls are commonly seen hovering or soaring over open areas (Mitchell et al. 2005).

No surveys have been conducted to date to estimate the population size of Hawaiian short-eared owl. The species was widespread at the end of the 19th century, but numbers are thought to be declining (Mostello 1996, Mitchell et al. 2005).

Hawaiian short-eared owls occupy a variety of habitats, including wet and dry forests, but are most common in open habitats such as grasslands, shrublands, and montane parklands, including urban areas and those actively managed for conservation (Mitchell et al. 2005). Evidence indicates the owls became established on Hawaiʻi in relatively recent history, with their population likely tied to the introduction of Polynesian rats (*Rattus exulans*) to the islands by Polynesians.

Pellet analyses indicate that rodents, birds, and insects, respectively are their most common prey items of Hawaiian short-eared owls (Snetsinger et al. 1994, Mostello 1996). Birds depredated by Hawaiian short-eared owl have included passerines, seabirds, and shorebirds (Snetsinger et al. 1994, Mostello 1996, Mounce 2008). The Hawaiian short-eared owl relies more heavily on birds and insects than its continental relatives (Snetsinger et al. 1994), likely because of the low rodent diversity of the Hawaiian Islands (Mostello 1996).

Hawaiian short-eared owls nest on the ground. Little is known about their breeding biology, but nests have been found throughout the year. Females perform all incubating and brooding, while males feed females and defend nests. The young may leave the nest on foot before they are able to fly and depend on their parents for approximately two months (Mitchell et al. 2005).

Current Threats to the Hawaiian Short-eared Owl

Loss and degradation of habitat, predation by introduced mammals, and disease threaten the Hawaiian short-eared owl. Hawaiian short-eared owls appear particularly sensitive to habitat loss and fragmentation. Ground nesting birds are more susceptible to the increased predation pressure that is typical within fragmented habitats and near rural developments (Wiggins et al. 2006). These nesting habits make them increasingly vulnerable to predation by rats, cats, and the small Indian mongoose (Mostello 1996, Mitchell et al. 2005).

Some mortality of Hawaiian short-eared owls on Kauaʻi has been attributed to “sick owl syndrome,” which may be caused by pesticide poisoning or food shortages. They may be vulnerable to the ingestion of poisoned rodents. However, in the one study on mortality that has been conducted, no evidence was found that organochlorine, organophosphorus, or carbamate pesticides caused mortality in Hawaiian short-eared owls (Thierry and Hale 1996). Other causes of death on Maui, Oʻahu, and Kauaʻi have been attributed to trauma (apparently vehicular collisions), emaciation, and infectious disease (pasteurellosis) (Thierry and Hale 1996). However, persistence of these owls in lowland, non-native and rangeland habitats suggests that they may be less vulnerable to extirpation than other native birds. This is likely because they may be resistant to avian malaria and avian pox (Mitchell et al. 2005), and because they are opportunistic predators that feed on a wide range of small animals.

Little information is available on the impacts of wind facilities on owls. However, four fatalities of short-eared owl (*Asio flammeus flammeus*) have been recorded at McBride Lake, Alberta, Canada, Foote Creek Rim, Wyoming, Nine Canyon, Wyoming, and Altamont Wind Resource Area, California (Kingsley and Whittam 2007). Hawaiian short-eared owls are present year-round and observed regularly in the vicinity of the KWP facility on Maui, with no fatalities reported in approximately three and a half years of operation. In the vicinity of turbines, most observations of Hawaiian short-eared owl have been below the rotor swept zone of the turbines and thus their susceptibility to collision appears to be low (G. Spencer/First Wind, pers. comm.). At Wolfe Island, Ontario, it was observed that short-eared owls were most vulnerable to colliding with turbine blades when avoiding predators and during aerial flight displays (Stantec Consulting Ltd. 2007). Short-eared owls on Oʻahu have no aerial predators and thus may only be vulnerable to colliding with turbines during flight displays.

Occurrence of the Hawaiian Short-eared Owl in the Project Area and Off-site Microwave Tower

Hawaiian short-eared owls were only detected once at the Kahuku Wind Power project area during the 15-month long avian point count surveys conducted by First Wind and SWCA. One Hawaiian short-eared owl was heard on-site in July 2008 by personnel conducting the radar survey for seabirds. Because these owls are active during daytime and crepuscular periods, it seems probable that they would have been detected more frequently during the avian point counts if resident on-site. Therefore, it seems that Hawaiian short-eared owl is most likely an irregular visitor to the Kahuku Wind Power project area.

No Hawaiian short-eared owls were seen during the wildlife surveys at either microwave tower site. Due to the residential nature of the environment at the HECO Wailua substation microwave tower (asphalt roads, traffic, close proximity to houses), no Hawaiian short-eared owls are expected to utilize this site. Hawaiian short-eared owls may occur at the Flying R Ranch microwave site due to suitable agricultural and forest habitat in the vicinity.

Hawaiian Hoary Bat

Population, Biology, and Distribution of the Hawaiian Hoary Bat

The Hawaiian hoary bat is the only native land mammal present in the Hawaiian archipelago. It is a sub-species of the hoary bat (*Lasiurus cinereus*), which occurs across much of North and South America. Both males and females have a wingspan of approximately 1 ft (0.3 m), although females are typically larger-bodied than males (Mitchell et al. 2005).

The bat has been recorded on Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i, but no historical population estimates or information exist for this sub-species. Population estimates for all islands in the state in the recent past have ranged from hundreds to a few thousand bats (Menard 2001). However, based on monitoring currently underway on the Island of Hawai‘i, the population is estimated to possibly be as high as 100,000 bats on the Island of Hawai‘i alone (F. Bonaccorso/USGS, pers. comm.). The Hawaiian hoary bat is believed to occur primarily below an elevation of 4,000 ft (1,220 m). This sub-species has been recorded between sea level and approximately 9,050 ft (2,760 m) in elevation on Maui, with most records occurring at or below approximately 2,060 ft (628 m) (USFWS 1998).

Hawaiian hoary bats roost in native and non-native vegetation from 3 to 29 ft (1 to 9 m) above ground level. They have been observed roosting in a wide variety of tree species and in fern clumps. The species has rarely been observed using lava tubes, cracks in rocks, or man-made structures for roosting. While roosting during the day, Hawaiian hoary bat are solitary, although mothers and pups roost together (USFWS 1998).

Preliminary study of a small sample of Hawaiian hoary bats (n=18) on the Island of Hawai‘i have estimated short-term (1-2 weeks) home range sizes of 104.8 ± 94.9 (SD) ac (42.4 ± 38.4 ha) with core areas of approximately 13.3 ± 13.6 (SD) ac (5.4 ± 5.5 ha, USGS, unpublished data). The size of home ranges and core areas varied widely between individuals. Core areas included feeding ranges that were actively defended, especially by males, against conspecifics. For some individuals, core areas included night roosts, but typically did not include day roosts. Roosting and feeding areas may be disjunct as the average long-axis (maximum length of home range) was 2.7 ± 2.9 (SD) mi (4.4 ± 4.6 km), with a maximum length of 11.1 mi (17.8 km), indicating that some individuals travelled long distances between roosting and feeding areas.

It is suspected that breeding primarily occurs between April and August. Lactating females have been documented from June to August, indicating that this is the period when non-volent young are most likely to be present. Breeding has only been documented on the Islands of Hawai‘i and Kaua‘i (Baldwin 1950, Kepler and Scott 1990, Menard 2001). It is not known whether bats observed on other islands breed locally or only visit these islands during non-breeding periods. Seasonal changes in the abundance of Hawaiian hoary bat at locations of different elevations indicate that altitudinal migrations occur on the Island of Hawai‘i. During the breeding period (April through August), Hawaiian hoary bat occurrences increase in the lowlands and decrease at high elevation habitats. Hawaiian hoary bat occurrences are especially low from June until August in high elevation areas. In the winter, especially during the post-lactation period in October, bat occurrences increase in high elevation areas and in the central highlands, possibly receiving bats from the lowlands (Menard 2001).

Hawaiian hoary bat feed on a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes and termites (Whitaker and Tomich 1983). Prey is detected using echolocation. Water courses and edges (e.g., coastlines and forest/pasture boundaries) appear to be important foraging areas. The species is also attracted to insects that congregate near lights (USFWS 1998, Mitchell et al. 2005). They begin foraging either just before or after sunset depending on the time of year (USFWS 1998, Mitchell et al. 2005).

Current Threats to the Hawaiian Hoary Bat

The availability of roosting sites is believed to be a major limitation in many bat species. Possible threats to the Hawaiian hoary bat include pesticides (either directly or by impacting prey species), predation, alteration of prey availability due to the introduction of non-native insects, and roost disturbance (USFWS 1998). Management of the Hawaiian hoary bat is also limited by a lack of information on key roosting and foraging areas, food habits, seasonal movements, and reliable population estimates (USFWS 1998).

In their North American range, hoary bats are known to be more susceptible to collision with wind turbines than most other bat species (Johnson et al. 2000, Erickson 2003, Johnson 2005). Most mortality has been detected during the fall migration period. Hoary bats in Hawaiʻi do not migrate in the traditional sense, although as indicated, some seasonal altitudinal movements occur. Currently, it is not known if Hawaiian hoary bats are equally susceptible to turbine collisions during their altitudinal migrations as hoary bats are during their migrations in the continental US. At the KWP facility on Maui, one Hawaiian hoary bat fatality has been recorded after three and a half years of operation. This incident occurred in late September at an elevation of approximately 2750 ft (838 m) above sea level (SWCA and First Wind 2010).

Occurrence of the Hawaiian Hoary Bat in the Project Area and Off-site Microwave Towers

Three to five Anabat detectors were deployed in various locations on the Kahuku Wind Power project area. Anabat detectors detect the presence of bats by recording ultrasonic sounds emitted by bats during echolocation. These studies are presently still on-going. Anabat detectors that did not detect bat calls after a month were moved to new locations to increase the area sampled at the project area.

Bat activity recorded by the Anabat detectors from April 2008 to April 2009 were at a rate of 0.0130 bat passes/detector/night or 0.016 bat call sequences/detector/night (see HCP). The year-long data suggests that bat activity may increase from June to September and are lowest or absent from December to February. The detection rates at Kahuku Wind Power are 40-fold lower than detection rates recorded at Hakalau National Wildlife Refuge on the Island of Hawaiʻi, (0.660 passes/detector/ night; F. Bornaccorso, unpublished report). Bat activity at the Kahuku Wind Power project area was similar to the post-construction bat activity recorded at the Kaheawa Wind Power project, which had an activity rate of 0.014 bat call sequences/detector/night (Kaheawa Wind Power LLC 2009). One observed fatality has been recorded at the KWP facility after 3.5 years of project operation (SWCA and First Wind 2010).

The actual number of bats represented by the detections made by the Anabat detectors on the Kahuku Wind Power site is not known. No bats were sighted at the Kahuku Wind Power project area during the nocturnal point count surveys conducted from October 2007 through December 2008. Day and Cooper (2008) visually observed one Hawaiian hoary bat on-site incidental to the seabird radar survey in July of 2008. Given these results, it is presumed that a very small number of Hawaiian hoary bats forage over the Kahuku Wind Power project area on a somewhat regular, though possibly seasonal, basis.

No surveys for Hawaiian hoary bats were conducted at either microwave tower site. As bats may forage in a wide variety of habitats, and may congregate near lights, bats may occur at either the HECO Waialua substation microwave tower site (rural) or the Flying R Ranch site (agricultural).

POTENTIAL IMPACTS OF THE PROPOSED ACTION

This appendix provides a summary of expected direct and indirect impacts. Much more extensive information concerning potential effects of the project on listed wildlife is contained in the Kahuku Wind Power State HCP (SWCA and First Wind 2010).

Construction and operation of Kahuku Wind Power would create the potential for federally and state-listed bird and bat species to collide with wind turbines, temporary and permanent met towers, overhead collection lines, relocated distribution lines, and cranes used for construction of the turbines. No listed species are considered to have potential to collide with either proposed off-site microwave tower. The potential for each listed species to collide with on-site project components was identified based on the results of the on-site surveys and the proposed project design. Fatality estimate models were developed that incorporated rates of species occurrence, observed flight heights, encounter rates with turbines and met towers, and considered ability of birds to avoid project components. Ability of birds to avoid turbines was then varied in the models to create a range of probabilities of mortality for each species on an annual basis. Range of expected mortality coincides with the amount of "direct take" expected from construction and operation of the Kahuku Wind Project.

In addition to "direct take," mortality of listed species resulting from collisions with project components can also result in "indirect take." For example, it is possible that adult birds killed through on-site collisions could have been tending to eggs, nestlings, or dependent fledglings, or adult bats could have been tending to dependent juveniles. The loss of these adults would then also lead to the loss of the eggs or dependent young. Loss of eggs or young would be "indirect take" attributable to the proposed project. Methods for determining indirect take are described in detail in the HCP.

The terms and equations discussed are presented below:

Total Direct Take = Observed Take + Unobserved Take
Adjusted Take = Total Direct Take + Indirect Take

"Total Direct Take" will be calculated based on an estimator approved by USFWS and DLNR such as the one proposed in Huso (2008), presented below:

$$\hat{m}_{ij} = \frac{c_{ij}}{\hat{r}_{ij}\hat{p}_{ij}\hat{e}_{ij}}$$

where

$\mathbf{m_{ij}}$	estimated mortality
$\mathbf{r_{ij}}$	estimated proportion of carcasses remaining after scavenging
$\mathbf{e_{ij}}$	effective search interval
$\mathbf{p_{ij}}$	estimated searcher efficiency
$\mathbf{c_{ij}}$	Observed take

No direct or indirect take of listed species is expected to result from on-site habitat disturbances. The only listed species with potential to occur regularly "on the ground" in the project area are Hawaiian hoary bat, which have shown very low but regular activity rates on site and could theoretically roost in trees on the property, and Hawaiian short-eared owl, which may roost in low vegetation or nest on the ground within the property. Hawaiian hoary bats breed at low elevations, so it is possible dependent juvenile bats occur in the project area during the months of June to August. Likewise, the project area possibly does contain suitable nesting habitat for Hawaiian short-eared owl, though the occurrence of regular breeding on site is considered highly unlikely because of only one visual observation of a Hawaiian short-eared owl during the year-long avian surveys. Vegetation clearing for the project will be performed during times of year when Hawaiian hoary bats are not expected to be breeding in order to avoid potential for harm to non-volent juvenile bats. As Hawaiian short-eared owls breed year round, it is not possible to time clearing activities to avoid potential for conflict with nesting by this species. Vegetation clearing will be suspended within 300 ft (91 m) of any area where distraction displays, vocalizations, or other indications of nesting by adult Hawaiian short-eared owl are seen or heard, and resumed when it is apparent that the young have fledged or other confirmation that nesting is no longer occurring.

For most of the Covered Species, expected rates of take are expected to average less than one individual per year. DOFAW-DLNR requires that applications for ITLs request take authorizations in terms of whole numbers of individuals. Consequently, the HCP also identifies the whole number of individuals for which take authorization is being sought by Kahuku Wind Power LLC. However, those numbers reflect requested level of take authorization rather than the expected rate at which mortality would occur (i.e., the actual impact of the Proposed Action). A summary of the estimated and requested take of the Covered Species is provided in Table 2.

The whole number of individuals for which take authorization is being sought by Kahuku Wind Power LLC is referred to in the HCP and herein as the Baseline level of take. Take exceeding the Baseline level is referred to in the HCP as a Higher level of take, while take occurring at a rate below Baseline is referred to as a Lower rate.

Table 2. Summary of estimated and requested authorized take of Covered Species at the Kahuku Wind Power facility.

Covered Species	**Expected Rate of Take**		**Requested ITL Authorization**	
	Annual	***20-Yr Project Life***	***Annual***	***20-Yr Project Life***
Hawaiian petrel	0.17 adults 0.17 chicks	4 adults 4 chicks	2 adults 2 chicks	4 adults 4 chicks
Newell's shearwater	0.34 adults 0.16 chicks	7 adults 4 chicks	2 adults 1 chick	8 adults 4 chick
Hawaiian duck	0.026 adults 0.031 ducklings	1 adult 1 duckling	2 adults 2 ducklings	8 adults 8 ducklings
Hawaiian stilt	0.026 adults 0.0012 chicks	1 adult 1 chick	2 adults 1 chicks	8 adults 4 chicks
Hawaiian coot	0.026 adults 0.012 chicks	1 adult 1 chick	2 adults 1 chicks	8 adults 4 chicks
Hawaiian moorhen	0.026 adults 0.017 chicks	1 adult 1 chick	2 adults 2 chicks	8 adults 6 chicks
Hawaiian short-eared owl	0.33 adults 0.31 owlets	7 adults 7 owlets	2 adults 2 owlets	8 adults 8 owlets
Hawaiian hoary bat	0.19 adults 0.34 juveniles	4 adults 7 juveniles	5 adults 3 juveniles	12 adults 9 juveniles

Mitigation Measures

Mitigation measures proposed by Kahuku Wind Power LLC to compensate for the expected impacts of the project were selected in collaboration with biologists from USFWS, DLNR-DOFAW, First Wind, and SWCA, and with members of the ESRC. The mitigation proposed to compensate for impacts to these species is based on anticipated levels of incidental take as determined through on-site surveys, modeling, and the results of post-construction monitoring conducted at other wind projects in Hawai'i and elsewhere in the United States. Mitigation takes into account the expected annual rate of direct and indirect take. Mitigation measures proposed by Kahuku Wind Power LLC to compensate for potential impacts to Covered Species are included in the various sections below. A summary of mitigation efforts proposed by Kahuku Wind Power for the Covered Species is provided in Table 3. A more detailed description of the criteria used for determining appropriate mitigation measures is outlined in the State HCP (SWCA 2009).

Table 3. Proposed mitigation for the Covered Species: Lower, Baseline and Higher Take Scenarios.

Species	**Proposed Mitigation by Measured Take Level**		
	Lower	**Baseline**	**Higher**
Seabirds	Same as Baseline	Mitigation for Newell's shearwater and Hawaiian petrel at Makamakaʻole or other suitable seabird nesting sites on Maui or Kauaʻi or elsewhere	Increased mitigation efforts at the same site or additional mitigation measures at one or more additional sites on Maui or Kauaʻi or elsewhere
Waterbirds	Same as Baseline	Predator control and vegetation maintenance at Hamakua Marsh for 3 to 5 years; subsequent mitigation efforts to meet baseline requested take as required	Additional mitigation efforts at Hamakua Marsh or predator control and monitoring at additional wetlands
Hawaiian short-eared owl	Same as Baseline	Upfront contribution of $25,000 for research and rehabilitation and $25,000 up to a maximum of $50,000 for management as it becomes available	Additional funding of $15,000 for research and rehabilitation and $15,000 up to a maximum of $30,000 to implement management strategies
Hawaiian hoary bat	Same as Baseline	Up to a maximum of $150,000 for management of bat habitat	Low-wind speed curtailment and additional funding of $15,000 up to a maximum of $75,000 for management

In addition to species-specific measures, general wildlife-related measures have also been proposed by Kahuku Wind Power LLC. A wildlife education and observation program will be conducted for all regular on-site staff. The program will be long-term, on-going, and updated as necessary. Staff will be trained to identify listed and non-listed native species of birds that may be found on-site, to record observations of species protected by the ESA and/or MBTA, and to take appropriate steps when and if downed wildlife is found. As part of their safety training, temporary employees, contractors, and any others that may drive project roads will be educated as to project road speed limits (10 mph), the possibility of downed wildlife being present on roads, and the possibility of Hawaiian short-eared owls flying across roads. These types of personnel will be instructed to contact the Site Safety Officer immediately if they detect any downed wildlife on-site.

The protocol for the recovery, handling, and reporting of downed wildlife will follow that developed for KWP on Maui (Kaheawa Wind Power LLC 2006). This protocol was developed in cooperation with DLNR and USFWS. All regular on-site staff will be trained in the protocol which will include documenting all observed mortality or injury to wildlife (including MBTA-protected birds not otherwise covered by the Kahuku Wind Power HCP). USFWS and DLNR will be notified promptly upon discovery of an injured or dead federally listed species. Any federally listed species found dead or injured in the project area will be left as found for collection by USFWS personnel, but will be photo-documented and guarded against scavenging. Injured listed species will be photographed from a discrete distance and monitored. Collections will be made only by staff personnel permitted by USFWS and DLNR to handle and salvage wildlife (see HCP for more detail).

Seabirds (Newell's Shearwater and Hawaiian Petrels)

Seabird mortality due to collisions with human-made objects, such as power lines, has been documented in Hawaiʻi on the Islands of Maui (Hodges 1994) and Kauaʻi (Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998). At the KWP facility on Maui, only a single seabird mortality (an adult Hawaiian petrel) has been documented since operations began in June 2006 (Kaheawa Wind Power, LLC 2008). Modeling of expected impacts to Newell’s shearwater and Hawaiian petrel as identified below was performed by Day and Cooper (2008). Mitigation measures proposed to compensate for impacts to Newell’s shearwater and Hawaiian petrel are identified following the impact assessment for Hawaiian petrel.

Newell's Shearwater

Impacts from Turbines and Met Towers

Day and Cooper (2008) estimated that direct take of Newell’s shearwater at Kahuku Wind Power would range from approximately 0.00374 and 0.05643 shearwaters/turbine/year (based on 90-99% avoidance rates). This equates to an average annual fatality rate ranging between 0.04488 and 0.67716 shearwaters per year for all 12 turbines. The annual fatality rate due to collisions with met towers was expected to range between 0.001622 and 0.01622 shearwaters/tower (Day and Cooper 2008). Accordingly, the total estimated average fatality rate for the 12 turbines and one permanent met tower is projected to range between approximately 0.0465 – 0.6934 shearwaters/year. Observed fatality rates at existing projects suggest that petrels and shearwaters actually exhibit an avoidance rate approximating 95% or greater with respect to wind turbines and other tall objects in their airspace. The estimated average fatality rate at a 95% avoidance level for all 12 turbines and one met tower equates to approximately 0.34 shearwaters/year.

Impacts from Other Project Components

In addition to collisions with turbines and met towers, some limited potential exists for shearwaters to collide with cranes during the construction phase of the project. Cranes used during construction are typically comparable in height to the turbine towers (Kaheawa Wind Power, LLC 2006). However, the construction phase is expected to last less than six months, with cranes on-site for only three to four months. Given the brevity of the construction period and the low occurrence rate of the species, potential for Newell’s shearwaters to collide with construction cranes is considered to be negligible.

Potential for shearwaters to collide with the on-site and off-site microwave towers, overhead collection lines, relocated distribution lines, and utility poles also exists. All these structures are 60 ft tall or less. Studies have shown that only 1% of Newell’s shearwaters (n = 688 birds; B. Cooper, pers. comm.) fly below 60 ft and of these individuals, the estimated collision avoidance rate is 97% (Day et al., In prep). Given that the seabird traffic rate on O‘ahu is extremely low, the likelihood of a seabird flying at such low altitudes and colliding with the microwave towers, overhead collection lines, relocated distribution lines and utility poles related to the project is considered to be remote.

To our knowledge, no seabird mortality (or mortality of any other listed species) has been recorded at the existing Crown Castle tower near Flying R Ranch or at the Waialua Substation site, although we also are not aware that any systematic mortality monitoring has been conducted at these locations. Because the proposed Waialua Substation and Flying R Ranch towers would be located in areas with structures similar in height to the proposed microwave towers (utility poles, street pole, etc.) and associated overhead cables, the towers are not expected to create a significant collision hazard to any Covered Species if they should happen to transit the tower location.

Therefore, none of these structures were identified as a potential source of take of Newell's shearwater in the mortality modeling performed for the species and, thus, the amount of take requested to be authorized through the ITL is based solely on mortality expected to occur as a result of construction and operation of the WTGs and met towers.

However, if in the unlikely event a seabird mortality is found in the future and that mortality can be attributed to the on-site construction cranes, Kahuku Wind Power on-site or off-site microwave towers, associated overhead cables or utility poles Kahuku Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site. After commissioning, the lease for both offsite microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS).

Impacts from Project Related Activities

Some potential also exists for construction or maintenance vehicles to strike downed shearwaters (birds already injured by collision with turbines or towers) while traveling project roads. Project personnel will be trained to watch for downed shearwaters and other wildlife and speed limits (10 mph) will be emplaced and enforced to minimize potential for vehicular strikes to result in death of birds that otherwise might have been able to be rehabilitated. Despite this, it is assumed that day-to-day maintenance of the wind facility may very occasionally result in the fatality of a shearwater. This source of mortality does not result in an increase in the amount of direct take expected from the proposed project because these birds are accounted for in the mortality modeling.

Therefore, it is projected that take of Newell's shearwater as a result of collision with project-related components and vehicle strikes will occur at the average rate of 0.34 shearwaters/year.

Indirect Take and Take Limits

Adult birds are most likely to collide with turbines and associated structures while commuting between nesting and feeding grounds during incubation or chick feeding periods. This is generally the period of June through October. Potential also exists for shearwaters to collide with turbines in April, when scouting for nesting sites takes place. Newell's shearwaters are not expected to be flying across the project area at other times of year. Based on the above, an indirect take assessment would be applied to any adult shearwaters found directly taken during the period of 1 June through 31 October. Indirect take would not be assessed to adult shearwaters found at other times of year or applied to immature shearwaters. Little information is available for Newell's shearwaters on nestling growth rates and development or adult visitation rates. Therefore, it is assumed that care by both parents is necessary throughout the breeding season for a chick to fledge successfully. Indirect take would be applied at the rate of 0.46 chicks per adult. The calculation used to reach this number is presented in Table 4 below (life history data presented can be found in the HCP).

Table 4. Calculation of indirect take for Newell's shearwater.

Newell's shearwater	Season	Average no. of chicks per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Adult	Jun-Oct	1	0.46	1.0	0.46
Adult	Nov - May	--	0.00	--	0.00
Immature	All year	--	0.00	--	0.00

Actual expected rates of take and rates of take requested to be authorized by the Baseline ITL through the expected 20-year life of the project are summarized below. Also identified below are rates of take proposed to qualify as "Lower," and "Higher" for purposes of identifying when it would be appropriate or necessary to consider adaptive management practices.

Expected Rate of Take

Annual average	0.34 adults/immatures and 0.16 chicks	0.50 birds/year
20-year project life	7 adults/immatures and 4 chicks	

Requested ITL Authorization

Baseline annual level of take	2 adults/immatures and 1 chick	3 birds/year
5-year limit of take	6 adults/immatures and 3 chicks	
20-year limit	8 adults/immatures and 4 chicks	

Higher Rate of Take

One-year period	Total direct take of 3 – 4 adults/immatures and 1 – 2 chicks
5-year period	Total direct take of 7 – 8 adults/immatures and 3 – 4 chicks

20-year limit	Total direct take of 9 - 12 adults/immatures and 4 – 6 chicks

Lower Rate of Take

5-year period	Total direct take of 0 adults/immatures and 0 chicks

The most recent population estimate of Newell's shearwater was approximately 84,000 birds, with a possible range of 57,000 to 115,000 birds (Ainley et al. 1997). However, radar studies and population modeling have indicated that the population of Newell's shearwater is likely on a decline especially on Kaua'i (Ainley et al. 2001, Day et al. 2003). Declines in Newell's shearwater populations are attributed to loss of nesting habitat, predation by introduced mammals (mongoose, feral cats, rats, and feral pigs) at nesting sites, and fallout of juvenile birds associated with disorientation from urban lighting (Ainley et al. 1997, Mitchell et al. 2005, Hays and Conant 2007).

The expected loss of an average of 0.5 shearwater per year (0.34 adult shearwater and 0.16 chicks) is approximately 0.0005% to 0.001% of the estimated Newell's shearwater population. Given these very low percentages, it is considered extremely unlikely that take caused by the proposed project would result in significant adverse effects to Newell's shearwater at the population level.

However, rates of take at the Higher level may present a greater risk for the subset of the population that breeds on O'ahu, which is poorly known but presumed small. Higher rates of take are expected to occur only in the unlikely event that less than 90 percent of the shearwaters passing over the site fail to detect and avoid the turbines and met towers (Day and Cooper 2008).

Predation by introduced mammals and downing due to urban lighting are considered the primary threats to the recovery of Newell's shearwater. Proposed mitigation measures are expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. For this reason, no significant adverse impacts to the species' overall population are anticipated.

Hawaiian Petrel

No birds believed to be Hawaiian petrels were recorded flying over the site during the radar studies, and their documented numbers on O'ahu are very low. Because no Hawaiian petrels were identified flying over the site, mortality modeling for this species would identify an expected rate of take of zero. Given the results of the radar studies and the very low number of petrels believed to occur on O'ahu, it does seem that the risk of the proposed project causing take of this species is very low, but not zero. Therefore, it is assumed that the average annual direct take of adult Hawaiian petrel will be half that of Newell's shearwater (0.34 shearwaters/year), or 0.17 petrels/year. This estimate includes potential fatality caused by turbines, met towers, on-site and off-site microwave towers, overhead cables, utility poles, and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

After commissioning, the lease for both off-site microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS.

As with Newell's shearwater, adult petrels have the potential to collide with turbines and associated structures while commuting between nesting and feeding grounds during the pre-laying period (late February to April) and incubation or chick-feeding periods (May through October). Indirect take accounting for possible loss of eggs or chicks would be assessed to any direct take of Hawaiian petrels occurring during the breeding period of May through October, but would not be assessed if direct take of this species occurs during the pre-laying period or at other times of year. The risk of collision outside the pre-laying period or breeding season is considered minimal as these birds do not return to land during that time.

Potential for survival of a chick following a collision by one of its parents appears dependent upon the time at which the parent is lost. Both parents alternate incubating the egg (May-June), allowing one or the other to leave the colony to feed. Therefore, it is believed that both parents are essential for the successful hatching of the egg (Simons 1985). Both parents also contribute to the feeding of chicks. Chicks are fed 95% of all food they will receive from their parents within 90 days of hatching (Simons 1985). Because hatching generally occurs in late June, chicks should have received 95% of their food by the end of September. After this time, it is likely that many chicks could fledge successfully without further parental care as some chicks have been recorded as having been abandoned by their parents up to three weeks prior to fledging (Simons 1985). Consequently, it is considered probable that after September many chicks would be capable of fledging if subsequent care was provided by only one parent. Based on this, for assessing indirect take, it will be considered that both parents are essential to the survival of a Hawaiian petrel chick through September, but that a chick has a 50% chance of fledging successfully if adult take occurs in October.

Not all adult Hawaiian petrels visiting a nesting colony breed every year. Simons (1985) found that 11% of breeding-age females at nesting colonies were not breeding. Most non-breeding birds and failed breeders leave the colony for the season by mid-August (Simons 1985). Therefore, it appears there would be an 89% chance that an adult petrel taken from May through August was actually breeding, but nearly a 100% chance that birds taken in September or October would be tending to young. Based on the above life history parameters and information identified in Table 5 below, indirect take would be assessed at the rate of 0.89 chick per adult taken between May and August, 1.00 chick per adult taken in September, and 0.50 chick per adult taken in October (life history data presented can also be found in the HCP).

Table 5. Calculation of indirect take for Hawaiian petrel.

Hawaiian petrel	Season	Average no. of chicks per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Adult	May-Aug	1	0.89	1.0	0.89
Adult	Sept	1	1.00	1.0	1.00
Adult	Oct	1	1.00	0.5	0.50
Adult	Nov - Apr	--	0.00	--	0.00
Immature	All year	--	0.00	--	0.00

Based on estimated rates of direct and indirect take, annual take of this species resulting from project operations is expected to average well less than one bird per year (0.17 adult/year + (maximum 1 chick/year x 0.17) = 0.34 bird/year). Birds taken through assessment of “unobserved direct take” will be assumed to have been adults lost during the breeding season.

The total direct take of two adults per year could result in an indirect take assessment of a maximum of two chicks. Consequently, the Applicant suggests the Baseline ITL should allow for a total direct take of two Hawaiian petrels and the indirect take of two chicks per year of project operation. Expected rates of take and rates of take requested to be authorized by the ITL through the expected 20-year life of the project are summarized below, along with rates of take considered to qualify as “Lower” and “Higher.”

Expected Rate of Take

Annual average	0.17 adults/immatures and 0.17 chicks	0.34 birds/year
20-year project life	4 adults/immatures and 4 chicks	

Requested ITL Authorization

Baseline annual level of take	2 adults/immatures and 2 chicks	4 birds/year
5-year limit of take	4 adults/immatures and 4 chicks	
20-year limit	4 adults/immatures and 4 chicks	

Higher Rate of Take

One-year period	Total direct take of 3 - 4 adults/immatures and 3 – 4 chicks
5-year period	Total direct take of 5 – 6 adults/immatures and 5 – 6 chicks

20-year limit	Total direct take of 5 - 6 adults/immatures and 5 – 6 chicks

Lower Rate of Take

5-year period	Total direct take of 0 adults/immatures and 0 chicks

The current population of Hawaiian petrel is estimated to be approximately 20,000 birds, with 4,000 to 5,000 breeding pairs (Mitchell et al. 2005). The average rate of take of Hawaiian petrel is expected to be no more than 0.34 petrel/year (0.17 adult and 0.17 chick). This represents less than 0.009% of the estimated Hawaiian petrel breeding population and less than 0.002% of the estimated total population. Given these very low percentages, it is considered extremely unlikely that take of Hawaiian petrel caused by the proposed project would result in significant adverse effects to Hawaiian petrel at the population level.

Rates of take at the Higher level may present a greater risk for the subset of the population that breeds on O‘ahu, which is poorly known but presumed small if present at all. However, higher take levels are considered very unlikely to occur since this species was not believed to have been recorded flying over the project area during the radar survey (Day and Cooper 2008). Thus, significant adverse effects to O‘ahu populations of Hawaiian petrel are not expected.

Predation by introduced mammals and downing due to urban lighting are considered the primary threats to recovery of Hawaiian petrel. Proposed mitigation measures are expected to more than offset the anticipated take and contribute to the species’ recovery by providing a net conservation benefit, as required by State law. For this reason, no significant adverse impacts to the species’ overall populations are anticipated.

Seabird Mitigation

Radar studies documented passage of very few targets resembling Newell’s shearwaters and no definitive Hawaiian petrels over the project area and because of this, the level of take of Newell’s shearwater and Hawaiian petrel on-site is anticipated to be very low. As Newell’s shearwaters are suspected to breed on O‘ahu only in small numbers, and nesting pairs are likely to be widely scattered (IUCN Red List 2009, G. Spencer/FirstWind, pers. comm.), finding a seabird colony on O‘ahu where implementing mitigation measures is practicable and cost effective is not expected. Therefore, with the concurrence of ESRC, USFWS, and DLNR, mitigation for the possible take of seabirds for the Kahuku Wind Power project will be implemented at known Hawaiian petrel and Newell’s shearwater breeding colonies on Maui, Kaua‘i or elsewhere to provide a net benefit and maximize contributions to the recovery goals of the two species.

Mitigation for seabirds takes into account the expected annual rate of direct and indirect take. Replacement for take of adults or juveniles will include replacement by either increased adult survival or increased fledging success. If increases in adult survival rates at the nesting sites can be demonstrated, then it may be possible to replace a taken adult directly with another adult. However, when replacement is provided by fledglings, the rate of survival to adulthood will be taken into account to ensure that a sufficient number of fledglings reach adulthood to replace those adults incidentally taken.

In addition, because Hawaiian petrels and Newell’s shearwaters mature at age 5 and 6 years, respectively, mitigation also takes into account the loss of offspring that may have been produced by taken adults during the time that it takes for replacement fledglings to reach sexual maturity. Juvenile survival rates to adulthood are assumed to be 30% for the Hawaiian petrel (Simons and Hodges 1998) and 24% for Newell’s shearwater (Ainley et al. 2001). The loss of productivity is calculated based on the percentage of the adult population breeding per year, yearly adult survivorship, and the reproductive success of a pair or individual (see HCP). At the suggestion of USFWS, it is assumed that it could require up to two years for a bird that has lost its mate to a collision event to find a new mate and begin reproducing again. Therefore, in calculating lost productivity, for each of the first two years following an incidental take, lost reproductive success is assumed to be the average annual productivity of a pair. In subsequent years, lost productivity is assumed to be half that rate (i.e. the lost production attributable to the taken individual as its former mate by then will be assumed to again be breeding with a new mate).

Table 6 below lists the yearly number of fledglings required to be produced to offset the Baseline level of take anticipated at Kahuku Wind Power assuming same-year replacements for the direct take of adults and indirect take of fledglings. If an increase in adult survival is demonstrated, then a one-for-one replacement for adults is also possible.

Table 6. Baseline Mitigation Required for Hawaiian Petrel and Newell's Shearwater.

Species	**Baseline take level**			**Average annual fledgling production requirement**
Hawaiian petrel	20-year take limit	Adults	4	
		Fledglings	4	
	Annual average	Adults	0.2	0.67 (=0.2 / 0.30[a])
		Fledglings	0.2	0.2
	Total fledglings			**0.87**
	Total loss of productivity (years 1 and 2)			0.23 (=0.2 x 0.89[b] x 0.93[c] x 0.7[d] x 2)
	Total loss of productivity (years 3 and 4)			0.12 (=0.2 x 0.89[b] x 0.93[c] x (0.7[d]/2) x 2)
	Total fledglings required per year			**1.22**
Newell's shearwater	20-year take limit	Adults	8	
		Fledglings	4	
	Annual average	Adults	0.4	1.67 (=0.4 / 0.24[a])
		Fledglings	0.2	0.20
	Total fledglings			**1.87**
	Total loss of productivity (years 1 and 2)			0.23 (=0.40 x 0.46[b] x 0.90[c] x 0.7[d] x 2)
	Total loss of productivity (years 3 - 5)			0.17 (=0.40 x 0.46[b] x 0.90[c] x (0.7[d]/2) x 3)
	Total fledglings required per year			**2.27**

[a] fledgling survival to adulthood
[b] percentage of the adult population breeding per year
[c] yearly adult survivorship
[d] reproductive success of a pair

Baseline Mitigation for Shearwater and Petrel

It is proposed that Baseline mitigation for both seabird species will consist of predator trapping or habitat and colony enhancement at a seabird colony on Maui, Kauaʻi or elsewhere. Downed Newell's shearwaters may also be rehabilitated as part of a mitigation alternative. Currently, the preferred mitigation site is situated on West Maui at Makamakaʻole. Mitigation efforts at this seabird colony are already on-going and currently consist of trapping of cats and mongoose by KWP (Kaheawa Wind Power LLC, 2009). As described below, several alternatives have been developed for Kahuku Wind Power to complement the management activities occurring at this seabird colony.

Alternative 1 for Baseline Mitigation

Discussions with ESRC, USFWS, and DOFAW have led to a recommendation that Kahuku Wind Power, KWP, and KWP II[2] pool resources and implement a comprehensive plan for seabird colony

---

[2] Kaheawa Wind Power (KWP) II, a Maui wind power generation project, is seeking a section 10(a)(1)(B) permit from the USFWS to authorize the incidental take of Hawaiian petrel and Newell's shearwater, among other species.

management at Makamakaʻole. Collectively, KWP, KWP II, and Kahuku Wind Power would pool funding to implement a fencing and predator trapping (and if needed a social attraction) project. The area to be fenced shall have the potential to encompass the target number of burrows to meet the Baseline mitigation requirements for all three projects. The cat-proof fence will be approximately 1.6 – 2 miles (2.6 – 3.2 km) long, the actual length and location of the fence and the size of the enclosed area will be determined in concurrence with USFWS and DLNR. Ideally the identified area will have enough naturally occurring burrows to meet the Baseline mitigation requirements. The Applicant will coordinate closely with USFWS and DLNR to conduct site feasibility assessment within the first year of permit issuance. Kaheawa Wind Power will also revise the existing Makamakaʻole Mitigation Plan and submit the plan as part of the feasibility analysis. The fencing and subsequent predator control will only be implemented if the results of the feasibility assessment are indicative of a high probability of being able to meet the net conservation benefit requirement for all three projects via the specified measures. A decision will be made by September 1, 2010 whether to fence the specified area.

If a decision is made to construct the fence, all applicable permits will be obtained and the fence will be constructed within the first year of project operation, as practicable. Fencing will only be conducted during the non-breeding season of the two Covered seabird species. Following the erection of the fence, cats and mongoose will be eradicated within the area, and rat populations will be controlled. Cat, rat, and mongoose activity will be monitored within the fenced area using track pads and other suitable methods. Monitoring will also be conducted to document the effects of reduced predation on seabird survival and productivity within the enclosure.

If insufficient naturally occurring burrows are found within the fenced area, the Applicant will consult with USFWS and DLNR to determine the next most appropriate action. One alternative is to implement social attraction techniques for both Covered seabird species within the fenced area to increase the number of active burrows. Social attraction will consist of broadcasting vocalizations of nesting Hawaiian petrels and/or Newell's shearwaters (whichever is needed) during the prospecting and breeding season to encourage nesting within the area. Artificial burrows would be installed to increase available nesting habitat. Natural and artificial burrows would be monitored to document the success of the social attraction study.

If the fencing and social attraction study is deemed successful by USFWS and DLNR, the fence will be maintained throughout the life of the three projects and monitoring in the enclosure for cats and mongoose will continue and these species will be re-eradicated if they are found to have breached the fence. If the social attraction and fencing study is deemed to be unsuccessful, mitigation efforts up to that point will be sufficient to meet the Baseline requested take of all three projects (see HCP).

The actual measures implemented at Makamakaʻole will be determined in concurrence with DLNR, USFWS, Kahuku Wind Power, KWP, and KWP II. Input will be sought from the Seabird Recovery Group for the State of Hawaiʻi. However, if mitigation efforts at another seabird colony are identified as a greater need or having a greater potential benefit, priority will be given to other colonies on East Maui, West Maui or Kauaʻi or in other areas as determined by DLNR and USFWS.

Alternative 2 for Baseline Mitigation

One possible mitigation alternative that has emerged for Hawaiian petrels through discussion with the National Park Service at Haleakalā National Park is the opportunity to participate in the management of the Hawaiian petrel colony breeding in the crater of Haleakalā. This alternative also has the potential to be a combined effort of Kahuku Wind Power with KWP I and KWP II, however it is presented here as an alternative for Kahuku Wind Power. This site has the largest known breeding colony of Hawaiian petrels (USFWS 2005, Hodges and Nagata 2001) with over 1,000 known nests in and around Haleakala Crater. The National Park Service has indicated that an approximately 220 ac (89 ha) area with approximately 100 burrows are protected from habitat damage by feral goats and pigs, but are not protected from predators. The National Park Service does not have funds to conduct the needed predator control in this area and does not anticipate receiving funds in the near future (K. Bailey/NPS, pers. comm., Figure 7). If Kahuku Wind Power participates in the management effort, Kahuku Wind Power will contract the labor and purchase equipment (e.g., traps and bait) required to conduct predator trapping in this area (or a section thereof, depending on mitigation requirement), and to conduct monitoring to document success. Trapping and monitoring protocols used will closely follow the protocols that have already been established by the National Park Service for managing the rest of the colony (Hodges and Nagata 2001). This effort would run for an initial period of five years. If after the initial five years of predator trapping, mitigation is still not at least one fledgling above Baseline requested take, mitigation will continue until that is achieved (see HCP). The limits of the area to be treated, need for additional years of treatment and other details of the mitigation efforts will be decided with concurrence of the National Park Service, DLNR and USFWS. If this alternative were to become a combined effort of all three wind projects then the size of the area and number of years of effort would be determined in concurrence with DLNR and USFWS.

For Newell's shearwater, Kahuku Wind Power proposes to provide support for colony-based protection and productivity enhancement on Kaua'i. This may involve supplementing an island-wide HCP developed for the island of Kauai in proportion to the authorized take and any loss of productivity that may occur in the interim. If the island-wide HCP does not come into fruition within 3 years, then colony-based mitigation will be implemented, either by Kahuku Wind Power alone or as part of a cooperative effort with another entity. Several known colonies on Kaua'i presently receive little or no management attention, and it is considered highly probable that other colonies remain to be discovered. The site chosen by Kahuku Wind Power for colony-based mitigation would be selected with the concurrence of the DLNR and USFWS. Kahuku Wind Power would either support an existing conservation need at a known colony or direct mitigation at a newly discovered colony where no management presently exists. The success of the mitigation efforts of Kahuku Wind Power will be measured using the method that is currently implemented at that site at the time. If the chosen mitigation site was previously unmanaged, the same measures of success used to estimate success at managed sites will be applied as appropriate. Funding has been provided in the budget to allow for the maximum cost scenario, i.e., providing mitigation for petrels at Haleakala National Park, and colony protection and management for Newell's shearwaters on Kaua'i.

