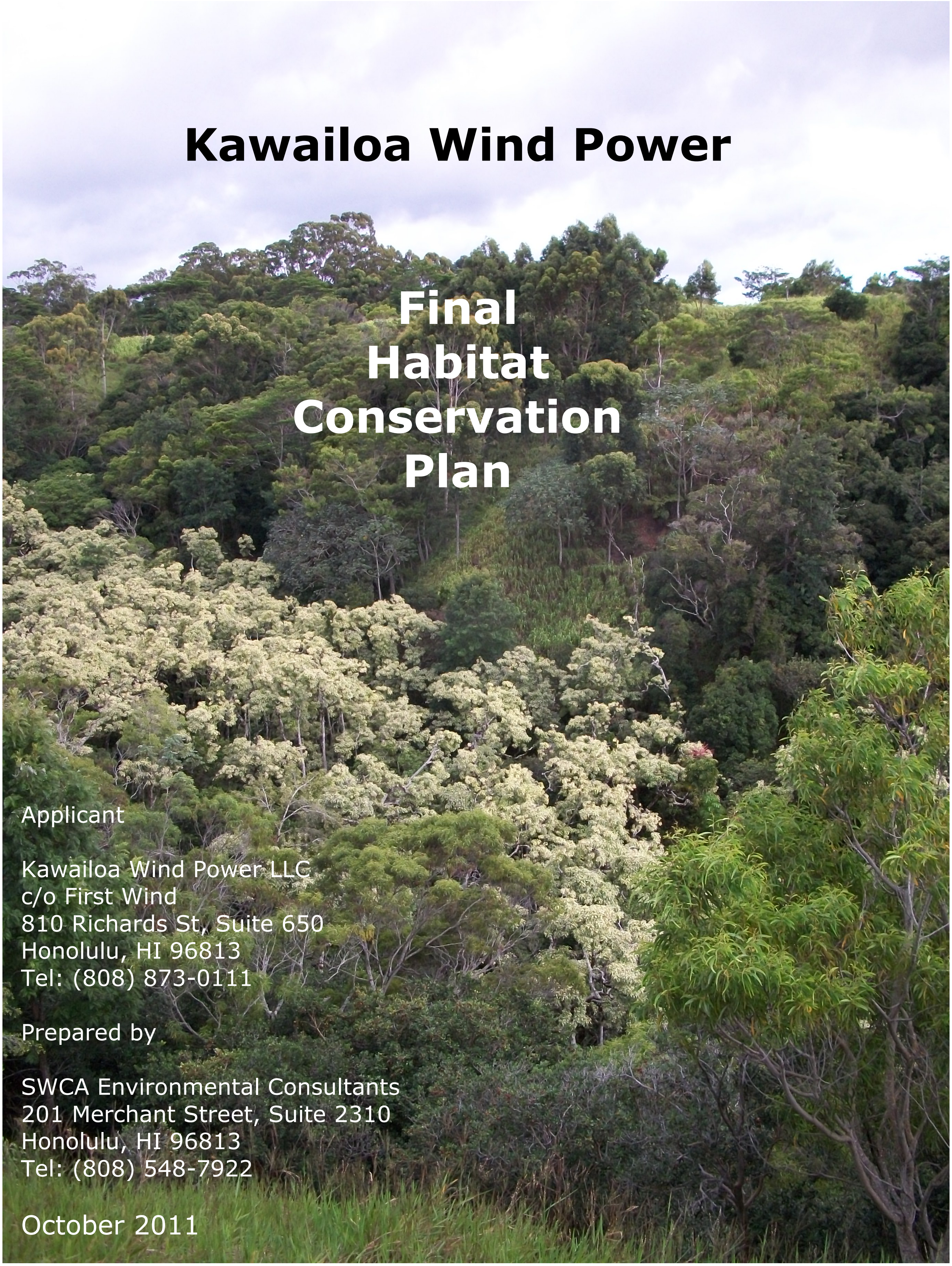


Kawailoa Wind Power

Final Habitat Conservation Plan

Applicant

Kawailoa Wind Power LLC
c/o First Wind
810 Richards St, Suite 650
Honolulu, HI 96813
Tel: (808) 873-0111

Prepared by

SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, HI 96813
Tel: (808) 548-7922

October 2011

TABLE OF CONTENTS

1.0 INTRODUCTION AND PROJECT OVERVIEW 1
1.1 Summary 1
1.2 Applicant Background 7
1.3 Regulatory Context 8
1.3.1 Federal Endangered Species Act (16 U.S.C. 1531-1544) 8
1.3.2 Federal National Environmental Policy Act (42 U.S.C. 4371 et seq.) 9
1.3.3 Federal Migratory Bird Treaty Act (16 U.S.C. 703-712) 9
1.3.4 Federal National Historic Preservation Act (16 U.S.C. 470-470b, 470c-470n) 10
1.3.5 Hawaiʽi Revised Statutes, Chapter 195D 10
1.3.6 Hawaiʽi Revised Statutes, Chapter 343 12
1.4 Project Description 13
1.4.1 Project History 13
1.4.2 Project Design and Components 13
1.4.3 Purpose and Need for Kawailoa Wind Power Project 14
1.5 List of Preparers 16
2.0 DESCRIPTION OF HABITAT CONSERVATION PLAN 17
2.1 Purpose of this HCP 17
2.2 Scope and Term 17
2.3 Surveys and Resources 17
3.0 ENVIRONMENTAL SETTING 19
3.1 Location, Vicinity, & Climate 19
3.2 Topography and Geology 19
3.3 Soils 20
3.4 Hydrology, Drainage and Water Resources 20
3.4.1 Surface water 20
3.4.2 Flooding 22
3.4.3 Groundwater 22
3.5 Environmental Contaminants 23
3.6 Land Use Designations 23
3.7 Flora 25
3.7.1 Flora Within the Project Area 25
3.7.2 Flora at Off-site Microwave Facility Locations 27
3.8 Wildlife 28
3.8.1 Surveys Conducted 28
3.8.1.1 Radar surveys 28
3.8.1.2 Bird and Bat surveys 28
3.8.2 Non-Listed Wildlife Species 31
3.8.2.1 Herons and Egrets 33
3.8.2.2 Other Birds 34
3.8.2.3 Invertebrates 34
3.8.2.4 Mammals 34
3.8.3 Wildlife at Off-site Microwave Facility Locations 34
3.8.4 Listed Wildlife Species 35
3.8.4.1 Newell's Shearwater 36
3.8.4.2 Waterbirds 39
3.8.4.2a Hawaiian Duck 39
3.8.4.2b Hawaiian Stilt 41
3.8.4.2c Hawaiian Coot 43
3.8.4.2d Hawaiian Moorhen 44

3.8.4.3 Hawaiian Short-eared Owl....45
3.8.4.4 Hawaiian Hoary Bat....47

4.0 BIOLOGICAL GOALS AND OBJECTIVES....51

5.0 ALTERNATIVES....52

5.1 No-Action ("No Build") Alternative....52
5.2 Alternative Communications Site Layout....52
5.3 Avoidance and Minimization Measures....54
5.3.1 USFWS Guidelines....56

6.0 POTENTIAL IMPACTS....62

6.1 Impacts to Birds....62
6.2 Impacts to Bats....63
6.3 Estimating Project-related Impacts....63
6.3.1 Take Levels....65
6.3.2 Monitoring of Take Levels....65
6.3.3 Estimating Indirect Take....66
6.3.4 Seabirds....67
6.3.4.1 Newell's Shearwater....67
6.3.5 Hawaiian Waterbirds....71
6.3.5.1 Hawaiian Duck....71
6.3.5.2 Hawaiian Stilt....75
6.3.5.3 Hawaiian Coot....77
6.3.5.4 Hawaiian Moorhen....79
6.3.6 Hawaiian Short-eared Owl....82
6.3.7 Hawaiian Hoary Bat....84
6.3.7.1 Impacts of the Facility on Bat Habitat....84
6.4 Cumulative Impacts to Listed Species....91
6.4.1 Seabirds (Newell's Shearwater)....92
6.4.2 Waterbirds (Hawaiian Duck, Hawaiian Stilt, Hawaiian Coot, Hawaiian Moorhen)....93
6.4.3 Hawaiian Short-eared Owl....94
6.4.4 Hawaiian Hoary Bat....94
7.1 Selection of Mitigation Measures....95
7.1.1 Re-Allocation of Funds and Commitment to Provide Necessary Mitigation....97
7.2 General Measures....97
7.2.1 Wildlife Education and Observation Program (WEOP)....97
7.2.2 Downed Wildlife Protocol....97
7.3 Newell's Shearwater....98
7.3.1 Tier 1 Mitigation....99
7.3.2 Mitigation for Tier 2 Rates of Take....99
7.3.3 Additional Research to Improve Avoidance and Minimization Measures at Tier 2 Rates of Take....100
7.3.4 Measures of Success....100
7.4 Waterbirds (Hawaiian Duck, Hawaiian Stilt, Hawaiian Coot, and Hawaiian Moorhen)....101
7.4.1 Tier 1 Mitigation....103
7.4.2 Mitigation for Tier 2 Rates of Take....106
7.4.3 Mitigation Measures for Waterbirds as a Covered Activity....106
7.4.4 Measures of Success....107
7.5 Hawaiian Short-eared Owl....107
7.5.1 Tier 1 Mitigation....107
7.5.1.1 Funding for Owl Rehabilitation or Research....108
7.5.1.2 Funding of Management Actions....108
7.5.2 Mitigation for Tier 2 Rates of Take....109