Mitigation for Higher Rates of Take of Petrel and Shearwater

Results of post-construction monitoring will be evaluated to determine whether rates of seabird take are exceeding Baseline levels (see HCP for a detailed explanation).

If take levels are found to be occurring at Higher rates, Kahuku Wind Power will increase the amount of funding provided for fencing and predator control efforts or other mitigation measures. Additional funding could be used to increase mitigation efforts at the chosen site or implement mitigation measures at additional sites on Maui, Kaua'i or elsewhere. Selection of additional sites, identification of the appropriate mitigation initiatives, and level of effort will be determined in consultation with DLNR and USFWS.

Mitigation for Lower Rates of Take of Petrel and Shearwater

If rates of take have not already been identified as occurring at Higher rates, a determination will be made whether take of seabirds is occurring below Baseline levels. A Lower rate of take will be determined for Kahuku Wind Power if no downed Hawaiian petrels or Newell's shearwaters are found attributable to the project after five consecutive years of project operation. If mitigation occurs at Makamaka'ole (see above), and fencing and trapping is proceeding as planned, no change in mitigation will be implemented even if take occurs at a Lower level.

If Alternative 2 is chosen (see above) and mitigation efforts at that point in time have met the Baseline requested take, mitigation obligations will have been met and will cease with the concurrence of DLNR and USFWS. Once mitigation returns to Baseline or Higher levels, mitigation provided will be commensurate with the requested take for the required tier, even if Lower take levels are determined later in the life of the project. These measures will be implemented with the concurrence of DLNR and USFWS.

Measures of Success for Petrel and Shearwater

Mitigation efforts provided by Kahuku Wind Power will contribute to habitat and colony enhancement, and the control of predator populations and thus will provide a net benefit to, and aid in the recovery of, the two seabird species.

In general, mitigation will be deemed to be successful if the mitigation efforts result in one more fledgling or adult than that required to compensate for the requested take of the required tier. For Alternative 1, these mitigation requirements may be met if sufficient burrows are fenced and enough fledglings and adults are accrued to exceed the requested take level requirements. Fledglings accrued will be the net increase in pair productivity of each seabird species over that of baseline productivity estimates for each seabird species under unmanaged conditions using best available information. Likewise, the adults accrued will be the difference in adult survival rates at the managed site over that under unmanaged conditions. Unmanaged conditions will be represented using the best available information from published studies of the same or similar species.

However, if insufficient naturally occurring burrows are found, since the measures proposed to increase the number of nesting pairs are considered experimental (i.e. using social attraction to increase colony size and artificial burrows to increase available nesting habitat) it was decided with prior concurrence of DLNR and USFWS, that if the social attraction study is executed as agreed upon, the knowledge gained from conducting the fencing and social attraction study, regardless of outcome, is sufficient to meet the Baseline take requirement. This is so because while social attraction methods appear to hold great promise, they have not been proven in Hawaiʻi, and the results from these mitigation efforts will assist the agencies in determining the next steps to take to promote the recovery of the Hawaiian petrel and Newell's shearwater.

If Alternative 2 is chosen, mitigation will be deemed to be successful if the mitigation efforts result in one more fledgling or adult than that required to compensate for the requested take of the required tier.

To ensure the success of the mitigation effort, Kahuku Wind Power will establish a $150,000 Seabird Contingency Fund. The fund will be compounded at 2.5% annually over the entire 20-year term of the HCP resulting in a total possible maximum of $245,792 (if left unused at year 20). If the fund is drawn upon at any time, the interest will continue to accrue for the remaining balance. This fund will be available to implement adaptive measures to ensure that mitigation is commensurate with the actual take. If at the end of the 20-year period the mitigation is still not commensurate with actual take, any remaining contingency funds will be used for further mitigation efforts and to ensure a net benefit.

Hawaiian Waterbirds

The Kahuku Wind Power HCP proposes to mitigate for possible impacts to Hawaiian duck, Hawaiian stilt, Hawaiian coot, and Hawaiian moorhen concurrently at one wetland site because of the similar habitat requirements of these species, and because they face similar threats to their habitat and reproductive success. Mitigation proposed for these species is identified following the impact assessments for all four species.

Hawaiian Duck

Hawaiian Duck Hybrids:

Impacts from Turbines and Met Towers

The estimated passage rate of Hawaiian duck hybrids over the Kahuku Wind Power project area is 0.0029 birds/ha/hr or 8.0 birds/day for the entire site. Modeling provides an estimated average fatality rate that ranges from 0.0004 to 0.0042 ducks/turbine/year. This equates to an average annual fatality rate ranging from 0.005 to 0.050 ducks/year for all 12 turbines. Average fatality caused by collision with the one permanent met tower is estimated to range from 0.00006 to 0.0006 ducks/year. Combined, the total estimated average fatality rate at Kahuku Wind Power for all 12 turbines and one met tower ranges from 0.001 - 0.051 ducks/year.

Low mortality of waterbirds has been documented at wind turbines situated coastally, like the proposed Kahuku Wind Power project, despite the presence of high numbers of waterbirds in the vicinity (Kingsley and Whittam 2007). Studies at wind energy facilities located in proximity to wetlands and coastal areas have shown that waterbirds and shorebirds are among the birds most wary of turbines and that these birds readily learn to avoid the turbines over time (Koford et al. 2004, Jain 2005, Carothers 2008). Avoidance behavior has also been documented by nēnē at the existing KWP facility on Maui (Kaheawa Wind Power 2008). Because of this, an avoidance rate of 95% (95% of the ducks approaching the turbines and met tower successfully avoid them) was used in the modeling to identify the expected average mortality rate of hybrid Hawaiian ducks resulting from proposed project operations. The estimated average rate of mortality at 95% avoidance is 0.026 ducks/year for all 12 turbines and the one met tower on site.

Passage rates of ducks over Kahuku Wind Power may temporarily increase due to events associated with extremely heavy rainfall (e.g. 5 inches of rain or more per day) which can occur every few years on O'ahu. These rains usually cause significant flooding in the northern portions of the island, where Kahuku Wind Power is situated. During one such event, some standing water was observed on site at Kahuku Wind Power and these features were noted to attract Hawaiian duck hybrids to the site for a short period of time (a few days). The observed ponding was in an area characterized as pasture area. In order to reduce the risk for waterbirds, Kahuku Wind Power intends to grade this area during construction to improve drainage and prevent standing water from collecting during such periods of heavy rain. The area in question is not a wetland or water as defined under state or federal laws and, given how rarely it holds water, does not provide resources regularly utilized by Hawaiian duck hybrids. Overall, USFWS, SWCA, and Kahuku Wind Power LLC believe that minimizing the potential for collisions of listed waterbirds with project structures outweigh the significance in the loss of these small, ephemeral, and infrequently- used habitat areas.

Impacts from Other Project Components

Hawaiian duck hybrids frequently fly at altitudes that the microwave tower, overhead collection lines, relocated distribution lines and utility poles on-site would extend to. Therefore, potential for ducks to collide with these structures exists. However, as Hawaiian hybrid ducks are primarily diurnal, they are expected to easily avoid the microwave tower which would be highly visible during daylight hours. Observations of ducks conducted at nearby wetlands demonstrated that Hawaiian duck hybrids easily negotiated the overhead powerlines strung across the wetland habitat. No ducks were observed to have any collisions or near-collisions with the overhead powerlines or utility poles (147 flocks observed, average of two bird per flock). Consequently, potential for hybrid Hawaiian ducks to collide with the microwave tower, overhead collection lines, relocated distribution lines, and utility poles on-site to is considered to be negligible.

Some very limited and temporary potential would also exist for ducks to collide with cranes during the construction phase of the project. However, the cranes would be highly visible, and so should be readily avoided. In addition, as discussed for Newell's shearwater, the cranes are only expected to be present on-site for a brief period. Consequently, potential for hybrid Hawaiian ducks to collide with construction cranes is considered to be negligible. No Hawaiian duck hybrids are expected to be present at either offsite microwave tower site. Therefore, none of these structures were identified as a potential source of take of Hawaiian duck hybrids in the mortality modeling performed for the species and, thus, the amount of take requested to be authorized through the ITL is based solely on mortality expected to occur as a result of construction and operation of the WTGs and met towers.

However, if in the unlikely event a seabird mortality is found in the future and that mortality can be attributed to the on-site construction cranes, Kahuku Wind Power on-site or off-site microwave towers, associated overhead cables or utility poles, Kahuku Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site. After commissioning, the lease for both offsite microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS (SWCA and First Wind 2010).

Impacts from Project-related Activities

Some potential also exists for construction or maintenance vehicles to strike downed ducks (ducks already injured by collision with turbines or towers) while traveling project roads. Project personnel will be trained to watch for downed ducks and other wildlife and speed limits (10 mph) will be emplaced and enforced to minimize potential for vehicular strikes to result in death of ducks that otherwise might have been able to be rehabilitated. Despite this, it is assumed that day-to-day maintenance of the wind facility may occasionally result in the fatality of hybrid ducks. As discussed for Newell's shearwater, this potential source of mortality is accounted for in the collision mortality estimate and so does not result in an increase in the amount of take expected from the proposed project.

Therefore, it is projected that take of Hawaiian duck hybrids as a result of collision with project components and vehicle strikes will occur at the average rate of 0.02 ducks/year.

Indirect Take and Take Limits

It is assumed that adult ducks are most likely to collide with turbines and associated structures during non-breeding periods or toward the end of their breeding period when ducklings are larger and can be left unattended for longer periods of time. Breeding adults are expected to be much more likely to remain in their home ranges while incubating or attending to heavily dependent young, and so are not expected to fly over the Kahuku Wind Power site during those times. Hybrid Hawaiian ducks will breed year round, although a peak in breeding occurs from March to June.

For purposes of assessing indirect take, any adult hybrid Hawaiian duck mortality recorded during the months of March through June will be assumed to have been actively breeding. However, based on the previous paragraph, it will also be assumed that such ducks would have been tending to older ducklings, which likely would be fewer in number than original clutch size (studies indicate that average number of young produced per pair of Hawaiian ducks per nesting attempt is 1.225). It will be assumed that any ducks found from July through February will have had a 25% chance of having been breeding actively and tending to older ducklings. It is also assumed that death of a male adult will not to lead to indirect death of ducklings because the males do not provide any parental care for eggs or ducklings. Based on these assumptions, as indicated in Table 7 below, the amount of indirect take that would be assessed for each direct adult duck mortality ranges from 0.00 to 1.225 ducklings depending on time of year and gender of the fatality (life history data in HCP).

Table 7. Calculation of indirect take of the Hawaiian duck hybrid.

Hawaiian duck hybrid	Season	No. young per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect (A*B*C)
Male	All year	1.225	0.25 - 1.00	0.00	0.00
Female	Peak breeding Mar-Jun	1.225	1.00	1.0	1.225
Female	Jul - Feb	1.225	0.25	1.00	0.31
Immature	All year	--	0.00	--	0.00

Because of previously discussed assumptions concerning unobserved direct take, any one hybrid Hawaiian duck found to have collided with a project component in a year will lead to an assessment of total direct take for that year of greater than one that likely would be rounded up to 2 ducks/year (based on expected results from take monitoring and subsequent adjustments for searcher efficiency and scavenging rates). While the second bird taken under this scenario would be assumed and, therefore, of unknown age or gender, it will be assumed that all hybrid Hawaiian ducks taken through “unobserved direct take” will be female adults with a 25% chance of having been in breeding condition. This is based on the information that hybrid Hawaiian ducks have one clutch a year, and are expected to be breeding three months of the year (a one-month incubation period followed by parental care for 2 months; 3 months breeding / 12 months per year = 0.25). Consequently, following the above table, indirect take will be assessed to ducks lost through “unobserved direct take” at the rate of 0.31 ducklings/duck (1.225 x 0.25 x 1.00 = 0.306).

The total direct take of 2 adults per year could result in an indirect take assessment of 0.31 to 1.535 ducklings per year, which is rounded here up to 2 ducklings per year. Consequently, while the chance of take occurring in any year appears to be exceptionally low, because of need to allow for assessment of unobserved direct take, the Applicant suggests the Baseline ITL should allow for a total direct take of 2 hybrid Hawaiian ducks and the indirect take of 2 ducklings in any year of project operation. Expected rates of take and rates of take requested to be authorized by the ITL through the expected 20-year life of the project are summarized below, along with rates of take considered to qualify as “Lower” and “Higher.”[3]

Expected Rate of Take

Annual average	0.026 adults/immatures and 0.031 ducklings
20-year project life	1 adult/immature and 1 duckling

Requested ITL Authorization

Baseline level of take	2 adults/immatures and 2 ducklings	4 birds/year
5-year limit of take	6 adults/immatures and 6 ducklings	
20-year limit	8 adults/immatures and 8 ducklings	

Higher Rate of Take

One-year period	Total direct take of 3 - 4 adults/immatures 3 - 4 ducklings
5-year period	Total direct take of 7 - 8 adults/immatures and 7 – 8 ducklings
20-year period	Total direct take of 9 - 12 adults/immatures and 9 – 12 ducklings

Lower Rate of Take

5-year period	Total direct take of 0 adults/immatures and 0 ducklings

An estimated 300 hybrid Hawaiian ducks are present on O‘ahu (Engilis et al. 2002, USFWS 2005a). The expected level of take over the 20-year life of the project is approximately one adult duck and one duckling being tended at the time of collision. Mortality realized at this very low rate is not expected to cause significant negative impacts to the O‘ahu population of hybrid Hawaiian ducks. Regardless, because it is anticipated that all hybrid Hawaiian ducks on O‘ahu will ultimately be removed/relocated to allow for the reintroduction of pure Hawaiian ducks, loss of hybrid ducks as a result of operation of the Kahuku Wind Project is not considered to be biologically significant or adverse.

Pure Hawaiian Ducks:

The possibility of existence of genetically pure Hawaiian ducks on O‘ahu is currently considered very remote (Engilis et al. 2002, USFWS 2005a, A. Engilis, pers. comm.). However, as discussed, the USFWS is planning on James Campbell NWR playing a key role in the future reintroduction of pure Hawaiian ducks to O‘ahu (USFWS 2005a, J. Kwon/USFWS, pers. comm.). At present it is uncertain when that will occur, but it is possible that reintroductions could occur during the 20-year life of the project.

The reintroduction of pure Hawaiian ducks would first require the removal of all hybrid Hawaiian ducks and feral mallards from O’ahu. If that were to occur during the life of the project, the potential for hybrid ducks to be killed through collision with project components as described above would be eliminated and replaced with potential for project operations to cause mortality of pure Hawaiian ducks. There likely would be some interval of time between eradication of the hybrid ducks and re-introduction of the pure ducks in which no potential existed for Hawaiian-type ducks to collide with the proposed turbines and met tower.

---

[3] The level of take expected over the 20-year life of the project was derived by multiplying the expected annual average (0.2) by 20 and rounding up to the nearest whole integer (1). The requested 20-year take authorization is greater than 1 adult duck to not only allow for assessment of unobserved take, but to guard against possible future increases in the duck population altering their passage rate through the project area.

It is not known how many pure Hawaiian ducks would be released or what behavior patterns they would establish, so it is not possible at this time to estimate accurately an expected passage rate and model expected mortality rates. However, it does seem probable that the number of pure ducks released would be lower than the number of hybrid Hawaiian ducks currently present in the general project area, and that population of pure ducks would eventually build to approximate that of the current hybrid population. Consequently, it appears the potential for collisions would initially be lower than that expected for the hybrid ducks but could eventually match it. Given the low rate at which the hybrid ducks are expected to collide with project components and the degree to which that rate was rounded up to yield an annual rate of take of 1 duck/year, it is expected that rates of take of pure Hawaiian ducks would be similar to those identified above for hybrid Hawaiian ducks. Should reintroduction of pure Hawaiian ducks occur during the lifetime of the project, the Applicant believes the same take authorizations and limits should be applied to the species as requested for the hybrid ducks above.

Hawaiian Stilt

Risk factors for Hawaiian stilt interacting with wind turbines and meteorological towers are poorly understood. As with Hawaiian petrel, no Hawaiian stilts were observed flying over the project area during the avian surveys. Consequently, modeling would result in an estimated take rate of zero because known stilt passage rate is zero. Because Hawaiian stilts occur regularly in the Kahuku area, it is considered that the project would create some risk of causing take of this species, however small. The estimated rate of take of the Hawaiian stilt will be assumed to be the same as for Hawaiian duck hybrids, or an average of 0.026 stilts/year lost through interaction with turbines, met towers, on-site and off-site microwave towers and overhead cables, utility poles and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

After commissioning, the lease for both off-site microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS).

It is assumed that adult stilts are most likely to collide with turbines and associated structures during non-breeding periods or toward the end of their breeding period when chicks are larger and can be left unattended for longer periods of time. Hawaiian stilts are highly territorial during the breeding season (Robinson et al. 1999) and are much more likely to be defending their territories while incubating or attending to heavily dependent young, and so are not expected to fly over the Kahuku Wind Power site during those times. Hawaiian stilts breed from February to August.

For purposes of assessing indirect take, any adult Hawaiian stilt mortality recorded during the months of February through August will be assumed to have been actively breeding. However, based on the previous paragraph, it will also be assumed that such a stilt would have been tending to older chicks, which likely would be fewer in number than original clutch size (studies indicate that average clutch size is 4, while average number of fledglings produced per pair of Hawaiian stilts is 0.9). Stilt mortality that occurs outside the breeding season will be assumed to be of non-breeding birds and will not be assigned any indirect take. Since both sexes provide fairly equal amounts of parental care, the amount of indirect take assessed will be shared equally between males and females. Parents have not been documented to feed their chicks, thus at least half the brood is likely to survive even with the loss of one parent (Robinson et al. 1999). Based on these assumptions, as indicated in Table 8 below, the amount of indirect take assessed for each direct adult stilt mortality is 0.45 during the breeding season (life history data in the HCP).

Because of previously discussed assumptions concerning unobserved direct take, any one Hawaiian stilt found to have collided with a project component in a year will lead to an assessment of total direct take for that year of greater than one that likely would be rounded up to 2 stilt/year (based on expected results from take monitoring and subsequent adjustments for searcher efficiency and scavenging rates). While the second bird taken under this scenario would be assumed and, therefore, of unknown age or gender, it will be assumed that all Hawaiian stilts taken through “unobserved direct take” will be adults.

Table 8. Calculation of indirect take for the Hawaiian stilt.

Hawaiian Stilt	Season	Average no. of fledglings per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Adult	Feb-Aug	0.9	1.00	0.5	0.45
Adult	Sep-Jan	--	0.00	--	0.00
Immature	All year	--	0.00	--	0.00

In addition, because stilt could be flying through the project area at any time of year, the likelihood of stilt being in breeding condition is assumed to be 16.67%. This is based on the information that Hawaiian stilts have one clutch a year, and are expected to be breeding two months of the year (a one month incubation period followed by parental care for one month; 2 months breeding / 12 months per year = 0.1666). Consequently, following the above table, indirect take will be assessed to stilts lost through "unobserved direct take" at the rate of 0.08 fledglings/stilt (0.9 x 0.1667 x 0.5 = 0.075).

The total direct take of 2 adults per year could result in an indirect take assessment of 0.53 fledglings per year, which is rounded here up to 1 fledgling per year. Consequently, the Applicant suggests the ITL should allow for a total direct take of 2 Hawaiian stilts and the indirect take of 1 fledgling in any year of project operation. Expected rates of take and rates of take requested to be authorized by the ITL through the expected 20-year life of the project are summarized below, along with rates of take considered to qualify as "Lower" and "Higher."[4]

Annual Expected Rate of Take

Annual average	0.026 adults/immatures and 0.0012 fledglings
20-year project life	1 adult/immature and 1 fledgling

Requested ITL Authorization

Baseline level of take	2 adults/immatures and 1 fledgling	3 birds/year
Five-year limit of take	6 adults/immatures and 3 fledglings	
20-year limit	8 adults/immatures and 4 fledglings	

Higher Rate of Take

One-year period	Total direct take of 3 - 4 adults/immatures and 1 - 2 fledglings
5-year period	Total direct take of 7 - 8 adults/immatures and 3 – 4 fledglings
20-year limit	Total direct take of 9 – 12 adults/immatures and 5 – 6 fledglings

Lower Rate of Take

5-year period	Total direct take of 0 adults and 0 fledglings

O'ahu supports 35-50% of the state's stilt population with approximately 450 to 700 birds present on the island. The take of stilts at the expected rate of one adult stilt and one fledgling over 20 years is not expected to significantly impact the population of the stilt on O'ahu. Moreover, the proposed mitigation (see below) is expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. The mitigation is expected to be successful as the Hawaiian stilt is classified as a species with a high potential for recovery (USFWS 2005a) where the biological and limiting factors are well understood, the threats are understood and easily alleviated and intensive management is not needed or the known techniques have been documented with a high probability of success (USFWS 1983).

---

[4] The expected level of take over 20 years was rounded up to the nearest whole integer and requested take authorizations allow for assessment of unobserved direct take and changes in Hawaiian stilt passage rates over time.

Levels of take under the Higher Take scenario may begin to impact the state population due to its small population numbers. This scenario however, is considered extremely unlikely to occur as Hawaiian stilts have not been seen flying overhead during avian surveys at Kahuku Wind Power and the baseline take estimate probably overestimates the amount of take that will actually occur. As stated above, mortality of waterbirds at wind farms has historically been low, despite the proximity of large populations of waterbirds near turbines. Waterbirds also learn to avoid turbines over time (Kingsley and Whittam 2007, Carothers 2008). The proposed mitigation for Higher Take levels is expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. For these reasons, no adverse impacts to the species' overall population are anticipated.

Hawaiian Coot

As with Hawaiian stilt, the risk factors for Hawaiian coot interacting with wind turbines and met towers are poorly understood. A small number of fatalities of American coot have been reported at wind facilities in North America, although these involved projects where surface waters occurred within the project area. No permanent surface water occurs within the Kahuku Wind Power site to serve as an attractant to Hawaiian coots, and no coots were observed flying through the site during the avian surveys. Consequently, as for Hawaiian petrel and Hawaiian stilt, mortality modeling for this species would result in a projected rate of take of zero. Because Hawaiian coots occur regularly in the Kahuku area and are known to make local and even inter-island movements, it seems the potential for take of this species occurring from the proposed project, while very low, is not zero. Therefore, as with Hawaiian stilt, for the purposes of the HCP, it will be assumed that the rate of take of Hawaiian coot will be the same as for hybrid Hawaiian ducks, or an average of 0.026 coots/year resulting from interactions with turbines, met towers, on-site and off-site microwave towers, associated overhead cables, utility poles and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

After commissioning, the lease for both off-site microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS).

It is assumed that adult coots are most likely to collide with turbines and associated structures during non-breeding periods when the birds could be making local or inter-island movements. Hawaiian coots are territorial during the breeding season (Polhemus and Smith 2005, Smith and Polhemus 2003) and are much more likely to be defending their territories while incubating or attending to heavily dependent young, and so are not expected to fly over the Kahuku Wind Power site during those times. Hawaiian coots have been documented to breed year round with the peak breeding period between March and September.

For purposes of assessing indirect take, any adult Hawaiian coot mortality recorded during the months of March through September will be assumed to have been actively breeding. However, as mentioned for other species, it is assumed that coots would not be flying at such distance from nesting locations unless their young were older and could be left alone for longer periods of time. Thus, for indirect take assessed to mortalities recorded from March to September, it will be assumed that such coots would have been tending to older chicks, which likely would be fewer in number than original clutch size (studies indicate that average number of fledglings produced per pair of Hawaiian coot is 0.9). It will be assumed that any coot found from October through February will have had a 25% chance of having been breeding actively and tending to older chicks. Since both sexes provide fairly equal parental care, the amount of indirect take assessed is equally shared between males and females. Older chicks are not fed but guided to food by their parents, thus at least half the brood is likely to survive even with the loss of one parent (Brisbin et al. 2002). Based on these assumptions, as indicated in Table 9 below, the amount of indirect take assessed for each direct adult coot mortality ranges from 0.11 to 0.45 chicks depending on the time of the year (life history data in HCP).

Table 9. Calculating indirect take for the Hawaiian coot.

Hawaiian coot	Season	No. chicks per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Adult	Peak breeding Mar-Sept	0.9	1.00	0.5	0.450
Adult	Oct - Feb	0.9	0.25	0.5	0.113
Immature	All year	--	0.00	--	0.000

Because of previously discussed assumptions concerning unobserved direct take, any one Hawaiian coot found to have collided with a project component in a year will lead to an assessment of total direct take for that year of greater than one that likely would be rounded up to 2 coots/year (based on expected results from take monitoring and subsequent adjustments for searcher efficiency and scavenging rates). While the second bird taken under this scenario would be assumed and, therefore, of unknown age, it will be assumed that all Hawaiian coots taken through “unobserved direct take” will be adults. In addition, because coots could be flying through the project area at any time of year, the likelihood of coot being in breeding condition is assumed to be 33%. This is based on the information that Hawaiian coots have one clutch a year, and are expected to be breeding four months of the year (a one month incubation period followed by parental care for three months; 4 months breeding / 12 months per year = 0.33). Consequently, following the above table, indirect take will be assessed to chicks lost through “unobserved direct take” at the rate of 0.15 chicks/coot (0.9 x 0.33 x 0.5 = 0.15).

The total direct take of 2 adults per year could result in an indirect take assessment of 0.15 to 0.6 chicks per year, which is rounded here up to 1 chick per year. Consequently, the Applicant suggests the Baseline ITL should allow for a total direct take of 2 Hawaiian coots and the indirect take of 1 chick in any year of project operation. Expected rates of take and rates of take requested to be authorized by the ITL through the expected 20-year life of the project are summarized below, along with rates of take considered to qualify as “Lower” and “Higher.”[5]

Annual Expected Rate of Take

Annual average	0.026 adults/immatures and 0.012 chicks
20-year project life	1 adult/immature and 1 fledgling

Requested ITL Authorization

Baseline level of take	2 adults/immatures and 1 fledgling	3 birds/year
5-year limit of take	6 adults/immatures and 3 fledglings	
20-year limit	8 adults/immatures and 4 fledglings	

Higher Rate of Take

One-year period	Total direct take of 3 - 4 adults/immatures and 2 fledglings
5-year period	Total direct take of 7 - 8 adults/immatures and 3 – 4 fledglings
20-year limit	Total direct take of 9 – 12 adults/immatures and 5 – 6 fledglings

Lower Rate of Take

5-year period	Total direct take of 0 adults and 0 fledglings

O‘ahu supports between 500 and 1,000 coots, or up to 33% of the state population. The expected loss of one adult coot and one fledgling over the life of the project, if realized, is not expected to have a significant impact on the population of the coot on O‘ahu. Moreover, the proposed mitigation is expected to more than offset the anticipated take and contribute to the species’ recovery by providing a net conservation benefit, as required by State law. The mitigation is expected to be successful as the Hawaiian coot is classified as a species with a high potential for recovery (USFWS 2005a) where

---

[5] The expected level of take over 20 years was rounded up to the nearest whole integer and requested take authorizations allow for assessment of unobserved direct take and changes in Hawaiian coot passage rates over time.

the biological and limiting factors are well understood, the threats are understood and easily alleviated and intensive management is not needed or the known techniques have been documented with a high probability of success (USFWS 1983).

Levels of take under the Higher Take scenario may begin to impact the state population due to its small population numbers. This scenario however, is considered extremely unlikely to occur as Hawaiian coots have not been seen flying overhead during avian surveys at Kahuku Wind Power and the baseline take estimate probably overestimates the amount of take that will actually occur. As stated above, mortality of waterbirds at wind farms has historically been low, despite the proximity of large populations of waterbirds near turbines. Waterbirds also learn to avoid turbines over time (Kingsley and Whittam 2007, Carothers 2008). The proposed mitigation for Higher Take levels is expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. For these reasons, no adverse impacts to the species' overall population are anticipated.

Hawaiian Moorhen

Hawaiian moorhens were never detected at Kahuku Wind Power during the 15-month long avian point count survey and are thought to be at very low risk of collision with turbines because of their sedentary habits. For the same reasons discussed for Hawaiian stilt and Hawaiian coot, risk of collision by this species is not zero, and will be assumed to occur at the same rate assumed for those species, or on an average of 0.02 moorhens/year as a result of collision with turbines, met towers, on-site and off-site microwave towers, associated overhead cables, utility poles and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

After commissioning, the lease for both off-site microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS.

Like Hawaiian coots, it is assumed that adult moorhens are most likely to collide with turbines and associated structures during non-breeding periods or, possibly, toward the end of their breeding period when chicks are larger and can be left unattended for longer periods of time. Hawaiian moorhen are territorial during the breeding season (Polhemus and Smith 2005, Smith and Polhemus 2003) and are much more likely to be defending their territories while incubating or attending to heavily dependent young, and so are not expected to fly over the Kahuku Wind Power site during those times. Hawaiian moorhen have been documented to breed year round with the peak breeding period between March to August.

For purposes of assessing indirect take, any adult Hawaiian moorhen mortality recorded during the months of March through August will be assumed to have been actively breeding. However, based on the previous paragraph, it will also be assumed that such moorhens would have been tending to older chicks, which likely would be fewer in number than original clutch size (studies indicate that average number of fledglings produced per pair of Hawaiian moorhens is 1.3). It will be assumed that any moorhen found from September through February will have had a 25% chance of having been breeding and tending to older chicks. Since both sexes provide fairly equal parental care, the amount of indirect take assessed is equally shared between males and females. Older chicks forage with adults, feeding themselves the majority of the time, thus, at least half the brood is likely to survive even with the loss of one parent (Bannor and Kiviat 2002). Based on these assumptions, as indicated in Table 10 below, the amount of indirect take assessed for each direct adult moorhen mortality ranges from 0.16 to 0.65 fledglings depending on the time of the year (life history data in HCP).

Because of previously discussed assumptions concerning unobserved direct take, any one Hawaiian moorhen found to have collided with a project component in a year will lead to an assessment of total direct take for that year of greater than one that likely would be rounded up to 2 moorhens/year (based on expected results from take monitoring and subsequent adjustments for searcher efficiency and scavenging rates). While the second bird taken under this scenario would be assumed and, therefore, of unknown age, it will be assumed that all Hawaiian moorhens taken through "unobserved direct take" will be adults. In addition, because moorhens could be flying through the project area at any time of year, the likelihood of moorhens being in breeding condition is assumed to be 58%. This is based in the information that Hawaiian moorhens can have up to two clutches a year, and are expected to be breeding seven months of the year (two clutches at a one month incubation period followed by parental care for two and a half months; 3.5 months per clutch x 2 clutches / 12 months per year = 0.5833). Consequently, indirect take will be assessed to chicks lost through "unobserved direct take" at the rate of 0.38 chicks/moorhen (1.3 x 0.58 x 0.5 = 0.38).

Table 10. Calculating indirect take for the Hawaiian moorhen.

Hawaiian moorhen	Season	Average no. of chicks per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Adult	Peak Mar-Aug	1.3	1	0.5	0.65
Adult	Sept - Feb	1.3	0.25	0.5	0.1625
Immature	All year	--	0.00	--	0.00

The direct take of one adult will result in assessment of an indirect take of a maximum of 0.65 chick. Because of assumptions concerning unobserved direct take, the Applicant suggests the Baseline ITL should allow for a total direct take of 2 adults moorhens and the indirect take of 1.03 chicks, rounded up to 2 chicks, in any year of project operation. Expected rates of take and rates of take requested to be authorized by the ITL through the expected 20-year life of the project are summarized below, along with rates of take considered to qualify as "Lower" and "Higher."[6]

Annual Expected Rate of Take

Annual average	0.026 adults/immatures and 0.017 fledglings	
20-year project life	1 adults/immatures and 1 fledgling	

Requested ITL Authorization

Baseline level of take	2 adults/immatures and 2 fledglings	4 birds/year
5-year limit of take	6 adults/immatures and 4 fledglings	
20-year limit	8 adults/immatures and 6 chicks	

Higher Rate of Take

One-year period	Total direct take of 3 - 4 adults/immatures and 2 – 3 fledglings
5-year period	Total direct take of 7 - 8 adults/immatures and 4 – 6 fledglings
20-year limit	Total direct take of 9 – 12 adults/immatures and 6 – 8 fledglings

Lower Rate of Take

5-year period	Total direct take of 0 adults/immatures and 0 fledglings

Biannual waterbird surveys record an average of 341 moorhens throughout the state (USFWS 2005a). This average is likely an inaccurate estimate of true population size as common moorhens are secretive and difficult to census (USFWS 2005a). The expected loss of one adult Hawaiian moorhen and one fledgling over the 20-year project life is not expected to result in significant adverse effects to the sub-species at the population level. The proposed mitigation is expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, as required by State law. The mitigation is expected to be successful as the moorhen is classified as a species with a high potential for recovery (USFWS 2005a), where the biological and limiting factors are well understood, the threats are understood and easily alleviated and intensive management is not needed or the known techniques have been documented with a high probability of success (USFWS 1983).

---

[6] the expected level of take over 20 years was rounded up to the nearest whole integer and requested take authorizations allow for assessment of unobserved direct take and changes in Hawaiian moorhen passage rates over time

Levels of take in the range of the Higher Take scenario may begin to adversely impact the state population given its potentially small size. Take at this level, however, is considered extremely unlikely to be realized as Hawaiian moorhens have not been seen at Kahuku Wind Power and the Baseline take estimate seems to be a conservative overestimate. The behavior of Hawaiian moorhen also supports this supposition as moorhens are rarely seen flying, preferring to swim or walk (Bannor and Kiviat 2002). Moorhens in Hawaiʻi are highly sedentary (while migratory on continental North America) and no records of inter-island flights have been documented (Bannor and Kiviat 2002). Hawaiian moorhens however do disperse in spring to breed (Nagata 1993). The Applicant's proposed mitigation for the anticipated take will contribute to a greater understanding of the species' occurrence and status, which in turn will help guide future management and recovery efforts and should result in an overall net conservation benefit for the species. For these reasons, no adverse impacts to the species' overall population are anticipated.

Waterbird Mitigation

Mitigation for potential impacts to the four endangered waterbird species is proposed to be conducted concurrently at one wetland site because of their similar habitat requirements, and because they face similar threats to their habitat and reproductive success. Proposed mitigation for the take of waterbirds by operation of the Kahuku Wind Power project will focus on predator control and vegetation maintenance at wetland sites on Oʻahu that have regular waterbird nesting activity as identified by DLNR and USFWS. Potential wetland sites identified during discussions with DLNR and USFWS included Hamakua Marsh State Wildlife Sanctuary, James Campbell Wildlife Refuge, Kawai Nui Marsh, Ukoa Pond and Pouhala Marsh. James Campbell Wildlife Refuge is a federally-owned wetland site, and therefore a lower priority as a mitigation site. It was decided that since Kawai Nui Marsh and Ukoa Pond were unmanaged sites with few waterbirds, it would be difficult to implement successful mitigation measures at these locations. Pouhala Marsh, while managed, already had future funding designated to the area. Therefore, Hamakua Marsh, a 23-acre wetland located on east Oʻahu, was identified as the mitigation site of first choice for Kahuku Wind Power by USFWS and DLNR.

Hamakua Marsh is a state-managed wetland with documented nesting of all four waterbirds in the area. Mitigation by Kahuku Wind Power at this site would also aid in the recovery of the listed waterbird species. Under the Hamakua Marsh Ecosystem Restoration and Community Development Project, management activities conducted at Hamakua Marsh included the removal of red mangrove (*Rhizophora mangle*) from the banks, outplanting of native species, and providing adequate nesting habitat for the waterbird species. Waterbird nesting activity and habitat utilization were measured at Hamakua Marsh in 2003 and 2004 to document their response of these management activities (Smith and Polhemus 2003, Polhemus and Smith 2005). Since 2005 DLNR has conducted the predator trapping, vegetation maintenance, and monitoring of waterbird productivity at the marsh.

Mitigation efforts will be directed at increasing productivity and mitigation success will be measured in terms of increased fledgling production over baseline productivity (productivity rates measured before predator control) at the end of the reproductive season for each year. The take of adults or subadults at Kahuku Wind Power will be compensated for by increasing the number of fledglings produced while taking into account fledgling survival to adulthood. For example, if 50% of all Hawaiian stilt fledglings survive to adulthood, the required compensation for the direct take of one adult Hawaiian stilt would be the production of two fledglings so that one can be expected to replace the taken bird. If increased adult survival can be demonstrated, then adults may also be directly replaced by another adult.

In addition to mitigating for the effects of direct and indirect take, mitigation also needs to account for any loss of productivity that could have occurred between the time the direct take occurs and the time that mitigation is provided. Factors that need to be taken into consideration when accounting for loss of productivity include demographic factors such as the age and sex of the individuals taken, the time of year the take occurs, the type of mitigation provided, and the time that elapsed between commencement of mitigation efforts and the direct take.

Mitigation measures as described below would be conducted in collaboration with DLNR staff. Monitoring of waterbird health, reproductive success, and population size will also be funded to quantify the success of the mitigation measures. Monitoring would also be essential to identify any emerging threats or to determine the relative significance of existing threats if conditions change over time. This can contribute vital information to adaptive management as needed. The design and scope of each year's effort would be determined with DLNR in consultation with biologists at USFWS and Kahuku Wind Power. Consultation is necessary to ensure that the proposed management actions for waterbirds on O'ahu satisfy the mitigation criteria required of Kahuku Wind Power by both DLNR and USFWS and will be complementary to any other management activities that may be taking place for the benefit of these species.

Mitigation targets have been identified based on the "Baseline" and "Higher" take levels. On-site post-construction monitoring will be used to determine whether waterbird take is occurring at Baseline, Higher or Lower levels. Initial mitigation is intended to compensate for take occurring at Baseline level. If post-construction monitoring shows that take is actually occurring below or in excess of Baseline level, adjustment to mitigation efforts would be made (see low and higher take).

As rates of take likely will vary between waterbird species, the level of mitigation effort at the chosen wetland will be determined by the highest rate of take. For example, if three species are found to be taken at the Lower rate but one is taken at a Higher rate, Baseline mitigation would be adjusted to compensate for the Higher rate of take. This would be expected to result in the production of fledglings for other waterbird species in excess of that which would otherwise be required. The Applicant would be able to receive credit for such "extra" fledglings that could then be used to compensate for take incurred in later years.

Baseline Mitigation for Waterbirds

Mitigation for the Baseline level of take of the four waterbirds will consist of:

Funding of $291,500 will be provided for three years of management at Hamakua Marsh to a qualified contractor or personnel approved by USFWS or DLNR. Funding will also be provided toward the purchase of a truck (up to a maximum of $12,000) and the initial purchase of monitoring equipment (up to a maximum of $2,000) if necessary. Funding may be provided up to five years as long as the total available funding of $291,000 is not exceeded. Additional contingency funds are provided in the event a third party contractor is required and will only be used for this purpose. Following permit issuance for predator control, vegetation maintenance, and monitoring of waterbird populations and reproductive activity, the following will be conducted:

a. Predator trapping and baiting will begin during the first breeding season after permit issuance to remove predators (e.g., cats, rats, mongoose). Predator trapping will be conducted year round using traps, leg holds, and/or snares. Traps would be placed along the perimeter of the fences 160 to 200 ft (50 - 60 m) apart. Leg holds and snares would be placed deeper within the fenced area, depending on visual observations of predators. Traps will be checked every 48 hrs and snares and leg holds every 24 hrs in accordance with USFWS guidelines. Bait stations will be deployed year-round following protocols set forth by the Department of Agriculture.

b. Vegetation maintenance will be conducted to remove and prevent invasive species from encroaching on waterbird nesting habitat and to enhance available nesting habitat where possible.

c. Monitoring of reproductive activity and waterbird populations will quantify the effectiveness of the predator control methods. Monitoring of reproductive activity will be conducted weekly from December through September.

The predator control, vegetation maintenance, and monitoring will be performed by a qualified contractor or personnel approved by DLNR and USFWS. After the first three to five years of predator trapping, the number of fledglings or adults accrued for the covered waterbird species will be examined, and if they are at least one more than required to compensate for the Baseline requested take, the required mitigation is considered fulfilled. This standard applies to the Hawaiian coot, Hawaiian stilt and Hawaiian moorhen. Currently, as no pure Hawaiian ducks exist on O'ahu due to hybridization, mitigation for Hawaiian ducks will consist of removal of hybrids at Hamakua marsh.

Feral ducks, mallards and Hawaiian duck hybrids still occur at Hamakua marsh and will need to be removed (SWCA and First Wind 2010).

If the number of fledglings or adults accrued are less than required, additional funding (up to a maximum of $291,000) will be provided by the Applicant for additional mitigation measures until the Baseline requested take for the Hawaiian coot, Hawaiian stilt, and Hawaiian moorhen are met (see HCP). As the fledglings accrued for each species may be uneven due to differences in pair abundance or reproductive success, more effort may be concentrated on enhancing the productivity of a specific federally listed waterbird species in order to achieve the required number of fledglings to meet the Baseline requested level of take, provided the measures do not negatively affect the productivity of other Covered Species at the mitigation site. The design and scope of each year's effort will be determined by DLNR in coordination with biologists at USFWS and Kahuku Wind Power. Coordination is necessary to ensure that the proposed management actions funded by Kahuku Wind Power and performed by DLNR for Hamakua Marsh satisfy the mitigation criteria required of Kahuku Wind Power by both DLNR and USFWS. A draft management plan for Hamakua Marsh outlining management measures is provided in the State HCP.

If monitoring indicates that factors other than predator control are important or pressing in aiding the recovery of the endangered waterbird species covered in the HCP, Kahuku Wind Power in concurrence with USFWS and DLNR will direct the specified funds toward whatever management action is deemed most appropriate at the time. Should another waterbird nesting site be identified as a more suitable location for mitigation measures, management actions may be conducted in an alternate site as appropriate. Other important management techniques for wetland habitat improvement in Hawai‘i could include water level control, disease prevention, and monitoring of environmental contaminants (USFWS 2005a).

Mitigation for Higher Rates of Take of Waterbirds

If a Higher rate of take occurs for any of the waterbird species, the number of fledglings or adults accrued for that Covered species will be examined to determine if the fledglings or adults accrued are enough to cover the number required to be commensurate with the requested take at the Higher tier and achieve a net conservation benefit for the species. If this is determined to be so, then no additional mitigation will be provided. If it is determined that this is not the case, mitigation efforts will first be increased at the Hamakua Marsh site. Increased efforts could include intensifying the trapping effort or implementing additional vegetation management. If increased efforts at Hamakua Marsh are not sufficient to increase adult survival or produce enough fledglings required to be commensurate with the requested take at the Higher tier, and achieve a net conservation benefit for the species at the measured take levels, Kahuku Wind Power will provide funding for a similar set of waterbird management measures at one or more additional sites. Selection of additional sites, and identification of appropriate levels of effort will be determined in consultation with DLNR and USFWS.

Mitigation for Lower Rates of Take of Waterbirds

Lower rates of take can only be determined after 5 years of post-construction monitoring. Lower rates of take for waterbirds will only be identified if no take has been documented over the past 5 years. It is anticipated that by the time Lower rates of take are determined, mitigation at the Baseline level would already have been achieved and no changes to mitigation measures are anticipated.