7.5.3 Measures of Success 109
7.6 Hawaiian Hoary Bat 109
7.6.1 Tier 1 Mitigation 113
7.6.1.1 Research on Bat Habitat Utilization and Bat Interactions at Kawailoa Wind Power ... 113
7.6.1.2 Implementation of Management Measures 113
7.6.2 Mitigation for Tier 2 Rates of Take 117
7.6.2.1 Additional Research at Kawailoa Wind Power 117
7.6.2.2 Additional Bat Habitat Management Measures for Tier 2 or Tier 3 117
7.6.3 Measures of Success 118
7.7 Immediate Revegetation to Control Soil Erosion 118
7.8 Managing Invasive Species 119
7.9 Replanting of Native Trees 119
8.0 IMPLEMENTATION 120
8.1 HCP Administration 120
8.2 Monitoring and Reporting 120
8.2.1 Monitoring 120
8.2.2 Reporting 121
8.3 Adaptive Management Program 122
8.4 Funding 123
8.5 Changed Circumstances Provided for in the HCP 124
8.6 Changed Circumstances Not Provided for in the HCP 127
8.7 Unforeseen Circumstances and "No Surprises" Policy 127
8.8 Notice of Unforeseen Circumstances 127
8.9 Permit Duration 127
8.10 Amendment Procedure 127
8.10.1 Minor Amendments 128
8.10.2 Major Amendments 128
8.11 Renewal and Extension 128
8.13 Other Measures 129
8.14 Permit Transfer 129
9.0 CONCLUSION 130
10.0 LITERATURE CITED 131

List of Figures

Figure 1-1. Kawailoa Wind Power Location and Site Layout 2
Figure 1-2. Location of Off-site Communication Facilities.. 3
Figure 3-1. Soil Types within the Project Area...21
Figure 3-2. State of Hawai'i Land Use Boundaries Map. 24
Figure 3-3. Bird Point Count Stations...29
Figure 3-4. Anabat Locations. 30
Figure 3-5. Distribution of Bat Passes Over Survey Period. 50
Figure 3-6. Time Distribution of All Bat Calls Detected. 50
Figure 6-1. Mean ± SE Activity of Migratory Bats at 30 m and Corrected Bat Fatalities/Turbine/Year Across Sites in Southern Alberta, Canada. 86
Figure 7-1. Hoary Bat and Large-Bodied Bat Activity at Open- and Closed-Canopy Habitats (figure from Brook and Ford 2005) 111
Figure 7-2. Bat Activity Levels Between the Uplands and Riparian Areas (figure from Grindal et al. 1999) 111

List of Tables

Table 1-2. Requested Take Levels for Covered Species. 6
Table 1-3. Mitigation Measures for the Covered Species... 7
Table 1-4. Existing and Potential Wind Energy Facilities throughout Hawai'i..................................15
Table 3-1. Streams within the Kawailoa project area. 22
Table 3-2. Native Hawaiian plants observed in the project area. 25
Table 3-3. Bird Species at the Project Site, Nearby Ponds and Vicinity. 31
Table 3-4: List of Species Recorded at Each Location along the Transect in Each Site. 36
Table 3-5. Federally or State-listed Species with Potential to be Impacted by the Kawailoa Wind Power Project. 37
Table 5-1. Comparison of Kawailoa Wind Power with Site Development and Construction BMPs Outlined in the Wind Turbine Guidelines Advisory Committee Recommendations (2010). 56
Table 6-1. Calculation of Indirect Take for Newell's Shearwater. 69
Table 6-2. Calculation of Total Indirect Take for Newell's Shearwater from Observed and UnobservedDirect Take. 70
Table 6-3. Calculation of Indirect Take of the Hawaiian Duck Hybrid..73
Table 6-4. Calculation of Total Indirect Take for the Hawaiian Duck from Observed and Unobserved Direct Take. 74
Table 6-5. Calculation of Indirect Take for the Hawaiian Stilt. 75
Table 6-6. Calculation of Total Indirect Take for the Hawaiian Stilt from Observed and Unobserved Direct Take. 76
Table 6-7. Calculating Indirect Take for the Hawaiian Coot...78

Table 6-8. Calculation of Total Indirect Take for the Hawaiian Coot from Observed and Unobserved Direct Take. 78

Table 6-9. Calculating Indirect Take for the Hawaiian Moorhen. 80

Table 6-10. Calculation of Total Indirect Take for the Hawaiian Moorhen from Observed and Unobserved Direct Take. 81

Table 6-11. Calculating Indirect Take for the Hawaiian Short-eared Owl. 83

Table 6-12. Fatality Rates and Bat Activity Indices at Five Wind-energy Facilities on the Mainland United States (from Kunz et al. 2007). 87

Table 6-13. Direct Take Calculations Based on LWSC and Activity. 88

Table 6-14. Calculating Indirect Take for the Hawaiian Hoary Bat. 89

Table 6-15. Calculation of Total Indirect Take for the Hawaiian Hoary Bat from Observed and Unobserved Direct Take. 90

Table 6-16. Current and Pending Take Authorizations for the Covered Species on O'ahu, Maui and Kaua'i through Habitat Conservation Plans and Safe Harbor Agreements. 92

Table 7-1. Mitigation Measures for Different Tiers of Proposed Take. 96

Table 7-2. Annual Fledgling Production Requirements for Tier 1 Take of Listed Waterbird Species Based on Same-year Replacement of Take by Fledglings[1]. 103

Table 7-3. Comparison of Activity Rates from March 1 – June 7 2011 at Ponds and Other Vegetated Habitats at Kawailoa Wind Power and Vicinity. Anabats highlighted in yellow were deployed at the irrigation ponds. 112

List of Appendices

Appendix 1. Biological Resources Surveys (Hobdy)

Appendix 2. Jurisdictional Wetland Determination Study (SWCA)

Appendix 3a, b. Radar and Visual Studies of Seabirds (ABR Inc.)

Appendix 4. Kawailoa Wind Power Wildlife Monitoring Report and Fatality Estimates for Waterbirds and Bats (SWCA)

Appendix 5. Life History Information on Covered Species (SWCA)

Appendix 6. Wildlife Education and Observation Program (SWCA and First Wind)

Appendix 7. Wildlife Casualty Monitoring Protocol (SWCA and First Wind)

Appendix 8. Funding Matrix

Appendix 9. Calculating Direct Take

Appendix 10. Off-site Microwave Towers Biological Resources Survey (Hobdy)

Appendix 11. Take Reporting Form

Appendix 12. Mollusc Survey for the Kawailoa Wind Farm Project, Mount Kaala Microwave Communication Facilities, Mount Ka‘ala, Kamananui, Waialua, O‘ahu. (SWCA)

Appendix 13. Mitigation Timeline and Reporting Requirements

Appendix 14. Letter from Bat Expert Dr. Mike O’Farrell on the Effectiveness of Wetland and Forest Restoration for Improving Bat Foraging Habitat.

Appendix 15. Goodnature Automatic Cat Trap Development Project Timeline

1.0 INTRODUCTION AND PROJECT OVERVIEW

1.1 Summary

Kawailoa Wind Power LLC (or the "Applicant") proposes to construct and operate a new 70-megawatt (MW), 30-turbine commercial wind energy generation facility at Kawailoa in the northern portion of the Island of O'ahu, Hawai'i (Figure 1-1). The proposed project, known as Kawailoa Wind Power, is situated within an approximately 4,200-acre (1,700 ha) parcel of privately owned land that is zoned agricultural. Kawailoa Wind Power will supply wind-generated electricity to the Hawaiian Electric Company (HECO). Figure 1-1 shows the layout of the various project components, within a series of corridors which cumulatively represent the maximum project footprint. The footprint was developed based on the distribution of wind resources and other site constraints such as topography and military flightlines.

Kawailoa Wind Power will consist of:

- 30 wind turbine generators (WTGs)
- 4.0 mi of overhead and 7.2 mi of underground collector lines
- one electrical substation
- an operations and maintenance (O&M) building
- a laydown area
- a possible battery energy storage system (BESS)
- two communication towers
- two point of interconnection (POI) facilities
- up to two permanent unguyed meteorological (met) towers. Up to four temporary guyed met towers will be also be erected for varying lengths of time prior to and during construction to gather meteorological data and for power-curve testing
- improvements to 8.2 mi of existing roads, and an addition of 4.3 mi of unpaved access roadways to connect the new WTGs to other project components
- possible installation, operation, and maintenance of up to four microwave dish antennae on two existing Hawaiian Telcom facilities near the summit of Mt. Ka'ala

The project will have a permanent footprint of 22.0 ac. after disturbing approximately 335 ac. during construction. Approximately 259 ac. of the disturbed area is likely to remain under long term vegetation management due to the maintenance of search plot areas around turbines and met towers for downed wildlife monitoring (Table 1-1). The maximum extent of the project footprint is illustrated in Figure 1-1. Since the development of the project footprint, the location of a few of the project components were revised (such as the location of the proposed overhead lines) and now extend beyond the limits of the footprint presented. However, these areas were already included in the botanical and wildlife studies conducted and the analyses of the potential impacts of this project also include these areas. (CH2M Hill 2011a, b).

Together with the State agency, the Division of Forestry and Wildlife (DOFAW) and the Federal Agency U.S Fish and Wildlife Services (USFWS), Kawailoa Wind Power has determined that construction and operation of the wind farm has the potential to result in the incidental take of six Federally listed threatened or endangered species: the Hawaiian stilt or ae'o (*Himantopus mexicanus knudseni*), Hawaiian coot or 'alae ke'oke'o (*Fulica alai*), Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian moorhen or 'alae 'ula (*Gallinula chloropus sandvicensis*), Newell's shearwater or 'a'o (*Puffinus auricularis newelli*), and Hawaiian hoary bat or 'ope'ape'a (*Lasiurus cinereus semotus*). One State-listed endangered species, the Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*), is also believed to have potential to collide with the proposed WTGs or other project infrastructure. The endangered mollusc species (*Achatinella mustelina*) was historically found adjacent to the proposed site for off-site communications, and a population is present approximately 50 meters away. Measures have been proposed to avoid impact to these snails during the installation of the antennae on the existing towers (for the proposed action) or erection of new towers (for the second alternative).