Measures of Success for Waterbirds

It is anticipated that mitigation for the covered waterbird species will be funded by the Applicant and conducted by a qualified contractor or personnel approved by USFWS and DLNR. Funding will be provided by the Applicant within 6-months of issuance of the ITL and Baseline mitigation will commence within the first year of the project start date unless circumstances beyond the control of Kahuku Wind Power prevent it from happening. At which point, the Applicant, DLNR and USFWS will discuss and concur on an appropriate start date and modify mitigation efforts if necessary to enable mitigation efforts to commence as soon as possible. If after 3 years, mitigation has still yet to commence, the same equivalent amount of funding will be used to conduct alternate mitigation measures at the same site or at an alternate site. The alternate mitigation measures will be decided in concurrence with DLNR and USFWS. Upon entering a Higher Take level, additional funding will be made available within 6-months of the determination to implement the required mitigation to be commensurate with the requested take at the Higher tier and achieve a net conservation benefit for the species.

If monitoring after two years of predator control indicate that mitigation efforts are not above the baseline productivity (i.e. productivity in the absence of management), as part of adaptive management, mitigation efforts may increase, or other measures may be implemented instead. The baseline productivity will also be examined to determine if it is biologically reasonable and adjusted if necessary. Other measures may also be implemented should monitoring identify more pertinent threats that need to be addressed, or other management activities to be more effective in increasing survival and productivity. Mitigation may also be implemented at other waterbird sites should that be agreed upon as the action most likely to benefit the Covered Species. All actions implemented will be determined in consultation with DLNR and USFWS.

After the initial 3 -5 year mitigation period, the mitigation will be deemed successful if the number of fledglings and adults accrued exceed the requested take for Hawaiian coot, Hawaiian stilt and Hawaiian moorhen and result in a net benefit for the three Covered species over the entire permit term. For the Hawaiian duck, mitigation will be deemed successful if the culling of feral ducks, mallards and Hawaiian duck hybrids is carried out as far as practicable and that these ducks do not occur in such numbers on site as to negatively impact the other Covered Species in terms of space or resource use. Net benefit will also be considered to have been achieved as these mitigation efforts will have contributed to a reduction in introduced predator populations, which is considered a form of habitat improvement, and will have contributed to the recovery of the species.

If mitigation efforts still fall short of more than one fledgling required to meet the Baseline requested take, mitigation efforts will be re-evaluated and modified by further consultation with DLNR and USFWS. Mitigation will be extended beyond the 3 -5 year period to ensure that the Baseline requested take for Hawaiian coot, Hawaiian stilt and Hawaiian moorhen are met and result in a net benefit for the three Covered species over the entire permit term. As the increase in adult survival or production of fledglings accrued for each species may be uneven due to differences in pair abundance or reproductive success, more effort may be concentrated on enhancing the productivity of a specific Covered waterbird species in order to achieve the required number of fledglings to meet the Baseline requested level of take, provided the measures do not negatively affect the productivity of other Covered species at the mitigation site. .

To ensure the success of the mitigation effort, Kahuku Wind Power will establish a $150,000 Waterbird Contingency Fund. The fund will be compounded at 2.5% annually over the 20-year term of the HCP resulting in a total possible maximum of $245,792 (if left unused at year 20). If the fund is drawn upon at any time, the interest will continue to accrue for the remaining balance. This fund will be available to implement adaptive measures to ensure that mitigation is commensurate with the actual take. If at the end of the 20-year period the mitigation is still not commensurate with requested take, any remaining contingency funds will be used for further mitigation efforts.

Hawaiian Short-eared Owl

Data on status of Hawaiian short-eared owl in the project area is too scant to enable a reasonable estimation of the mortality rate for this species that may result from completion of the proposed project. Observations of short-eared owls at the KWP facility suggest most generally fly low over the ground, preferring open pastures and grasslands away from most structures (G. Spencer/FirstWind, pers. comm.). Potential for short-eared owls to collide with wind turbines seems it would be greatest when birds were performing aerial breeding displays or if the birds were needing to avoid some aerial predator. The paucity of observations of this species from the project area strongly suggests Hawaiian short-eared owls do not breed in or directly adjacent to the project area, so the probability of short-eared owls colliding with wind turbines while performing breeding displays appears to be exceedingly low. No potential aerial predators of Hawaiian short-eared owl occur on O‘ahu, so it also appears very unlikely that short-eared owls would collide with any of the proposed wind turbines for this reason. Post-construction monitoring data from North America suggest the species is generally not vulnerable to collision with wind turbines.

Potential for short-eared owls to collide with on-site and off-site project components including the permanent, un-guyed met tower, microwave towers, overhead collection lines, relocated distribution lines, utility poles or cranes during the turbine construction period is considered negligible because these structures would be immobile and stationed in cleared sites. Thus, the towers, cranes and overhead cables should be readily visible to, and avoidable by, owls. All overhead collection lines will be spaced according to APLIC guidelines and no electrocution related mortalities are expected.

The expectation that short-eared owls are not likely to collide with project related structures, is supported by the results of post-construction monitoring and general observations made at the KWP facility on Maui. Short-eared owls are observed regularly at the KWP facility yet, as indicated above, no short-eared owl fatalities with any project components have been recorded after more than three and a half years of operation (G. Spencer/FirstWind, pers. comm.). One carcass however was incidentally found under MECO transmission lines in 2009. The paucity of recorded fatalities at a site where the species occurs regularly and, hence, has greater exposure to collision hazards, suggests strongly that risk of collision at the Kahuku Wind Power facility would be very low given that the species has rarely been documented on the site.

Some potential exists for construction or maintenance vehicles to strike short-eared owls that may be hunting low over the project area. Project personnel will be educated regarding the possibility of owls flying low across project roadways or resting on the ground adjacent to roadways and speed limits (10 mph) will be emplaced and enforced on project roadways to minimize potential for vehicle strikes to harm short-eared owls.

Given the above information, it is possible that no Hawaiian short-eared owl fatalities will be realized during the life of the Kahuku Wind Power project. However, because the species is known to occur in the general vicinity of the project area at least on occasion, the risk of collision cannot therefore be considered zero. Given the on-site survey results and monitoring results from the KWP site on Maui, it seems reasonable to assume that the chance of the proposed project causing a short-eared owl fatality in any given year is well less than 1.0. It is assumed that the proposed project will on average result in the loss of 0.33 Hawaiian short-eared owl/year.

This equates to one owl every three years and was chosen as a conservative estimate based on the findings at KWP where no short-eared owls have been lost to project operations after three years. This mortality rate includes loss due to interaction with turbines, met towers, on-site and off-site microwave towers and overhead cables, utility poles and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

Adult owls have potential to collide with turbines or be struck by vehicles at any time of year and presumably regardless of breeding status. Hawaiian short-eared owls breed year round with no known peak breeding season. The average breeding period (from brooding to fledging) is two months long. Thus, at any given time the probability that an owl killed on-site was actively breeding would be 0.167 (2 months / 12 months per year = 0.1667). Because the owls breed year round, it will be assumed that any owl that might be killed could have been tending to a full clutch of eggs or a nest of newly hatched young. As males only provide food and females exclusively brood and feed young, the loss of either parent is likely to result in the loss of the entire brood. Consequently, as depicted in Table 11 below, the amount of indirect take that will be assessed for the direct take of any adult Hawaiian short-eared owl is 0.95 owlets (life history data in HCP).

Table 11. Calculating indirect take for the Hawaiian short-eared owl.

Hawaiian short-eared owl	Season	Average no. of owlets per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Adult	All year	5.6	0.17	1.0	0.95
Immature	All year	--	0.00	--	0.00

As discussed, because of assumptions concerning unobserved direct take, any one Hawaiian short-eared owl found to have collided with a project component in a year will lead to an assessment of total direct take for that year of greater than one. Consequently, the Applicant suggests the ITL should allow for a total direct take of 2 adults or recently fledged Hawaiian short-eared owls per year of project operation.

The direct take of one adult owl will result in an assessment of indirect take of 0.95 owlets or essentially rounded to one owlet. Consequently, the Applicant suggests the Baseline ITL should also allow for the indirect take of 2 owlets/year, which would account for the amount of incidental take that would be assessed to the total direct take of 2 adults (2 x 0.95 = 1.9). Expected rates of take and rates of take requested to be authorized by the ITL through the expected 20-year life of the project are summarized below, along with rates of take considered to qualify as “Lower” and “Higher.”[7]

Expected Rate of Take

Annual average	0.33 adults/immatures and 0.31 owlets	0.64 birds/year
20-year project life	7 adults/immatures and 7 owlets	

Requested ITL Authorization

Baseline level of take	2 adults/immatures and 2 owlets	4 birds/year
5-year limit of take	6 adults/immatures and 6 owlets	
20-year limit	8 adults/immatures and 8 owlets	

Higher Rate of Take

One-year period	Total direct take of 3 - 4 adults/immatures and 3 - 4 owlets
5-year period	Total direct take of 7 - 8 adults/immatures and 7 – 8 owlets
20-year period	Total direct take of 9 -12 adults/immatures and 9 – 12 owlets

Lower Rate of Take

5-year period	Total direct take of 0 adults and 0 owlets

No population numbers for Hawaiian short-eared owl are available for the island of O‘ahu or any of the other Hawaiian Islands. However, given the rate of assumed loss (0.33 adults and 0.31 owlets), it is unlikely that the proposed project would cause a significant impact on the Hawaiian short-eared owl population on O‘ahu. The Applicant’s proposed mitigation for the anticipated take will contribute to a greater understanding of the species’ occurrence and status on O‘ahu, which in turn will help guide future management and recovery efforts and should result in an overall net conservation benefit for the species.

Higher levels of take may impact the O‘ahu population if its population is small, but such take would not be expected to affect the status of the species on other islands. However, realization of take at higher levels is considered extremely unlikely to occur because Hawaiian short-eared owl have been heard only once at the Kahuku Wind Power site over the course of 15 months of surveys, and given the results of the monitoring surveys performed at KWP on Maui. However, the proposed mitigation for the Higher take levels will contribute to a greater understanding of the species’ occurrence and status, which in turn will help guide future management and recovery efforts and should result in an overall net conservation benefit for the species.

Hawaiian Short-eared Owl Mitigation

Monitoring of population trends and documentation of habitat occupancy were identified as key monitoring and conservation priorities for the Hawaiian short-eared owl by the Hawai‘i Comprehensive Wildlife Conservation Strategy (Mitchell et al. 2005). This was because of a lack of basic life history information on the Hawaiian short-eared owl, making management techniques to enhance Hawaiian short-eared owl populations on O‘ahu hard to identify and their effectiveness difficult to quantify because of an absence of adequate baseline studies.

---

[7] The expected 20-year rate was derived by multiplying 0.33 owls/year by 20 years and rounding up to the nearest whole integer. The requested 20-year authorization was increased from 7 to 8 because it is expected that total direct take will always be assessed in multiples of two.

Mitigation targets have been identified based on the levels of take identified as “Baseline” or “Higher.” On-site post-construction monitoring will be used to determine actual rates of Hawaiian short-eared owl take. Initial mitigation is intended to compensate for take at Baseline level. If post-construction monitoring shows that take is actually occurring below or in excess of Baseline level, adjustment to mitigation efforts would be made as described below.

Baseline Mitigation for the Hawaiian Short-eared Owl

Mitigation for possible take of the Hawaiian short-eared owl by Kahuku Wind Power will consist of three parts: funding research; rehabilitation of injured owls; and subsequently implementing management actions on O‘ahu as they are identified and as needed to bring mitigation ahead of take (i.e., provide a net benefit). Therefore, upon issuance of the incidental take permit, Kahuku Wind Power will contribute $25,000 to appropriate programs to support owl research and rehabilitation.

As little is known about the life history of the Hawaiian short-eared owl, research could be designed to develop protocols to monitor Hawaiian short-eared owl populations, determine habitat use and preferences and evaluate the effectiveness of habitat management techniques. Concurrently, funding will also be used to develop a rehabilitation program for Hawaiian short-eared owls that are found injured (such due to vehicular collisions) and brought in by the public or agencies.

The allocation of funds to research and rehabilitation will be determined by DLNR and USFWS. The research funding may be used for (but not limited to) the purchase of radio transmitters, receivers, or provide support for personnel to conduct research such as a population census. However, these funds will be used for whatever management or research activity is deemed most appropriate at the time, with the concurrence of USFWS and DLNR.

The rehabilitation program could consist of training selected veterinarians in the assessment and appropriate care of injured Hawaiian short-eared owls. This would in turn enable the veterinarians to obtain the necessary permits required to handle the state-endangered birds. Other possible funding applications could be a public outreach program where the public would be informed of the appropriate steps to take upon encountering an injured Hawaiian short-eared owl. The allocation of funds for owl rehabilitation will be determined by DLNR and USFWS and will be used for whatever rehabilitation activity is deemed most appropriate at the time. Hawaiian short-eared owls rehabilitated under the funding of Kahuku Wind Power will be credited as compensation for take that is incurred at the Kahuku Wind Power facility.

It is anticipated that the research conducted will result in the identification of practicable management actions that will aid in the recovery of Hawaiian short-eared owl populations on O‘ahu. At this point, Kahuku Wind Power will provide additional funding of $25,000 up to a maximum of $50,000 to implement a chosen management measure as agreed upon by USFWS and DLNR. The level of funding provided for management will be decided with the concurrence of DLNR and USFWS and will be used to compensate for the Baseline requested take (adjusted for take already mitigated for in the rehabilitation program) and also provide a net benefit to the species.

Mitigation for Higher Rates of Take of the Hawaiian Short-eared Owl

If monitoring indicates a Higher level of take, Kahuku Wind Power will provide additional funding of $15,000 for increased owl research and rehabilitation. Examples of possible research include studies of where Hawaiian short-eared owls are likely to breed, quantification of productivity, or developing and testing the effectiveness of management techniques. However, should research indicate that other areas of study are more important or pressing in aiding the recovery of the species, in concurrence with USFWS and DLNR, these funds will be used for whatever management or research activity is deemed most appropriate at the time.

This funding will be followed by an additional $15,000 up to a maximum of $30,000 for implementing chosen management actions as they become available, with the concurrence of USFWS and DLNR. The level of funding provided for management will be decided upon with concurrence of DLNR and USFWS and will be commensurate with take and also provide a net benefit to the species.

Mitigation for Lower Rates of Take of the Hawaiian Short-eared Owl

Because it is proposed to provide $25,000 up-front for owl research under the Baseline scenario, the Baseline rate of mitigation will have been committed prior to identification of any Lower rate of take. Consequently, no adjustment to the Baseline mitigation effort would be made if monitoring surveys indicate a rate of take below the Baseline level.

Measures of Success for the Hawaiian Short-eared Owl

The success of the mitigation efforts will be determined as follows:

1. Funding for owl research will be considered successful if within 6-months of issuance of the ITL, Kahuku Wind Power contributes $25,000 to an appropriate program to support owl research and rehabilitation. Or if upon entering a Higher Take level, an additional $15,000 is provided for research within 6-months of the determination;
2. Implementation of management measures will be considered successful if Kahuku Wind Power contributes $25,000 to $50,000 (for take at or below Baseline) plus an additional $15,000 to $30,000 (in the event of Higher Take) to fund management that is commensurate with the requested take for the required tier, and the management is carried out and is demonstrated to provide a net benefit to the species. Criteria for the success of the management measures will be determined when the protocols for the chosen management measures are developed.

To ensure the success of the mitigation effort, Kahuku Wind Power will establish a $75,000 Hawaiian Short-eared Owl Contingency Fund. The fund will be compounded at 2.5% annually over the entire 20-year term of the HCP resulting in a total possible maximum of $122,896 (if left unused at year 20). If the fund is drawn upon at any time, the interest will continue to accrue for the remaining balance. This fund will be available to implement adaptive measures to ensure that mitigation is commensurate with the actual take. If at the end of the 20-year period the mitigation is still not commensurate with actual take, any remaining contingency funds will be used for further mitigation efforts.

Hawaiian Hoary Bat

Based on surveys conducted to date, a low but consistent level of Hawaiian hoary bat activity occurs on site. There has been one other confirmed sighting of a Hawaiian hoary bat at Pūpūkea on the North Shore of O‘ahu in 2002 (T. Menard, pers. comm.). Monitoring suggests that bats may potentially occur in very low numbers year-round at the project area with some small increase in activity between June and September. Post-construction monitoring at the KWP facility on Maui has demonstrated that bat activity there is also low. A single observed direct take has occurred at KWP after more than 3-years of post-construction monitoring.

Extensive monitoring of bat activity at existing wind farms has shown a strong positive relationship between the total number of bat passes/detector/night with the estimated total fatalities/turbine/year determined through observed fatalities (Kunz et al. 2007). Essentially, the number of bat fatalities/turbine/year is almost equivalent to the number of bat passes per night for each detector on site (see Table 12). The data on echolocation passes reported in these studies did not distinguish among species so it is not possible to know if the correlation between mortality and bat call rates holds for all species. Moreover, echolocation calls were recorded at different heights at some sites and only at ground level at others.

Unfortunately, the echolocation call data for the above studies were all collected after the wind energy facilities were constructed. It is unclear whether pre-construction bat pass data, such as is available for the Kahuku Wind Power site, can fairly be used to estimate operational fatality rates. Operational monitoring has shown relatively high bat mortality rates at some wind power sites where no bat activity was recorded during pre-construction surveys, suggesting that certain bat species, especially migratory tree (*Lasiurus*) bats, may be attracted to wind turbines (Kunz et al. 2007). Other research suggests that clearing for wind projects in wooded habitats can alter how and where bats hunt for food. As a result, pre-construction investigations of bat activity in wooded habitats may not provide an accurate prediction of where and how many bats will occur in the post-construction landscape.

Table 12. Fatality rates and bat activity indices at 5 wind-energy facilities on the mainland United States (from Kunz et al. 2007).

Study area	Dates of study[1]	Bat mortality (no./turbine/yr)	Bat activity (no./detector/night)	Detector nights	Source
Mountaineer, WV	31 Aug- 11 Sep 2004	38	38.2	33	E.B. Arnett, Bat Conservation International, unpubl. data
Buffalo Mountain, TN	1 Sep 2000- 30 Sep 2003	20.8	23.7	149	Fiedler 2004
Top of Iowa, IA	15 Mar-15 Dec 2003, 2004	10.2	34.9	42	Jain 2005
Buffalo Ridge, MN	15 Mar-15 Nov 2001, 2002	2.2	2.1	216	Johnson et al. 2004
Foote Creek Rim, WY	1 Nov 1998-31 Dec 2000	1.3	2.2	39	Gruver 2002

[1] Sample periods and duration of sampling varied among studies, with no fatality assessments conducted or bat activity monitored in winter months.

The Anabat remote data-loggers used on-site resulted in measurement of approximately 0.016 call sequences/detector/night or 0.010 bat passes/ detector/night. Take estimates for Hawaiian hoary bat for the Kahuku Wind Power project are calculated with the following assumptions:

1) that changes in landscape and construction of turbines do not attract bats to the area;
2) that post-construction bat activity remains the same as the measured pre-construction bat activity; and
3) the number of bat fatalities/turbine/year is equivalent to the number of bat passes/night for each detector on site (as shown by Kunz et al. 2007)

However, since the level of bat activity is already very low, the estimated take of bats per turbine is based on the number of call sequences per detector night, rather than the number of bat passes (Assumption 3) in order to give a more conservative fatality estimate. Based on these assumptions, the estimated average rate of take for the Kahuku Wind Power project is 0.016 bats/turbine/year. This equates to a total average take of 0.19 bats/year for all 12 turbines on the site. It therefore seems reasonable to assume that the average direct take will be much less than one bat per year for the entire project. Bat activity at the Kahuku Wind Power project area was similar to the post-construction bat activity recorded at the Kaheawa Wind Power project, which had an activity rate of 0.014 bat call sequences/detector/night (SWCA and First Wind 2010). One observed fatality has been recorded at the KWP facility after 3.5 years of project operation.

Potential for bats to collide with met towers on-site and off-site microwave towers and overhead cables, utility poles, other associated structures or cranes is considered to be negligible because they would be immobile and should be readily detectable by the bats through echolocation. While the guy wires on the temporary met towers may pose a somewhat greater threat to bats, bats while present at KWP on Maui, have not been found to have collided with the guyed met towers after three years of operation nor with any cranes during the construction phase of that project. Of 64 wind turbines studied at Mountaineer Wind Energy Center in the Appalachian plateau in West Virginia, bat fatalities were recorded at operating turbines, but not at a turbine that remained non-operational during the study period. This supports the expectation that presence of the stationary structures such as met tower and cranes should not result in bat fatalities (Kerns et al. 2005).

However, if in the unlikely event a bat mortality is found in the future and that mortality can be attributed to the on-site construction cranes, Kahuku Wind Power on-site or off-site microwave towers, associated overhead cables or utility poles, Kahuku Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site.

After commissioning, the lease for both offsite microwave tower sites may be turned over from Kahuku Wind Power LLC to HECO. If so, any take responsibility associated with potential take at the off-site tower may be transferred as well. The transfer of responsibility would be determined in consultation with DLNR and USFWS.

Hoary bats are thought to move to higher elevations during the months of January through March (Menard 2001), and so may be less prevalent in the project area during those months. The limited bat activity data collected to date collected at Kahuku Wind Power also suggest that this may be occurring but not conclusively. However, as there is generally little information on hoary bats on O'ahu, it is assumed that levels of bat activity on-site remain constant throughout the year. Consequently, adult bats are considered to have equal potential to collide with turbines throughout the year and regardless of breeding status.

Hawaiian hoary bats breed between April and August (Menard 2001). Females are solely responsible for the care and feeding of young, and twin pups are typically born each year, although single pups sometimes occur. To date, no breeding records for Hawaiian hoary bat exist for O'ahu, however, any female bats directly taken from April through August will be examined and, if determined to be pregnant or lactating, indirect take will be assessed. No indirect take will be assessed for female bats found at other times of year, or for male or immature bats found at any time of year. The rate at which indirect take will be assessed for pregnant or lactating female bats found during the months of April through August is 1.8 juveniles per adult female, as indicated in Table 13 below (life history data can be found in the HCP).

As indicated, the average rate of direct take of Hawaiian hoary bats expected as a result of project operations is 0.19 bats per year. Indirect take associated with this level of direct take would either be zero or 0.34 juveniles per year (0.19 x 1.8 = 0.34). This yields an expected average rate of take of less than 0.53 bats per year.

Table 13. Calculating indirect take for the Hawaiian hoary bat.

Hawaiian hoary bat	Season	Average no. of juveniles per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Female	Apr-Aug Pregnant or lactating	1.8	1.0	1.00	1.80
Female	Sep-Mar	--	0.0	--	0.00
Male	All year	--	0.0	0.00	0.00
Immature	All year	--	0.0	--	0.00

The DLNR and ESRC have recommended that annual take limits allow for at least one **observed** take a year. Again, because of assumptions concerning unobserved direct take, any one (1) Hawaiian hoary bat found to have collided with a project component in a year will lead to an assessment of total direct take for that year of greater than 1 likely to be rounded up to 4 bats (based on expected results from searcher efficiency and scavenging rates at Kahuku Wind Power). Existing literature on adjusting total direct take for bats suggest that a ratio of one observed take to three unobserved takes is not unreasonable and may be conservative (e.g. Arnett et al. 2005, Jain et al. 2007, Fiedler et al. 2007, First Wind and Kaheawa Wind Power 2008). While the other bats taken under this scenario would be assumed and, therefore, of unknown age or gender, it will be assumed that all Hawaiian hoary bats taken through “unobserved direct take” will be adults and will have a 50% chance of having been female (based on the sex ratio of males to females during the breeding season). In addition, because bats could be flying through the project area at any time of year, the likelihood of a bat being in breeding condition is assumed to be 33%. This is based in the information that Hawaiian hoary bats have one brood a year, and are expected to be breeding four months of the year (a three month gestation period followed by parental care for one month, NatureServe 2008). Consequently, following the above table, indirect take will be assessed to bats lost through “unobserved direct take” at the rate of 0.30 juveniles/bat (05. x 0.33 x 1.8 = 0.30).

Indirect take assessed to a total direct take of 4 bats could range up to 3 juveniles (1.80 + 0.30*3 = 2.7). Consequently, the Applicant suggests the Baseline ITL should allow for a total direct take of 4 adult or volent juvenile Hawaiian hoary bats and the indirect take of up to 3 dependent juvenile bats per year of project operation. Expected rates of take and rates of take requested to be authorized by the ITL through the expected 20-year life of the project are summarized below, along with rates of take considered to qualify as “Lower” and “Higher.”

Expected Rate of Take

Average	0.19 adults/immatures and 0.34 juveniles	0.54 bats/year
20-year project life	4 adults/immatures and 7 juveniles	

Requested ITL Authorization

Baseline annual level of take	4 adults/immatures and 3 juveniles	7 bats/year
5-year limit of take	10 adults/immatures and 8 juveniles	
20-year limit	12 adults/immatures and 9 juveniles	

Higher Rate of Take

One-year period	Total direct take of 5 - 8 adults/immatures and 3 – 6 juveniles
5-year period	Total direct take of 11 -12 adults/immatures and 8 – 9 juveniles
20-year period	Total direct take of 13 - 18 adults/immatures and 9 - 14 juveniles

Lower Rate of Take

5-year period	Total direct take of 0 adults/immatures and 0 juveniles

No recent population estimates exist for Hawaiian hoary bat, though previous estimates have ranged from several hundreds to several thousands (Tomich 1969, Menard 2001). The bat population on the island of Hawai‘i is estimated to be in the tens of thousands (F. Bonnacorso/USGS, pers. comm.). The Recovery Plan for the Hawaiian Hoary Bat (USFWS 1998) states “since no accurate population estimates exist for this subspecies and because historical information regarding its past distribution is scant, the decline of the bat has been largely inferred.” Although overall numbers of Hawaiian hoary bats are believed to be low, they are thought to occur in the greatest numbers on the Island of Hawai‘i and Kaua‘i (Menard 2001).

The identified Baseline Take level is low and is considered unlikely to result in a significant impact on the overall population of the Hawaiian hoary bat. Higher levels of take may begin to impact the O‘ahu population, if the population is very small, but they would not likely impact the status of the species on other islands where populations are assumed to be more robust. The Applicant’s proposed mitigation for the anticipated take will contribute to a greater understanding of the species’ status on O‘ahu, which in turn will help guide future management and recovery efforts and should result in an overall net conservation benefit for the species.

Hawaiian Hoary Bat Mitigation

Because of the lack of life history information on the Hawaiian hoary bat, research is identified as one of the key components in the recovery of this subspecies. The Recovery Plan for the Hawaiian Hoary Bat (USFWS 1998) states that “Research is the key to reaching the ultimate goal of delisting the Hawaiian hoary bat because currently available information is so limited that even the most basic management actions cannot be undertaken with the certainty that such actions will benefit the subspecies.”

Recent research by Gorresen et al. (2008) on Hawaiian hoary bat detectability and occupancy has identified several key areas of research required to improve life history knowledge. The areas identified are:

- Determining bat occupancy in different habitats
- Determining bat distribution across seasons on a local and regional scale
- Determining seasonal and daily peak bat activity periods
- Monitoring of population trends

Development and implementation of a survey and monitoring program remains a high priority and a key recovery objective for the Hawaiian hoary bat (Gorresen et al. 2008, USFWS 1998).

Mitigation targets have been identified based on the levels of take identified as “Baseline” or “Higher.” On-site monitoring during operations will be used to determine the tier at which Hawaiian hoary bat take is occurring. Mitigation is intended to compensate for take at Baseline level. If monitoring shows that take is actually occurring below or in excess of Baseline level, adjustment to mitigation efforts would be made as described below.

<u>Baseline Mitigation for the Hawaiian Hoary Bat</u>

Mitigation for the Hawaiian hoary bat by Kahuku Wind Power was developed through discussions with USFWS, DLNR, and bat experts at USGS, and involved identifying the most immediate needs required for the recovery of the species. Based on the feedback received, the Applicant proposes a combination of the following:

1. on-site surveys to add to the knowledge base of the species’ status on O‘ahu;
2. on-site research into bat interactions with the wind facility;
3. implementation of bat habitat improvement measures to benefit bats as determined based on the results of ongoing research, in consultation with DLNR, USFWS, and ESRC

Bat Habitat Utilization at Kahuku Wind Power and Vicinity

Kahuku Wind Power LLC will continue to survey for and monitor Hawaiian hoary bats within and in the vicinity of the Kahuku Wind Power project area. Surveys will be conducted during years when systematic fatality monitoring is conducted (i.e., during the first two years and at five year intervals thereafter, or as otherwise determined under the adaptive management provisions) to allow observed activity levels to be correlated with any take that is observed. A critical component identified as essential to Hawaiian hoary bat recovery is the need to develop a standardized survey protocol for the Hawaiian hoary bat monitoring program to enable results collected by different parties to be directly comparable. Therefore, the Applicant will expand or modify ongoing efforts to conform to USGS (HBRC) protocols being used in the Hawaiian Islands. Kahuku Wind Power LLC will also join the Hawai‘i Bat Research Cooperative (HBRC) and as a contribution to the on-going research efforts in the state, will conduct its own surveys and monitoring at Kahuku Wind Power and the vicinity. Twelve anabat detectors will be deployed at Kahuku Wind Power and, if suitable sites are identified and landowner permission is granted, in adjacent lands with other habitat types (e.g. gulches or ponds) or in coastal wetland areas.

The goal of this research will be to document bat occurrence, habitat use and habitat preferences on site, as well as identify any seasonal and temporal changes in Hawaiian hoary bat abundance. This research will be an extension of a 5-year survey already underway on the Island of Hawai‘i and another that will shortly commence on Maui.

Research on Bat Interactions with the Wind Facility

In conjunction with the two year study to determine habitat utilization by bats at Kahuku Wind Power and its vicinity, Kahuku Wind Power proposes to conduct additional on-site research that will contribute to identifying areas of potential interactions and vulnerabilities of Hawaiian hoary bats at wind facilities, as follows:

1. Kahuku Wind Power will survey for bat activity near turbine locations for the first two years of operation using acoustic bat detectors. Surveys will also be conducted during

years when systematic fatality monitoring is conducted. USGS (HBRC) monitoring protocols will be used and adjusted if necessary. Thermal imaging or night vision technology will be used to assist acoustic monitoring as trends are detected and would follow similar protocols developed during pre-construction monitoring. The use of additional techniques and technologies will also be considered. These data will be analyzed in an effort to determine seasonal and daily peak bat activity periods on-site, and comparison of data with pre-construction activity levels will help determine if bats are being attracted to the wind facility.

2. Incidental bat observations will be recorded under the WEOP (see HCP).

This in-house research is expected to advance avoidance and minimization strategies that wind facilities in Hawaiʻi and elsewhere can employ in the future to reduce bat fatalities.

Implementation of Management Measures

The Applicant will contribute an additional negotiated amount of $25,000 up to a maximum of $150,000 to fund an appropriate management program. As recommended by DLNR, USFWS, and ESRC that the measures if implemented as stipulated will be sufficient to mitigate for the Baseline requested take and provide a net benefit to the species.

DLNR, USFWS, ESRC, and Kahuku Wind Power LLC will consult to determine the most appropriate measures for implementation. Because the measures have not yet been determined, a budget range for implementing measures has been established based on preserving or enhancing foraging and/or roosting habitat capable of supporting a commensurate number of bats to achieve the mitigation requirement. The Baseline requested take of 12 adult bats and 9 juveniles equates to a total of 15 adults (with an estimated 30% survival rate of juveniles to adulthood). The core area for an adult bat is estimated to be 13.3 ac (5.4 ha), therefore, a total area of approximately 200 ac (82.5 ha) may be required for 15 adults, assuming no spatial overlap and no empty territories. One preliminary option to improve bat habitat was developed during discussion with DLNR and is listed below.

Native habitat plant restoration at a previously burned forest on Maui was identified as one option for enhancing bat habitat. The Polipoli area of the Kula Forest Reserve in East Maui was burned by a wildfire in 2007. A total of approximately 2,300 acres of forested public lands, including the Polipoli area, within Kula Forest Reserve was burned at this time. This burn unit was dominated by mature closed canopy forest comprised primarily of pines, cypresses, and redwoods. One of the goals in the restoration of this burned unit was to enhance native species habitat and native ecosystem recovery (DLNR 2007b). This unit was known to support a variety of native birds and the Hawaiian hoary bat before the wildfire (F. Duvall/DOFAW, pers. comm.). The initial outplanting has been completed and 50, 30 and 20 percent of the 1,800 acre reforestation areas were planted with native trees (koa – ohia mixture), redwoods, and grass/shrublands, respectively.

DLNR has identified a need for funding for native habitat plant restoration which consists of supplemental planting to replace seedling mortality, implementation of rodent control, weed control and fertilization programs to enhance tree seedling survival and forest establishment. Kahuku Wind Power will support native habitat plant restoration for the entire 1,800 ac reforestation area, estimated to cost $125,000 in 2010 or $100,000 for the year 2011. Alternatively, funding may be used to conduct native habitat plant restoration at the Polipoli area for two years. The funding will be provided to support the plantation native habitat plant restoration which will be conducted by a qualified contractor or personnel approved by DLNR or USFWS.

It is anticipated that the measure outlined above or any others that are developed in the future will be conducted in partnership with other conservation groups or entities and that these activities will complement other restoration, reforestation or conservations goals occurring in that area at the time. The allocation of the funds for any mitigation measure would be determined by the Applicant in consultation with USFWS and DLNR. Funds will be directed toward whatever management or research activity is deemed most appropriate at the time.

Mitigation for Higher Rates of Take of the Hawaiian Hoary Bat

Should Kahuku Wind Power exceed the Baseline rate of take Kahuku Wind Power will immediately implement low wind-speed curtailment by increasing the cut-in speed of all turbines (or a subset of turbines if so determined by DLNR and USFWS) from their normal operation to 5m/s during periods when bats are active, approximately from dusk till sunrise. Low wind speed curtailment will be implemented unless there is strong evidence that the observed fatalities are a result of some other cause that can be corrected by other means. The final determination of whether to implement low wind speed curtailment will be made by DLNR and USFWS, in consultation with Kahuku Wind Power.

Recent studies on the mainland indicate that most bat fatalities occur at relatively low wind speeds, and consequently the risk of fatalities may be significantly reduced by curtailing operations on nights when winds are light and variable. Research is suggesting this may best be accomplished by increasing the cut-in speed of wind turbines from their normal levels (usually 3.5 or 4 m/s, depending on the model). Research conducted by Arnett et al. (2009) found that bat fatalities could be reduced by 53-87 percent when cut-in speed was increased to 5 m/s. No significant additional improvement over this level was detected when the cut-in speed was increased to 6.5 m/s. Because power increases exponentially with wind speed, at low wind speeds the power loss is generally modest, however, incrementally increasing the cut-in speed above 5 m/s results in an exponential increase in lost power. These findings are encouraging and hold promise for reducing fatalities at projects where bat fatalities have been found to be high.

The times of the year when curtailment is implemented (i.e. year-round or seasonal) at Kahuku Wind Power will be decided based on bat detection data on site, seasonal distributions of observed fatalities on site, and best available science, with concurrence from USFWS and DLNR.

In addition to the immediate implementation of low-wind speed curtailment, Kahuku Wind Power will review the fatality records in an effort to determine whether additional measures can be implemented that will reduce or minimize take. If causes cannot be readily identified Kahuku Wind Power will conduct supplemental investigations that may include but not be limited to:

1. additional analysis of fatality and operational data;
2. deployment of acoustic bat detectors to identify areas of higher bat activity during periods when collisions are believed to be occurring;
3. using thermal imaging or night vision equipment to document bat behavior; and
4. determining whether certain turbines are causing most of the fatalities or if fatality rates are related to specific conditions (e.g., wind speed, other weather conditions, season).

Other measures to reduce bat fatalities will be implemented as identified and feasible and may include changes in project operations such as modifying structures and lighting, and implementing measures to repel or divert bats from areas of high risk without causing harm if practicable. These data may also be used to refine low-wind speed curtailment options, such as determining the times of year when curtailment is mandatory, or if curtailment can be confined to a subset of “problem” turbines. These additional measures will be implemented by Kahuku Wind Power with the concurrence of USFWS and DLNR.

An additional negotiated amount of $15,000 up to a maximum of $75,000 will also be provided to implement appropriate Hawaiian hoary bat management measures when identified. This budget range has been determined based on an expenditure of up to 50% above the maximum Baseline budget, which is reasonable considering that provisions for low-wind speed curtailment would be triggered before the 20-year Baseline take levels are reached. This funding will be used to conduct mitigation measures that will be deemed to be appropriate to compensate for the requested take at the Higher tier. The most appropriate mitigation measure to be implemented will be determined in consultation with DLNR and USFWS.

Mitigation for Lower Rates of Take of the Hawaiian Hoary Bat

As the proposed Baseline mitigation will be carried out within the first two years of project operation, no change to mitigation measures will occur should a Lower rate of take be determined.

Measures of Success for the Hawaiian Hoary Bat

The success of the mitigation efforts will be determined as follows:

1. Both components of on-site research into Hawaiian hoary bat habitat utilization and bat interaction with wind facilities will be considered successful if Kahuku Wind Power joins the HBRC and the specified survey and monitoring is carried out, including proper deployment and operation of bat detectors, data reduction and analysis, and reporting of findings to DLNR, USFWS and ESRC;
2. In the event that Kahuku Wind Power exceeds the Baseline rate of take measures to reduce bat fatalities will be considered successful if one or more causes can be identified and corrective measures are implemented that result in an estimated 50 percent or greater reduction in bat fatalities over previous levels when averaged over a five-year period;
3. Implementation of management measures will be considered successful if Kahuku Wind Power contributes $25,000 to $150,000 (for take at or below Baseline) within 6-months of beginning project operations, plus an additional $15,000 to $75,000 (for Higher Take upon exceeding the 20-year Baseline requested take) within 6-months of the determination, to fund management that is commensurate with the requested take at the required tier, and the management is carried out and is agreed upon by USFWS and DLNR to provide a net benefit to the species.

To ensure the success of the mitigation effort, Kahuku Wind Power will establish a $100,000 Hawaiian Hoary Bat Contingency Fund. The fund will be compounded at 2.5% annually over the entire 20-year term of the HCP resulting in a total possible maximum of $163,861 (if left unused at year 20). If the fund is drawn upon at any time, the interest will continue to accrue for the remaining balance. This fund will be available to implement adaptive measures to ensure that mitigation is commensurate with the requested take of the required tier. The fund will also be used to implement measures to reduce the likelihood of collisions on site or the protection of roost sites as identified by USFWS and DOFAW. If at the end of the 20-year period the mitigation is still not commensurate with actual take, any remaining contingency funds will be used for further mitigation efforts.

LITERATURE CITED

Adams, J. 2008. “Petrels in the Pacific: Tracking the Far-ranging Movements of Endangered ‘Ua‘u (Hawaiian Petrel).” US Geological Survey, Western Ecological Research Center. Available at: www.microwavetelemetry.com/newsletters/spring_2007Page4.pdf. Accessed February 11, 2008.

Ainley, D.G., L. DeForest, N. Nur, R. Podolsky, G. Spencer and T.C. Telfer. 1995. Status of the threatened Newell’s Shearwater on Kaua‘i: Will the population soon be endangered?

Ainley, D.G., T.C. Telfer, and M.H. Reynolds. 1997. Townsend’s and Newell’s Shearwater (*Puffinus auricularis*). In: The Birds of North America, No. 297. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Ainley, D.G., R. Podolsky, L. DeForest, G. Spencer, and N. Nur. 2001. The status and population trends of the Newell’s Shearwater or Kauz'i: insights into modeling. Studies in Avian Biology No. 22: 108-123.

Altamont Pass Avian Monitoring Team. 2008. Altamont Pass Wind Resource Area Bird Fatality Study. July. (ICF J&S 61119.06.) Portland, OR. Prepared for Altamont County Community Development Agency.

APLIC (Avian Power Line Interaction Committee). 1994. Mitigating bird collisions with power lines: the state of the art in 1994. Edison Electric Institute, Washington, DC. 78 pp.

APLIC (Avian Power Line Interaction Committee). 1996 (reprinted 2000). Suggested practices for raptor protection on powerlines: the state of the art in 1996. Edison Electric Institute/Raptor Research Foundation, Washington, DC. 125 pp.

Arnett, E.B. and M.D. Tuttle. 2004. Cooperative Efforts to Assess the Impacts of Wind Turbines on Bats. Bat Research News 45(4):201-202.

Arnett, E., W. Erickson, J. Kerns, and J. Horn, J. 2005. Relationships Between Bats and Wind Turbines in Pennsylvania and West Virginia: An assessment of fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Report prepared for Bats and Wind Energy Cooperative. Available at: http://www.batsandwind.org/pdf/ar2004.pdf.

Arnett, E.B., K. Brown, W.P. Erickson, J. Fielder, T.H. Henry, G.D. Johnson, J. Kerns, R.R. Kolford, T. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersly. 2008. Patterns of fatality of bats at wind energy facilities in North America. Journal of Wildlife Management 72: 61-78.

Arnett E.B., M. Schirmacher, M.M.P. Huso and J. Hayes. 2009. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Baerwald, E.F., G.H. D'Amours, B.J. Klug, and R.M.R. Barclay. 2008. Barotrauma is a Significant Cause of Bat Fatalities at Wind Turbines. Current Biology 18(16):695-696.

Baker, Patrick J.; Scowcroft, Paul G.; Ewel, John J. 2009. Koa (*Acacia koa*) ecology and silviculture. Gen. Tech. Rep. PSW-GTR-211. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 129 p.

Baldwin, P.H. 1950. Occurrence and Behavior of the Hawaiian Bat. Journal of Mammalogy, 31: 455–456.

Bannor, B.K. and E. Kiviat. 2002. Common Moorhen (*Gallinula chloropus*). In: The Birds of North America, No. 685. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Bellwood, J.J. and J.H. Fullard. 1984. Echolocation and Foraging Behaviour in the Hawaiian Hoary Bat, *Lasiurus cinereus semotus.* Canadian Journal of Zoology 62:2113-2120.
Berger, A.J. 1972. Hawaiian birdlife. The University Press of Hawaii, Honolulu, HI.

Bradley, J.S., R.D. Wooller, I.J. Skira, and D.L. Serventy. 1989. Age-dependent survival of breeding short-tailed shearwaters *Puffinus tenuirostris*. Journal of Animal Ecology 58:175–188.

Brisbin, Jr., I. Lehr and T.B. Mowbray. 2002. American Coot (*Fulica americana*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology.

Brisbin, Jr., I.L., H.D. Pratt, and T.B. Mowbray. 2002. American Coot (*Fulica Americana*) and Hawaiian Coot (*Fulica alai*). In: The Birds of North America, No. 697. (A. Poole and F. Gill, eds.). Philadelphia, PA.

Browne, R.A., C.R. Griffin, P.R. Chang, M. Hubley, and A.E. Martin. 1993. Genetic divergence among populations of the Hawaiian Duck, Laysan Duck, and Mallard. Auk 110:49–56.

Byrd, G.V. and C.F. Zeillemaker. 1981. Ecology of Nesting Hawaiian Common Gallinules at Hanalei, Hawai‘i. Western Birds 12(3):105-116.

Byrd, G.V., J.L. Sincock, T.C. Telfer, D.I. Moriarty, and B.G. Brady. 1984. A Cross-Fostering Experiment with Newell's Race of Manx Shearwater. The Journal of Wildlife Management 48(1):163-168.

Carothers, S.W. 2008. Expert Report: Evaluation of Risks to Avian (birds) and Chiropteran (bats) Resources. Gulf Wind Project, Kenedy County, Texas.

Cooper, B.A. and R.H. Day. 2003. Movement of the Hawaiian Petrel to Inland Breeding Sites on Maui Island, Hawaiʻi. Waterbirds 26(1):67-71.

Cooper, B.A. and R.H. Day. 2004a. Results of Endangered Bird and Bat Surveys at the Proposed Kaheawa Pastures Wind Energy Facility on Maui Island, Hawaiʻi, Fall 2004. Prepared by ABR, Inc., Forest Grove, OR and Fairbanks, AK for Kaheawa Wind Power, LLC, Makawao, HI and UPC Wind Management, LLC, Newton, MA. 16 pp.