No other listed, proposed or candidate species have been found or are known or expected to be present in the project area.

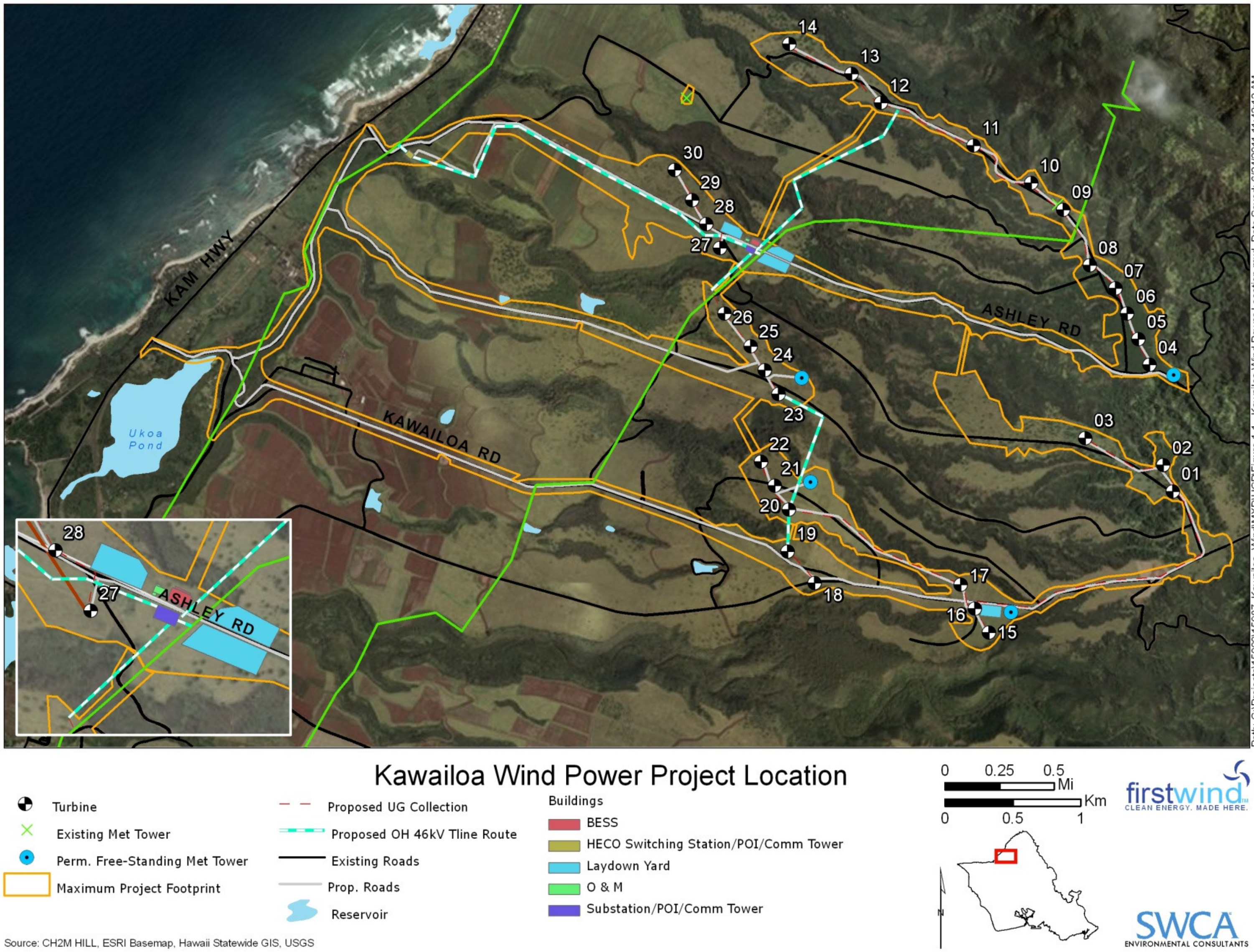


Figure 1-1. Kawailoa Wind Power Location and Site Layout

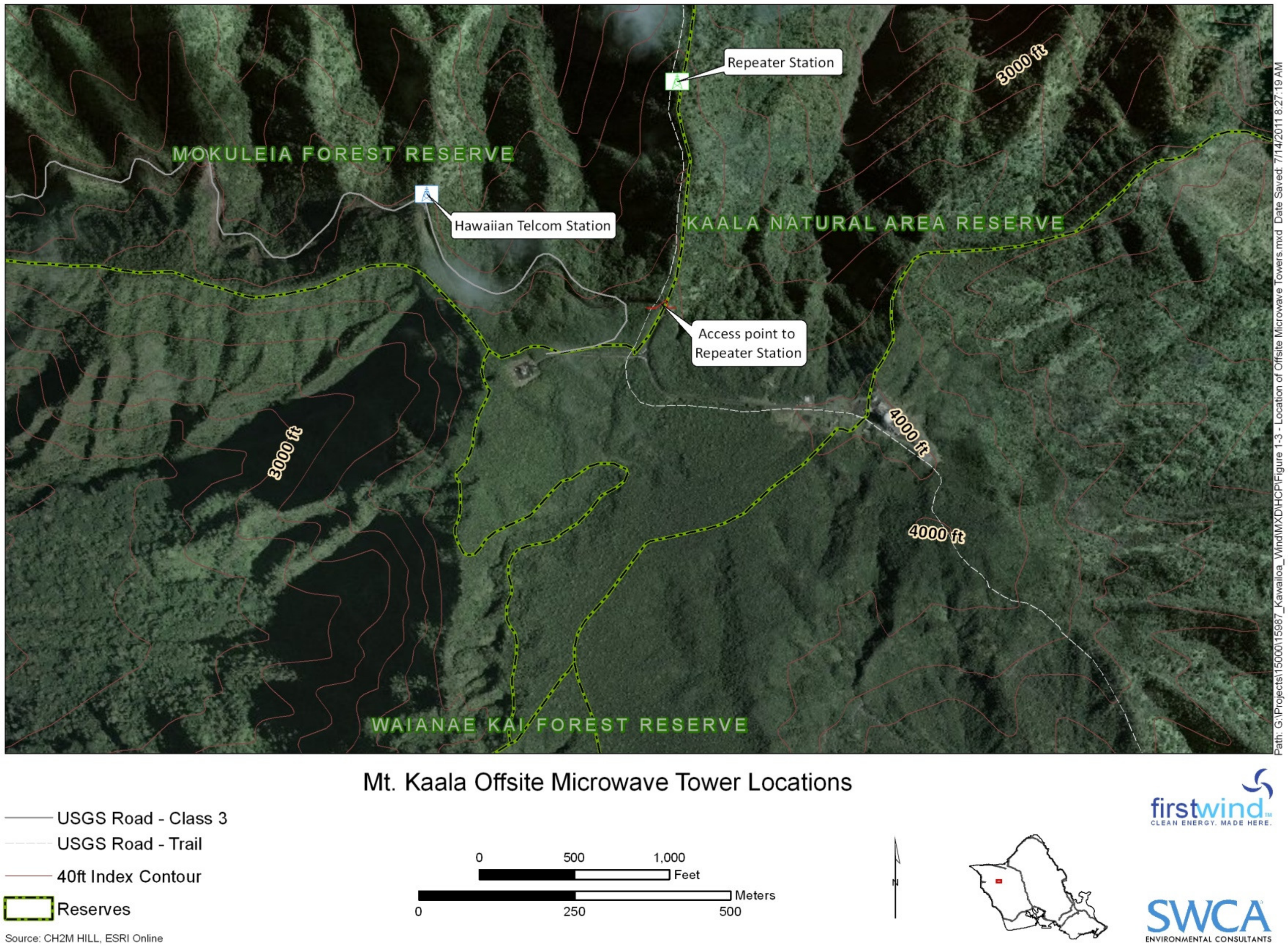


Figure 1-2. Location of Off-site Communication Facilities.

Table 1-1. Areas of Disturbance Associated With Each Project Component (All Areas Are Approximate).

Project Component	Quantity	Description of Area to be Disturbed (ft = feet, ft^2 = square feet)	Total Extent of Disturbance	Permanent Footprint of Facilities
WIND FARM SITE				
Wind turbine generators	30 turbines	Wildlife search areas = 9.9 acres per turbine (370 foot radius) [a] Temporary work area = 2.9 acres per turbine (200 foot radius) Permanent foundation = 2,800 ft^2 per turbine (30 foot radius)	251.0 acres [a]	1.9 acres
Electrical collector lines [b]	4.0 miles of overhead lines [c] (approximately 78 poles)	Corridor width = 50 feet Footprint = 5 ft x 5 ft (25 ft^2) per pole	12.6 acres	0.04 acre
	7.2 miles of underground lines [d]	Corridor width = 3 feet [d]	3.2 acres	--
Electrical substation	1	200 ft x 300 ft = 60,000 ft^2 (1.38 acre)	1.4 acre	1.4 acre
Battery energy storage system	1	100 ft x 250 ft = 25,000 ft^2 (0.57 acre)	0.6 acre	0.6 acre
Interconnection facilities (each includes a control house and communication tower)	2	200 ft x 200 ft = 40,000 ft^2 (0.9 acre)	1.8 acres	1.8 acres
O&M building	1	70 ft x 100 ft = 7,000 ft^2 (0.2 acre)	0.2 acre	0.2 acre
Laydown area	3	350 ft x 375 ft = 131,250 ft^2 (3.0 acres) 350 ft x 375 ft = 131,250 ft^2 (3.0 acres) 420 ft x 725 ft = 304,500 ft^2 (7.0 acres)	13.0 acres	0.5 acre [e]
Meteorological monitoring equipment	2 towers [f]	Wildlife search areas = 1.96 acre per tower (165 foot radius) Foundation = 35 ft x 35 ft (1,225 ft^2)	3.9 acre	0.1 acre
Onsite access roads	4.3 miles of existing access roads to be widened [g]	Width of straight sections = 40 ft Width around turns ≤ 85 ft Permanent width = 16 ft	14.5 acres	2.1 acres
	6.8 miles of new access roads		32.9 acres	13.2 acres
Subtotal			**335.1 acres**	**21.7 acres**