Cooper, B.A. and R.H. Day. 2004b. Modeling Annual Seabird Use and Fatality at the Proposed Kaheawa Pastures Wind Energy Facility, Maui Island, Hawaiʻi. Prepared by ABR, Inc., Forest Grove, OR and Fairbanks, AK for Kaheawa Wind Power, LLC, Makawao, HI and UPC Wind Management, LLC, Newton, MA. 7 pp.

Cryan, P.M. 2008. Mating Behavior as a Possible Cause of Bat Fatalities at Wind Turbines. Journal of Wildlife Management 72(3):845-849.
Cryan, P.M. and A.C. Brown. 2007. Migration of Bats Past a Remote Island Offers Clues Toward the Problem of Bat Fatalities at Wind Turbines. Biol. Conserv. 129(1-2):1-11.

Day, R.H. and B.A. Cooper. 1995. Patterns of Movement of Dark-Rumped Petrels and Newell Shearwaters on Kauai. Condor 97(4):1011-1027.

Day, R.H., and B.A. Cooper. 2002. Petrel and shearwater surveys near Kalaupapa, Molokai Island, June 2002. Unpublished report prepared for National Park Service, Hawaii National Park, HI, by ABR, Inc.—Environmental Research & Services, Fairbanks, AK, and Forest Grove, OR. 17 pp.

Day, R.H. and B.A. Cooper. 2008. Results of Endangered Seabird and Hawaiian Hoary Bat Surveys on Northern Oahu Island, Hawaii, October 2007 and July 2008. Prepared by ABR, Inc., Forest Grove, OR and Fairbanks, AK for FirstWind, LLC.

Day, R.H., B.A. Cooper, and T.C. Telfer. 2003a. Decline of Townsend's (Newell's) Shearwaters (*Puffinus auricularis newelli*) on Kauai, Hawaii. Auk 120:669-679.

Day, R.H., B.A. Cooper, Brian A.; Blaha, Richard J. 2003b. Movement Patterns of Hawaiian Petrels and Newell's Shearwaters on the Island of Hawaiʻi. Pacific Science 57(2):147-159.
Del Hoyo, J., A. Elliott and J. Sargatal. 1992. The Handbook of the Birds of the World, Volume I. Ostrich to Ducks. Lynx Edicions, Barcelona.

DesRochers, David W., Michael D. Silbernagle, Aaron Nadig, J. Michael Reed. 2006. Improving population estimates of Hawaiian Moorhen *(Gallinula chloropus sandvicensis)* with call response surveys and banding data, unpublished.

DLNR (Department of Forestry and Wildlife). 2007a. Kaʻena Point Ecosystem Restoration Project. Available at: http://www.state.hi.us/dlnr/DLNR/kaena/Kaena_DEA_to_OEQC_Entire.pdf Accessed May 18, 2009

DLNR (Department of Forestry and Wildlife). 2007b. Proposed Hazard Reduction and Reforestation in the Aftermath of the Upper Waiohulu Wildfire. Available at: http://www.state.hi.us/dlnr/dofaw/pubs/KFRproposal-03.27.0761_full.pdf

Dobson AF. and Madeiros J. 2009. Threats facing bermuda's breeding seabirds: measures to assist future breeding success. Proceedings of the Fourth International Partners in Flight Conference Tundra to Tropics pp 223-226.

Drever, M.C., A. Wins-Purdy, T.D. Nudds, and R.G. Clark. 2004. Decline of Duck Nest Success Revisited: Relationship With Predators and Wetlands in Dynamic Prairie Environments. The Auk 121(2):497-508.

Engilis, Jr., A., K.J. Uyehara, and J.G. Giffin. 2002. Hawaiian Duck (*Anas wyvilliana*). In: The Birds of North America, No. 694. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Engilis, Jr., A. and M. Naughton. 2004. U.S. Pacific Islands Regional Shorebird Conservation Plan. U.S. Shorebird Conservation Plan. U.S. Department of the Interior, Fish and Wildlife Service. Portland, OR.

Engilis, Jr., A. and T.K. Pratt. 1993. Status and Population Trends of Hawaii's Native Waterbirds, 1977-1987. Wilson Bulletin 105:142-158.

Erickson, W.P. 2003. Updated Information Regarding Bird and Bat Mortality and Risk at New Generation Wind Projects in the West and Midwest. National Wind Coordinating Committee, Wildlife Workgroup Meeting, November 18, 2003. Resolve, Inc., Washington, D.C. Available at: http://www.nationalwind.org/events/wildlife/2003-2/presentations/erickson.pdf.

Erickson, W.P., G.D. Johnson, M.D. Strickland, D.P. Young, Jr., K.J. Sernka and R.E. Good. 2001. Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States. National Wind Coordinating Committee Publication.

Evans, K., D. Woodside and M. Bruegmann. 1994. A Survey of Endangered Waterbirds on Maui and O'ahu and Assessment of Potential Impacts to Waterbirds from the Proposed Hawaii Geothermal Project Transmission Corridor. U.S. Fish and Wildlife Services, Ecological Services. Honolulu, Hi.

FAA (Federal Aviation Administration). 2000. Obstruction marking and lighting. Advisory Circular AC 70/7460-1K, Air Traffic Airspace Management, March 2000. 31 pp.

Federal Register. 2004. Incidental Take Permit and Habitat Conservation Plan for the Kaua'i Island Utility Cooperative, Hawai'i. 69(135): 42447- 42449.

Fiedler, J. K. 2004. Assessment of bat mortality and activity at Buffalo Mountain windfarm, Eastern Tennessee. Thesis, University of Tennessee, Knoxville, USA.

Fiedler, J. K., T. H. Henry, C. P. Nicholson, and R. D. Tankersley. 2007. Results of bat and bird mortality monitoring at the expanded Buffalo Mountain windfarm, 2005. Tennessee Valley Authority, Knoxville, USA. http://www.batcon.org/windliterature.

First Wind and Kaheawa Wind Power. 2007a. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan 2006 Annual Report Part 1. 43pp.

First Wind and Kaheawa Wind Power. 2007b. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan 2006 Annual Report Part 2. 52pp.

First Wind and Kaheawa Wind Power. 2008. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan Year 2 HCP Implementation. 82pp.

Fullard, J.H. 2001. Auditory Sensitivity of Hawaiian Moths (Lepidoptera: Noctuidae) and Selective Predation by the Hawaiian Hoary Bat (Chiroptera: *Lasiurus cinereus semotus*) Proceedings of the Royal Society of London B. 268:1375-1380.

Garrettson, P.R., and F.C. Rohwer. 2001. "Effects of Mammalian Predator Removal on Production of Upland-Nesting Ducks in North Dakota." Journal of Wildlife Management 65(3):398–405.

Gruver, J.C. 2002. Assessment of Bat Community Structure and Roosting Habitat Preferences for the Hoary Bat (Lasiurus cinereus) Near Foote Creek Rim, Wyoming. Thesis, University of Wyoming, Laramie, USA.

Gummer, H. 2003. Chick Translocation as a Method of Establishing New Surface-nesting Seabird Colonies: A Review Wellington (New Zealand) New Zealand Department of Conservation. Science Internal Series 150.

Haines, W.P., M.L. Heddle, P. Welton, and D.A. Rubinoff. 2009. Recent Outbreak of the Hawaiian Koa Moth, Scotorythra paludicola (Lepidoptera: Geometridae), and a Review of Outbreaks between 1892 and 2003. Pacific Science 63(3): 349-369

Harrison, C. 1990. Seabirds of Hawaii. Natural History and Conservation. Cornell University Press, Ithaca.

Hawaii Audubon Society. 2005. Hawaii's Birds: 6th Edition. Island Heritage: Waipahu: Hawaii.

Hays, W.S.T. and S. Conant. 2007. Biology and Impacts of Pacific Island Invasive Species. 1. A Worldwide Review of Effects of the Small Indian Mongoose, *Herpestes javanicus* (Carnivora : Herpestidae). Pacific Science 61(1):3-16.

Hötker, H, K.M. Thomsen, H. Jeromin. 2006. Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats. Facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. Michael-Otto-Institut im NABU, Bergenhusen.

Hu, D., C. Glidden, J.S. Lippert, L. Schnell, J.S. MacIvor, and J. Meisler. 2001. Habitat use and limiting factors in a population of Hawaiian Dark-romped Petrels on Mauna Loa, Hawai'i. Pages 234-242 *in* J. M. Scott, S. Conant, and C. van Riper III, eds. Ecology, conservation, and management of endemic Hawaiian birds: A vanishing avifauna. Stud. Avian BioI. 22.

Huso, M. 2008. Statistical properties of fatality estimators. Paper presented at NWCC Research Meeting, Milwaukee, Wisconsin. November 2008.

IPCC (Intergovermental Panel on Climate Change). 2007. 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jain, A.A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. Masters Thesis, Iowa State University. 113 pp.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study–2006. Annual report prepared for PPM Energy and Horizon Energy, Curry and Kerlinger LLC, Cape May Point, New Jersey, USA. ,http://www.batcon.org/windliterature.

Jacobs, D.S. 1994. Distribution and Abundance of the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus*, on the Island of Hawaii. Pacific Science 48(2): 193–200.

Janss, G.F.E. 2000. Avian mortality from power lines: a morphologic approach of a species-specific mortality. Biological Conservation 95:353-359.

Johnson, G. D. 2005. A Review of Bat Mortality at Wind-energy Developments in the United States. Bat Research News 46:45-49.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd and D.A. Shepherd. 2000. Final Report, Avian Monitoring Studies at the Buffalo Ridge, Minnesota Wind Resource Area: Results of a 4-year study. Prepared for Northern States Power Company, Minneapolis, by Western Ecosystems Technology, Inc.

Johnson, G.D., W.P. Erickson, M.D Strickland 2003a. Mortality of Bats at a Large-scale Wind Power Development at Buffalo Ridge, Minnesota. American Midland Naturalist 150(2):332-342.

Johnson, G.D., W.P. Erickson, and M.D. Strickland. 2003b. What is Known and Not Known About Bat Collision Mortality at Windplants? In: Carlton, R. L. (ed.), Proc. Workshop on Avian Interactions at Wind Turbines, 16-17 October, 2002, Jackson Hole, WY. Electric Power Research Inst., Palo Alto, CA.

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat activity, composition, and collision mortality at a large wind plant in Minnesota. Wildlife Society Bulletin 32:1278–1288.

Joyce, T., Zaun, B., Kuhn, D. and Holmes, N. 2008. A seabird social attraction project at Kilauea Point National Wildlife Refuge. Abstract from the 16th Hawaii Conservation Conference, 2008. http://hawaii.conference-services.net/resources/337/1232/pdf/HCC16_0225.pdf

Kaheawa Wind Power, LLC. 2006. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan. Ukumehame, Maui, Hawai‘i.

Kaheawa Wind Power, LLC. 2008a. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan, Year 2 HCP Implementation (July, 2007 – June, 2008).

Kaheawa Wind Power, LLC. 2008b. KWP I and KWP II Acoustic Monitoring of Bat Activity. Unpublished report.

Kaheawa Wind Power, LLC. 2009. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 3 Annual Report. First Wind Energy, LLC, Environmental Affairs, Boston, MA 02111.

Kepler, C.B. and J.M. Scott. 1990. Notes on the Distribution and Behavior of the Endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), 1964–1983. Elepaio 50: 59-64.

Kerlinger, P. and J. Guarnaccia. 2005. Avian Risk Assessment for the Kenedy Wind Project, Kenedy County, Texas. Report Prepared for Superior Renewable Energy. Curry & Kerlinger, Cape May Point, New Jersey.

Kerns, J., W. P. Erickson, and E. B. Arnett. 2005. Bat and Bird Fatality at Wind Energy Facilities in Pennsylvania and West Virginia. Pages 24–95 In: Arnett, E.B., editor. Relationships Between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. A Final Report Submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas, USA. http://www.batcon.org/windliterature. Accessed 1 Sep 2007.

Kingsley, A., and B. Whittam. 2007. Wind Turbines and Birds: A Background Review for Environmental Assessment, Draft. Canadian Wildlife Service, Environment Canada, Gatineau, Quebec.

Koford, R., A. Jain, G. Zenner and A. Hancock. 2004. Avian Mortality Associated with the Top of Iowa Wind Farm: Progress Report, Calendar Year 2003. Iowa Cooperative Fish and Wildlife Research Unit, Iowa State University, Ames, Iowa. 9pp.

Kunz, T.H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szewczak. 2007. Assessing Impacts of Wind-energy Development on Nocturnally Active Birds and Bats: A Guidance Document. Journal of Wildlife Management 71: 2449–2486.

Kushlan, J.A., M.J. Steinkamp, K.C. Parsons, J. Capp, M.A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R.M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas, Washington, DC.

Martin, E.M. and P.I. Padding. 2002. Preliminary Estimates of Waterfowl Harvest and Hunter Activity in the United States During the 2001 Hunting Season. United States Fish and Wildlife Service Division of Migratory Bird Management, Laurel, Maryland.

Menard, T. 2001. Activity Patters of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) in Relation to Reproductive Time Periods. Masters thesis, Univ. of Hawaii, Hawaii.

Mitchell, C., C. Ogura, D.W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. Hawaii's Comprehensive Wildlife Conservation Strategy. Department of Land and Natural Resources. Honolulu, HI. Available at: http://www.state.hi.us/dlnr/DLNR/cwcs/index.html. Accessed August 21, 2008.

Mostello, C.S. 1996. Diets of the Pueo, Barn Owl, the Cat, and the Mongoose in Hawai'i: Evidence for Competition. Masters Thesis, University of Hawaii at Manoa.

Mounce, H.L. 2008. What threat do native avian predators pose to Hawaiian Honeycreepers? Two case of predation by Pueo (*Asio flammeus sandwichensis*). 'Elepaio 68:19-26.

Nagata, S.E. 1983. Status of the Hawaiian Gallinule on Lotus Farms and a Marsh on Oahu, Hawaii. M.Sc. Thesis, Colorado State University, Fort Collins, Colorado.

National Wind Coordination Collaborative (NWCC). 2004. Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions. Fact Sheet: Second Edition. 7 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: December 24, 2008).

NESH Working Group 2005. DRAFT Newell's Shearwater Five-year Workplan. http://state.hi.us/dlnr/DLNR/fbrp/docs/NESH_5yrPlan_Sept2005.pdf

Nishibayashi, E. 1997. Downed Wildlife Survey at Six Leeward West Maui Wind Monitoring Towers. Unpublished report prepared for Zond Pacific, Inc., Wailuku, HI, by Eric Nishibayashi Biological Consulting, Kahului, HI. 11 pp.

Nordström, M., J. Högmander, J. Munnelin, N. Laanetu, and E. Korpimäki. 2002. Variable responses of waterfowl breeding populations to long-term removal of introduced American mink. Ecography 25: 385-394.

Percival, S.W. 2003. Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment. 25 pp.
Podolsky, R.H. 1990. Effectiveness of social stimuli in attracting Laysan Albatross to new potential nesting sites. The Auk 107 (1): 119-125.

Podolsky, R. and S.W. Kress. 1992. Attraction of the endangered Dark-rumped Petrel to recorded vocalizations in the Galápagos Islands. The Condor 94: 448-453.

Podolsky, R., D.G. Ainley, G. Spencer, L. DeForest, and N. Nur. 1998. Mortality of Newell's Shearwaters Caused by Collisions with Urban Structures on Kaua'i. Colonial Waterbirds 21: 20–34.

Pratt, T. K. 1988. Recent observations, March-May 1988. 'Elepaio 48:65–66.

Pratt, H.D., P.L. Bruner, and D.G. Berrett. 1987. The Birds of Hawaii and the Tropical Pacific. Princeton University Press, Princeton, NJ.

Rauzon, M.J. and D.C. Drigot. 2002. "Red mangrove eradication and pickleweed control in a Hawaiian wetland, waterbird responses, and lessons learned," in Turning the Tide: The Eradication of Invasive Species, edited by C.R. Veitch and M.N. Clout, Occasional Paper of the IUCN Species Survival Commission No. 27, IUCN – The World Conservation Union, Gland, Switzerland.

Reed, J.M., C.S. Elphick, and L.W. Oring. 1998. Life-history and Viability Analysis of the Endangered Hawaiian Stilt. Biological Conservation 84:35-45.

Reynolds, M.H. and G.L. Richotte. 1997. Evidence of Newell's Shearwater breeding in Puna District, Hawaii. Journal of Field Ornithology 68:26-32.

Reynolds, M.H., B.A. Cooper, and R.H. Day. 1997. Radar study of seabirds and bats on windward Hawaii. Pacific Science 51: 97-106.

Richardson, F. and D.H. Woodside. 1954. Rediscovery of the nesting of the Dark-rumped Petrel in the Hawaiian Islands. Condor 56: 323-327.

Robinson, J.A., J.M. Reed, J.P. Skorupa, and L.W. Oring. 1999. Black-necked Stilt (*Himantopus mexicanus*). In The Birds of North America, No. 449. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Schwartz, C.W. and E.R. Schwartz. 1949. A Reconnaissance of the Game Birds in Hawaii. Board of Commissioners of Agriculture and Forestry, Division of Fish and Game, Territory of Hawaii, Hilo.

Scowcroft, P.G. and Giffin, J.G. 1983. Feral herbivores suppress mamane and other browse species on Mauna Kea. Journal of Range Management 36: 638-645

Simons, T.R. 1983. Biology and conservation of the endangered Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*). CPSU/UW83-2. Seattle: National Park Service, Cooperative Park Studies Unit, University of Washington, Seattle.

Simons, T.R. 1984. A population model of the endangered Hawaiian dark-rumped petrel. J. Wildl. Mgmt. 48(4) 1065-1076.

Simons, T.R. 1985. Biology and behavior of the endangered Hawaiian Dark-rumped Petrel. Condor 87:229-245.

Simons, T. R., and C. N. Hodges. 1998. Dark-rumped Petrel (Pterodroma phaeopygia). In The Birds of North America, No. 345 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Smith D.G., and J.T. Polhemus. 2003. Habitat Use and Nesting Activity by the Hawaiian Stilt (*Himanotopus mexicanus knudseni*) and Hawaiian Moorhen (*Gallinula chloropus sandvicensis*) at the Hamakua Marsh State Wildlife Sanctuary, Kailua, O'ahu. 'Elepaio 63(8):59-62.

Smith, D.G., J.T. Polhemus, and E.A. VanderWerf. 2002. Comparison of Managed and Unmanaged Wedge-tailed Shearwater Colonies on Oahu: Effects of Predation. Pacific Science 56: 451-457.

Snetsinger, T.J., S.G. Fancy, J.C. Simon, and J.D. Jacobi. 1994. Diets of Owls and Feral Cats in Hawai'i. 'Elepaio 54:47-50.

Spear, L.B., D.G. Ainley, N. Nur, S.N.G. Howell, S.N.G. 1995. Population size and factors affecting at-sea distributions of four endangered *procellariids* in the tropical Pacific. Condor 97:613-638.

Stantec Consulting Ltd. 2007. Environmental Review Report for Wolfe Island Wind Project. Kingston, Ontario.

SWCA Environmental Consultants (SWCA) and First Wind. 2008. Kahuku Wind Power Wildlife Monitoring Report and Fatality Estimates for Waterbirds and Bats (October 2007 – October 2008).

SWCA Environmental Consultants (SWCA) and First Wind. 2010. Kahuku Wind Power Draft Habitat Conservation Plan. Dated March 2010.

Swindle, Keith. Veterinarian, USFWS. Personal communication.

Szewczak, J. M., and E.B. Arnett. 2006. Ultrasound emissions from wind turbines as a potential attractant to bats: a preliminary investigation. An investigative report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Szewczak J.M. and Arnett E. 2009. Ultrasound emissions from wind turbines as a potential attractant to bats: a preliminary investigation.

Taylor, G.A. 2000a. Action plan for seabird conservation in New Zealand. Part A: threatened seabirds. *Threatened Species Occasional Publication 16*. Department of Conservation, Wellington, New Zealand. 234 p.

Taylor, G.A. 2000b. Action plan for seabird conservation in New Zealand. Part B: non-threatened seabirds. *Threatened Species Occasional Publication 17*. Department of Conservation, Wellington, New Zealand. 199 p.

Telfair, R.C., II. 1994. Cattle Egret (*Bulbulcus ibis*). In: The Birds of North America, No. 113. (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Telfer, T.C. 1986. Newell's shearwater nesting colony establishment study on the island of Kauai. Final Report, Statewide Pittman-Robertson Program. Department of Lands and Natural Resources, State of Hawaii, Honolulu, HI.

Telfer, T.C., J.L. Sincock, G.V. Byrd, and J.R. Reed. 1987. Attraction of Hawaiian Seabirds to Lights: Conservation Efforts and Effects of Moon Phase. Wildlife Society Bulletin 15:406–413.

Tetra Tech EC, Inc. 2008. Draft Environmental Assessment For Issuance of an Endangered Species Act Section 10 (a)(1)(B) Permit for the Incidental Take of Listed Species for the Lanai Meteorological Towers Project. Castle & Cooke Resorts, LLC. Prepared for U.S. Fish & Wildlife Service.

Thierry, M.W. and J. Hale. 1996. Causes of Owl Mortality in Hawaii, 1992 to 1994. Journal of Wildlife Diseases 32(2): 266-273.

Tomich, P.Q. 1969. Mammals in Hawaii: A Synopsis and Notational Bibliography. B.P. Bishop Museum, Honolulu, HI. Spec. Pub. 57. 238 pp.

USFWS. 1983. Hawaiian Dark-Rumped Petrel and Newell's Manx Shearwater Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. 57 pp.

USFWS. 1998. Recovery Plan for the Hawaiian Hoary Bat *(Lasiurus cinereus semotus*). U.S. Fish and Wildlife Service, Portland, OR.

USFWS. 2000. Notice of Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process. Federal Register 65(106):35242-35257

USFWS. 2002. Oʻahu National Wildlife Refuge Complex. Annual Narrative Report Calendar Year 2002. Honolulu, HI.

USFWS. 2003. Interim Voluntary Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines. Available at: http://www.fws.gov/habitatconservation/wind.html. Accessed March 20, 2009.

USFWS. 2005a. Draft Revised Recovery Plan for Hawaiian Waterbirds, Second Draft of Second Revision. U.S. Fish and Wildlife Service, Portland, OR.

USFWS. 2005b. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, OR.

USFWS. 2007. City and County of Honolulu Conditional Use Permit Application No. 2007/CUP-141 for UPC Wind Farm, Kahuku, Oahu, Hawaii. Letter to City and County of Honolulu, Department of Planning and Permitting.

USFWS. 2008. Draft Environmental Assessment for Fencing of the Kona Forest Unit of the Hakalau Forest National Wildlife Refuge Hawaiʻi County, Hawaiʻi. South Kona District
Hawaiʻi County, Hawaiʻi.

Appendix L.

LINDA LINGLE
GOVERNOR OF HAWAII

LAURA H. THIELEN
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

RUSSELL Y. TSUJI
FIRST DEPUTY

KEN C. KAWAHARA
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
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

February 19, 2010

Sharon Thomas, Environmental Protection Specialist
Department of Energy
Washingon DC 2055

LOG NO: 2010.0344
DOC NO: 1002NM37
Archaeology

Dear Ms. Thomas:

SUBJECT: **National Historic Preservation Act – Section 106 Compliance —**
A Comprehensive Archaeological Survey at the First Wind Kahuku Wind Power Project Area
Kahuku Ahupua'a, Koolauloa District, 'Oahu, Hawai'i
TMK: (1) 5-6-005:007 and 014

Thank you for providing us the opportunity to review the *A Comprehensive Archaeological Survey at the First Wind Kahuku Wind Power Project Area [Rechtman, Ph.D., Rechtman Consulting, 2009].* The inventory covers 230 acres. One site 4707 which was previously identified and which is related to the plantation era and the irrigation ditch system is for features outside the APE were found. It is significant under criteria D and eligible for the Hawaii State and National Register of Historic Places. We concur with this finding.

Site 4707 is not functional, in the state of disrepair and lost its integrity. Information has been collected during this study to warrant a no historic properties affected by this project. We concur with this determination

Please contact me at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Nancy A. McMahon

Nancy A. McMahon (Deputy SHPO),
Archaeology and Historic Preservation Manager

C: Bob Rechtman, Rechtman Consulting

Department of Energy
Washington, DC 20585

January 20, 2010

Ms. Nancy A. McMahon
Deputy SHPO
State Historic Preservation Division
Kākuhihewa Building, Room 555
601 Kamokila Boulevard
Kapolei, HI 96707

Dear Ms. McMahon:

The Department of Energy (DOE) is preparing an Environmental Assessment (EA) under the National Environmental Policy Act for a Federal loan guarantee to Kahuku Wind Power, LLC (First Wind) to support construction of a new 30 megawatt (MW) commercial wind energy generation facility on the northeastern portion of O'ahu, Hawai'i. This letter is to request concurrence on a "finding of no historic properties affected" for the First Wind project on the basis of those materials required by 10 CFR Part 800.11d (1) through (3).

1) A description of the undertaking, specifying the Federal involvement, and its area of potential effects (APE), including photographs, maps, drawings, as necessary:

The proposed action evaluated by DOE in its EA is to issue a loan guarantee to First Wind for its wind energy generation facility, which would consist of 12 Clipper LibertyTM 2.5 MW wind turbine generators, an operation and maintenance building, one permanent meteorological tower, one on-site and two off-site microwave towers, seven microwave dishes, an electrical substation, a Battery Energy Storage System, and a network of unpaved service roadways.

In consultation with you, an APE was decided upon for this study (Attachment 1). The APE consists of approximately 230 acres within Tax Map Parcels (TMK:1-5-6-05:007 and 014) located in Kahuku Ahupua'a, Ko'olauloa District, Island of O'ahu. The subject property is located to the west of the town of Kahuku, south of Kamehameha Highway (Hwy 83), approximately 2.5 kilometers inland from the coast. It is currently used for cattle ranching, but historically, nearly the entire area was planted in sugarcane as part of the Kahuku Plantation Company's fields. The subject property is bounded by large parcels that are also used for cattle ranching, diversified agriculture, and military training. Elevations range from 40 to 400 feet above sea level. A detailed description of the APE is included in the attached report, *A Comprehensive Archaeological Survey of the First Wind Kahuku Wind Power Project Area in Compliance with Section 106 of the National Historic Preservation Act* (Attachment 2).

Once complete, the power generating facility would be incorporated into the Hawaiian Electric Company's (HECO) power grid, and First Wind would be required to establish a high-speed

Printed with soy ink on recycled paper

communications system using microwave radio technology in order to protect the electrical grid in case of outages. The microwave communication system would involve the placement of line of sight microwave dishes at several locations (both on and off-site) between the project area and the two HECO electrical substations located at Wahiawa and Waialua. Seven locations would be utilized for the placement of microwave dishes. Two of these would be within the existing First Wind project area and their placement is within the established APE for the wind energy project. Three would be a co-location on existing communications towers, and thus would have no effect on historic properties; and two would require the construction of new towers. Of this latter category, one would be located within the HECO Waialua Substation in Haleiwa (TMK: 1-6-6-018:037) and the other would be located on agricultural land at "Flying R Ranch" in Waialua. A detailed description of the tower locations, including maps and pictures, has been provided in Attachment 3.

2) A description of the steps taken to identify historic properties, including, as appropriate, efforts to seek information pursuant to Part 800.4(b);

In addition to conducting documentary research on previous archaeological studies, extensive community consultation was conducted by First Wind and an intensive archaeological field investigation was completed. The archaeological report referenced above has been prepared and is attached (Attachment 2). As a result of the study, one State Inventory of Historic Places (SIHP) site was recorded within the APE. This site, SIHP Site 4707 (retaining a site designation for seemingly related features that exist outside of the current APE), incorporates the extensive plantation infrastructure (primarily an irrigation network) that a review of historical archival data indicates dates from the late nineteenth to the middle twentieth century. The nature and extent of this site within the current APE is fully documented by the attached study.

In response to consultation with Native Hawaiian organizations and individuals within the community, First Wind will preserve the coral bluff areas that are within the overall property under their control, but outside the current APE.

Research and field investigations of the tower locations, including maps and pictures, are provided in Attachment 2.

3) The basis for determining that no historic properties are present or affected.

Based on our review of the project and the information attached, DOE has determined that no historic properties would be affected by the proposed project and No Effect on Historic Properties as defined in NHPA regulations would occur (36 CFR 800.16(b)).

As contained in the federal legislation and its implementing regulation (Section 106 of the National Historic Preservation Act and 36 CFR Part 800, respectively), a resource must be considered a historic property, that is a resource "listed or eligible for listing in the National Register of Historic Places" before a determination of effects can be made. Regarding SIHP Site 4707, the significance of the site was evaluated based on National Register criteria (36 CFR § 60.4 (a) through (d)). Site 4707, although not functional and in a state of disrepair, does retain sufficient integrity to be considered significant under criterion (d) for the historical information it has yielded relative to the development of the sugarcane industry in Hawai‘i; however, DOE believes that a reasonable and adequate amount of information has been collected about this potential historic property during the current study such that no further mitigation is warranted, and a no adverse effects determination for this site with respect to the proposed First Wind undertaking is appropriate.

Regarding the microwave towers, HECO's Waialua Substation is an already developed site, and the placement of an additional tower within this site would have no effect on historic properties. The proposed Flying R Ranch site was previously disturbed, and no archaeological resources were encountered during the field investigation.

If, during construction activities, an unanticipated discovery of cultural materials or sites is made, all excavation would cease and your office would be contacted. Appropriate consultation requirements would be initiated and completed prior to any further disturbance of the discovery-site area.

DOE would appreciate a concurrence on our determination of no effect. You may fax this information to me at (202) 586-7809, send via email at sharon.r.thomas@hq.doe.gov, or mail to Sharon Thomas, U.S. Department of Energy, CF-1.3, 1000 Independence Ave. S.W., Washington, DC 20585. You may also contact me by phone at 202-586-5335 if you have any questions.

Sincerely,

SR Thomas

Sharon R. Thomas
Environmental Protection Specialist

Enclosures

LINDA LINGLE
GOVERNOR OF HAWAII

LAURA H. THIELEN
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

RUSSELL Y. TSUJI
FIRST DEPUTY

KEN C. KAWAHARA
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
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

August 18, 2009

Dr. Bob Rechtman
Rechtman Consulting, LLC
507-A e. Lanikaula St
Hilo, Hawai'i 96720

LOG NO: 2009.3701
DOC NO: 0908NM29
Archaeology

Dear Dr, Dega:

SUBJECT: National Historic Preservation Act – Section 106 Compliance —
Proposed APE Concurrence – Wind Farm
Kahuku Ahupua'a, Koolauloa District, 'Oahu, Hawai'i
TMK: (1) 5-6-005:007 and 014

Thank you for providing us the opportunity to discuss First Wind's project. We concur with the proposed parcel boundaries, APE, and tower locations based on the map submitted in your August 4, 2009 letter. Based on community input the coral bluff areas will be avoided. We look forward to reviewing your new comprehensive archaeological survey for this project.

Please contact me at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Nancy A. McMahon

Nancy A. McMahon (Deputy SHPO),
Archaeology and Historic Preservation Manager

Department of Energy
Washington, DC 20585

May 5, 2010

Mr. Clyde Nāmu'o
Chief Executive Officer
Office of Hawaiian Affairs
711 Kapi'olani Blvd., Suite 500
Honolulu, HI 96813

Dear Mr. Nāmu'o:

As you are aware, the Department of Energy (DOE) is evaluating whether or not to issue a Federal loan guarantee to Kahuku Wind Power, LLC (First Wind) to support construction of a new 30 megawatt commercial wind energy generation facility on the northeastern portion of O'ahu, Hawai'i. Thank you for reviewing the material prepared by DOE as part of the historic resources review of the proposed project in compliance with Section 106 of the National Historic Preservation Act and for your February 12 letter, which stated that the Office of Hawaiian Affairs (OHA) concurs with DOE's "finding of no historic properties affected" for the First Wind project.

You requested additional information on the consultation process conducted for the proposed new tower that would be situated within Kamananui Ahupua'a, Waialua District, Island of O'ahu, also referred to as the Flying R Ranch site. As a result of on your request, DOE undertook an effort to consult with knowledgeable individuals of Kamananui Ahupua'a regarding any culturally or historically significant resources at or surrounding the site. Based on suggestions from OHA, three individuals were contacted regarding the site. Thomas Shirai, a resident of Mokuleia, is unaware of any historic sites on or near the property. In an e-mail communication dated April 15, he stated, "I can't recall any Hawaiian Cultural Sites in the area of your potential site for your project. The sites I know of are located outside of your area." Kimo Armitage and Malia Evans, former residents of Haleiwa, were also contacted. Neither of them is aware of any culturally or historically significant sites on the Flying R Ranch property.

Thank you again for your review and comment on the historic resources review conducted by DOE for the proposed First Wind project. Your input and assistance is greatly appreciated.

Sincerely,

SR Thomas

Sharon R. Thomas
Environmental Protection Specialist

PHONE (808) 594-1888 FAX (808) 594-1865

STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPI'OLANI BOULEVARD, SUITE 500
HONOLULU, HAWAI'I 96813

HRD10/4609B

February 12, 2010

Sharon R. Thomas, Environmental Protection Specialist
Department of Energy
Washington, DC 20585

Re: National Historic Preservation Act and
National Environmental Protection Act consultation
Commercial wind energy generation facility
Kahuku, Island of O'ahu

Aloha e Sharon R. Thomas,

The Office of Hawaiian Affairs (OHA) is in receipt of your January 20, 2010 letter with enclosures initiating consultation pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended (36 CFR) and the National Environmental Protection Act for the proposed construction of a commercial wind energy generation facility in Kahuku on the Island of O'ahu.

The area of potential effect (APE) for this proposed undertaking has been determined to be approximately 230 acres and an archaeological survey report for the APE was included with your letter. It is our understanding that the entire APE was previously used for sugarcane cultivation and cattle ranching. An archaeological survey of the APE was conducted pursuant to 36 CFR §800.4 and resulted in the designation of one historic property which has been identified as the remnants of sugarcane field infrastructure. This historic property has been assigned significance under "Criterion d" of the criteria used to consider eligibility for the National Register of Historic Places. It is recommended that an adequate amount of information has been collected and no further mitigation work is proposed. The Department of Energy has determined that pursuant to 36 CFR §800.5(b) this proposed undertaking warrants a "no adverse effect" determination and OHA concurs with your determination.

We do request clarification on one of the seven locations which will be utilized for the installation of a line of sight microwave communication system situated on towers. Two of these locations are within the above mentioned APE, three will be placed on existing towers and one will be placed on a tower constructed with a previously developed portion of the Hawaiian

Electric Company Waialua substation. OHA requests clarification on the final proposed new tower which will be situated within Kamananui Ahupua'a. While the proposed location of tower is has been previously bulldozed and is situated within a larger area currently used for ranching and no historic properties are known to exist within a proposed access road corridor, it is our hope that a consultation effort was initiated with knowledgeable individuals of Kamananui Ahupua'a.

We do appreciate the summary of consultation efforts within Kahuku Ahupua'a detailed in the archaeological report included with your letter. This consultation resulted in the identification of the coral bluffs located within and adjacent to the APE as having a rich history and retaining their significance to the Kahuku community. As a result, a commitment has been made to preserve these coral bluff areas and to document their significance. OHA applauds these efforts to truly listen and respond to the community through meaningful consultation

Thank you for initiating consultation. Should you have any questions, please contact Keola Lindsey, Lead Advocate-Culture at (808) 594-1904 or keolal@oha.org.

‘O wau iho nō me ka ‘oia‘i‘o,

Clyde W. Nāmu‘o
Chief Executive Officer

Department of Energy
Washington, DC 20585

January 20, 2010

Mr. Clyde Nāmu'o
Chief Executive Officer
Office of Hawaiian Affairs
711 Kapi'olani Blvd., Suite 500
Honolulu, HI 96813

Dear Mr. Nāmu'o:

The Department of Energy (DOE) is preparing an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA) for a Federal loan guarantee to Kahuku Wind Power, LLC (First Wind) to support construction of a new 30 megawatt commercial wind energy generation facility on the northeastern portion of O'ahu, Hawai'i. The wind energy generation facility would consist of 12 Clipper LibertyTM 2.5 MW wind turbine generators, an operation and maintenance building, one permanent meteorological tower, one on-site and two off-site microwave towers, seven microwave dishes, an electrical substation, a Battery Energy Storage System, and a network of unpaved service roadways.

As part of this environmental review process, DOE is also conducting a historic resources review in compliance with Section 106 of the National Historic Preservation Act (NHPA). To that end, studies were completed (attachments enclosed), which after documentary research, consultation, and field survey concluded that no historic properties would be affected. This letter is to notify you of DOE's "finding of no historic properties affected" for the First Wind project.

We would greatly appreciate receiving any comments or concerns you may have within 30 days of receipt of this letter. Please send written comments to me via fax at 202-586-7809, email at sharon.r.thomas@hq.doe.gov, or mail to Sharon Thomas, U.S. Department of Energy, CF-1.3, 1000 Independence Ave. S.W., Washington, DC 20585. You may also contact me by phone at 202-586-5335 if you have any questions.

Sincerely,

SR Thomas

Sharon R. Thomas
Environmental Protection Specialist

Enclosures

Printed with soy ink on recycled paper

Thomas, Sharon (CF)

From: Thomas, Sharon (CF)
Sent: Wednesday, April 28, 2010 8:12 AM
To: 'Ralph Makaiau'
Cc: Kahea; Stephany Vaioleti; stibbardm003@hawaii.rr.com; Kent Fonoimoana; Jr Primacio (primacioj002@hawaii.rr.com); olevaof@byuh.edu; kuilimaeast@hawaii.rr.com; David Tanoue (info@honoluludpp.org); ddelacruz@honolulu.gov
Subject: RE: EA Kahuku Wind Power, LLC (First Wind)

Dear Mr. Makaiau:

Thank you for your March 12 e-mail note expressing the support of the Kahuku Community Association Board of Directors for the Kahuku Wind Power LLC Wind Energy Generation Project. The proposed project is currently being evaluated by the U.S. Department of Energy (DOE) for a Federal loan guarantee, and you were consulted regarding the cultural resources study done on the project site. In addition to your note, we discussed your questions and comments during our subsequent phone conversation on the proposed project, which are addressed in this response.

Flooding of agricultural lands adjacent to the site due to extreme rain events is one of your concerns. Flooding impacts are address in the Environmental Assessment, and DOE determined that flood hazard would not increase as a result of the proposed project. The occurrence of the flooding we discussed pre-existed Kahuku Wind Power LLC's purchase of the site, and none of the activities related to the proposed project would contribute to or increase flooding. Kahuku Wind Power LLC has committed to work with the Natural Resources Conservation Service on plans for increasing the growth of plants in the exposed areas surrounding the drainage ditch. Additional plants would help control the erosion of soil caused by storm water flowing through the drainage ditch, and potentially help stabilize the water channel and reduce flooding. Kahuku Wind Power LLC is also committed to continue working with local community associations to address flooding concerns.

The bluff you identified in Figure 1 of the archeological survey at Kamehameha Highway at benchmark 19 as a cave-in threat is not part of the proposed project site, nor would any of the activities on the site increase the potential for falling rocks or rock slides.

You commented that power quality is a concern for the community and requested an independent monitoring station to keep the community informed of the quality of power being added to the power grid. Power generated by the proposed project would be sold to the Hawaiian Electric Company (HECO). HECO requires that Kahuku Wind Power LLC meet several technical performance standards (including voltage control, frequency control, and ramp rate), which is how the utility would ensure the quality of power going into their system. Only HECO would have information about the characteristics of power coming out of their system. Since electricity customers are receiving power that HECO provides to the end user, data provided by Kahuku Wind Power LLC on the power going into the system would not be of use to the customer or community. HECO may be able to provide the type of information you've requested.

The proximity of the wind turbines to residences was another one of your concerns. Wind turbines on the proposed project site would be at least 3500 feet from the nearest residentially zoned land and at least 1200 feet from the nearest structure on agriculturally zoned land, which is outside the 1000 feet safety buffer zone you suggested.

Regarding community outreach, Kahuku Wind Power LLC has been engaged in a grassroots community outreach effort since 2007 and has met with individuals, families and community organizations including the Kahuku Village Association, Kahuku Community Association, Laie Community Association, and Defend Oahu Coalition. Kahuku Wind Power LLC has visited neighborhoods in Kahuku to inform community members about the project and to provide a point of contact for any questions about the project. In addition to working with the Kahuku community, the outreach efforts have included individuals and organizations from neighboring communities in the Koʻolau Loa district and on the North Shore.

Throughout this process, Kahuku Wind has worked with community leaders, organizations, individuals, and families to determine how best to become a long-term contributing member of the Kahuku, North Shore, and Koʻolau Loa communities. The ongoing dialogue established in these meetings have helped Kahuku Wind Power LLC to determine how it can contribute to the community's welfare, whether by working to prevent flooding, using the wind farm property for agricultural activities, or supporting educational activities. Kahuku Wind Power LLC has worked with teachers at the Kahuku High & Intermediate School to teach students about renewable energy and develop ways to incorporate the development, construction, and operation of the wind farm into an educational opportunity for students. Kahuku Wind Power LLC also donated $5,000 to help launch a renewable energy innovation center at the school and has continued to work with teachers and community volunteers to utilize the center to encourage students' interests in the fields of math, science, engineering, and technology. Kahuku Wind Power LLC plans to continue working with the high school and local community associations to support efforts related to education, flood minimization, and agricultural activities.

In response to your question about opportunities for community entities to share in alternative energy projects involving DOE funding, information on what constitutes an eligible project for a loan guarantee is available on our website at www.lgprogram.energy.gov. I also encourage you to look at other DOE programs, such as the Office of Energy Efficiency and Renewable Energy at www.eere.energy.gov.

Thanks again for your comments. I enjoyed talking with you.

Sincerely,

Sharon Thomas
Environmental Protection Specialist
DOE

From: Ralph Makaiau [mailto:rmakaiau@tbrdevelopment.com]
Sent: Friday, March 12, 2010 5:07 PM
To: Thomas, Sharon (CF)
Cc: Kahea; Stephany Vaioleti; stibbardm003@hawaii.rr.com; Kent Fonoimoana; Jr Primacio (primacioj002@hawaii.rr.com); Ralph Makaiau; olevaof@byuh.edu; kuilimaeast@hawaii.rr.com; David Tanoue (info@honoluludpp.org); ddelacruz@honolulu.gov
Subject: DOE: EA Kahuku Wind Power, LLC (First Wind)

Dear Ms. Thomas,
I am in receipt of the DOE EA packet dated February 25, 2010. I am responding to you as the President of Kahuku Community Association specifically to the EA. I would like to comment on several issues:

1. Regarding the study area and overall land parcel, present land contour lends itself to be a major contributor to runoff sheet flooding into lands immediate east of parcel (State Ag Park). As an originating runoff contributor, discharges are not directed (contradicts EA claim) to respective drainages such as Hoolapa Gulch, Kalaeokahipa Gulch, Ohia Stream, Hospital Ditch, Kii Stream and as a result Ag lands mauka of Kamehameha Hwy are flooded and eventually lands makai of Kamehameha Hwy become flood way/flood plain waters into Kahuku Village. EA has no supporting information regarding 25 year, 50 year, 100 year or 500 year flood impacts. Kahuku would like this runoff water to be removed as a threat to the Village, bird sanctuary, Ag farming, aqua culture farming..
2. Kamehameha Hwy at BM19 (Tanaka Store) Fig. 1. Study area (APE) location, North/Northeast coral bluff poses a geological threat of cave-in to Kamehameha Hwy. This appears to be a land owner liability.
3. Power quality is a big concern for community. An independent monitoring station available to keep community informed of quality power being added to power grid is requested.
4. Safety buffer zone of 1000 feet to neighboring Ag zoned land is acceptable; more for neighboring residentially zone land.
5. Wind farming has its cultural shock impact/s, it is requested that First Wind have ongoing participation with community relations greater than Native/Historical Hawaiian traditions. Agriculture/Aqua-cultural, Healthcare, and Education are current significant contributors to this community, outside of the local PUC jurisdiction, is it possible for community entities to share in alternative energy technology inclusive in DOE sponsorship?

The Kahuku Community Association Board of Directors is supportive of responsible alternative energy project specific to First Wind and land parcel described.