MT. KA`ALA SITE				
Communication equipment at existing Hawaiian Telcom building	Up to 2 microwave antenna dishes	Dish mounted on existing tower (no ground disturbance, tree trimming if needed)	--	--
Communication equipment at existing Hawaiian Telcom repeater station	Up to 2 microwave antenna dishes	Dish mounted on existing tower (no ground disturbance, tree trimming if needed)	--	--
Subtotal			**0 acre**	**0 acre**
ENTIRE PROJECT				
Total			**335.1 acres**	**21.7 acres**

Source: CH2M Hill (2011).

NOTES:

[a] Based on a radius of 370 feet for the search plot around each turbine, the total area of disturbance associated with the turbines would be approximately 296.2 acres. However, approximately 45.2 acres is considered to be unsearchable because of steep topography; therefore, the total area within the search plots is anticipated to be approximately 251.0 acres.

[b] The 46kV connector lines running from the substation to the points of interconnection (POIs) are quantified as part of this category.

[c] Of the 4.0 miles of overhead lines, approximately 1.9 miles associated with the 46kV connector lines would be located along access roads and presumably would fall within the footprint of those features. The calculation of total area disturbed by the overhead lines is based only on the remaining 2.1 miles of lines that are not located along access roads. It is possible that some of these overhead spans would instead be routed underground along access roads; the extent of disturbance associated with placing these lines underground would be equal to or less than those presented in this table.

[d] Of the 7.2 miles of underground lines, approximately 7.1 miles are along access roads, so no additional disturbance is anticipated beyond the 3-foot-wide trench. For the 0.1 mile of line that is not located along an access road, temporary disturbance is expected to occur within a 50-foot-wide corridor.

[e] The permanent footprint of the laydown areas would include the parking area for the O&M building, water tank storage, and septic system.

[f] A total of four potential meteorological monitoring tower locations have been identified; up to two permanent towers would be installed in a subset of these locations. In addition, four temporary towers would also be installed, but would be located within the work areas for the wind turbines, so there would be no additional disturbance area.

[g] The calculation of total area disturbed by the onsite access roads assumes the primary access roads leading up to the turbines (approximately 8.2 miles) would be improved, but not widened, and therefore would not have any additional area of disturbance. The existing access roads between the turbine strings would be temporarily widened up to 40 feet to allow for movement of the construction crane; these roads are assumed to have an average existing width of 12 feet. Therefore, the total area to be temporarily disturbed would be equal to the road length (4.3 miles) multiplied by an average increase in width of 28 feet (40 feet minus 12 feet). The permanent footprint would be equal to the road length (4.3 miles) multiplied by an average increase in the footprint of 4 feet (16 feet minus 12 feet).

These seven Federally or State-listed species are known to, or may have potential to, fly in the vicinity of the project area and could be injured or killed if they collide with WTGs or other project components. Adjusted take estimates at Kawailoa Wind Power for all listed species consider both direct and indirect take. Direct take comprises individuals that are killed or injured colliding with WTGs, the permanent unguyed met towers, construction vehicles or equipment, or other project components. Indirect take accounts for the fact that listed adults that are killed or injured by project components could be in the process of tending to eggs, nestlings or dependent young.

Thus, the loss of these adults would also lead to the loss of eggs or dependent young, which would be attributable to the proposed project.

The Applicant is seeking an Incidental Take Permit (ITP) in accordance with Section 10(a)(1)(B) of the Federal Endangered Species Act (ESA) of 1973, as amended, and an Incidental Take License (ITL) in accordance with Chapter 195-D of Hawaiʽi Revised Statutes. These permits are issued by the U.S. Fish and Wildlife Service (USFWS) and Hawaii Department of Land and Natural Resources (DLNR), respectively. The requested take for Kawailoa Wind Power is tiered to accommodate a range of take levels and are summarized in the table below (Table 1-2).

Table 1-2. Requested Take Levels for Covered Species.

Covered Species	Level of Take	Requested Authorization
		20-Yr Limit
Newell's Shearwater	Tier 1 Tier 2	3 adults/ immatures and 2 chicks/eggs 6 adults/ immatures and 3 chicks/eggs
Hawaiian Duck	Tier 1 Tier 2	4 adults/ immatures and 4 ducklings 6 adults/ immatures and 6 ducklings
Hawaiian Stilt	Tier 1 Tier 2	8 adults/ immatures and 4 fledglings 12 adults/ immatures and 6 fledglings
Hawaiian Coot	Tier 1 Tier 2	8 adults/ immatures and 4 fledglings 12 adults/ immatures and 6 fledglings
Hawaiian Moorhen	Tier 1 Take by capture from trapping Tier 2 Take by capture from trapping	8 adults/ immatures and 4 fledglings 50 individuals 12 adults/ immatures and 6 fledglings 50 individuals
Hawaiian Short-Eared Owl	Tier 1 Tier 2	4 adults/ immatures and 4 owlets 6 adults/ immatures and 6 owlets
Hawaiian Hoary Bat	Tier 1 Tier 2 Tier 3	16 adults/ immatures and 8 juveniles 32 adults/ immatures and 16 juveniles 48 adults/ immatures and 24 juveniles