Respectfully submitted,
Mahalo
Ralph

Department of Energy
Washington, DC 20585

February 25, 2010

Mr. Ralph Makaiau
56-134 Pualalea St
Kahuku, HI 96731-2051

Dear Mr. Makaiau:

The Department of Energy (DOE) is preparing an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA) for a Federal loan guarantee to Kahuku Wind Power, LLC (First Wind) to support construction of a new 30 megawatt (MW) commercial wind energy generation facility on the northeastern portion of O'ahu, Hawai'i. The wind energy generation facility would consist of 12 Clipper Liberty™ 2.5 MW wind turbine generators, an operation and maintenance building, one permanent meteorological tower, one on-site and two off-site microwave towers, seven microwave dishes, an electrical substation, a Battery Energy Storage System, and a network of unpaved service roadways.

As part of this environmental review process, DOE is also conducting a historic resources review in compliance with Section 106 of the National Historic Preservation Act (NHPA). To that end, studies were completed (attachments enclosed), which after documentary research, consultation, and field survey concluded that no historic properties would be affected. As a community leader and participant in the public outreach conducted by First Wind, DOE is sending this letter to notify you of DOE's "finding of no historic properties affected" for the First Wind project.

If you have any comments, I would greatly appreciate receiving them by March 31, 2010. Please send written comments to me via email at sharon.r.thomas@hq.doe.gov, or mail to Sharon Thomas, U.S. Department of Energy, CF-1.3, 1000 Independence Ave. S.W., Washington, DC 20585. You may also contact me by phone at 202-586-5335 if you have any questions.

Sincerely,

SR Thomas

Sharon R. Thomas
Environmental Protection Specialist

Enclosures

Printed with soy ink on recycled paper

RC-0488

A Comprehensive Archaeological Survey of the First Wind Kahuku Wind Power Project Area in Compliance with Section 106 of the National Historic Preservation Act

(TMKs: 1-5-6-05:007 and 014)

Kahuku Ahupuaʻa
Koʻolauloa District
Island of Oʻahu

DRAFT REPORT

PREPARED BY:

Robert B. Rechtman, Ph.D.

PREPARED FOR:

Wren Wescoatt
First Wind Energy, LLC
810 Richards Street, Suite 650
Honolulu, HI 96813

October 2009

RECHTMAN CONSULTING, LLC
507-A E. Lanikaula St. Hilo, Hawaii 96720
phone: (808) 969-6066 fax: (808) 443-0065
e-mail: bob@rechtmanconsulting.com
ARCHAEOLOGICAL, CULTURAL, AND HISTORICAL STUDIES

A Comprehensive Archaeological Survey of the First Wind Kahuku Wind Power Project Area in Compliance with Section 106 of the National Historic Preservation Act

(TMK: 1-5-6-05:007 and 014)

Kahuku Ahupuaʻa
Koʻolauloa District
Island of Oʻahu

Rechtman Consulting

EXECUTIVE SUMMARY

At the request of First Wind, in compliance with Section 106 of the National Historic Preservation Act (NHPA), Rechtman Consulting, LLC has prepared this comprehensive archaeological survey report for the proposed development of a wind farm (First Wind Kahuku Project Area) on TMKs:1-5-6-05:007 and 014 within Kahuku Ahupuaʻa, Koʻolauloa District, Island of Oʻahu. In consultation with the State Historic Preservation Officer (SHPO), an area of potential effects (APE) was decided upon for this study. The APE was defined given the nature of the proposed development, the history of past land use, and the expressed community desire (following extensive consultation) to preserve the coral bluff formations that exist within the subject property. Areas containing these latter features will be identified as conservation easements, and there will be no development activities planned for any areas outside of the defined roughly 230 acre APE.

The subject property is located to the west of the town of Kahuku, south of Kamehameha Highway (Hwy 83), approximately 2.5 kilometers inland from the coast. It is currently used for cattle ranching, but historically, nearly the entire area was planted in sugarcane as part of the Kahuku Plantation Company's fields. The subject property is bounded by large parcels that are also used for cattle ranching, diversified agriculture, and military training. Elevations range from 40 to 400 feet above sea level.

Three previously conducted archaeological studies included portions of TMK:1-5-6-05:007and 014 (Jensen 1989; Kennedy 1989; Stride et al. 2003). Collectively, these previous surveys resulted in the identification of eighteen archaeological sites that contained a total of forty-two features. All but three of the previously recorded sites were assigned State Inventory of Historic Places (SIHP) site numbers. None of these sites were identified within the currently defined APE, although one site, SIHP Site 4707 was assigned to an irrigation feature that is no doubt related to the historic sugar plantation infrastructure that also exists within the current APE. The historical record indicates that by 1935, irrigated sugarcane fields covered nearly the entire APE, which also contained an artesian well and a several acre reservoir.

In an effort to identify historic properties, extensive community consultation was conducted by First Wind and an intensive archaeological field investigation was completed. As a result of the current study one site was recorded within the APE. This site, SIHP Site 4707 (retaining a site designation for seemingly related features that exist outside of the current APE), incorporates the extensive plantation infrastructure (primarily an irrigation network) that a review of historical archival data indicates dates from the late nineteenth to the middle twentieth century. The nature and extent of this site within the current APE is fully documented by the current study. As contained in the federal legislation and its implementing regulation (Section 106 of the National Historic Preservation Act and 36 CFR Part 800, respectively), a resource must be considered a historic property, that is a resource "listed or eligible for listing in the National Register of Historic Places" before a determination of effects can be made. The significance of this site is evaluated based on National Register criteria (36 CFR § 60.4), which are as follows:

> The quality of significance in American History, architecture, archaeology, engineering, and culture is present in districts, sites buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and,
>
> (a) that area associated with events that have made a significant contribution to the broad patterns of our history; or
> (b) that are associated with the lives of persons significant in our past; or
> (c) that embody the distinctive characteristics of a type, period, or method of construction; or that represent the work of a master; or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or;
> (d) that have yielded, or may be likely to yield, information important in prehistory or history

Site 4707, although not functional and in a state of disrepair, does retain sufficient integrity to be considered significant under Criterion d for the historical information it has yielded relative to the development of the sugarcane industry in Hawaiʻi, thus making the site potentially eligible for listing in the National Register of Historic Places. However, it is suggested that a reasonable and adequate amount of information has been collected about this potential historic property during the current study to warrant a no mitigation work requirement, and thus a no adverse effects determination for this site with respect to the proposed Kahuku Wind Power undertaking.

CONTENTS

FIGURES

TABLES

INTRODUCTION

At the request of First Wind, in compliance with Section 106 of the National Historic Preservation Act (NHPA), Rechtman Consulting, LLC has prepared this comprehensive archaeological survey for the proposed development of a wind farm (First Wind Kahuku Project Area) on roughly 230 acres (portions of TMKs:1-5-6-05:007 and 014) within Kahuku Ahupuaʻa, Koʻolauloa District, Island of Oʻahu (Figures 1 and 2). In consultation with the State Historic Preservation Officer (SHPO), pursuant to 36 CFR 800.4(a)(1), an area of potential effects (APE) was decided upon for this study. The APE was defined given the nature of the proposed development, the history of past land use, and the expressed community desire (following extensive consultation) to preserve the coral bluff formations that exist within the subject property. Areas containing these latter features will be identified as conservation easements, and there will be no development activities planned for any areas outside of the defined roughly 230 acre APE.

This report not only contains a physical description of the APE, but also provides a culture-historical context and a discussion of prior archaeological studies. This background information is used to develop a set of expectations for the study area as well as provide the contextual information with which to assess any historic properties that are identified within the APE.

Description of the APE

The APE consists of approximately 230 acres within Tax Map Parcels (TMK):1-5-6-05:007 and 014) located in Kahuku Ahupuaʻa, Koʻolauloa District, Island of Oʻahu (see Figures 1 and 2). The study area is located to the west of the town of Kahuku, south of Kamehameha Highway (Hwy 83), approximately 2.5 kilometers inland from the coast. It is currently used for cattle ranching, and it is bounded by large parcels that are also used for cattle ranching, diversified agriculture, and military training. Elevations within the study area range from 40 to 400 feet above sea level. This area is generally exposed to the prevailing northeasterly winds that cross the coastline at average speeds of 18-20 knots (Jensen 1989). Temperatures range from 65-85 degrees Fahrenheit, and the area receives on average 40-60 inches of rain per year (primarily between late November and February) (Armstrong 1983).

No permanently flowing streams are present within the study area, but two named, intermittent drainages, Kalaeokahipa Gulch (running southwest to northeast across the northwestern portion of the APE) and ʻŌhiʻaʻai Gulch (running along the eastern boundary of the larger property outside of the APE), are present along with several smaller, unnamed drainages. The drainages have created an up and down topography of steep rocky slopes interspersed with relatively flat soil areas between (Figure 3). To the north of the study area (nearer to the coast), and in a central area excluded from the APE, exposed coral reef escarpments are present that formed during a time when the ocean stand was at a higher level. Due to erosion, these steep escarpments are pocked with shallow overhangs and small caves. Several major soil types are present within the project area. The soil types are listed in Table 1, and their distribution across the project area is shown in Figure 4.

Nearly the entire APE was historically planted in sugarcane as part of the Kahuku Plantation Company’s fields. Evidence of this use is present across the parcel in the form of earthen ditches, concrete and metal flumes, and old roadways. Other remnants of sugarcane cultivation on the property include concrete foundations, a dry reservoir, old utility poles, and a large metal water pipe line (Figure 5) that is labeled “aqueduct” on the U.S.G.S. 7.5 minute series quadrangle for Kahuku (see Figure 1). Sugarcane was grown in the area until 1971 when the plantation closed its doors (Dorrance and Morgan 2000), and the project area became part of the Gunstock Cattle Ranch.

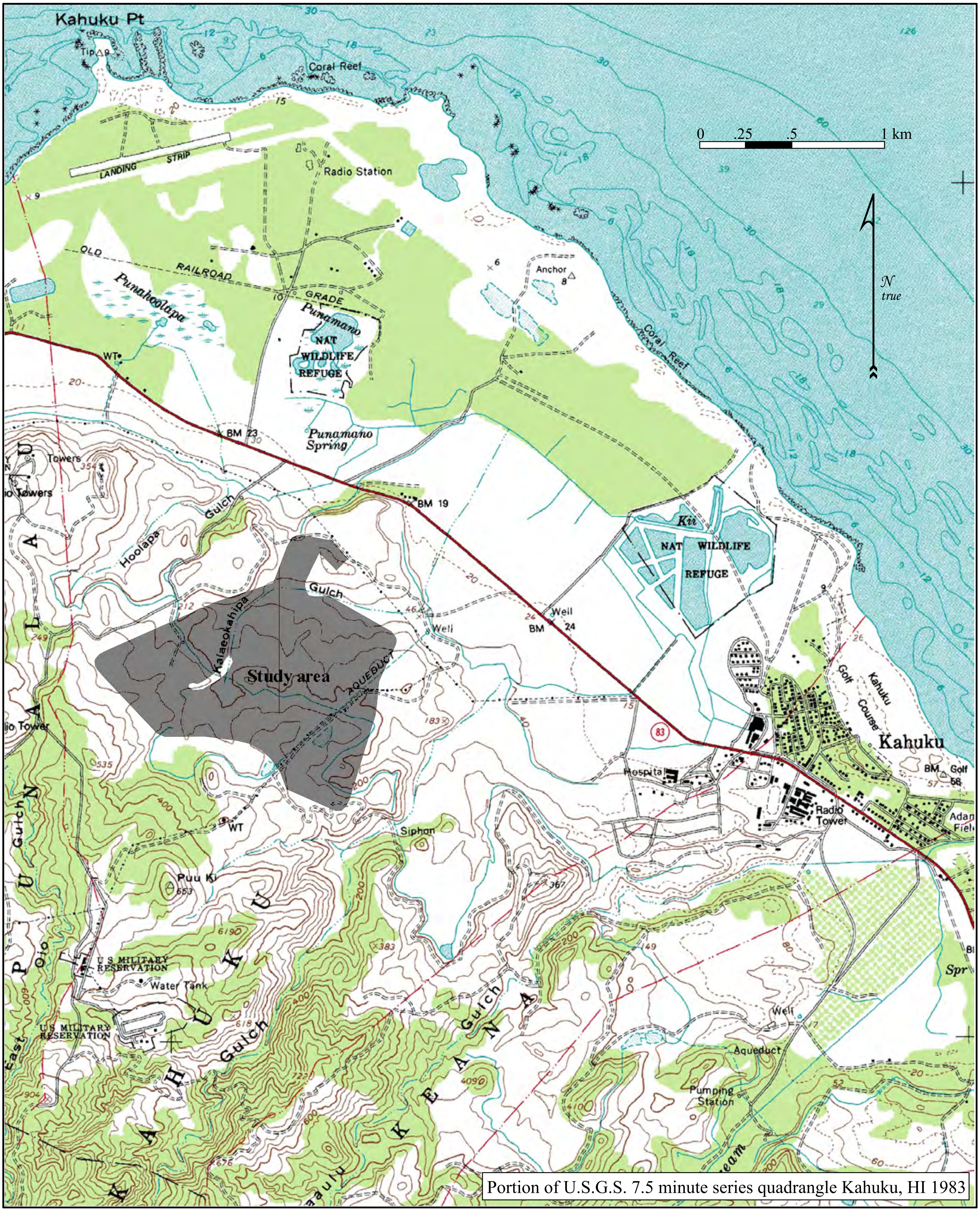


Figure 1. Study area (APE) location.

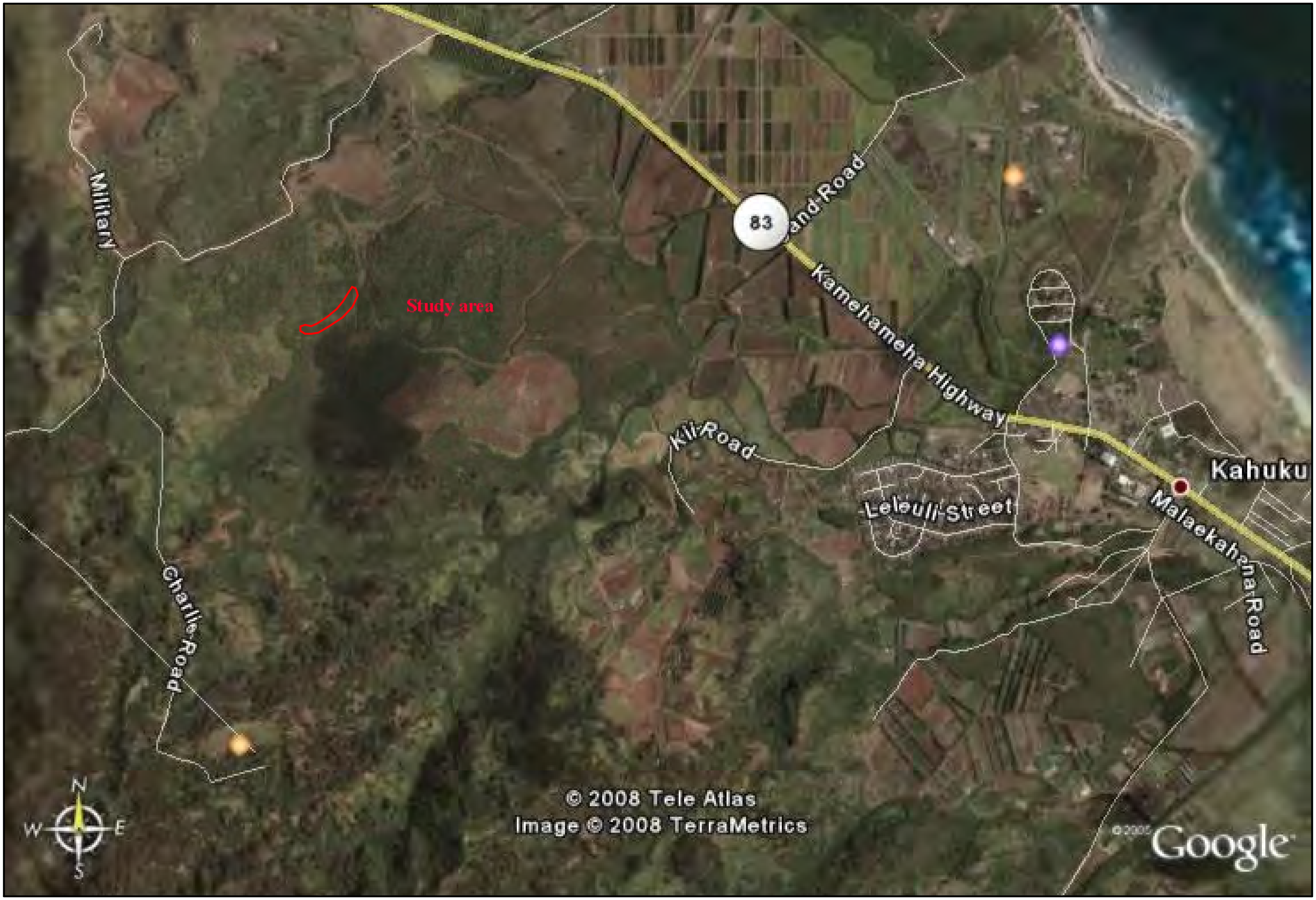


Figure 2. Aerial view of Kahuku showing the study area.

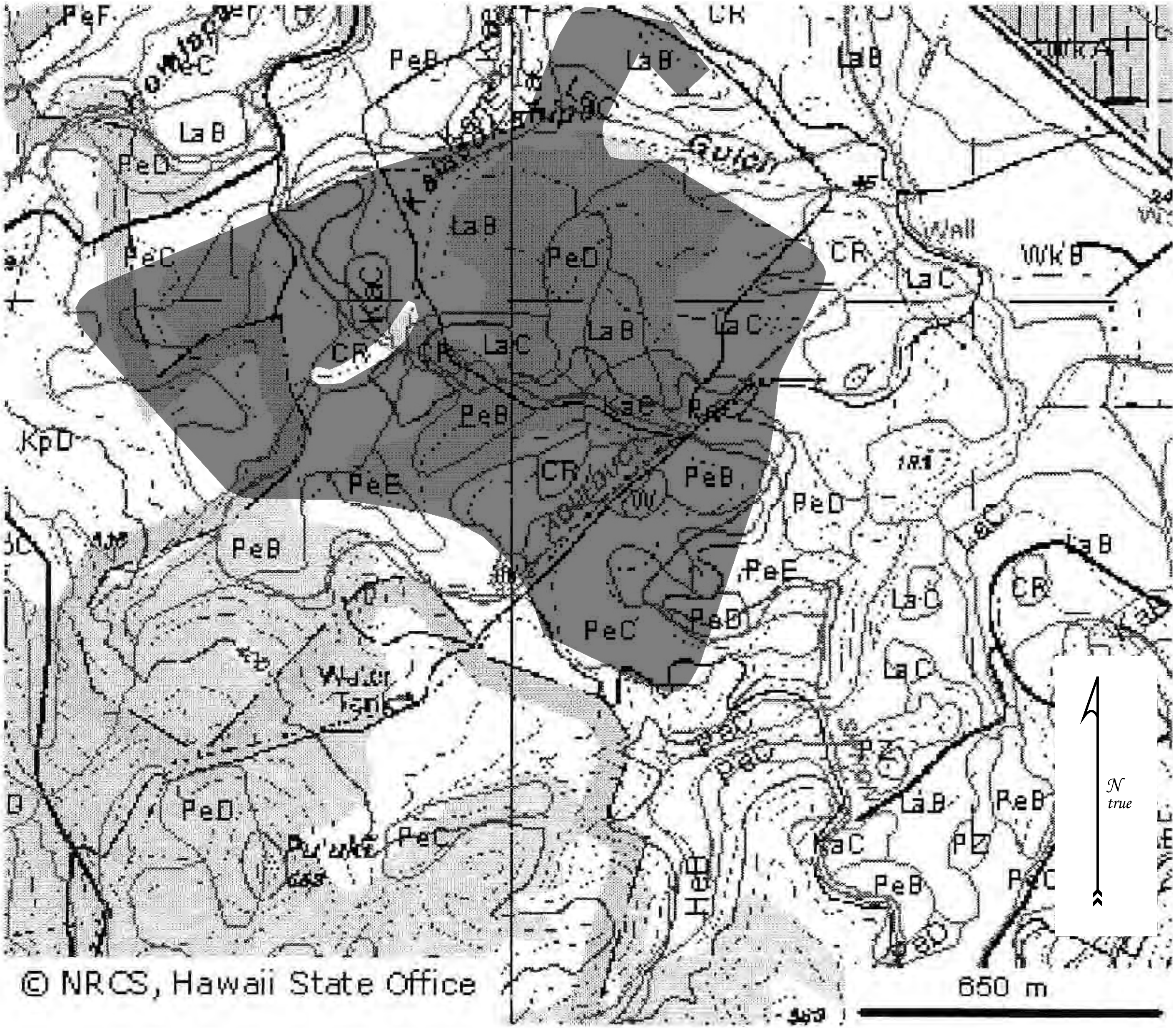
Figure 3. View to northeast of the project area from near the western boundary.

The study area is currently used as pasture for horses and cattle. It has a perimeter fence with several internal paddock areas, a corral, and water troughs. Dirt roads provide driving access to many areas within the parcel, and a paved road (Charlie Road) that is gated at the highway provides access to the property itself along its northwestern edge. In recent times soil was taken from a large area in the southeastern portion of the property to build a golf course at the nearby Turtle Bay Resort (Figure 6). Removal of this soil, and the deterioration of the Kahuku Sugar Plantation irrigation system over time have led to some severe erosion.

Owing to the historic and modern use of the project area for sugarcane cultivation and cattle ranching, vegetation within the parcel consists primarily of a thick secondary growth of California grass (*Urochloa mutica*), *koa-haole* (*Leucaena glauca*), Christmas-berry (*Schinus teribinthifolius*), and guava (*Psidium guajava*) interspersed with stands of ironwood trees (*Casuarina equisetifolia*), all-spice (*Pimenta dioica*), and various other non-native shrubs, vines, ferns, grasses, and weeds. The overall density of the vegetation growth within the subject parcel (especially the grasses) varies depending on the time of year and the amount of rain the area has received (Figures 7 and 8). In September of 2007, an area along the northern parcel boundary (continuing on to the neighboring parcel) had been recently mechanically cleared of all vegetation (Figure 9).

Table 1. Identified soils within the general project area (from Foote et al. 1972).

Map unit	***Soil Type***	***Soil Description***
CR	Coral outcrop	Coral outcrop consists of coral or cemented calcareous sand on the island of Oahu. The coral reefs formed in shallow ocean water during the time the ocean stand was at a higher level. Small areas of coral outcrop are exposed on the ocean shore, on the coastal plains, and at the foot of the uplands. Elevations range from sea level to approximately 100 feet. Coral outcrop makes up about 80 to 90 percent of the acreage. The remaining 10 to 20 percent consists of a thin layer of friable, red soil material in cracks, crevices, and depressions within the coral outcrop. This soil material is similar to that of the Mamala series.
KaeC	Kaena stony clay, 6 to 12 percent slopes	This soil occurs on alluvial fans. Included in mapping were small areas of clayey, dark reddish-brown soils that are moderately well drained to well drained. In a representative profile the surface layer is very dark gray clay about 10 inches thick. The next layer, 36 to more than 48 inches thick, is dark-gray and dark grayish-brown clay that has prismatic structure. It is underlain by highly weathered gravel. The soil is very sticky and very plastic, and it is mottled. It is slightly acid to neutral. Permeability is slow. Runoff is slow to medium, and the erosion hazard is slight to moderate. The available water capacity is about 1.4 inches per foot in the surface layer and about 1.7 inches per foot in the subsoil. Workability is difficult because of the narrow range of moisture content within which the soils can be cultivated. There are sufficient stones to hinder, but not prevent, cultivation. The shrink-swell potential is very high. In places the soil is affected by seepage.
KaC	Kaena clay, 6 to 12 percent slopes	This soil has a profile like that of Kaena stony clay, 6 to 12 percent slopes, except that there are few or no stones in the surface layer. Included in mapping were small stony areas at the higher elevations.
LaB	Lahaina silty clay, 3 to 7 percent slopes	This soil is on smooth uplands. Included in mapping were small areas that are underlain by consolidated sand at a depth below 30 inches. Cobblestones are common on the surface in a few places. In some places, near the coastal plains, the profile contains fragments of coral, stones, gravel, or sand. In a representative profile the surface layer is dark reddish-brown, silty clay about 15 inches thick. The subsoil, about 45 inches thick, is dusky-red and dark reddish brown subangular blocky silty clay and silty clay loam. The substratum is soft, weathered basic igneous rock. These soils are medium acid in the surface layer and slightly acid to medium acid in the subsoil. Permeability is moderate. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot in the surface layer and about 1.4 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more.
LaC	Lahaina silty clay, 7 to 15 percent slopes	On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small, steep areas and areas where a few cobblestones and stones are on the surface.
PeB	Paumalu silty clay, 3 to 8 percent slopes	On this soil, runoff is slow and the erosion hazard is slight. Workability is easy.
PeC	Paumalu silty clay, 8-15 percent slopes	On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Workability is slightly difficult.
PeD	Paumalu silty clay, 15 to 25 percent slopes	This soil occurs as small, irregularly shaped areas. Included in mapping were small, eroded areas. In a representative profile the surface layer and the subsoil are dark reddish-brown silty clay that has subangular and angular blocky structure. The surface layer is about 9 inches thick, and the subsoil is 30 to more than 60 inches thick. The substratum is highly weathered gravel. The soil is very strongly acid in the surface layer and strongly acid to medium acid in the subsoil. Permeability is moderately rapid. Runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.3 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. Workability is difficult because of the slope.
PeE	Paumalu silty clay, 25 to 40 percent slopes	On this soil, runoff is medium to rapid and the erosion hazard is moderate to severe.



© NRCS, Hawaii State Office

■ - Study area

Figure 4. Natural Resource Conservation Service (NRCS) soil map of Kahuku showing the study area.

Figure 5. View to south of the “aqueduct” (large metal water pipe line) crossing the project area.

Figure 6. View to north of the soil removal area for the Turtle Bay Resort golf course.

Figure 7. View to northeast of the vegetation during a dry period within the project area.

Figure 8. View to southeast of the vegetation during a wet period within the project area.

Figure 9. View to south of an area along the northern property boundary that was mechanically cleared of all vegetation.

BACKGROUND

To generate a set of expectations regarding the nature of historic properties that might be encountered within the APE, and to establish an environment within which to assess the significance of any such resources, a general historical context for the region and previous archaeological studies that included portions of the study area are summarized.

Culture-Historical Context and Ahupuaʻa Settlement Patterns

In an effort to provide a comprehensive and holistic understanding of the current study area and to generate a set of expectations for the subject parcel, archival and historical data relevant to Kahuku Ahupuaʻa, along with the general settlement patterns for the Koʻolauloa District are presented.

A Brief Overview of Hawaiian Settlement

Radiocarbon dates from the windward coast of Oʻahu suggest that initial settlement of the Koʻolauloa District likely began as early as A.D. 500, with large scale settlement occurring by A.D. 1100-1200, and steadily increasing until the time of Western contact (A.D. 1778) (Stride et al. 2003). Early settlement likely occurred from the Marquesas and Society Islands (Emory in Tatar 1982:16-18). In these early times, Hawaiʻi's inhabitants were primarily engaged in subsistence level agriculture and fishing (Handy and Handy 1972:287). The earliest settlement was a period of great exploitation and environmental modification, when early Hawaiian farmers developed new subsistence strategies by adapting their familiar patterns and traditional tools to their new environment (Kirch 1985; Pogue 1978). Their ancient and ingrained philosophy of life tied them to their environment and kept order. Order was further assured by the conical clan principle of genealogical seniority (Kirch 1984). According to Fornander (1969), the Hawaiians brought from their homeland certain universal Polynesian customs: the major gods *Kane*, *Ku*, and *Lono*; the *kapu* system of law and order; cities of refuge; the ʻ*aumakua* concept; various superstitions; and the concept of *mana*.

For generations following initial settlement, communities in Koʻolauloa were clustered along the shores which offered sheltered bays from which deep sea fisheries could be easily accessed. The near shore fisheries and coastal fishponds, which were enriched by nutrients carried in the fresh water, also offered opportunities for resource extraction and stewardship. It was in these coastal areas that clusters of houses were found, and where agricultural production first became established. Over a period of several centuries, these areas became populated and perhaps even crowded, and inland elevations began to be used for agriculture and some habitation. Taro would have been the dominant crop in this area with sweet potatoes planted only as a supplement for it (Handy and Handy 1972:282-283). Other crops would have included *wauke*, *noni*, gourds, sugarcane, *ʻawa*, breadfruit, bananas, coconuts, and ti (Stride et al. 2003). Other resources important to subsistence would have been gathered from the sea to the mountains.

The period between A.D. 1100–1650 was characterized by the greatest social stratification, major socioeconomic changes, and intensive land modification (Kirch 1985). Most of the ecologically favorable zones of the windward and coastal regions of all major islands were settled and the more marginal leeward areas were being developed. The concept of the *ahupuaʻa* was established during the A.D. 1400s (Kirch 1985), adding another component to a then well-stratified society. This land unit became the equivalent of a local community, with its own social, economic, and political significance. *Ahupua'a* were ruled by *aliʻi ʻai ahupuaʻa* or lesser chiefs; who, for the most part, had complete autonomy over this generally economically self-supporting piece of land, which was managed by a *konohiki*. *Ahupuaʻa* were usually wedge or pie-shaped, incorporating all of the eco-zones from the mountains to the sea and for several hundred yards beyond the shore, assuring a diverse subsistence resource base (Hommon 1986).

The *aliʻi* and the *makaʻāinana* (commoners) were not confined to the boundaries of the *ahupuaʻa*; when there was a perceived need, they also shared with their neighbor *ahupuaʻa ohana*. The *ahupuaʻa* was further divided into smaller sections such as the *ʻili*, *moʻoʻaina*, *paukuʻaina*, *kihapai*, *koele*, *hakuone*, and *kuakua* (Hommon 1986, Pogue 1978). The chiefs of these land units gave their allegiance to a territorial chief or *moʻi* (king). *Heiau* building flourished during this period as religion became more complex and embedded in a sociopolitical climate of territorial competition. Monumental architecture, such as *heiau*, "played a key role as visual markers of chiefly dominance" (Kirch 1990:206).

Entire *ahupuaʻa*, or portions of the land were generally under the jurisdiction of appointed *konohiki* or lesser chief-landlords, who answered to an *aliʻi-ʻai-ahupuaʻa* (chief who controlled the *ahupuaʻa* resources). The *aliʻi-ʻai-ahupuaʻa* in turn answered to an *aliʻi ʻai moku* (chief who claimed the abundance of the entire district). Thus, *ahupuaʻa* resources supported not only the *makaʻāinana* and *ʻohana* who lived on the land, but also contributed to the support of the royal community of regional and/or island kingdoms. This form of district subdividing was integral to Hawaiian life and was the product of strictly adhered to resources management planning. In this system, the land provided fruits and vegetables and some meat in the diet, and the ocean provided a wealth of protein resources. Also, in communities with long-term royal residents, divisions of labor (with specialists in various occupations on land and in procurement of marine resources) came to be strictly adhered to. It is in the general cultural setting outlined above, that we find the *ahupuaʻa* of Kahuku at the time of European contact.

Legendary Accounts of Kahuku Ahupuaʻa

The current study parcel is located in the *ahupuaʻa* of Kahuku, District of Koʻolauloa, Island of Oʻahu (Figure 10). Kahuku is a large *ahupuaʻa* (nearly 5,000 acres) that occupies the northeastern point of Oʻahu, stretching from the ocean to the Koʻolau mountains. It includes a rich fishery and a broad coastal plain (*makai* of the present day highway) rich with wetlands, springs, and brackish pools. Punamano, Punahoolapa, Polou, and Kalou are the names of a some of the bodies of water located *makai* of the subject parcel. This area was once renowned for its *hala* groves. Kalaiokahipa Ridge, a coral reef escarpment (located *mauka* of the present day highway), juts up above the coastal flat near the study areal. From there the land becomes increasingly steeper and more dissected as it enters the foothills and then the mountains, where it is cut off by the *ahupuaʻa* of Waimea.

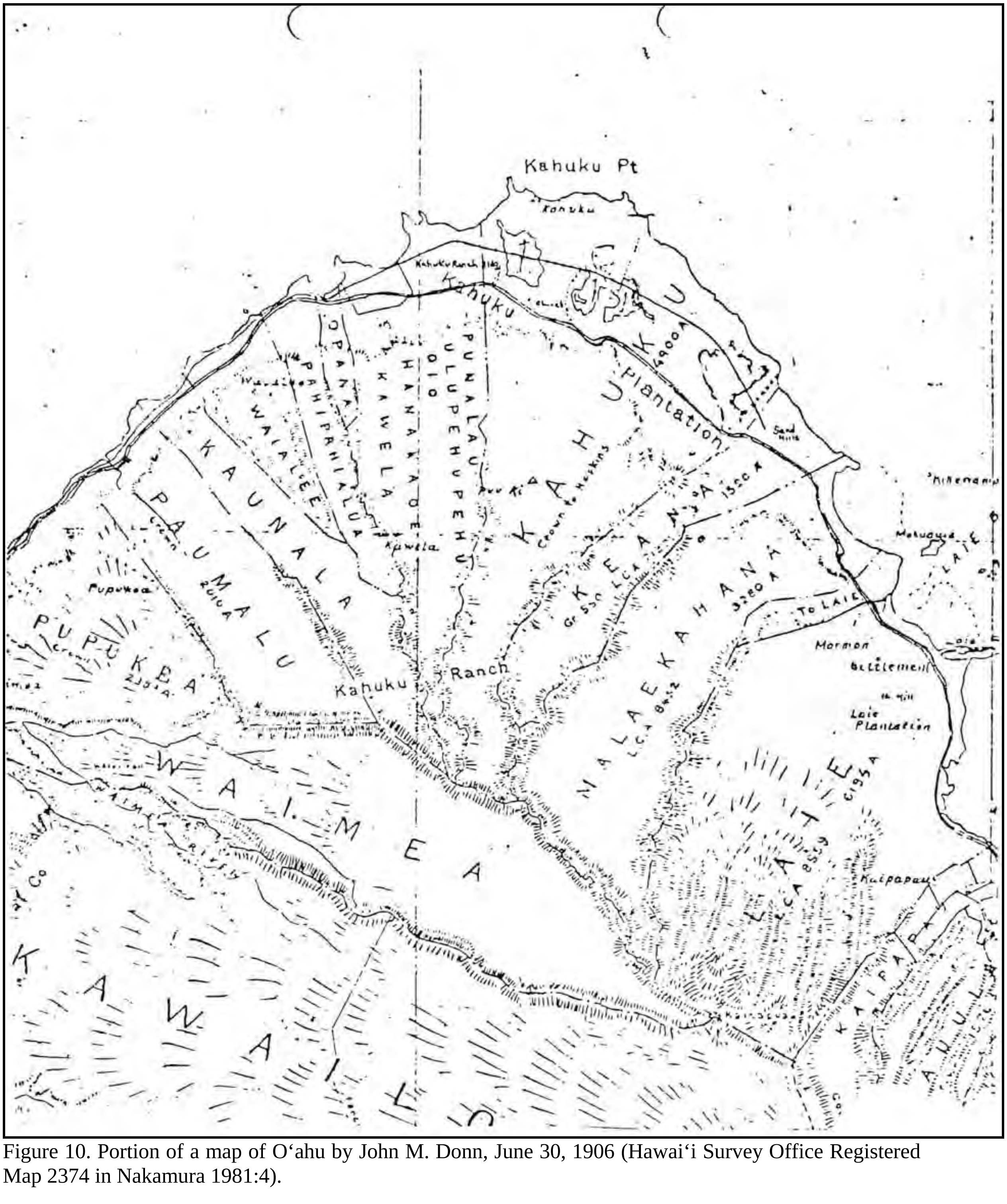


Figure 10. Portion of a map of O‘ahu by John M. Donn, June 30, 1906 (Hawai‘i Survey Office Registered Map 2374 in Nakamura 1981:4).

Kahuku Ahupuaʻa, and many of the places named within it, have traditional legends associated with them. Kahuku literally translates as "the projection" (Pukui et al. 1974:67). The naming of Kahuku and how it was perceived by the ancient Hawaiians is suggested in old stories. Legends relate that Kahuku was once a floating island that had been struck apart from Oʻahu by Lonokaeho, leaving an open gap in Kalaiokahipa ridge. The island was blown about in the ocean until the people of Koʻolauloa District captured it and reattached it to Oʻahu with hooks and ropes (Wong-Smith 1989:A-1). Several versions of this story are told (some stories also suggest that Kahuku was once under water). The following story from McAllister (1933) tells of the time when Kuhuku was not part of Oʻahu:

> Kane and Kanaloa lived in the vicinity of the ridge (Kalaiokahipa ridge); but that was at the time when the Kahuku plain was still under water, and the waves lapped about Kaliokahipa. The brothers are said to have obtained fish by dipping into two holes on opposite sides of a large rock which now lies in the cane field. [in Wong-Smith 1989:A-2]

Many legends tell of how Kahuku was reattached to Oʻahu. Two examples From Silva (1984) are presented below:

> [1] Legend tells us that Kahuku was a floating island situated several miles out to sea. For a long time, the people of Oʻahu had planned to make the island part of their land, for they saw it come close to Oʻahu's shores. The floating island of the Menehune did not have any fresh water springs because there were no high mountains covered with verdure and trees to capture the rains. So, the Little Folk used to paddle their islet into the bays of Oʻahu at night to haul water from the springs of the large island.
>
> One day, a resident of Kahuku suggested that all the people gather together to make strong hooks of whalebone and attach them to a stout rope made of sacred olona fibres. This was done.
>
> The Menehune came to take water as usual, then the residents of Oʻahu attached the large hooks to the floating isle while the Menehune started to paddle off again, but they could not move their islet or free it from they ivory hooks and Olona ropes.
>
> Today, many people who travel Kahuku section of Oʻahu and see the many islets seeming to float off shore, and hear the sea singing its songs, they say, 'Listen to the Menehune grumbling while they try to move their island that used to float!'
>
> The rumbling and grumbling is heard only at night, for that is the time for the Menehune to be working at Kahuku. [Paki 1972:53 cited in Silva 1984]
>
> [2] Kahuku District, according to legend, was once a floating island blown about by the winds. As it banged against Oahu, it made noises which disturbed the old women guarding the princess Laiekawai. The old women grappled the island with fishhooks and attached it securely to Oʻahu. Polou pool on the sea side of the Kahuku mill is one spot where the hook was fastened. The other end was fastened at Kukio pond 300 feet inland at Kahuku Point. [Boswell 1958:68 cited in Silva 1984]

McAllister (1933) describes what was formerly found in these pools where Kahuku was attached to Oʻahu:

> A story is told that Kahuku was once a land afloat, wafted about by the winds drifting over the ocean. Just how it came to Oahu is not told, but old Hawaiians point out Polou, the place where Kahuku is fastened to Oahu. Formerly it was possible to dive into the pool and when a depth of 40 fathoms was reached, a shelf of rock was found upon which to rest. Forty fathoms deeper Punakea (white line from coral) by which Kahuku was made fast could be seen. This hook was intricately fashioned of Kawila (*Alphitonia excelsior*). Seaward of the Waialee Industrial School, in another pool of water, known as Kalou, is the spot where Kahuku is attached to Waialee. In the immediate vicinity of Polou was a stone known as Kanaloa. [in Stride et al. 2003:8]

McAllister (1933) also describes a legend associated with Punamano, a spring and wetland located on the Kahuku plain *makai* of the study parcel. He relates that it is a small water hole that was:

> …pointed out by Kahione, Kaleo, and Luiko Kaio in the flat limestone plain of Kahuku Point. It is about 15 ft. in diameter and brackish in taste. My informants told this story:
>
> One time when the people of Kahuku were fishing they caught a small shark. Putting him in a calabash of water they carried him to their houses near the beach. Here he was cared for and put in larger and larger calabashes as he grew bigger. Finally haven outgrown even the largest calabash that could be found, it was decided to place him in one of the pools of brackish water which came to be known as Punamano. A man and woman living near the pool became guardians. They had lived in their grass huts with a breadfruit tree near the pool and taro and potato patches near the mountains for several years when the brother of the woman came to live with them. Sometime after, the man and his wife went to the mountains to gather taro and potatoes. The brother, who was staying at home, thought that he would like to have some food prepared when the sister and her husband returned. He climbed the breadfruit tree and gathered several, throwing the fruit into the water instead of on the ground, where it would have been bruised in the fall. After picking enough for a few days he descended the tree and gathered most of the fruits from the bank. Two had floated to the middle of the pond and he could not reach them. Now this man knew of the shark that lived in the pool, but he had frequently bathed in the pool and no thought of fear crossed his mind as he swam to the breadfruit. He did not know, however, that his sister and her husband had warned the shark not to allow anyone to steal breadfruit when they were gone. When the sister and her husband returned they could not find brother. Neither was the shark to be found, but they saw the breadfruit floating in the pool and the reddish color to the water. They guessed what had occurred. For nearly a mile they followed the bloody trail until they came to a spring known as Punahoolapa. Not only was the brother never seen, but the shark has never been seen to this day. A plantation pump now marks the spring near the sea side of the road. [in Wong-Smith 1989:A-7]

During Precontact and early Historic times the Kahuku plain was well known for its groves of *hala*. Wong-Smith (1989:A-5, A-6) provides several accounts of its renown:

> …he flew to Kahuku and adorned his neck with wreaths of the pandanus fruit and his head with flowers of sugarcane. [Thrum 1912:100]
>
> This is the land of the hala tree…”I sent out word…among the people that there should be no one leaving here (Kahuku) for Waimea or Waialua who had not a wreath of hala fruit…”: [Cummings 1913:241-242 cited in Wong-Smith 1989]
>
> …men from Kahuku were identified by leis of the orange hala fruit which they wore by order of their chief when they left their ahupuaʻa…[Wilcox 1975]

Halemano, a man credited with the evolution of hula, composed a chant to win back the attentions of his wife that mentions the *hala* of Kahuku (Wong-Smith 1989:A-6). The chant goes:

A kukui au a Kahewahewa	As I reported to Kahewahewa
Ku au nana I laila,	I stood and gazed, then
Haloiloi Kuu waimaka e uwe,	Tears filled my eyes causing me to weep.
Nani na hala ka oiwi o Kahuku,	How beautiful are the hala, native trees of Kahuku,
I ka lawe a ka makani he mikioi	As they are being fanned by the Mikoioi wind
	[Elbert 1965:280-281 cited in Silva 1984]

Other legends tell stories of Kalaiokahipa ridge, the coral reef escarpment that juts up above the Kahuku plain. The following examples are found in Wong-Smith (1989:A-3):

> The many caves in the porous formation were used as places of burial by the old Hawaiians. On the Waimea side is an overhanging ledge where formerly hung two stalactites from which water continually dripped. They very closely resembled the breasts of a woman , and this was said to be Nawaiolewa, a goddess of the region. Some years ago, a white man removed one of the stalactites, or breasts, according to the story, and the water immediately stopped dripping down from the other (McAllister 1933).
>
> Nawai-o-lewa is on the northwest side of the rocky brow of Kalaeokihipa and now only one breast is left to move in the gusty winds of Kuhuku-lewa. The other was broken off by that supernatural son of Ku and Hina…Between Kaleaokahipa and Nawaiolewa, just above is a small round opening to a secret cave…The small secret cave belonged to Ka-alae-huapi (Red head mud hen) and others in the first Kuhuku that was covered by a hala grove (J.K. Apuakehau, Kuokoa, June 29, 1922).
>
> The Hole of Kahipa and Nawaiuolewa is pointed out today but the story is lost. Kanui a woman 105 years old, told Mary Pukui that the two were brother and sister. In order to make it one, the two sat down and hooked their fingers together and drew the together. The hole marks the place where they sat (Kamakau Part II, Moolelo o Hawaii, Note 4, Chap 12).

Further up in the mountains, *mauka* of the study area, Kamakau (1964) tells of a famous hiding cave with an entrance in Kahuku. He writes:

> There is only one famous hiding cave, ana huna, on Oahu. It is Pokukaina….This was a burial cave for the chiefs, and much wealth hidden away there with the chiefs of old. On the Kona side the island the cave has three openings, one at Hailikulamanu—near the lower side of the cave of Koleana in Moanalua—another in Kalihi, and another in Puʻiwa. There was an opening at Waipahu, in Ewa, and another at Kuhuku in Koʻolauloa. The mountain peak of Konahuanui was the highest point of the ridgepole of this burial cave "house," which sloped toward Kahuku. Within the cave are pools of water, streams, creeks, and decorations by the hand of man (hana kinohinohʻia), and in some places level land. [Kamakau 1964:38]

History After Contact

On February 28, 1779, two weeks after the death of Captain James Cook, the H.M.S. Resolution captained by Charles Clerke rounded the northern tip of Oʻahu providing the first historical accounts of the Kahuku area. Clerke wrote:

> SUNDAY 28th. . . run round the Noern [Northern] Extreme of the Isle which terminates in a low Point rather projecting; off it lay a ledge of rocks extending a full Mile into the Sea, many of them above the surface of the Water; the Country in this neighborhood is exceedingly fine and fertile; here is a large Village, in the midst of it is run up a high Pyrimid doubtlessly part of a Morai. I stood into a Bay just to the Westward of this point the Eastern Shore of which was far the most beautiful [sic] Country we have yet seen among these Isles, here was a fine expanse of Low Land bounteously cloath'd with Verdure, on which were situated many large Villages and extensive plantations; at the Water side it terminated in a fine sloping, sandy Beach. . . [in Beaglehole 1967:I:572]

Lieutenant James King, also aboard the H.M.S. Resolution that day, wrote:

> WOA'HOO. . . saw this Island the beginning of last year, but only just as a high lump, We this Time sailed along its NE & NW sides but say nothing of its Southern part. What we did see of this Island was by far the most beautiful country of any in the Groupe;

> particularly the Neck that Stretches to the Northward and its NW side. Nothing could exceed the verdure of the hills, nor the Variety which the face of the Country display‘d. It /s north-eastern/ parts were cliffy, & rugg’d to the Sea side, but the Valley look’d exceedingly pleasant, near the N point we were charmed with the narrow border full of Villages, & and Moderate hills that rose behind them. . . [Beaglehole 1967:I:610 in Wong-Smith 1989:A-9, 10]

In 1794, British Captain, George Vancouver also visited the northern tip of O‘ahu, but found the Kahuku area to be slightly different than the verdant, well populated plain described by Clerke and King fifteen years earlier. He wrote:

> …In every other respect our examination confirmed the remark of Capt. King excepting that in point of cultivation or fertility, the country did not appear in so flourishing a state, nor to be so numerously inhabited, as he represented it to have been at that time, occasioned most probably by the constant hostilities that had existed since that period. [Vancouver 1798(3):71]

Much attention has been paid to these two descriptions of the Kahuku area, separated by only fifteen years, but describing two different places; one with thriving villages and extensive agricultural fields, and another that is not so populated or agriculturally productive. Handy and Handy (1972:462) ask, ”What catastrophe of the elements, slow or swift, has wrought change in Kahuku?” They write that:

> Kahuku *ahupua‘a* presents something of a paradox. McAllister (1933 p. 153) remarked in his survey that it did not seem possible that this “rather desolate, wind swept” plain could ever have supported much life, agricultural or human, before the era of industrial machinery and organization. Yet one of his informants “remembers the time when trees now found only in the mountains” covered it. [Handy and Handy 1972:462]

In 1833, E. O. Hall observed at Kahuku that “much taro land now lies in waste because of the diminished population of the district does not require its cultivation” (Hall 1839 in Handy and Handy 1972:462). The changes in Kahuku were the same changes taking place throughout the Hawaiian Islands. Although early explorers blamed the decline in population on warfare, a more likely reason for such rapid population decline was the introduction of Western diseases (Kuykendal 1938; Nakamura 1981; Wong-Smith 1989). Once introduced, the foreign diseases quickly decimated the Hawaiian population which had no immunity to them. The sudden dramatic reduction in population radically altered the Hawaiian way of life and paved the way for further change.

One of these changes was the Great *Māhele* of 1848. By the middle of the nineteenth century the ever-growing population of Westerners forced socioeconomic and demographic changes that promoted the establishment of a Euro-American style of land ownership, and the *Māhele* became the vehicle for determining ownership of native lands. During the *Māhele*, land interests of the King (Kamehameha III), the high-ranking chiefs, and the low-ranking chiefs, the *konohiki,* were defined. The chiefs and *konohiki* were required to present their claims to the Land Commission to receive awards for lands provided to them by Kamehameha III. They were also required to provide commutations to the government in order to receive royal patents on their awards. The lands were identified by name only, with the understanding that the ancient boundaries would prevail until the land could be surveyed. This process expedited the work of the Land Commission (Chinen 1961:13). During the *Māhele* all lands were placed in one of three categories: Crown Lands (for the occupant of the throne), Government Lands, and *Konohiki* Lands. All three types of land were subject to the rights of the native tenants therein.

As a result of the *Māhele*, Kahuku Ahupua‘a (4,752 acres) was retained as Crown Lands by King Kamehameha III (under the name of Victoria Kamamalu). According to the Waihona ‘Aina Māhele database, eighty-five claims for Land Commission Award (LCAw.) parcels were made within the *ahupua‘a* of Kahuku, but only seventy-two *kuleana* lots were awarded to native tenants. Nearly all of awards were located *makai* of the present day highway, and none of the LCAw. were located within the current study area (Figure 11). The locations of the LCAw. parcels generally confirm the expected Precontact settlement patterns discussed above for Kahuku Ahupua‘a, with the majority of the *kuleana* lots located near the coast and only a few at inland locations. Information contained in the LCAw. testimony provides insight into Hawaiian land use practices during the early Historic Period. Silva (1984) provides a tally of the land uses mentioned in the LCAw. testimony for Kahuku. Silva lists, “162 taro patches, 39 kula plots & gardens planted w/awa, banana, wauke, gourd, sweet potato, sugar cane, noni, watermelon, pili grass, 7 clusters of hala, 6 salt lands, 4 koa canoe trees, 2 fish ponds, 10 house lots, 1 sweet potato patch cultivated upon cliffs, 1 water course bank, 3 cultivated upland plots, 1 brackish spring, 1 wooded upland area of ulu, ohia, kukui, koa, ti, noni, etc…” (in Wong-Smith 1989:A-13).

Beginning in the 1850s, Kahuku and many neighboring *ahupuaʻa* were granted, leased, and sold to foreigners, who established sheep and cattle ranches on Oʻahu’s north shore (Williams and Patolo 1998). Two of the early ranches, which encompassed a large portion of the Koʻolauloa District, were known as the Mālaekahana and Kahuku Ranches. They were started by two Englishmen, Charles G. Hopkins and Robert S. Moffitt (by some accounts Robert Moffitt was actually Robert Stoney, an Irishman; Williams and Patolo 1998:21). Although many discrepancies exist in the researched materials, it appears that in 1851 the *ahupuaʻa* of Kahuku was sold to Charles Gordon Hopkins as part of Grant No. 550. Hopkins, who had arrived in Hawaiʻi from London on February 25, 1845, worked for the Hawaiian Government filling several official positions (Thrum 1911:44).

By 1851 Hopkins had become the agent responsible for the sale and rental of the Crown Lands of Kamehameha III (Korn 1958:208), and he had purchased over 8,000 acres of land on Oʻahu’s north shore, including Kahuku (Nakamura 1981). With this land Hopkins established the Kahuku Ranch and he was dubbed “Duke of Kahuku” by a writer of the *Pacific Commerial Advertiser* (Korn 1958:223). By the mid-1850s access to the ranch from Honolulu had been made easier by the construction of an around the island road, a predecessor of the present day Kamehameha Highway (Kuykendall 1938:25).

Emerson (1928) discusses the negative affect this era of land transactions and ranching had on the native residents of Kahuku. He writes:

> Kahuku had passed from control of its chief to that of an Englishman. The pastures of his big ranch extended along the shore for 12 miles, reaching inland to the mountain chain, and he was so autocratic that the natives could not own a dog, or pasture a cow or horse, without his consent. The depredations of herds and flocks on their small homesteads became unbearable, but they appealed in vain for their beloved *hala* trees and patches of vegetables. . . There was no redress, however, and with the fading of the forests the people also disappeared and the once populous district of Kahuku became a lonely sheep and cattle ranch. [Emerson 1928:135-136]

Many transactions involving the lands of Kahuku took place during the late 1850s and early 1860s (Nakamura 1981:8; Williams and Patolo 1998:20). By 1873 the Mālaekahana and Kahuku Ranches had been purchased by Herman A. Widemann (Thayer 1934:138). On January 19, 1874, Widemann sold his interest in the ranches to Julius L. Richardson for $45,000, who in turn sold them to James Campbell for $63,500 on October 2, 1876 (Thayer 1934:138). The following portion of an article from Hawaiian Gazette dated October 4, 1876, provides an overview of Campbell’s purchase. The article states:

> …It includes 25,000 acres in fee simple, and large tracts of mountain land under long leases, with $34,000 worth of livestock, including 3,000 head of cattle, with the choice band of merino sheep and horses now on it. It is unquestionably the best stock ranch on these islands, and it has brought to a high state of perfection under the management of the late proprietors, who divided the plain into ten or twelve large paddocks, walled with heavy stone walls. It stretches from Laie to Waimea, a distance of thirteen miles, and those who have ever visited it must have admired its lovely green pastures of manienie grass so fattening to stock. It is the intention of Mr. Campbell to increase his band of sheep to 30,000 of the choicest breed. The price paid is a handsome one, securing to its present proprietor the most desirable ranch on the Islands, and to Mr. Richardson a comfortable fortune, the result in part of his industry and good management, and in part to the Reciprocity Treaty, the first fruit from which he has been so fortunate as to reap…[in Wong-Smith 1989:A-14]

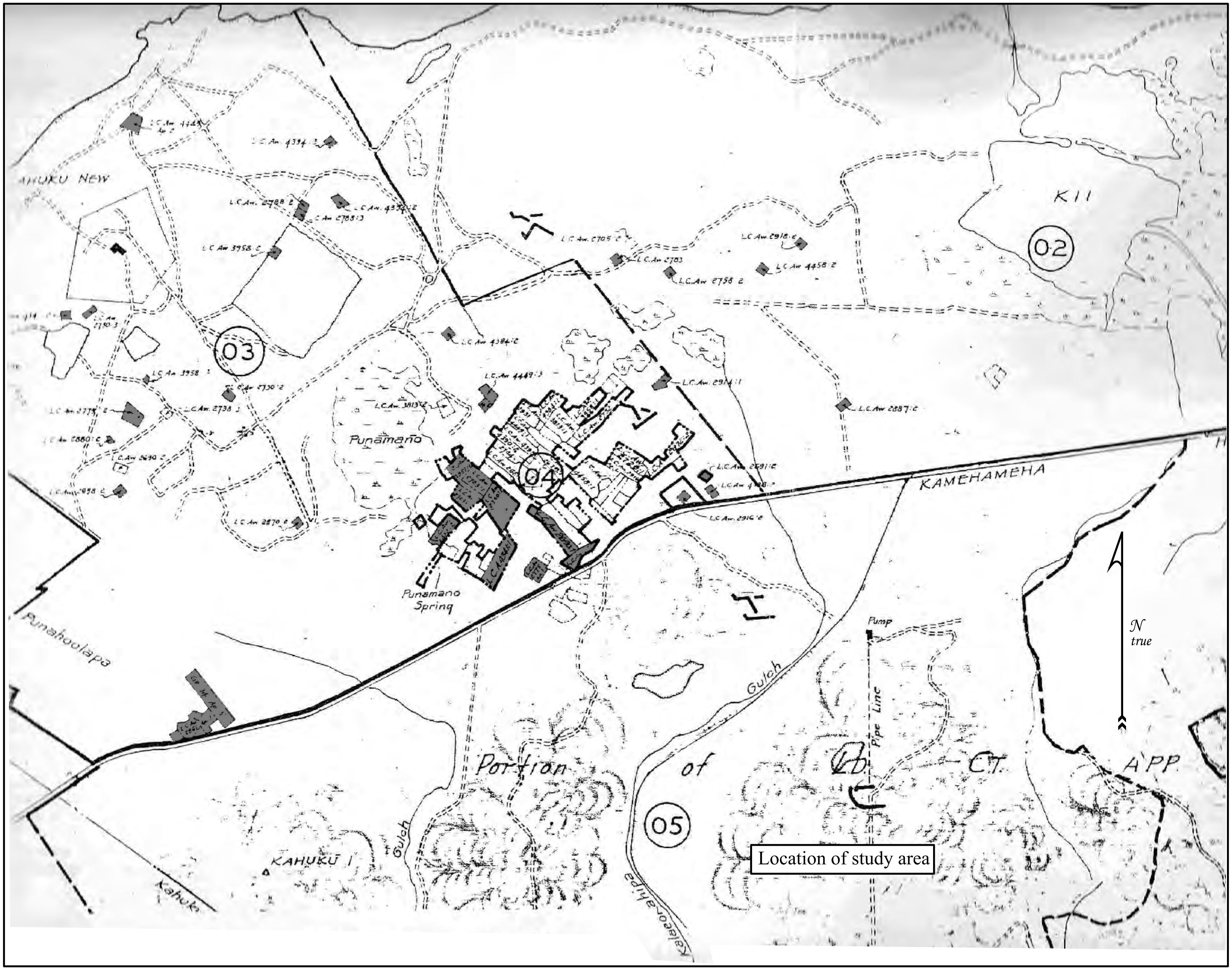


Figure 11. Tax map of Kahuku showing the distribution of Land Commission Awards (shaded) in the vicinity of the study area.

Campbell had arrived in Hawaiʻi in 1849 and first established the Pioneer Mill Company of Lahaina, a prosperous sugar plantation on the Island of Maui, which he sold his interests in to purchase Kahuku Ranch (Kuykendall 1967:67). Ushered in by Campbell, sugar was soon to become the dominant industry in Kahuku. On November 19, 1889, Campbell leased much of his Kahuku Ranch lands to Benjamin F. Dillingham for a term of 50 years (January 1, 1890 to December 31, 1939) at an annual rate of $50,000 (Kuykendahl 1967:69). In 1886, Dillingham had proposed, "The Great Land Colonization Scheme," writing:

> The Kahuku Ranch consists of 20,000 acres in fee simple and 5,000 acres Government leasehold…On the estate is a level tract of land at an elevation of from 10 to 25 feet above sea level…This tract is pronounced excellent Sugar cane land. There are already flowing artesian wells on either side of this level tract, while near the middle is an unfailing spring in which the water rises to within 2-1/2 feet of the surface, in a column of at least one foot in diameter, and flows thence to the sea. This proves that an ample supply may be found for irrigation.
>
> There have been offered by rice growers to the present owners $10,000 a year for 400 acres of this land, water for cultivation being furnished. A contract has been made to bore five additional artesian wells to comply with this requirement. [Dillingham 1886:76]

Another important part of Dillingham's scheme was the construction of an Oʻahu railroad. In 1889, Dillingham was granted franchise and charter by the Hawaiian Government to create the Oahu Railway and Land Company (Nakamura 1981). Construction began on the railroad in March of 1889, and the railroad began operations on January 1, 1899 (Kuykendall 1967:68). Its route brought it across the coastal plain of Kahuku, north of the current project area (see Figure 10).

On December 10, 1889, James B. Castle subleased a large portion of Kahuku lands from Dillingham. Castle then started the Kahuku Plantation Company, which was granted a charter to cultivate sugarcane on January 30, 1890 (Kuykendall 1967:69). At first, the company relied solely on pumped spring water, stream water, and rain water for irrigation, but these sources were found to be unreliable, and soon the company resorted to drilling artesian wells to supply water (Nakamura 1981). In the first year, five miles of 36-inch gauge railway (some of it portable) were laid to transport cane from the fields to the mill and then to the coast for shipping (Wilcox 1975). These lines eventually tied into the Oahu Railway lines, which operated on the island until 1947 (Dorrance and Morgan 2000:47).

In 1906, Alexander & Baldwin, Ltd. purchased Castle's interest in the Kahuku Plantation Company, thus becoming the largest share holder, and Henry P. Baldwin became the company's president (Wilcox 1975). By 1916, portions of the plantation were also being leased for pineapple cultivation (Wong-Smith 1989). By 1935 the irrigated sugarcane fields included nearly all of the current project area, which also contained two reservoirs (Figure 12). The Kahuku community flourished during its plantation days. Wong-Smith writes:

> …The plantation's hospital was the only medical facility from Waialua to Kaneohe. The plantation pioneered concrete stoves for laborer's cottages and sanitation drains that were used as models for other plantations. The first plantation day nursery and high school were established by Kahuku Plantation Co. The town of Kahuku boasted the biggest baseball diamond and the first golf course. The company laboratories pioneered the carbonation of white raw sugar, using the native limestone around Kahuku for filter. The company devised the money-saving use of molasses as mill fuel. The company also discovered that night lighting of the fields prevented tasseling and increased sugar yield of cane (Wilcox 1975). [Wong-Smith 1989:A-16]

Beginning in the mid-1950s inland portions of Kahuku Ahupuaʻa (3, 500 acres *mauka* of the current project area) were leased to the U. S. military for training purposes (Nakamura 1981:14). The Kahuku Plantation Co. continued to operate in Kahuku until 1971, when it was forced to shut its doors for economic reasons (Dorrance and Morgan 2000:47). The closing of the plantation brought tough economic times to the north shore of Oʻahu (Wong-Smith 1989:A-17). In the 1980s, a portion of the current project area was briefly used as the site of a now defunct wind farm (Nakamura 1981). The study area eventually became part of the Gunstock Cattle Ranch, and until recently it was used as pasture for horses and cattle.

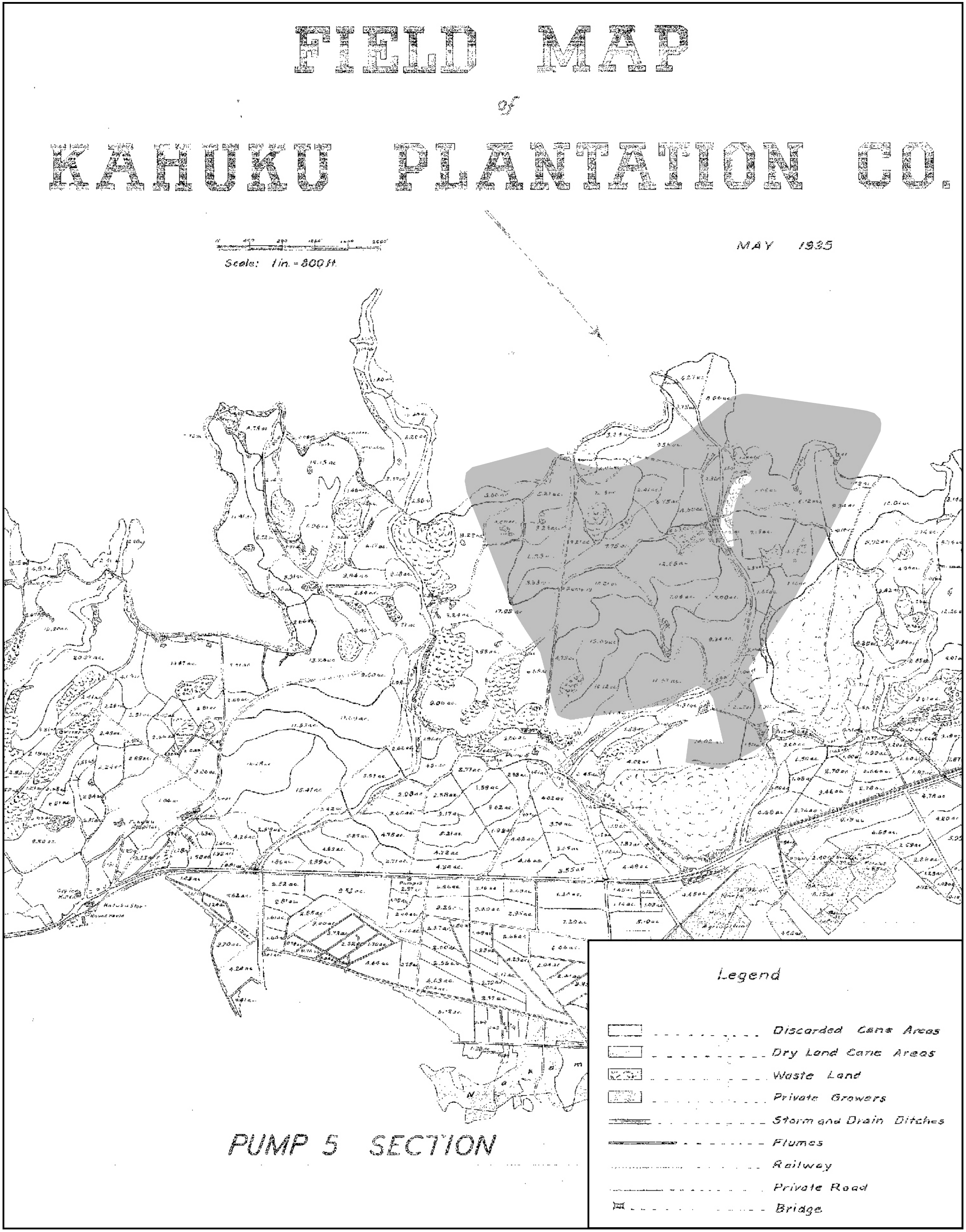


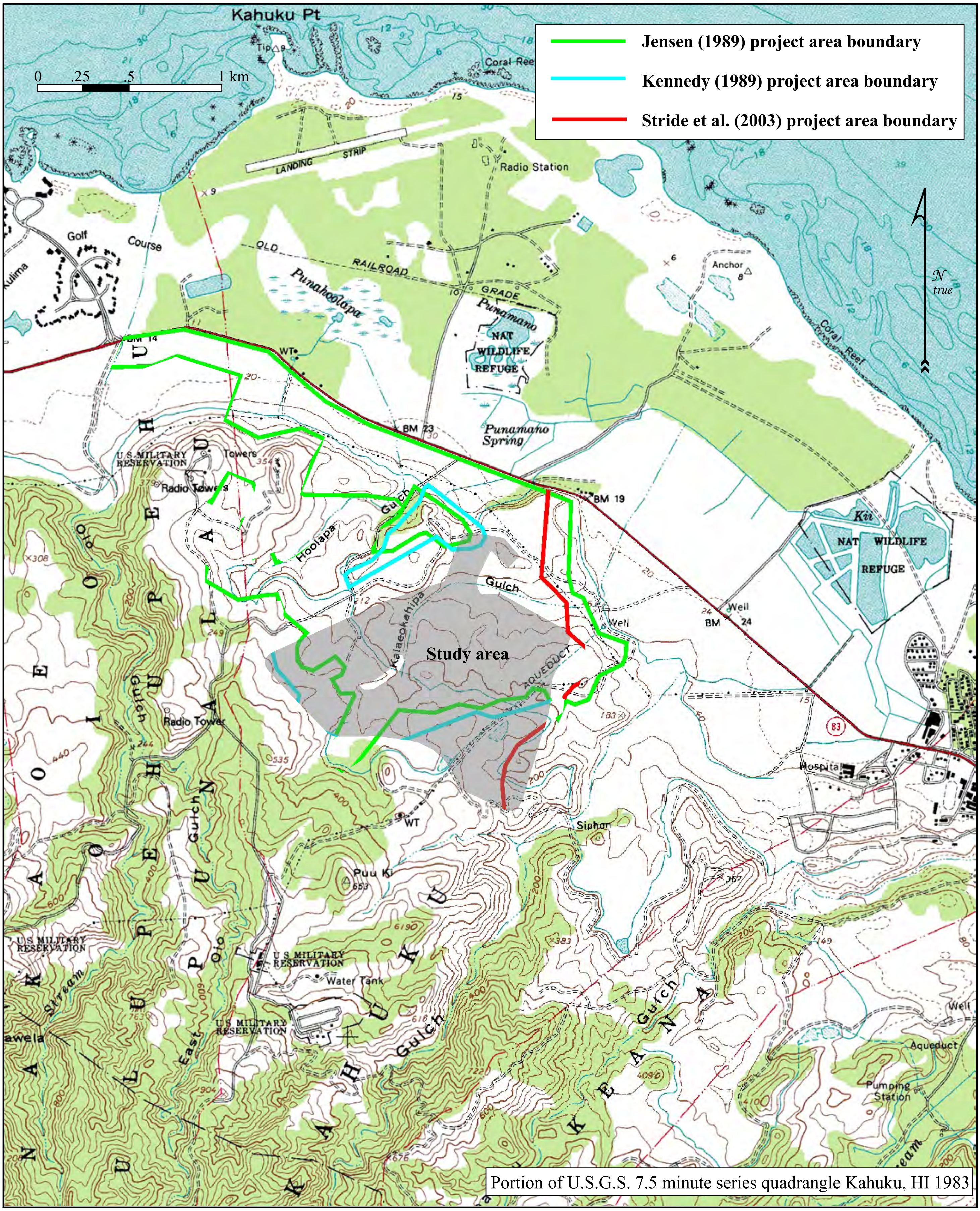
Figure 12. Portion of a 1935 Kahuku Plantation Co. field map (B.P. Bishop Museum Archives) showing the current study area (shaded).

Previous Archaeological Research

Three previous archaeological studies have included portions of TMKs:1-5-6-05:007 and 014 (Figure 13). All three studies were archaeological inventory surveys that also included lands outside the APE. Fieldwork for the first inventory survey was conducted in 1989 by Paul H. Rosendahl, Inc. (PHRI) (Jensen 1989), the second survey was conducted by Archaeological Consultants of Hawaii (ACH) also in 1989 (Kennedy 1989), and the third was conducted in 1992 by Cultural Surveys Hawaii, Inc. (CSH) (Stride et al. 2003). Collectively, these previous surveys resulted in the identification of eighteen archaeological sites within the boundaries of Parcel 007 that contained a total of forty-two features. All but three of the previously recorded sites were assigned State Inventory of Historic Places (SIHP) site numbers. Each of the sites, and its features, is listed in Table 2, and detailed descriptions are presented below. The site locations relative to the current project area boundaries are depicted in Figure 14.

Jensen (1989) conducted an archaeological inventory survey of two separate project areas for the proposed development of two golf courses (comprising 866 acres) within the Koʻolauloa District, Island of Oʻahu (referred to as Punamano and Malaekahana Project Areas). The 638-acre Punamano Project Area included a large portion of the current project area. Jensen (1989) recorded twenty-six sites within the Punamano Project Area, seven of which were situated within the boundaries of Parcel 007 (SIHP Sites 4076, 4077, 4078, 4079, 4080, 4081, 4085). Jensen described these seven sites as follows:

> **Site 4076 - Overhang**
>
> Site 4076 is a substantial overhang shelter formed along an eroded section of fossil sea bluff exposed in a small gulch in the eastern portion of the project area [see Figure 14]. The overhang extends for a total distance of 19 meters parallel with the exposed bedrock (east-west), and protrudes under the bedrock for an average of 2.75 m (north-south). A small pile of rocks is located at the eastern end of the shelter area, marking a possible fire hearth. Dark, ashy-colored midden covers the entire interior living surface, and appears to have accumulated to at least 30-40 cm depth (as determined from examination of two exposed areas within the deposit). A basalt adze and a drilled bivalve shell were observed on and recovered from the surface (provenience of these two collected artifacts is indicated on the site map, [Figure 15]). Two additional artifacts, both basalt flakes, were not collected.
>
> A gentle slope has been established in front of the cave opening by constructing a terrace which extends for a distance of c. 8 m parallel with, and which begins at a point c. 5 m in front of, the cave opening. This upper terrace may conceal a rock retaining wall buried beneath the loose soil fill. A second parallel terrace, definitely supported by a rock (limestone slab and boulder) retaining wall, was established at c. 10 meters in front of the cave. Immediately below the lower terrace retaining wall is a narrow and shallow ditch segment. Cultural material, consisting of portable artifacts and buried pockets of midden, may well have accumulated in portions of these two terraced areas in front of the overhang.
>
> This site may possess a substantial subsurface midden deposit, located both within, as well as in front of, the overhang shelter. There are no surface indications of significant past looting or other disturbances. [Jensen 1989:27]



Portion of U.S.G.S. 7.5 minute series quadrangle Kahuku, HI 1983

Figure 13. Map showing the aerial extent of previous archaeological studies that included portions of the current APE.

Table 2. Known archaeological sites and features located within TMK:1-5-6-05:007.

SIHP #	*PHRI #*	*ACH #*	*CSH #*	*Feature*	*Description*
4076	T-15	S-5	-	A	Overhang shelter
	-	S-5	-	B	Low stacked wall
	-	S-5	-	C	Overhang shelter
	-	S-5	-	D	Low stacked wall
	-	S-5	-	E	Low stacked wall
	-	S-5	-	F	Low stacked wall
	-	S-5	-	G	Overhang shelter
	-	S-5	-	H	Overhang shelter
4077	T-16	S-17	-	A	Terrace/retaining wall
	-	S-17	-	B	Wall/terrace
	-	S-17	-	C	*Auwai*/modified crevasse
4078	T-17	S-16	-	A	Overhang shelter
	-	S-16	-	B	Low stacked wall
	-	S-16	-	C	Low stacked wall
4079	T-19	S-9	-	-	Short wall segments
4080	T-20	S-10	-	-	Historic trash dump and bottle scatter
4081	T-21	S-7	-	-	Overhang shelter
4085	T-26	S-14	-	A	Enclosure
	T-26	S-14	-	B	Low rubble, partially stacked wall
4706	-	S-6	-	-	Enclosure complex
4707	-	S-15	-	-	1937 irrigation ditch
-	-	S-8	-	-	Habitation/Burial Complex
	-	S-8	-	A	Overhang shelter
	-	S-8	-	B	Rock-filled crevasse
	-	S-8	-	C	C-shape
	-	S-8	-	D	2 low stacked walls
	-	S-8	-	E	Overhang shelter
-	-	S-12	-	-	Overhang shelter
-	-	S-13	-	-	Terrace/alignment
4510	-	-	1	A	Overhang shelter
	-	-	1	B	Overhang shelter
4511	-	-	2	A	Overhang shelter
	-	-	2	B	Overhang shelter
4512	-	-	3	-	Enclosure
4513	-	-	4	A	Wall structure
	-	-	4	B	Terrace
	-	-	4	C	U-shaped enclosure
	-	-	4	D	Cobble paved terrace
	-	-	4	E	Overhang shelter
4514	-	-	5	-	Terrace
4515	-	-	6	A	Overhang shelter
	-	-	6	B	Overhang shelter/burial

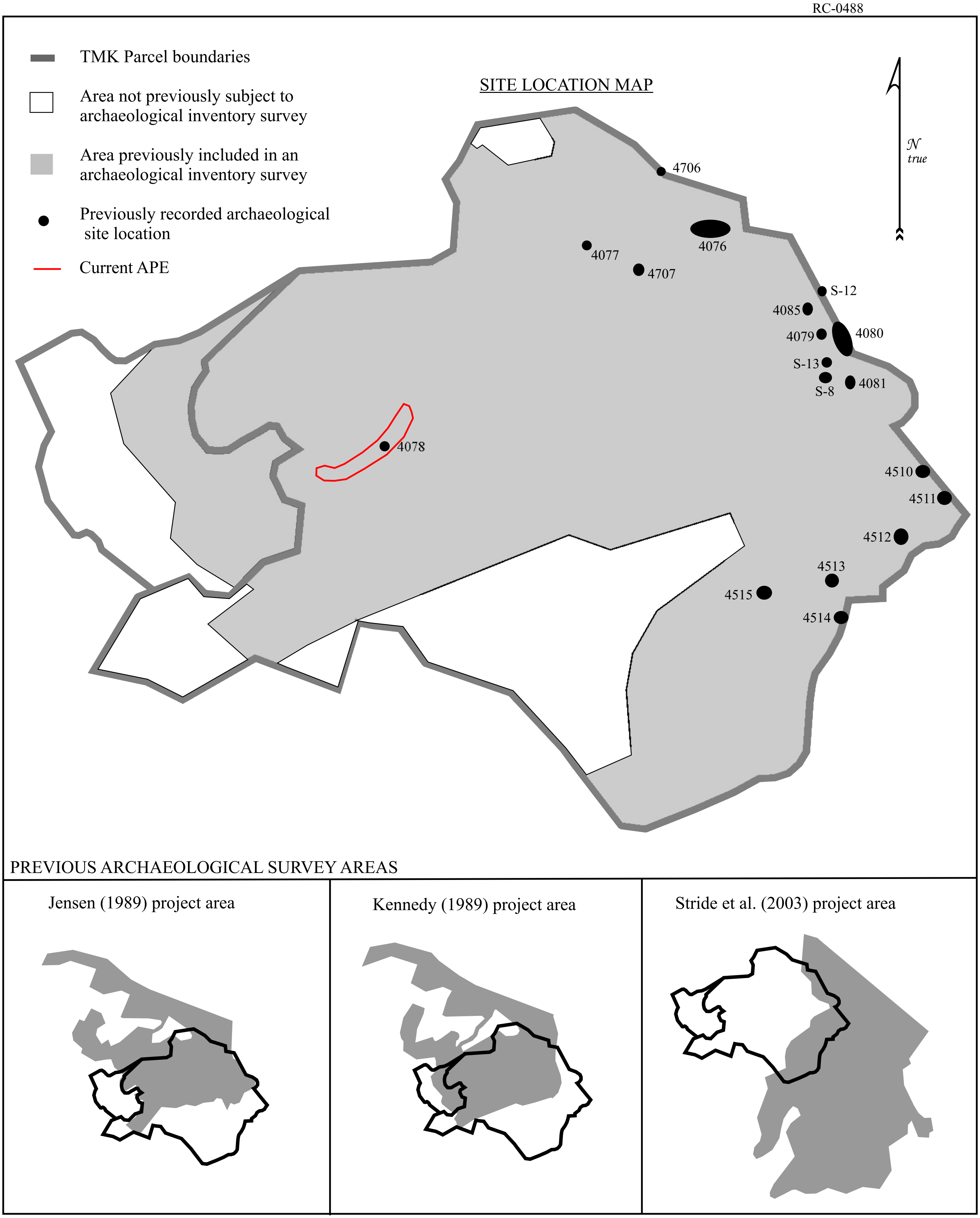


Figure 14. Map showing archaeological sites previously recorded within the study parcels and the extent of the previous survey coverage.

The project area falls within the Pump 5 Section of the former Kahuku Plantation Company's fields (see Figure 12). With the exception of a few small areas of wasteland, the entire APE was once planted in sugarcane. The APE consists of portions of former Fields 9, 10, and 16. These fields were segmented into smaller field units ranging between roughly 0.5 and 14 acres in size. Each of the smaller field units was bounded by irrigation ditches. The 1935 map of the Kahuku Plantation Company lands shows this system of irrigation ditches and the acreage of each of the small fields they bounded (see Figure 12). In addition to the ditches, the 1935 map also shows two reservoirs and Pump 18 within the APE. Pump 18 is shown along a pipeline that ran between Pump 5 (*makai* of the APE) and one of the reservoirs.

Although impacted by modern land disturbance, vegetation, and erosion, much of the sugarcane irrigation infrastructure is still present within the APE (see Figure 23). The system of irrigation ditches that remains today closely resembles the 1935 configuration of ditches. One of the two reservoirs and Pump 18 were relocated within the APE, and several additional irrigation features, added to the fields during the late 1930s and early 1940s, were also discovered. Though extensive, with miles of ditches that provided water to roughly 230 acres of fields within the APE, the network of irrigation features functioned fairly simply. The system relied on groundwater that was pumped up hill from Pump 5 through a large diameter metal pipe (labeled aqueduct on the 1983 U.S.G.S. Kahuku quadrangle; see Figure 1) to Pump 18, and then up to a reservoir located near the *mauka* boundary of the APE. From the reservoir water was gravity fed into a system of earthen and stone embanked ditches that gradually carried it down slope to the fields. At each field, a network of smaller earthen ditches, concrete flumes, and/or metal flumes was present that carried the water from the larger ditches to the rows of sugarcane. Water was directed through the irrigation system by opening and closing a series of sluice gates. Excess water and storm runoff was directed to Kalaeokahipa Gulch, and other smaller natural drainages that fed into it, where it ran toward the ocean and filtered back into the aquifer.

A number of different types of irrigation ditches and flumes are present within the APE including earthen berm lined ditches, earthen berm and stone lined ditches, stone lined trenches, excavated shallow earthen ditches, stone and concrete flumes, concrete flumes and ditches, sectional concrete flumes, and sectional metal flumes. As discussed above, the berm lined ditches are the main irrigation channels. These ditches generally run cross-slope, following the upper edges of steeper slope planes within the APE. As the ditches progress they gradually meander down slope to ensure that the water flows steadily in the desired direction. The route of each ditch is dictated by the topography of the slope edge that it follows. All of the ditches are excavated into the natural slope of the terrain, and the soil material removed from the water channel is piled along the downslope edge so that the upslope ditch edge is formed by the natural slope, and the downslope ditch edge is formed by bermed soil material (Figure 24). At bends, especially in steeply sloped areas, the interior downslope berm edges are lined with stacked stones to help prevent erosion (Figure 25).

The other types of flumes and ditches run off of the main irrigation ditches. At numerous locations along the route of each of the berm lined ditches, breaks are present in the downslope bermed edge that were used to direct water flow into the field areas. Typically the breaks in the bermed edges spill into stone lined trenches. Many of the stone lined trenches contain upright concrete panels with channeled edges that once held wooden sluice gates in place (Figure 26). Several of the concrete panels contain the inscription "K P" (Kahuku Platation?) on one side of the former gate and "No. 4" on the other side. Where the stone lined trenches diverge from the berm lined ditches they run for short distances, generally in several directions. The stone lined ditches usually flow into shallow excavated ditches, sectional concrete flumes, or sectional metal flumes that carried water to the rows of planted sugarcane.

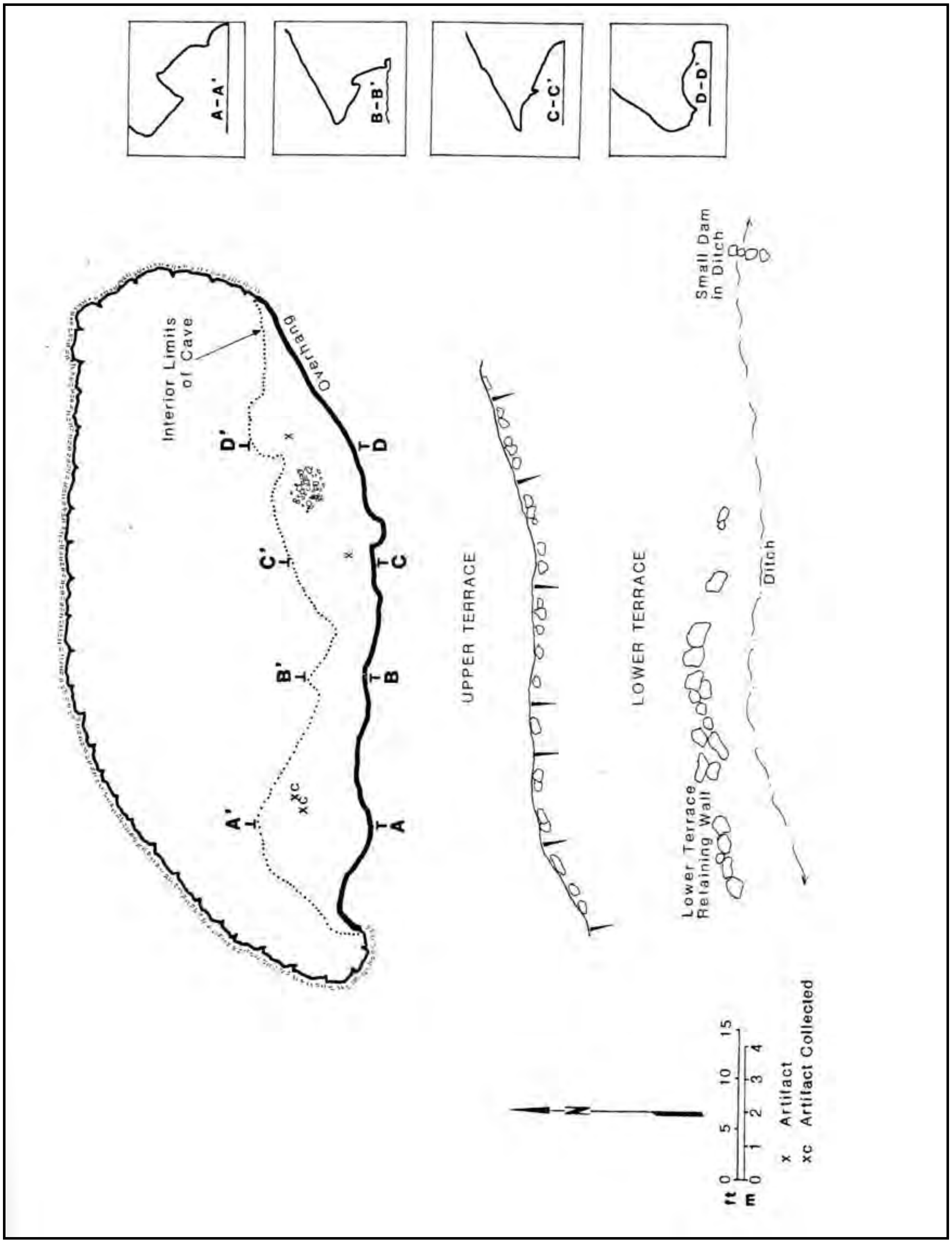


Figure 15. Plan view of Site 4076 from Jensen (1989:28).

Site 4077 - Terrace

Site 4077 is a short segment of “retaining wall” constructed from tabular sandstone slabs piled from three to four courses high and from one to two courses thick. The wall, located on a side hill above an isolated field near the center of the project area, measures only 2.6 m in length, 0.5 m in width, and 0.8 m high [see Figure 14]. No additional features, or other evidence of prehistoric or early historic use or occupation, were observed in association with the wall or within the nearby area. Additional features may have existed prior to the extensive cultivation to which the Punamano project area has been subjected over the past 100 years. [Jensen 1989:27]

Site 4078 - Overhang

Site 4078 is a small overhang, with the available living surface extended by constructing two short segments of rubble wall near the entrance. The site, located adjacent to a large cultivated field within the south-central portion of the project area [see Figure 14], has been formed by erosion of a portion of exposed limestone, creating an overhanging shelter which measures 4.5 meters north-south (wide) by 2.75 meters deep (east-west). The opening is oriented to the east. Two short sections of low wall have been constructed at the south end of the opening, effectively blocking a portion of the opening and simultaneously extending the habitable space at and around the shelter.

A few milled board fragments were observed within the immediate vicinity of the shelter, indicating contemporary use. Although no native cultural materials were observed on the surface, the wall may nevertheless represent Native construction and cultural materials may have accumulated within the dark brown soil located at and around the feature. [Jensen 1989:29]

Site 4079 - Short Wall Segments

Site 4079, located at the base of a limestone outcrop near the eastern edge of the project area [see Figure 14], consists of two short segments of wall constructed between natural rock outcrops, effectively completing a small U-shaped enclosure. One of the wall sections measures 2.9 m in length, is 0.75 m in width, and 0.80 m in height; the second wall is 3.8 m in length, 0.45 m in width, and 0.80 m in height. These features are probably historic in age and may relate to stock raising. No additional features, either prehistoric or historic, were observed in association or within the general vicinity. [Jensen 1989:29]

Site 4080 - Historic Trash Dump and Bottle Scatter

Site 4080 is located at the base of an exposed section of fossil sea bluff within the eastern portion of the project area [see Figure 14]. Dirt roads providing access to upland agricultural fields pass by the dump at two different locations and at distances which vary between 1 and 10 meters. The site extends roughly north-south along the base of the "cliff" for a distance of c. 50 meters, occupying the space (which varies from 15 to 25 meters in width) between the dirt road and the cliff face. Containing mostly seamed glass bottles with occasional milled boards fastened with wire nails, several bottle fragments with applied tops were also observed, indicating use at least as early as c. turn-of-the-century. Very recent use is also indicated, however, as "Vicks" "Vap-O-Rub" bottles, plastic items, and assorted metal objects, including at least one 4 ft by 8 ft sheet of galvanized tin roofing, were observed. The absence of explicitly household artifact types suggests that the dump was not created in conjunction with historic habitation. [Jensen 1989:29]

> ### Site 4081 - Overhang
>
> Site 4081, located near the extreme southeast corner of the project area [see Figure 14], consists of a single overhang shelter. The opening of the overhang measures 3 meters wide (parallel with the cliff face), and extends into the cliff a maximum of 1.75 m. A cobble and boulder wall has been constructed adjacent to the 3 meter-wide opening, leaving a narrow access opening at the south end of the feature.
>
> Potential prehistoric and/or historic use was indicated, not on the basis of habitation debris (midden or portable artifacts), but on the basis of the enclosing wall which indicated modification for use. [Jensen 1989:30]

1991

> ### Site 4085 - Rock Enclosure (Feature A) and Low Rubble, Partially Stacked Wall (Feature B)
>
> Site 4085 consists of a small rock enclosure and a partially stacked rock wall located within the eastern portion of the project area [see Figure 14]. Feature A rock enclosure is oval in plan view, measures approximately 3 meters in diameter (long axis), and was constructed by stacking limestone and basalt boulders and slabs from 1-2 courses wide and from 4 to 6 courses high. The perimeter length of the wall is 9.5 meters, which averages 0.35 m in width and 1.0 m in height. No portable artifacts or other features were observed in direct association, so that it is not possible to determine the feature's cultural affiliation. However, it seems likely that the feature was associated with late 19th or early 20th century sheep or cattle grazing operations within the project vicinity.
>
> Feature B is located approximately 23 meters to the north of Feature A, and consists of a bulldozer-pushed rock rubble wall, oriented approximately east-west, which measures 4.0 m in length, 2.4 m in width, and 0.6 m in height. At the east end of the “pushed” section of wall, and articulated with it, is a short section of stacked wall which extends the overall length of the wall by 1.6 m. This stacked section of wall is slightly less wide than the pushed section, ranging from 1.5-1.75 m, but is c. 0.75 m higher than the pushed portion. The stacked section of wall was clearly constructed subsequent to the bulldozed section, and is therefore not prehistoric or early historic. The stacked section appears to represent the need to establish a square corner, most likely for erecting a stock gate. No additional features or portable artifacts were observed in association with this pushed/stacked rock wall. [Jensen 1989:34-35]

As a result of the inventory survey, Jensen (1989) recommended Sites 4076 and 4078 for further data recovery, and Sites 4077, 4079, 4080, 4081, and 4085 for no further work.

Later that same year, Kennedy (1989) resurveyed and reevaluated the Punamano Project Area that had been previously inventoried by Jensen (1989). As a result of the Kennedy (1989) work two new sites and fourteen additional features were added to those already recorded by Jensen (1989). Both of these new sites (SIHP Sites 4706 and 4707) are located within the boundaries of Parcel 7. Site 4707 is located just outside of the current APE, and is clearly related to the many plantation features recorded within the current APE during the current study. Eleven of the newly recorded features are also located within the boundaries of the parcel, including seven new features at Site 4076, two new features at Site 4077, and two new features at Site 4078. Kennedy describes the two newly recorded sites and eleven additional features as follows:

> [**Site 4706**] (New ACH site) Enclosure complex. Two low stacked walls running parallel for approximately 30meters (NW-SE). Constructed of medium to large limestone blocks. Two small circular enclosures are located at either end consisting of a single course of medium limestone. A modified crevasse/ditch runs along the outer face of the northern wall. No surface artifact or midden observed.

[**Site 4707**] (New ACH site) 1937 irrigation ditch. Concrete and cobble lined irrigation ditch with date 1937 inscribed. Runs into modern ditch which follows Kalaeokahipa gulch through the property. [Kennedy 1989:10]

[**Site 4076**] New Features Found:

(B) Low stacked wall. Extends intermittently along length of ridge at top of coral escarpment for approximately 170 meters. Average width is 501cm., maximum height is 75cm. Constructed of medium sized rough limestone slabs 30-60cm. being the longest dimension. May have formed an enclosure in some places with parallel bedrock face on north.

(C) Overhang/shelter. Two overhang/shelters along south side of E-W ridge approximately 20meters below (south from) [4076] E. Sheltered area is 3-4meters in length x 2meters deep, with a maximum interior height of 1.5meters. Some kukui shells and other midden observed, along with a small quantity of “black glass” ca. 1880’s. Good excavation potential and a candidate for interpretive preservation along with the other features at Site [4076].

(D) Low stacked wall. 2.5meters length x 75cm. width x 50cm. average height. Wall structure partially closes off space between two reef blocks and may form an enclosure. Two small caves 1-2meters wide x 1meter deep are located on the interior (north) cliff face. No midden observed, however, some soil has accumulated within the enclosure and should be tested.

(E) Low stacked wall. 3.0meters length x 50cm. width, average height is 1.0meters. Forms semi-rectangular enclosure along top of ridge line.

(F) Low stacked wall. 5meters length N-S x 75cm. width x 1.30meters average height. Well constructed of flat limestone slabs 30-60cm. in diameter. Closes off a space between two coral outcrops.

(G) Overhang/shelter. Two overhangs running approximately 8meters E-W along cliff face, 1-2meters deep and average 1.5meters interior height. Numerous glass fragments ca. 1900-1920. No obvious surface midden but some soil accumulation

(H) Overhang/shelter. Two overhangs l0meters total length x 1.75meters deep and average 1.5meters interior height. No surface midden but some charcoal stains mixed with accumulated soil. [Kennedy 1989:9]

[**Site 4077**] New Features found:

(B) Wall/terrace. Approximately 1meter long, of similar size and construction as feature A to the north. It served a similar function, leveling a path or narrow terrace running 8meters SE-NW, 1.5meters average width.

(C) Auwai/modified crevasse. Modified crevasse running roughly E-W for 18meters along top of ridge 5-10meters upslope from terrace walls A and B. Channel width averages 50cm. with rocks from inside stacked on some edges along the course. Terminates on west with bulldozer push and on the east it approaches the terrace from above. [Kennedy 1989:10]

[**Site 4078**] New Features found:

(B) Low stacked wall. 30meters NW of feature A, low stacked wall of medium size flat limestone blocks 5meters length x 50cm. width x 1meter height. Closes off area between two cliffs.

> (C) Low stacked wall. Approximately 50meters SE of feature A is a second wall closing off a passage between two cliff faces and forming a trail boundary ascending the slope. structure is 4meters length x 75cm. width x 1meter height. [Kennedy 1989:10]

For the purposes of the Kennedy (1989) study, the boundaries of the Punamano Project Area were modified, in part, to exclude four sites located along the eastern edge of the current subject parcel that were previously recorded by Jensen (1989) (Sites 4079, 4080, 4081, and 4085). This excluded area also contained eight features that were not previously recorded by Jensen (1989). Kennedy (1989) does not offer detailed descriptions of these previously unrecorded features, but lists them in table form. The features were also not assigned SIHP site numbers, but were given only ACH temporary site numbers. Kennedy briefly described these eight features as follows: "S-8 — Habitation/Burial Complex; S-8 (A) — Rock-filled crevasse; S-8 (B) — Rock-filled crevasse; S-8 (C) — C-shape; S-8 (D) — 2 Low stacked walls; S-8 (E) — Overhang/shelter; S-12 — Overhang/shelter; and S-13 — Terrace alignment" (1989:12). The excluded sites were all located along cliff faces that were not to be graded during the proposed development of the golf course. Kennedy (1989:15) noted that, "since important sites identified within the former project area…are now just outside the boundary below the top of the cliffs, care must be taken that no construction debris is pushed over the edge as damage to these sites would be likely to occur as a result".

Stride et al. (2003) conducted an archaeological inventory survey for a proposed 785-acre Kahuku Agricultural Park located to the east/southeast of the study area. Although Stride et al. (2003) did not list the current study parcels (TMK:1-5-6-05:007 and 014) as part of their project area, their site location map clearly indicates that six of the recorded sites (Sites 4510, 4511, 4512, 4513, 4514, and 4515) are located within Parcel 007. It is possible that either, (1) the current TMK parcel did not exist at that time, or that (2) the fieldworkers, during the 1992 fieldwork, inadvertently surveyed an area west of the boundary of their project area and mistakenly recorded these sites as being on Parcel 009. Stride et al. (2003) also consistently refer to ʻŌhiʻaʻai Gulch as Ohia Gulch in the site descriptions. Stride et al. (2003) describe the six sites as follows:

> | | |
> |---|---|
> | **State Site #:** | 50-80-02-4510 |
> | **Site Type:** | Overhang Shelters |
> | **Function:** | Temporary Habitation |
> | **Total Features:** | 2 |
> | **Dimensions:** | 84 m^2 |
> | **Location:** | Ohia Gulch |
>
> **Description:** State Site 50-80-02-4510 [Figure 16] is comprised of two rock overhangs (Features A & B) in a coral/limestone cliff and they lie between a large break in the cliff wall. These overhang shelters are located at the northwest end of Ohia Gulch overlooking the flood plain. Both Features A and B are open to the east and contain a small litter of kukui nut and water-rounded stones. Surrounding Feature A is a leveled soil area. Feature B also has a small leveled soil area exterior to the shelter. The surrounding vegetation consists of Christmas *Macaranga* trees. Farther downslope toward the flood plain is tall California grass, Christmasberry, *koa haole*, and more *Macaranga* trees.
>
> Located directly below Feature B are remnants of a cement irrigation ditch associated with sugarcane and pineapple cultivation. The irrigation ditch appears to have run along the ridge of Ohia Gulch and a flume was constructed over Feature B and down into the flood plain.
>
> Feature A consists of a rock overhang. The entrance measures 1.2 m. wide by 1.2 m. high and the shelter is 1.8 m. deep. The interior consists of fairly level soil with loose cobbles on the surface. The level soil area exterior to Feature A measures 14 m. N/S by 5.5 m. E/S and there are fragments of kukui nut scattered about the level soil terrace.

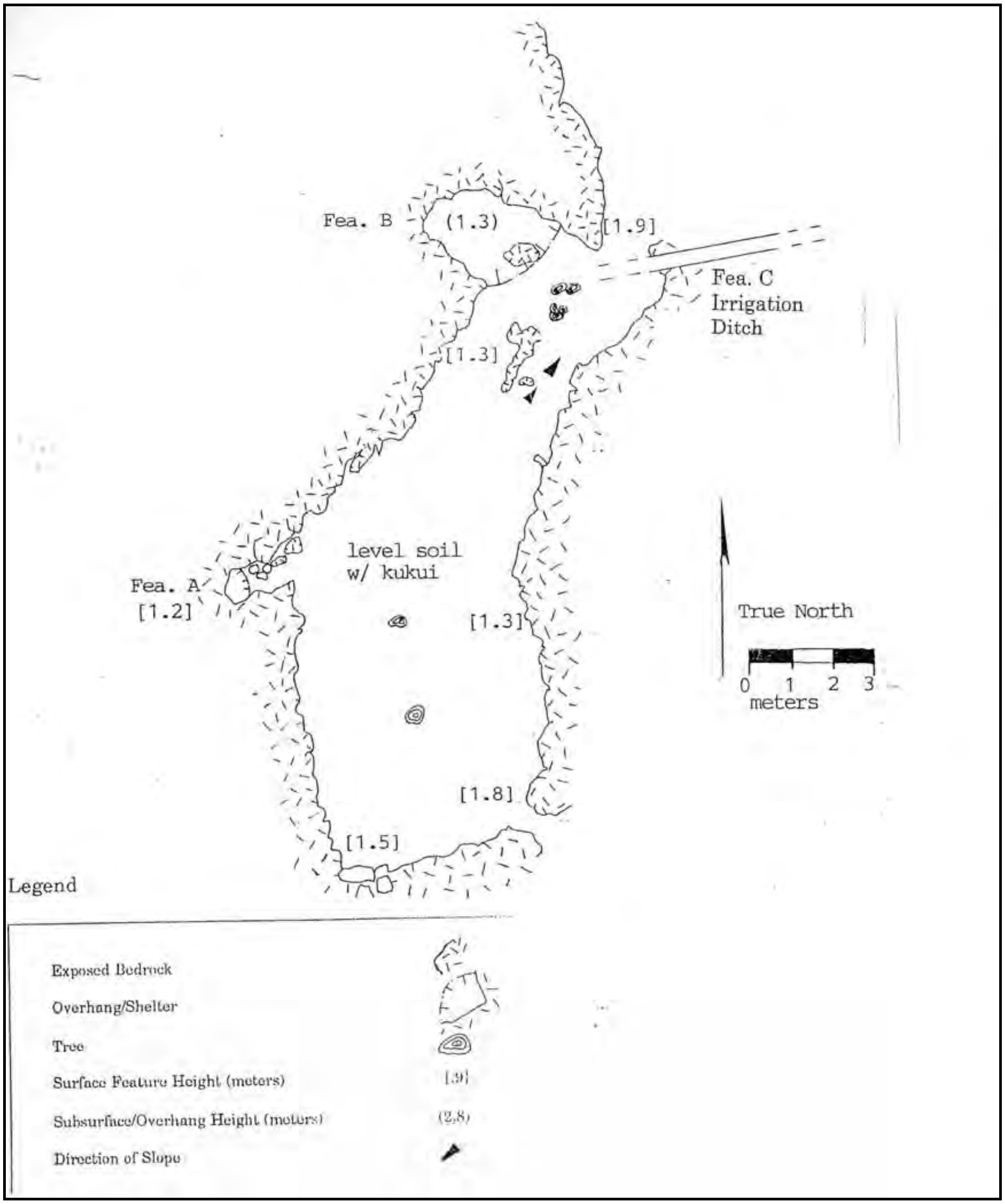


Figure 16. Plan view of Site 4510 (from Stride et al. 2003:32).

Feature B consists of an overhang shelter located approximately 5 meters to the northeast of Feature A along the same limestone cliff. The entrance measures 2.4 m. wide by 1.5 m. high and the overhang is 2.4 m. deep. Midden and modern pieces of wood and nails were also observed on the interior surface. The level soil area outside this feature measures 2. 7m. N/S by 3 m. E/S. No midden or artifacts were observed in this area.

Both Features A and B have fair excavation potential because of there are soil areas which could contain midden and artifacts, and because of the evidence of surface midden. The soil depth is estimated to be 50 cm. These features are both temporary habitation shelters.

The irrigation ditch (Feature C; [see Figure 16]), located directly below Feature B, is one of many ditches evident throughout the project area. A cement dam structure, also located below Feature B, within the flood plain channels water to other irrigation ditches. The dam structure is the only remaining intact section. Most of the cement ditches throughout the project area have been destroyed by bulldozing or natural weathering. [Stride et al. 2003:31, 33]

State Site #:	50-80-02-4511
Site Type:	Overhang Shelters
Function:	Temporary Habitation Shelters
Total Features:	2
Dimensions:	600 m^2
Location:	Ohia Gulch

Description: Site 50-80-02-4511 (CSH 2) [Figure 17] consists of two overhang shelters located *mauka* of 50-80-02-4510 (CSH 1) on the west side of Ohia Gulch along the limestone cliffs. The total area of this site is 40 meters N/S by 15 meters E/W. Both overhangs open to the east. The coral/limestone cliffs overhangs are modified to create a shelter. The vegetation in this area is *koa haole*, Christmas berry, California grass, and a Banyan tree.

Feature A consists of an overhang shelter measuring 16 m. wide (E/W) by 7 meters deep (N/S) with a maximum ceiling height of 2.9 meters. The surface is a sloping soil surface fairly rock free. The surface area is compact silty soil with scattered midden consisting of kukui nut shells and marine shell midden. No artifacts were observed.

A large boulder pile is located between Feature A and B along the same limestone cliff. The boulder pile measures 14 meters E/W by 9 meters N/S. This may have been a structure at one time but is presently heavily disturbed by the growth of a large banyan tree and possibly from bulldozer push from the ridge above.

Feature B consists of an overhang shelter located 13 meters to the west of Feature A. This features measures 9 meters wide (E/W) by 5 meters deep (N/S) and has a maximum ceiling height of 2 meters at the entrance. The interior of this shelter consists of fairly level soil surface with goat bones scattered about. Midden, including kukui nut and marine shell, was also observed on the interior surface of the interior of this shelter. At the northeast end of this shelter is small boulder alignment, approximately 2 meters long, oriented in a N/S direction. A metal site tag marker was observed at the entrance to this feature (ACH 5/2A; Coral Res. 10-16-90).

Both features remain in fair condition and have good excavation potential due to the thickness of the soil deposit and evidence of cultural material scattered about the interior surface of this shelter. The estimated soil depth for these shelters is 70 cm. [Stride et al. 2003:33, 35]

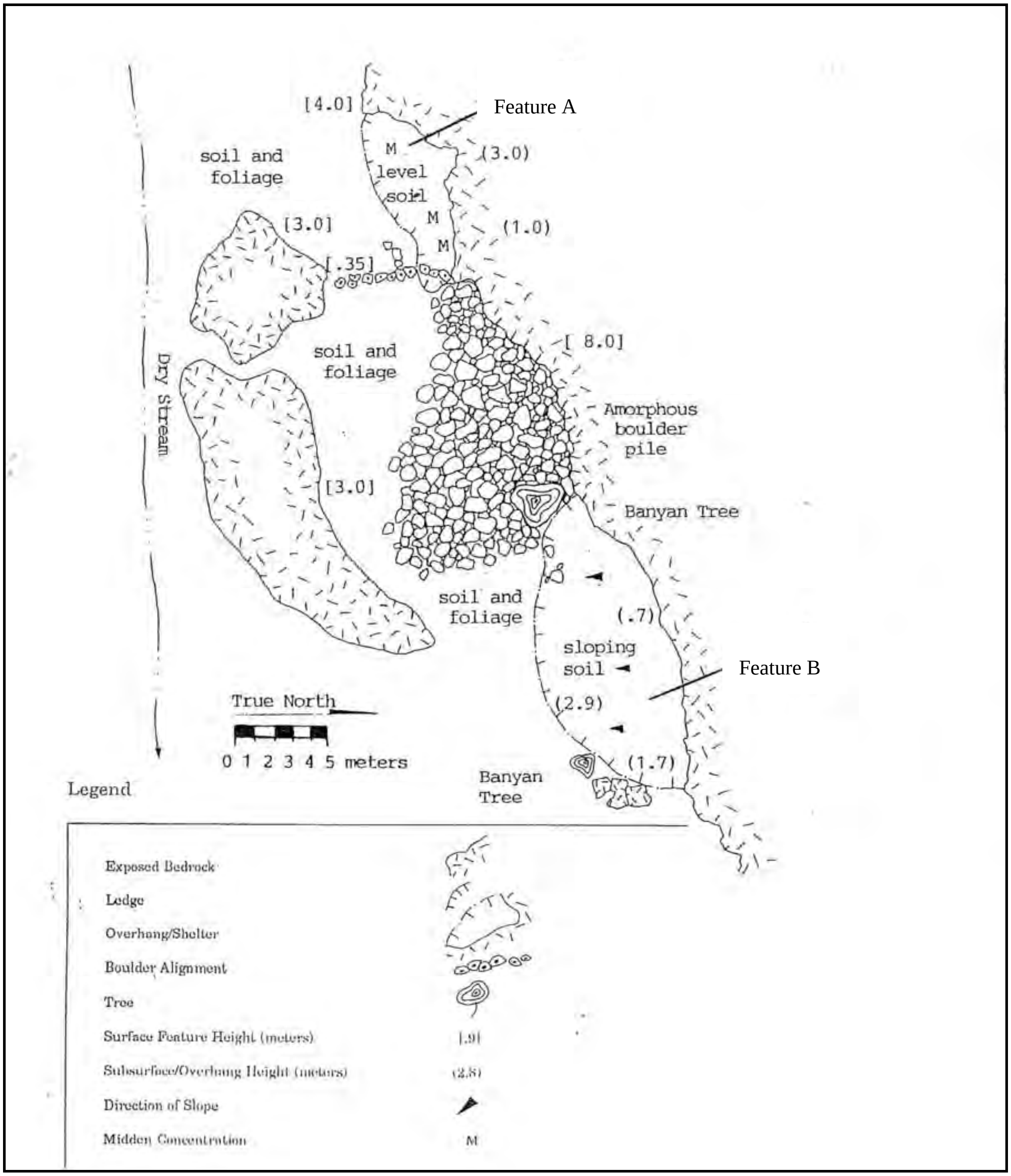


Figure 17. Plan view of Site 4511 (from Stride et al. 2003:34).

State Site #: 50-80-02-4512
Site Type: Enclosure
Function: Temporary Habitation Shelter
Total Features: 1
Dimensions: 13.1 m. N/S by 3 m. E/W
Location: Ohia Gulch

Description: State Site 50-80-02-4512 (CSH 3) [Figure 18] consists of an enclosure located *mauka* of site 50-80-02-4511 (CSH 2) on the west side of Ohia Gulch along the upper edges of the limestone cliffs. This site measures 13.1 meters N/S by 3 m. E/W and is constructed of stacked small to medium limestone boulders utilizing the natural walls of the surrounding limestone bluff to form an enclosure. The walls range from 30 cm high to 1.2 meters high, and average 75 cm thick. The naturally formed walls range from 2.5 meters to 3.5 meters high. The enclosure interior consists of a thin level soil with grass and shrub. The surrounding vegetation is *koa haole*, California grass, and banyan trees. No midden or indigenous artifacts were observed at this feature, although historic bottles, a sewing machine, and rusted pots and pans were observed directly to the east of this enclosure.

This feature has poor archaeological excavation potential because of its shallow soil deposit and absence of any visible "prehistoric" cultural material. [Stride et al. 2003:35]

State Site #: 50-80-02-4513
Site Type: Wall Segments/terraces/Enclosure/Overhang
Function: Permanent Habitation
Total Features: 5
Dimensions: 28 m. NE/SW by 12 m. NW/SE
Location: Ohia Gulch
Testing: 1 m^2

Description: State Site 50-80-02-4513 [Figure 19] complex consists of five designated features, A - E located on the west side of Ohia Gulch along the limestone cliffs in fairly level area. The total site measures 28 m. NE/SW by 12 m. NW/SE. These features are located on a large limestone outcrop sloping down toward an intermittent stream. The surrounding vegetation consists of banyan and *koa haole*.

Feature A consists of a wall segment 8 meters long, oriented generally in a NE/SW direction, averaging 1. 75 meters thick and 60 - 80 cm. high. This wall is constructed of stacked limestone boulders and slabs. Both the NE and SW ends of the wall abut a limestone outcrop. No surface midden or artifacts were observed at this feature. Although this wall remains in fair condition the excavation potential is poor for producing additional information.

Feature B consists of a cobble-paved terrace located directly to the south of Feature A. The entire terrace and paved area measures 9 m. NE/SW by 5 m. NW/SE. Approximately 5 m. of facing is visible with the paved area extending to the base of Feature A and to the west toward Feature C. The terrace is constructed of layered limestone slabs and cobble. The southern end of the terrace abuts a natural limestone outcropping approximately 1 meter high which acts to semi-enclose the area. At the northern end of the terrace is a collapsed wall. No midden or artifacts were observed at this terrace. The feature remains in fair condition and has fair excavation potential.

Trench 1 was excavated at Site 50-80-02-4513 Feature B terrace. A one-meter square test unit was excavated in the central portion of the terrace.

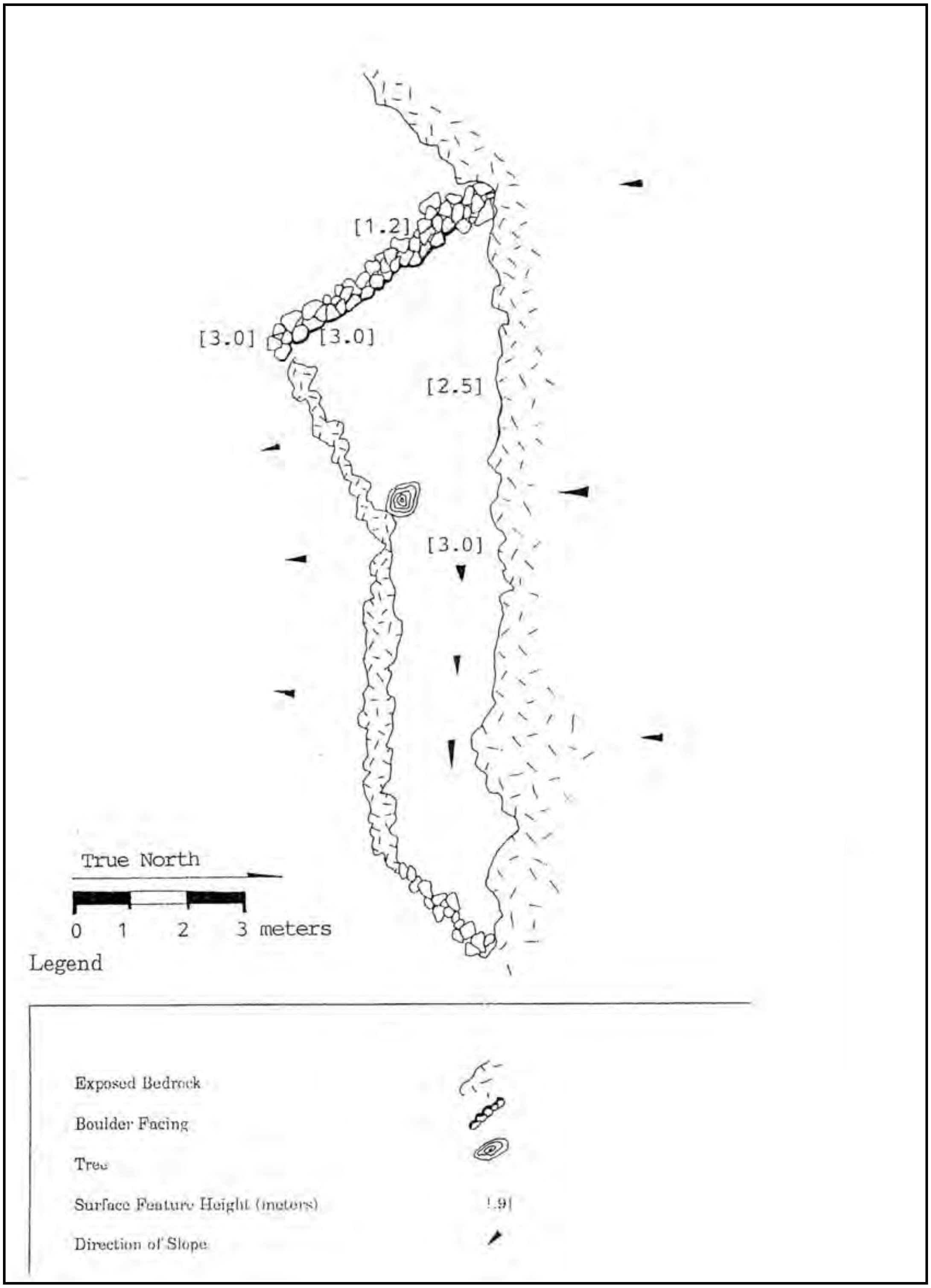


Figure 18. Plan view of Site 4512 (from Stride et al. 2003:36).

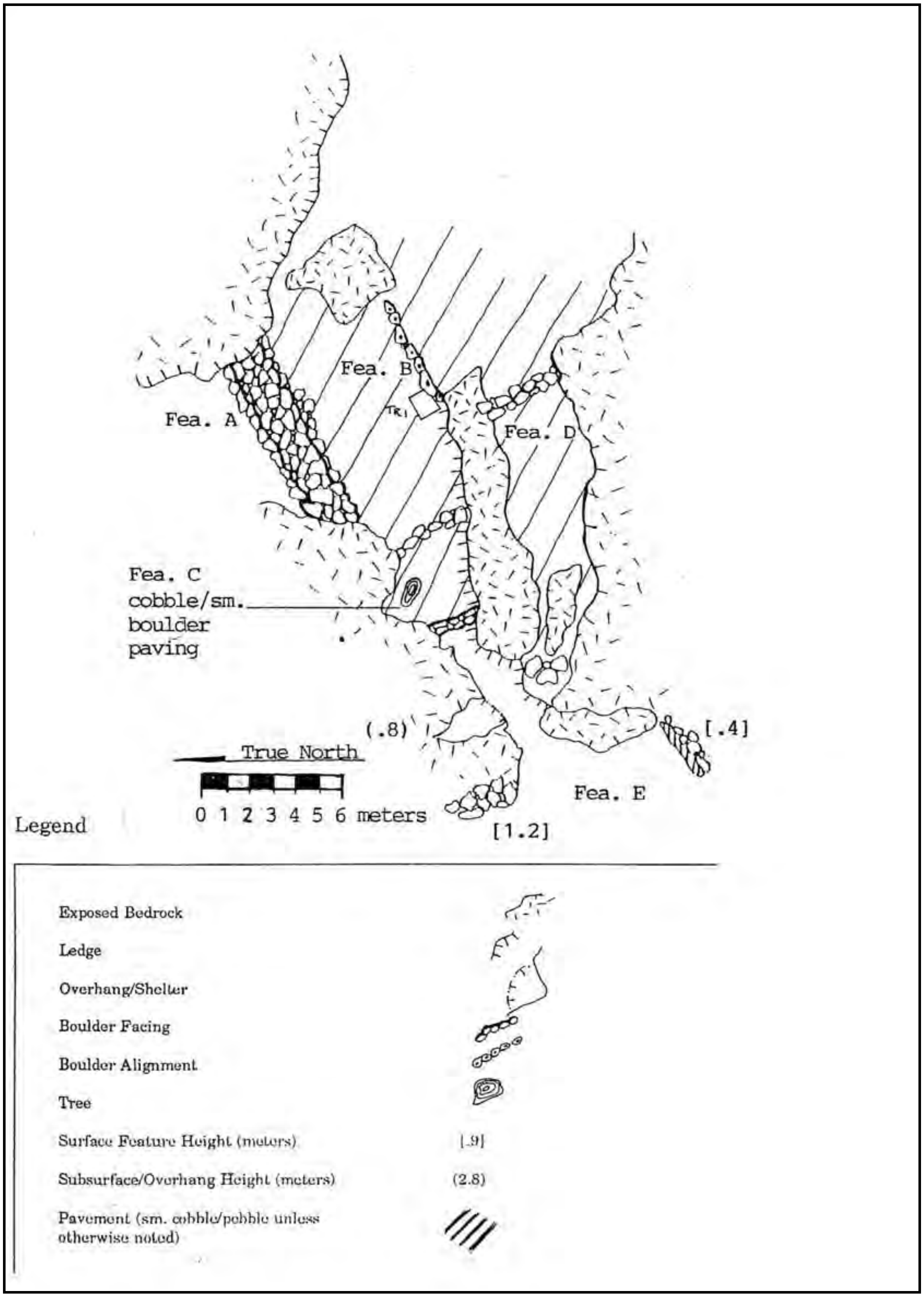


Figure 19. Plan view of Site 4513 (from Stride et al. 2003:38).

The excavation of Trench 1 revealed two stratigraphic units [Figure 20]. Stratum I, 0- 74/76 cmbs, consisted of mostly limestone cobbles and slabs with a filtered A-horizon, fine to medium crumb (5YR2.5/1 Black) soil. Stratum II, 70 - 80 cm., was a slightly compact cobbly dark reddish brown (5YR2.5/3), medium to coarse soil containing many limestone cobbles. This layer directly overlies bedrock.

Although no cultural material was collected from the excavation of Trench 1, this feature has been designated as part of a permanent habitation complex because of its size, construction, and its location to other features.

Feature C consists of a V-shaped enclosure located to the west of Feature B. This feature is open to the east and has a raised, paved interior. The back walls of this enclosure (south side) utilize the natural limestone outcropping to form the enclosure. These natural walls average 2 m. high also. The interior of this feature is a raised level paving approximately 40 cm. high. It is paved with small limestone cobbles and slabs. The interior measures 4 m. E/W by 3 m. N/S. No midden or artifacts were observed on the surface of this feature. A metal site tag marker was found on the back wall (ACH Temp #S1b, Coral Res, 10-16-90).

This feature remains in fair condition and has fair to good excavation potential.

Feature D consists of a limestone cobble-paved terrace located south of Features B and C. This terrace and paved area measure 7 m. E/W by 3.5 m. N/S. The relative flatness of this feature provides an open space. The only remaining facing of this terrace is visible on the south end of the terrace and utilizes a natural outcropping of limestone.

No midden or artifacts were observed on the surface of this feature. This feature remains in fair condition and the excavation potential is fair.

Feature E consists of an overhang shelter and two small rock alignments located 12 m. south of Feature A. The overhang shelter measures 3 m. wide at the entrance, 6.5 m. deep and 80 cm. high. The interior consists of shallow level soil with scattered goat bones about the surface. On the overhang is a silver tag which reads ACH L Temp S-K Coral Reserve 10/16/90. Approximately 3.5 m. southeast of the overhang is small rock alignment with upright slabs. This alignment measures 3 m. long, (oriented roughly NE/SW), is 50 cm. thick and 40 cm. high. Located 3 m. to the east of the overhang is another alignment constructed of small limestone boulders and cobbles. This alignment measures approximately 2.5 m. long (oriented roughly N/S), and is 50 cm. thick and 1.2 m. high. No midden or artifacts were observed.

This feature remains in fair condition. The overhang shelter has fair to poor excavation potential because of the shallow soil deposit. [Stride et al. 2003:35, 37]

State Site #:	50-80-02-4514
Site Type:	Terrace
Function:	Temporary Habitation
Total Features:	1
Dimensions:	1.5 m^2
Location:	Ohia Gulch

Description: Site 50-80-02-4514 consists of a single terrace located directly downslope of Site 4 near the dry streambed. This terrace measures 3 meters roughly N/S, 50 cm. wide, and approximately 75 cm. high. This terrace is constructed of small to medium size limestone boulders and slabs. This terrace retains a level soil area, and is fairly rock free. No midden or artifacts were observed at this site. This feature has fair excavation potential because of its possible thick soil deposit. It is thought to be a temporary habitation feature. [Stride et al. 2003:40]

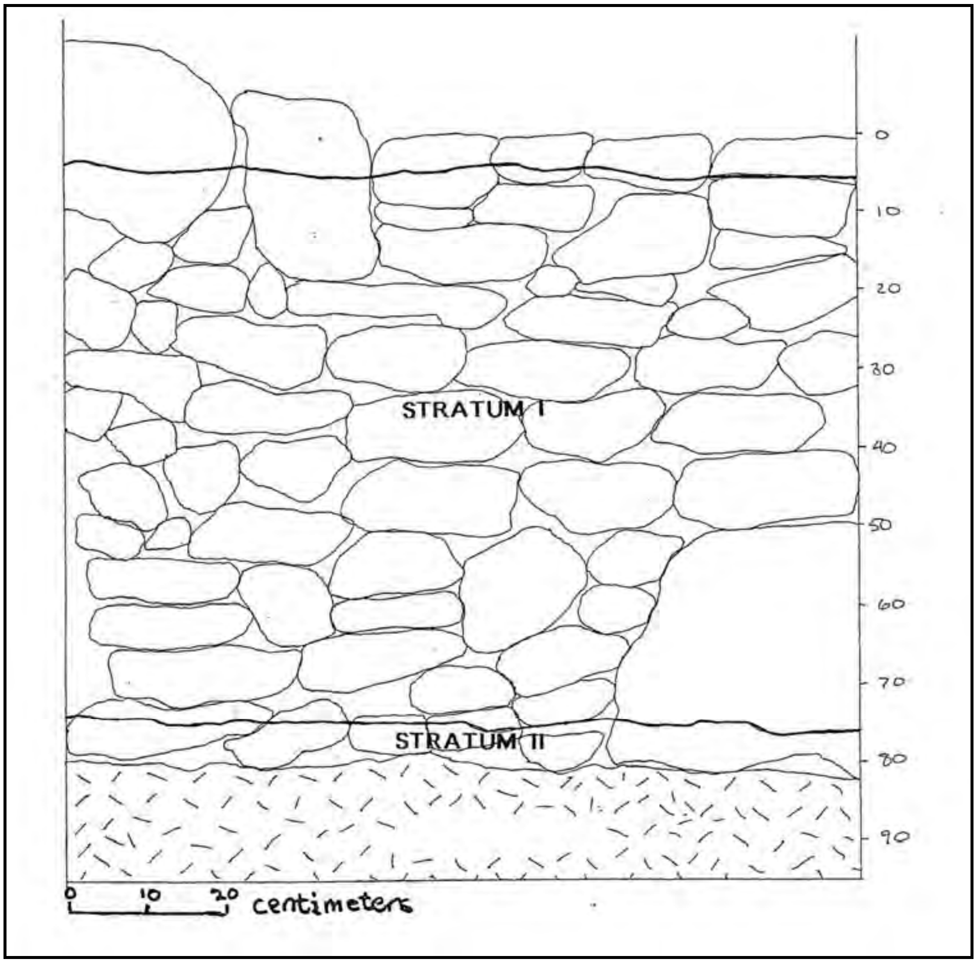


Figure 20. Site 4513, Feature B, Trench 1 west face profile (from Stride et al. 2003:39).

State Site #:	50-80-02-4515
Site Type:	Overhang Shelters
Function:	Temporary Habitation
Total Features:	2
Dimensions:	14 m. N/S by 10 m. E/W
Location:	Ohia Gulch
Testing:	1 m^2

Description: Site 50-80-02-4515 (CSH 6) [Figure 21] consists of two overhang shelters designated as Features A and B. This site is located at the base of a large limestone bluff southeast of CSH site 4. The surrounding vegetation consists of *koa haole,* Christmas berry, California grass and Banyan trees.

Feature A, the southern-most shelter, measures 5 m. wide (E/W) by 4 m. deep and is approximately 2 m. high. The soil floor interior is level and contains a few scattered boulders and cobbles as well as a small scatter of midden, including kukui nut and small mammal bones (goat). This feature is in good condition and has good excavation potential. The estimated soil depth is 60 cm. minimum

Feature B is another overhang shelter located north of Feature A. This shelter measures 4 m. wide (NE/SW) by 1 m. deep and 1.4 m. high. The interior of this shelter consists of rocky soil with a scatter of goat bones. This feature was selected for testing because of its good condition.

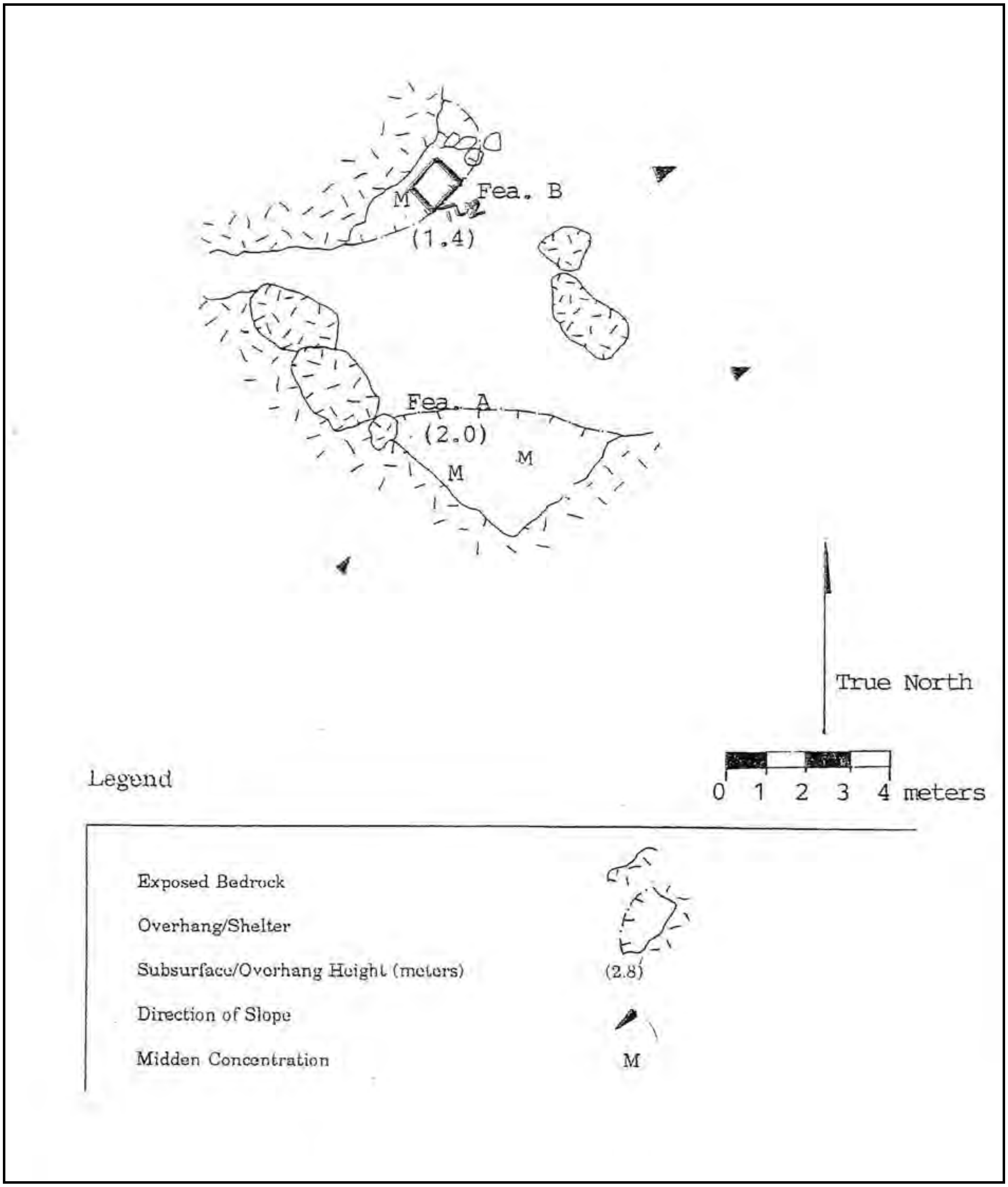


Figure 21. Plan view of Site 4515 (from Stride et al. 2003:41).

Trench 2, a 1m^2 test unit was excavated at State Site 50-80-02-4515 Feature B, an overhang shelter, in the soil floor interior in the southeast portion. A human burial was found during the excavation of this unit.

The excavation of Trench 2 revealed three stratigraphic units, Strata I, II, and III [Figure 22]. Stratum I, 0-20/30 cm., was a loose dark brown, fine to medium sub angular A - horizon (5YR 3/2) soil. Also incorporated in this stratum are small to medium size limestone cobbles. Stratum II, 20/30-40 cm., was a light brown, fine to medium crumb silt (5YR 4/2 Brown/dark brown) soil. This stratum incorporated larger boulders extending down into the Stratum III. During the removal of the sterile Stratum III layer, a pit of loosely compacted Stratum II soil was observed in the western half of the trench. This fill formed a burial pit within the Stratum III layer. The burial pit originates from the base of Stratum II and intrudes into Stratum III, thus the burial postdates Stratum III. Stratum III, 40-70 cm., was a very gravelly compact yellow brown (5YR 6/6 Reddish yellow) soil. This stratum, other than the intrusive burial pit, was sterile with evidence of decomposing bedrock.

Cultural Material

Cultural material was collected from Strata I and II, and from the interface between II and III during the excavation of Trench 2. Cultural material collected includes both midden and artifacts, and also charcoal samples to be analyzed and carbon dated.

Midden was collected from Strata I and II and from the interface between II and III. Stratum I produced a total of 92.6 grams of marine invertebrate, 5.6 grams of unsorted animal bones, 114.2 grams of kukui nut, and 491 grams of charcoal. Stratum II produced a total of 218.9 grams of marine invertebrate, 22.7 grams of unsorted bones, 82.7 grams of kukui nut, and 9.3 grams of charcoal. Midden was also collected from the boundary between the Stratum II and Stratum III. Stratum II is contemporaneous with the occupation of this feature.

Artifacts were collected from the Strata I and II only. Artifacts collected from Stratum I included one shell bead, 35 volcanic glass flakes, one basalt adze flake, and some gourd fragments. Artifacts collected from Stratum II included one *he'e* (octopus) lure sinker (basalt), and 40 volcanic glass flakes. No historic artifacts were found during the, excavation of Trench 2. No artifacts were found below Stratum II.

Human Burial

During the excavation of Trench 2 a human burial was discovered at 40 cm., in a pit originating in Stratum II. The burial was located in the west face of the trench in a clearly visible pit, flexed and articulated with the skull oriented to the west, and the skeleton placed on its right side. One associated artifact was observed with the burial, a stick, 65 cm. long and 2 cm. in diameter, worked on both ends. This stick was found on the top of the burial. Judging by the length of the long bones and the size of the skull, the burial appears to be a juvenile. The burial was recorded and the trench was backfilled to prevent any further disturbance.

Radio Carbon Sample

A charcoal sample was collected from the base of the burial pit. This sample originated as part of the burial fill from Stratum II as the pit was prepared in the otherwise sterile Stratum III layer. Therefore the charcoal sample would have been either contemporaneous with the burial or would have predated it. The radiocarbon date reveals that this site was probably utilized during "prehistoric" times. This feature has been interpreted as a temporary habitation shelter. [Stride et al. 1989:40, 43]

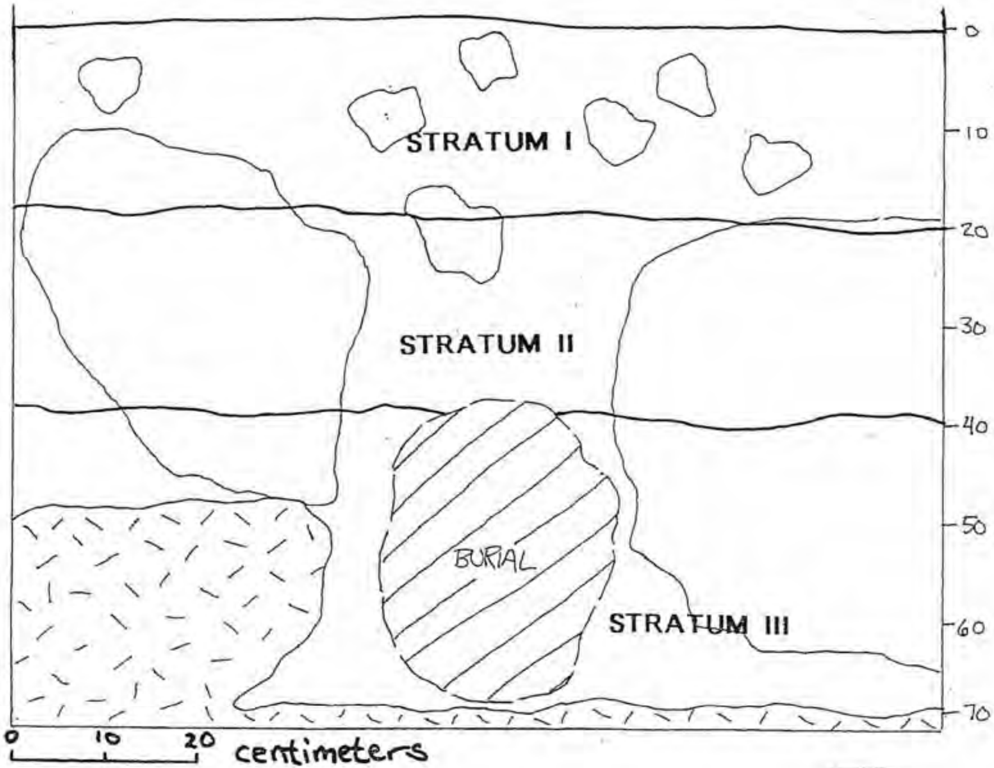


Figure 22. Site 4515, Feature B, Trench 2 west face profile (from Stride et al. 2003:42).

ARCHAEOLOGICAL EXPECTATIONS FOR THE APE

There were no sites recorded within the current APE as a result of the previous archaeological surveys that included portions of the current APE. However, a recent informal reconnaissance revealed the presence of an extensive network of irrigation features associated with former sugarcane cultivation, and the Kennedy (1989) study documented one such feature (Site 4707) just outside the current APE. The historical record indicates that by 1935 irrigated sugarcane fields covered nearly all of the study area, which also contained an artesian well and a several acre reservoir (see Figure 12). Given this extensive and intensive use, it is likely that any earlier archaeological features were significantly impacted if not completely destroyed. It is the current expectation that within the defined APE, Historic Period features related to plantation cultivation and possible military activity will make up the majority of the archaeological features observed. It is possible, however only remotely so, that Precontact resources have survived in spite of the more recent land use activities. Given the findings of the previous archaeological studies in areas just outside of the current APE, such resources could include burials, habitations, and agricultural features.

FIELDWORK

Fieldwork for the current project was conducted on August 20-24, 2007, September 11-14, 2007, and July 7-10, 2009 by Matthew R. Clark, B.A., Christopher S. Hand, B.A., Olivier M. Bautista, B.A., Ashton K. Dircks, B.A., Johnny R. Dudoit, B.A., and Jenna K. Matthews, B.A. under the supervision of Robert B. Rechtman, Ph.D.

Identifying Possible Historic Properties

The APE boundaries were identified in the field through the use of GPS. The study area was subject to pedestrian transects with spacing intervals ranging from 10 meters 30 meters based on vegetation and topography. When archaeological resources (or land alterations; e.g. bulldozing, fence lines, etc.) were encountered, they were plotted on a map using Garmin 76s handheld GPS technology (set to the WGS 84 datum), and mapped, photographed, and described. An attempt was also made to inspect those sites previously recorded outside of the APE but within the overall subject property to verify their locations relative to the current study area boundary.

In addition to the archaeological fieldwork, archival cartographic material relative to the plantation infrastructure was obtained and correlated with the field findings. Also, there was significant consultation with individuals and organizations knowledgeable about the area and past land use practices conducted therein. Beginning in the spring of 2006, First Wind established a dialogue with community members with respect to the current planned project. Consulted organizations have included the Koʻolauloa Neighborhood Board, the Boards of the Kahuku Village Association and the Kahuku Community Association, Kahuku Elderly Housing, and the Laie Community Association. First Wind has also been in discussions with community representatives for the Turtle Bay resort. In addition, First Wind is actively working with the administration and teachers at Kahuku High & Intermediate Schools and has presented information about the wind farm to a number of classes ranging from Hawaiian immersion to physical science. It was during the numerous consultation meetings and presentations that several individuals, including Ms. Dawn Wasson, highlighted the rich history of the coral bluffs located on and near the current study property. In response to the community concerns, First Wind has committed to preservation of the coral bluff areas as well as to the documentation of the *moʻolelo* concerning these areas.

Findings

As a result of the current study one site was recorded within the APE. This site, SIHP Site 4707 (retaining a site designation for a seemingly related feature that exist just outside of the current APE), incorporates the extensive plantation infrastructure (primarily an irrigation network, Figure 23) that a review of historical archival data indicates dates from the late nineteenth to the middle twentieth century. Kennedy (1989) first assigned Site 4707 to a concrete and cobble irrigation ditch with the inscription “1937” in a concrete portion of the ditch. This feature is part of the extensive irrigation network that is found within the current APE and thus a decision was made to retain the SIHP Site 4707 designation for all of the Kahuku Plantation infrastructural elements as they are functionally interrelated.

SIHP Site 4707

Site 4707 is the designation for the sugarcane field infrastructure that still remains within Kahuku. This infrastructure was developed by the Kahuku Sugar Plantation between 1890 and 1971. It is widespread within the current APE and beyond. What remains of the infrastructure within the APE is largely related to the irrigation of the cane fields and the transportation of the harvested cane from the fields to the mill. Specific features observed include flumes, ditches, pipes, reservoirs, wells, pumps and pump houses, markers, roads, and bridges.

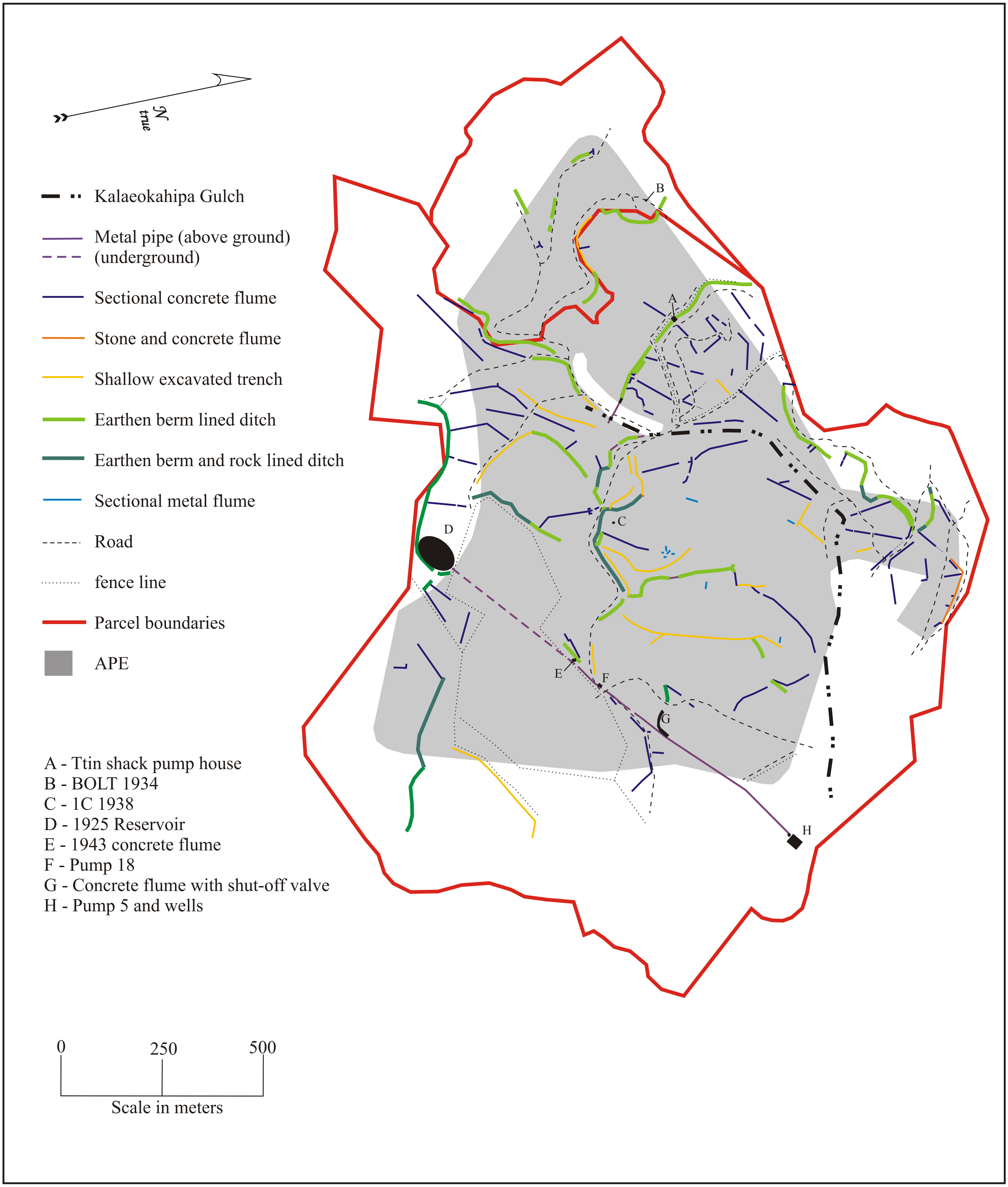


Figure 23. SIHP Site 4707 plan view.

The project area falls within the Pump 5 Section of the former Kahuku Plantation Company's fields (see Figure 12). With the exception of a few small areas of wasteland, the entire APE was once planted in sugarcane. The APE consists of portions of former Fields 9, 10, and 16. These fields were segmented into smaller field units ranging between roughly 0.5 and 14 acres in size. Each of the smaller field units was bounded by irrigation ditches. The 1935 map of the Kahuku Plantation Company lands shows this system of irrigation ditches and the acreage of each of the small fields they bounded (see Figure 12). In addition to the ditches, the 1935 map also shows two reservoirs and Pump 18 within the APE. Pump 18 is shown along a pipeline that ran between Pump 5 (*makai* of the APE) and one of the reservoirs.

Although impacted by modern land disturbance, vegetation, and erosion, much of the sugarcane irrigation infrastructure is still present within the APE (see Figure 23). The system of irrigation ditches that remains today closely resembles the 1935 configuration of ditches. One of the two reservoirs and Pump 18 were relocated within the APE, and several additional irrigation features, added to the fields during the late 1930s and early 1940s, were also discovered. Though extensive, with miles of ditches that provided water to roughly 230 acres of fields within the APE, the network of irrigation features functioned fairly simply. The system relied on groundwater that was pumped up hill from Pump 5 through a large diameter metal pipe (labeled aqueduct on the 1983 U.S.G.S. Kahuku quadrangle; see Figure 1) to Pump 18, and then up to a reservoir located near the *mauka* boundary of the APE. From the reservoir water was gravity fed into a system of earthen and stone embanked ditches that gradually carried it down slope to the fields. At each field, a network of smaller earthen ditches, concrete flumes, and/or metal flumes was present that carried the water from the larger ditches to the rows of sugarcane. Water was directed through the irrigation system by opening and closing a series of sluice gates. Excess water and storm runoff was directed to Kalaeokahipa Gulch, and other smaller natural drainages that fed into it, where it ran toward the ocean and filtered back into the aquifer.

A number of different types of irrigation ditches and flumes are present within the APE including earthen berm lined ditches, earthen berm and stone lined ditches, stone lined trenches, excavated shallow earthen ditches, stone and concrete flumes, concrete flumes and ditches, sectional concrete flumes, and sectional metal flumes. As discussed above, the berm lined ditches are the main irrigation channels. These ditches generally run cross-slope, following the upper edges of steeper slope planes within the APE. As the ditches progress they gradually meander down slope to ensure that the water flows steadily in the desired direction. The route of each ditch is dictated by the topography of the slope edge that it follows. All of the ditches are excavated into the natural slope of the terrain, and the soil material removed from the water channel is piled along the downslope edge so that the upslope ditch edge is formed by the natural slope, and the downslope ditch edge is formed by bermed soil material (Figure 24). At bends, especially in steeply sloped areas, the interior downslope berm edges are lined with stacked stones to help prevent erosion (Figure 25).

The other types of flumes and ditches run off of the main irrigation ditches. At numerous locations along the route of each of the berm lined ditches, breaks are present in the downslope bermed edge that were used to direct water flow into the field areas. Typically the breaks in the bermed edges spill into stone lined trenches. Many of the stone lined trenches contain upright concrete panels with channeled edges that once held wooden sluice gates in place (Figure 26). Several of the concrete panels contain the inscription "K P" (Kahuku Platation?) on one side of the former gate and "No. 4" on the other side. Where the stone lined trenches diverge from the berm lined ditches they run for short distances, generally in several directions. The stone lined ditches usually flow into shallow excavated ditches, sectional concrete flumes, or sectional metal flumes that carried water to the rows of planted sugarcane.

Figure 24. A typical soil berm lined ditch.

Figure 25. The typical stacked stone interior edge of an earthen berm lined ditch.

Figure 26. Sectional concrete flume.

The excavated ditches are all shallow channels in the earthen ground surface that run down slope. They are typically no more than 50 centimeters wide by 20 centimeters deep. The ditches may have been deeper when operational, but have filled in with sediment over time. These and the sectional concrete flumes are the most prevalent irrigation features within the APE. The sectional concrete flumes consist of mass produced, square sided, U-shaped, concrete channels (commonly referred to as Waialua Flumes) that were placed end to end in a line to carry water in a downslope direction (see Figure 26). Two different sectional types placed alternately were used to create these flumes (Figure 27). Type 1 is simply a concrete channel that measures 0.91 meters long by 0.27 meters wide by 0.215 meters tall, and Type 2 is a concrete channel with an outflow opening along either edge. The Type 2 concrete flume measures 1.22 meters long by 0.27 to 0.4 meters wide by 0.215 meters tall. The outflow openings measure 0.14 meters tall by 0.09 meters wide and they are blocked by a thin sheet of metal that could be pulled up to allow for water flow into the fields at a desired location (Figure 28). The concrete fume sections are held together and made water tight with a black tarlike material. The sectional metal flumes are the least prevalent within the project area, and it appears that many of the sections may have been removed from the APE after the Kahuku Plantation shut its doors in 1971. These sections are of modern origins, and were likely the last added to the fields. Each section is a shallow aluminum trough containing a rubber gasketed outflow opening at its base (Figure 29).

One other type of flume, limited to a couple of isolated locations within the APE is constructed of stone and concrete. This type of flume measures 1 to 1.25 meters wide and stands 0.5 meters tall (Figures 30 and 31). It consists of two perpendicular alignments of stacked stones, 50 centimeters distant from one another, which support a concrete lined channel, 0.5 meters wide by 0.5 meters tall, between them (see Figure 27). The sectional concrete flumes branch off of this type of flume, suggesting that it may have served as a main irrigation channel similar to the berm lined ditches. These stone and concrete type flumes are generally located in flatter terrain joining bermed ditches. The construction style suggests that they may be some of the older constructions within the Site 4707.

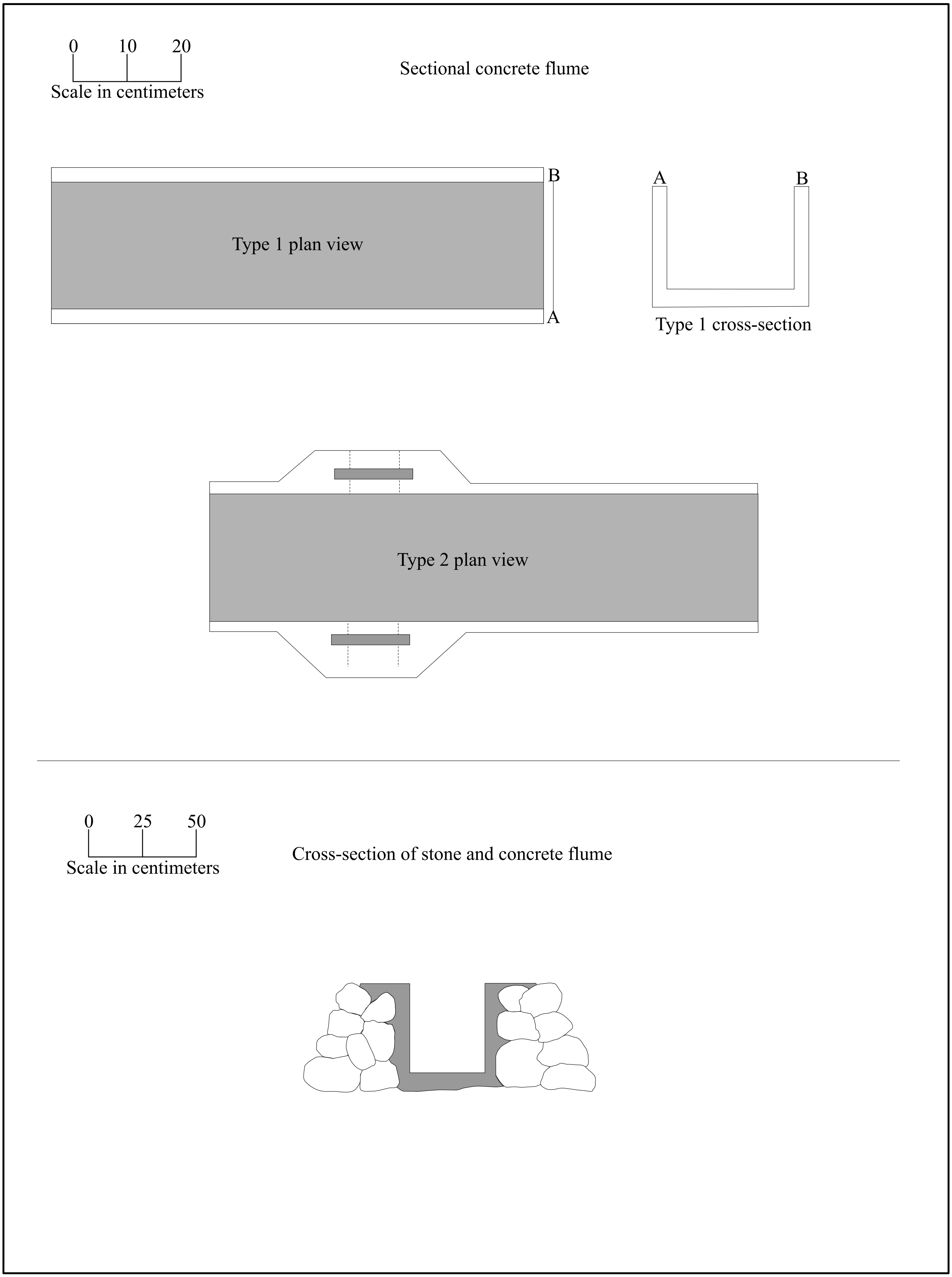


Figure 27. Sectional concrete flume plan view and stone and concrete flume cross-section.


Figure 28. Sectional concrete flume Type 2 outflow opening.


Figure 29. Sectional metal flume.

Figure 30. Stone and concrete flume edge.

Figure 31. Stone and concrete flume water channel.

Former cane haul roads within the APE typically follow the routes of the main irrigation ditches. These old roads are mostly overgrown and no longer drivable. Most of the currently drivable roads within the APE appear to date to the ranching use of the parcels (post-1971). These bulldozed roads cross cut the ditches and flumes and often follow fence lines. The cane haul roads are generally only recognizable as artificially leveled alignments following next to the ditches, or at locations where they formerly crossed a ditch. At locations where a road traversed a ditch either a concrete culvert or large diameter iron pipe is present that runs beneath the road bed (connecting to the ditch on each side), or a bridge is present. Former bridges were noted at two locations within the APE. Both were constructed of short spans of railroad rails overlaid with wooden planks, stones and soil, and were in extremely poor condition (Figure 32). A large amount of historic and modern trash (mostly 1930s to 1970s bottles and cans) was noted on the ground surface along the routes of the former cane haul roads.

Figure 32. A former bridge crossing an irrigation ditch.

Several dates of construction were identified in concrete at features within the APE. The dates indicate that the major infrastructural development for sugarcane cultivation within the APE took place between 1925 and 1943. The oldest date (August 1925) was discovered in concrete near the outflow pipe of the former reservoir located along the *mauka* boundary of the APE (Figure 33). This small reservoir (75 meters by 100 meters) no longer holds water. It has earthen embanked sides that stand up to 5 meters tall. The outflow pipe is located within a rectangular concrete lined depression at the base of its western embankment along its exterior edge (Figure 34). The reservoir was formerly filled by a large diameter metal pipe that ran underground to it from Pump 18 (Figure 35). The pipe enters the reservoir at an inlet pipe/valve located in its eastern corner (Figures 36 and 37). A second reservoir that was once present in the western portion of the APE according to the 1935 Kuhuku Plantation field map (see Figure 12) was not relocated. It appears that this second reservoir was turned into sugarcane fields at some point after 1935, as sectional concrete flumes cross the area where it was formerly located.

Figure 33. August 1925 inscribed in concrete near the reservoir outflow pipe, over view.

Figure 34. Reservoir outflow pipe, view to east.

Figure 35. Exposed section of an underground pipe between the reservoir and Pump 18, view to southeast.

Figure 36. Reservoir inlet pipe/valve, view to north.

Figure 37. Reservoir inlet pipe/valve, view to east.

Two iron pipes, set in concrete with dated inscriptions, where discovered at two separate locations within the APE. These pipes appear to be former survey markers. The first was found in a roadway at the base of a small steep-sided hill near the western extent of the APE. The inscription in the concrete at the base of that pipe reads, “BOLT / J.B.M. / 1934” (Figure 38). The second was found next to a pile of boulder rubble in the central portion of the APE. The inscription in the broken concrete at the base of that pipe reads, “1C / 1938” (Figure 39). Both pipes had been freed of the ground surface in which the concrete was originally poured, and neither pipe was at its original location.

The date “12-2-38” was discovered in the concrete foundation of a small, tin shack, pump house (Figure 40) located along the route of an earthen berm lined ditch near the northwestern boundary of the APE. The shack measures 3.75 meters long by 2.75 meters wide by 3.5 meters tall (Figure 41). It covers a pump mechanism and has a pipe inlet along one edge and a shut-off valve along another (Figure 42). The shack once had power running to it as indicated by a light switch inside and a rotted power pole nearby. This pump, which was added to the fields in 1938 after the 1935 Kahuku field map was prepared, appears to have directed water flow to fields outside (west of) the APE. Stone and concrete lined ditches conjoin and extend in several directions at the pump house (Figure 43).

The date “July 26, 1943” was discovered in a concrete flume section (Figure 44) along the large diameter metal pipe that runs between Pump 18 and the reservoir. This flume section connects to the underground pipe at is eastern end (Figure 45), and feeds into an earthen berm lined ditch at its western end. It is 6.5 meters long by 0.6 meters wide and 0.5 meters deep. The concrete along either edge is 0.25 meters thick. It appears as though this flume was added to allow water to be sent directly from the underground pipe to the berm lined irrigation ditch.

Figure 38. Iron pipe set in concrete discovered near the western boundary of the APE.

Figure 39. Iron pipe set in concrete discovered in the central portion of the APE.

Figure 40. “12-2-38” inscribed in the concrete foundation of a small tin shack pump house near the northwestern boundary of the APE.

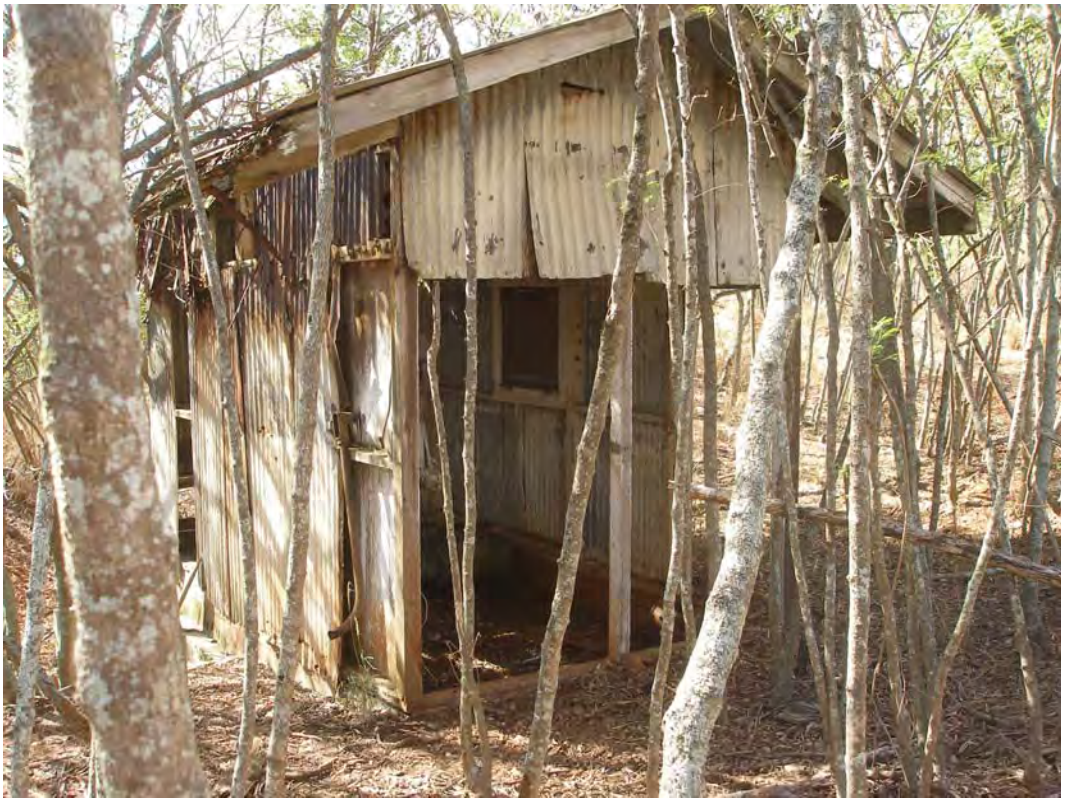


Figure 41. Tin shack, view to southeast.

Figure 42. Shut-off valve along the southern edge of the shack, view to east.

Figure 43. Stone and concrete lined ditch junctions next to the tin shack.

Figure 44. “July 26, 1943” inscribed in the wall of a concrete flume.

Figure 45. Concrete flume connecting to the underground pipe, view to east.

At two other unique irrigation features located along the route of the underground pipeline, the remains of Pump 18 and a concrete flume section with a shut-off valve, no dates were discovered in the concrete. Pump 18 was certainly constructed prior to 1935, perhaps at a date similar to the construction of the reservoir near the *mauka* boundary of the APE (ca. 1925). What remains of Pump 18 is an overgrown concrete foundation (Figure 46) containing the rusted pump mechanism (Figure 47). The foundation, which measures 4 meters square by 1.88 meters deep, formerly supported a small building that is no longer present. Stairs that once accessed the building are present along the exterior northern edge of the foundation (Figure 48). The underground pipe runs into the foundation at either end. To the southwest the pipe continues up slope to the reservoir, and to the northeast it continues down slope, out of the APE, to Pump 5 and two wells nearby it.

To the northeast of Pump 18 along the route of the pipeline a large stone and concrete flume with a shut-off valve is present that connects to the pipe. No date was discovered in the concrete at this flume, but based on its construction style and materials it appears newer than the other features along the route of the pipe. This flume is constructed of neatly stacked cobbles held together and covered with concrete. It measures 1.7 meters wide by 1.1 meters deep, and it has sloped sides. The flume feeds off of the metal pipe and curves from south to west emptying into an earthen berm lined ditch. The down slope, exterior northern edge is taller than the upslope exterior edge which is terraced into the slope. The northern edge stands nearly 2 meters high (Figure 49). Where the flume joins the pipe a metal shut-off valve is present within an area separated from the main flume channel by a brick wall (Figures 50, 51, and 52). It appears as though this flume was added to the APE irrigation system to allow water to be sent from the underground pipe to the berm lined irrigation ditch.

Figure 46. Pump 18 foundation, view to northeast.

Figure 47. Pump 18 machinery, view to southeast.

Figure 48. Stairs at Pump 18, view to northwest.

Figure 49. Northern exterior edge of stone and concrete flume, view to northwest.

Figure 50. Flume/pipe junction, view to southwest.

Figure 51. Shut-off valve, view to northeast.

Figure 52. Shut-off valve view to southwest.

SIGNIFICANCE EVALUATION AND DETERMINATION OF EFFECTS

The site recorded during the current study is assessed for its significance based on the National Register Criteria. This significance evaluation should be considered as preliminary until the Hawai‘i State Historic Preservation Officer (SHPO) provides concurrence. As contained in the Federal legislation and its implementing regulation (Section 106 of the National Historic Preservation Act and 36 CFR Part 800, respectively), a resource must be considered a Historic Property, that is a resource “listed or eligible for listing in the National Register of Historic Places” before a determination of effects can be made. The criteria for evaluating eligibility (36 CFR § 60.4) are as follows:

> The quality of significance in American History, architecture, archaeology, engineering, and culture is present in districts, sites buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and,
>
> (a) that area associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (b) that are associated with the lives of persons significant in our past; or
>
> (c) that embody the distinctive characteristics of a type, period, or method of construction; or that represent the work of a master; or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or;
>
> (d) that have yielded, or may be likely to yield, information important in prehistory or history.

Site 4707, although not functional and in a state of disrepair, does retain sufficient integrity to be considered significant under Criterion d for the historical information it has yielded relative to the development of the sugarcane industry in Hawai‘i; thus making the site potentially eligible for listing in the National Register of Historic Places. However, it is suggested that a reasonable and adequate amount of information has been collected about this potential historic property during the current study to warrant a no mitigation work requirement, and thus a no adverse effects determination for this site with respect to the proposed Kahuku Wind Power undertaking.

As noted in an earlier section of this study and in response to consultation with Native Hawaiian organizations and individuals within the community, First Wind will preserve the coral bluff areas that are within the overall property under their control, but that are outside of the current APE. As part of this preservation, First Wind is also dedicated to documenting of the *mo‘olelo* concerning these culturally significant areas. Such documentation will occur as part of an ongoing effort to conduct oral-historical interviews with knowledgeable community members.

REFERENCES CITED

Beaglehole, J.
1967 *The Journals of Captain James Cook.* Cambridge: Hakluyt Society.

Chinen, J.
1961 *Original Land Titles in Hawaii*. Honolulu: privately published.

Dillingham, B
1886 “Great Land Colonization Scheme.” IN Thos G. Thrum (ed.) *Hawaiian Almanac for 1902*, pp. 128-132. Honolulu.

Dorrance, W., and F. Morgan
2000 *Sugar Islands: The 165-Year Story of Sugar in Hawaii*. Mutual Publishing, Honolulu, Hawaii.

Emerson, O.
1928 *Pioneer Days in Hawaii.* Doubleday, Doran & Co., Garden City, New York.

Foote, D., E. Hill, S. Nakamura, and F. Stephens
1972 *Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii.* United States Department of Agriculture, in conjunction with the University of Hawaii Agricultural Extension. U.S. Government Printing Office, Washington, D.C.

Fornander, A.
1969 *An Account of the Polynesian Race: Its Origin and Migrations*. Tokyo: Charles E. Tuttle Co., Inc.

Hall, E.
1839 “Notes on a Tour Around Oahu.” *Hawaiian Spectator*, Vol. 2. Honolulu.

Handy, E.S.C., and E.G. Handy
1972 *Native Planters in Old Hawaii: Their Life, Lore and Environment*. B.P. Bishop Museum Bulletin 223. Bishop Museum Press, Honolulu. (with M.K. Pukui)

Hommon, R.
1986 Social Evolution in Ancient Hawaiʻi. IN Kirch, P.V. (ed.), Island Societies: *Archaeological Approaches to Evolution and Trans-formation*: 55-88. Cambridge: University Press.

Jensen, P.
1989 Archaeological Inventory Survey, Punamano and Malaekahana Golf Courses. Lands of Ulupehupehu, Punaluu, Kahuku, Malaekahana, and Laie Koolauloa District, Island of Oahu. Paul H. Rosendahl, Ph.D., Inc., Report 483-040489. Prepared for Kuilima Resort Company, Honolulu, Hawaii.

Kamakau, S.
1964 *Ka Poʻe Kahiko*: The People of Old. *B.P. Bishop Museum Special Publication* 51. Bishop Museum Press, Honolulu.

Kennedy, J.
1989 Archaeological Assessment & Reevaluation Report Concerning the Recently Surveyed, Proposed Punamano Golf Course; A Portion of the Country Courses at Kahuku (TMK:1-5-6-05, -7-01). Archaeological Consultants of Hawaii, Haleiwa, Hawaii. Prepared for Mr. William Wanket, Honolulu, Hawaii.

Kirch, P.

1984 *The Evolution of the Polynesian Chiefdoms*. Cambridge University Press, New York.

1985 *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory*. University of Hawaii Press, Honolulu.

1990 Monumental Architecture and Power in Polynesian Chiefdoms: A Comparison of Tonga and Hawaii. World Archaeology 22(2).

Korn, A.

1958 *The Victorian Visitors*. Honolulu: University of Hawaii Press.

Kuykendall, R.

1938 *The Hawaiian Kingdom 1778–1854. Foundation and Transformation*. Honolulu: University of Hawaii Press.

1967 *The Hawaiian Kingdom 1874–1893. The Kalakaua Dynasty*. Honolulu: University of Hawaii Press.

McAllister, J.

1933 Archaeology of Oahu. *B.P. Bishop Museum Bulletin* 104. Bishop Museum Press, Honolulu. (New York: Kraus Reprint Co., reprinted 1971)

Nakamura, B.

1981 Historical Survey of the Kahuku Wind Farm Site and Notes on the Power Transmission Line Route, Kahuku, Oʻahu, Hawaiʻi. Manuscript 060481. Department of Anthropology, B.P. Bishop Museum, Honolulu. Prepared for Bechtel Power Corp.

Pogue, J.

1978 *Mooleo Hawaii*. Hale Paipalapala Aupuni, Honolulu (Revised Edition).

Pukui, M., S. Elbert, and E. Mookini

1974 *Place Names of Hawaii*. Honolulu: University of Hawaii Press.

Silva, C.

1984 Preliminary Historical Documentary Research. IN Subsurface Archaeological Reconnaissance Survey, Kuilima Resort Expansion Project, Lands of Opana, Kawela, Hanakaoe, Oio, Ulupehupehu, Punalau and Kahuku, Koolauloa, Island of Oahu. PHRI Report 137-100784. Prepared for Group 70 and Kuilima Development Corp.

Stride, M., T. Craddock, and H. Hammatt

2003 Archaeological Inventory Survey of the Proposed 785-Acre Kahuku Agricultural Park (TMK:1-5-6-8:2). Cultural Surveys Hawaii, Inc. Prepared for M and E Pacific, Inc. (Revised)

Tatar, E.

1982 Nineteenth Century Hawaiian Chant. *Pacific Anthropological Records No. 33*. Department of Anthropology, B.P. Bishop Museum, Honolulu.

Thayer, W.

1934 “Report of the Examiner: In the Matter of the Application of A.N. Campbell, et al, Trustees of the Estate of James Campbell Deceased, for Registration of Tittle to Land in Koolauloa, Oahu. Land Court “1095.” In Hawaiʻi (Terr.) Land Court, *Land Court Application Number 1095*, 1934, pp. 130-183.

Thrum, T.
1911 “History of the Hudson’s Bay Company’s Agency in Honolulu.” IN Hawaiian Historic Society, *Eighteenth Annual Report…of the Hawaiian Historical Society for the year 1910.* Honolulu, Paradise of the Pacific Print, 1911, pp. 35-49.

1912 *Hawaiian Folk Tales*. Chicago: A. C. McClurg & Co.

Vancouver, G.
1798 *A Voyage of Discovery to the North Pacific Ocean, and Round the World*, Volumes 1-3. London: Robinsons and Edwards.

Wilcox, B.
1975 *The Kahuku Sugar Mill Story*. Honolulu: Island Heritage.

Williams, S., and T. Patolo
1998 Final Report, Archaeological Inventory Survey of the Kahuku Training Area, for the Legacy Resource Management Program, O‘ahu Island, Hawai‘i (TMK:1-5-6; -7). Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai‘i. Prepared for U.S. Army Corps of Engineers, Corps of Engineers District, Honolulu, Fort Shafter, Hawai‘i.

Wong-Smith, H.
1975 Preliminary Historical Documentary Research Punamano and Malaekahana Golf Courses Land of Kahuku, Island of O‘ahu. Appendix A in Jensen 1989. Paul H. Rosendahl, Ph.D., Inc., Report 483-040489. Prepared for Kuilima Resort Company, Honolulu, Hawaii.

RECHTMAN CONSULTING, LLC
507-A E. Lanikaula St. Hilo, Hawaii 96720
phone: (808) 969-6066 fax: (808) 443-0065
e-mail: bob@rechtmanconsulting.com
ARCHAEOLOGICAL, CULTURAL, AND HISTORICAL STUDIES

January 12, 2010 RC-0488

Sharon R. Thomas
Environmental Protection Specialist
US. Department of Energy
1000 Independence Ave, SW, CF-1.3
Washington, DC 20585

Dear Sharon:

This letter is submitted in support of your request to SHPO for “Concurrence with a Determination of No Historic Properties Affected” pursuant to the establishment of the First Wind off site microwave communication system. First Wind is developing an alternative energy production site on TMKs: 1-5-6-05:007 and 014 in Kahuku Ahupuaʻa, Koʻolauloa District, Island of Oʻahu. An archaeological survey report in compliance with Section 106 of the National Historic Preservation Act has already been submitted for this project area. Once complete, First Wind’s power generating facility will be incorporated into HECO’s power grid. In compliance with the U.S. Department of Energy and HECO, First Wind will be required to establish a high-speed communications system using microwave radio technology in order to protect the electrical grid in case of outages. The microwave communication system will involve the placement of line of sight microwave dishes at several locations (both on and off-site) between First Wind’s Kahuku project area and the two HECO electrical substations located at Wahiawa and Waialua (Figure 1).

In all, seven locations will be utilized for the placement of microwave dishes (see Figure 1). Two of these will be within the existing Kahuku project area and their placement is within the established APE for the wind energy project. Three will be a co-location on existing communications towers, and thus will have no effect on historic properties; and two will require the construction of new towers. Of this latter category one will be located within the HECO Waialua Substation in Haleiwa (TMK: 1-6-6-018:037). This area is an already developed site (Figures 2 and 3) and the placement of an additional tower within this site will have no effect on historic properties.

The final proposed new tower (40 feet tall) will be situated within Kamananui Ahupuaʻa, Waialua District, Island of Oʻahu (see Figure 1). The proposed tower site is located within a roughly 1,518 acre property (TMK: 1-6-7-002:004) that is owned by Dole Food Co., Inc. and leased by Waialua Ranch Partners. The property was included in previous island-wide archaeological studies conducted by McAllister (1933) and Sterling and Summers (1962). As a result of those studies three archaeological sites were recorded in the vicinity of the new tower location. The sites include a concealed burial cave in the cliff along the western edge of Kaumoku Gulch (Site 198), several piles of stones near the mouth of Kaumoku Gulch (Site 199), and a cave near the outlet of Kaumoku Gulch that was said to have contained human skeletal remains twenty years prior to the McAllister survey (Site 200). The Ito Ditch, constructed by the Waialua Agricultural Co. during the early twentieth century, also passes through the property *makai* of the current project area.

McAllister (1933) noted that blasting associated with the construction of this ditch appeared to have caused the ceiling of Site 200 to collapse.

The proposed new tower location is situated on the eastern ridge of Kaumoku Gulch at an elevation of roughly 750 feet above sea level (Figure 4). It is contained within a fenced paddock that is currently used as pasture by the Flying R Ranch. The location of the proposed tower places it well to the south and east of the sites previously recorded by McAllister (1933) and Sterling and Summers (1962). Two of the previously recorded sites (Sites 199 and 200) were noted on the property to the north of the proposed development area along an existing access road. An inspection of the development area by Rechtman Consulting, LLC on January 8, 2010 revealed that the 30 foot by 30 foot proposed new tower site has been previously bulldozed (Figure 5), and that no archaeological resources are present. A roughly 500 foot long by 15 foot wide proposed access road corridor that follows a firebreak road from an existing access road to the proposed tower location was also inspected (Figures 6 and 7), and again no archaeological resources were encountered.

Given the negative findings and the previous land disturbance that has already occurred at all of the proposed microwave dish sites, it is our conclusion that no historic properties will be affected by the establishment of the First Wind microwave communication system. Should you require additional information or if you have any questions please feel free to contact me directly.

Regards,

Bob Rechtman, Ph.D.
Principal Archaeologist

cc:/Wren Wescoatt – First Wind

Reference Cited

McAllister, J.
1933 Archaeology of Oahu. *B.P. Bishop Museum Bulletin* 104. Bishop Museum Press, Honolulu. (New York: Kraus Reprint Co., reprinted 1971)

Sterling, E., and C. Summers
1962 *Sites of Oahu*. Book 6. Vol. 1 Honolulu: Bishop Museum Press.

Figure 1. Locations of the proposed microwave dishes.

Figure 2. Existing HECO Waialua substation.

Figure 3. Existing HECO Waialua substation, new First Wind microwave tower to be erected in background near pole.

Figure 4. Proposed new tower location, view to southwest

Figure 5. Proposed new tower site, view to north.

Figure 6. Proposed access road corridor (existing firebreak road), view to southwest.

Figure 8. Gate along proposed access road route (near the existing access road),
view to northeast.