This HCP supports the issuance of these permits, and describes how the Applicant will avoid, minimize, mitigate and monitor the incidental take of threatened and endangered species that may occur during construction and operation of the proposed project. The general and species-specific mitigation measures the Applicant is proposing are intended to increase knowledge of the species' biology and distribution, enhance populations, or restore degraded native habitat. Mitigation measures are required to provide a net benefit to the species as required under State law. Mitigation measures are briefly summarized in the table below (Table 1-3) for the Covered Species.

Table 1-3. Mitigation Measures for the Covered Species.

Species	Proposed Mitigation by Measured Take Level	
	Tier 1	Tier 2 or Above
Seabirds	Development and testing of self-resetting cat trap, efficacy testing and implementation at a Newell's shearwater colony on Kaua'i.	Contribution to a restoration fund for predator control, social attraction and translocation of Newell's shearwaters to Kaho'olawe.
Waterbirds	Predator control, fencing, and vegetation maintenance at 'Uko'a Pond or other site for five years plus MOA between First Wind and the landowner for long-term commitment to management of pond for waterbirds. Subsequent mitigation efforts to meet Tier 1 requested take as required.	Additional mitigation efforts at 'Uko'a Pond or at additional wetlands.
Hawaiian short-eared owl	Upfront contribution of $12,500 for research and rehabilitation and up to a maximum of $25,000 to implement management strategies if/as they becomes available.	Additional funding of $6,250 for research and rehabilitation and up to a maximum of $12,500 to implement management strategies.
Hawaiian hoary bat	Restoration of wetland or forest habitat to increase foraging capacity and provide additional roost trees. Research to evaluate the efficacy of wetland or forest mitigation.	Tier 2 and Tier 3: Additional restoration of wetland or forest habitat to increase foraging capacity and provide additional roost trees.

Additionally, the HCP outlines a monitoring protocol to determine the actual take of each species after the facility begins operating. Most importantly, this HCP incorporates adaptive management provisions to allow for modifications to the mitigation and monitoring measures as knowledge is gained during implementation.

1.2 Applicant Background

Kawailoa Wind Power LLC is a subsidiary of First Wind, a Boston-based wind energy generation firm. Kawailoa Wind Power LLC was created for the express purpose of developing a new wind generation facility in Kawailoa, O'ahu. The principals of First Wind are among the country's leading wind power developers with extensive experience in financing, constructing, operating, and managing large wind energy projects in the United States. In Hawai'i, First Wind operates Kaheawa Wind Power I (30 MW) on Maui, and Kahuku Wind Power (30 MW) on O'ahu and has begun construction of Kaheawa Wind Power II on Maui.

1.3 Regulatory Context

1.3.1 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 designated as threatened or endangered and conserves the ecosystem on which the species depend. Candidate species, which may be listed in the near future, are not afforded protection under the ESA.

Section 9 of the ESA prohibits the unauthorized "take" of any endangered or threatened species of fish or wildlife listed under the ESA. Under the ESA, the term "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. "Harm" in the definition of "take" in the ESA means 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" in the definition of take in the ESA means 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).

The USFWS may permit, under certain terms and conditions, any taking otherwise prohibited by Section 9 of the ESA if such taking is incidental to the carrying out of an otherwise lawful activity. To apply for an ITP, an applicant must develop, fund and implement a USFWS-approved HCP to minimize and mitigate the effects of the incidental take. Such take may be permitted provided the following issuance criteria of ESA Section 10(a)(1)(B) and 50 CFR §17.22(b)(2) and 50 CFR §17.32(b)(2) are met:

- The taking will be incidental.
- The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such takings.
- The applicant will ensure that adequate funding for the conservation plan and procedures to deal with unforeseen circumstances will be provided.
- The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild.
- Other necessary or appropriate measures required by the Secretary of the Interior, if any, will be met.

To obtain an ITP, an applicant must prepare a supporting HCP that provides the following information described in ESA Section 10(a)(2)(A) and 50 CFR 17.22(b)(1) and 50 CFR §17.32(b)(1):

- The impact that will likely result from such taking.
- The measures the applicant will undertake to monitor, minimize, and mitigate such impacts, the funding that will be available to implement such measures, and the procedures to be used to deal with unforeseen circumstances.
- The alternative actions to such taking the applicant considered and the reasons why such alternatives are not proposed to be utilized.
- Such other measures that the Director of the USFWS may require as necessary or appropriate for purposes of the plan.

The *Habitat Conservation Planning and Incidental Take Permit Processing Handbook*, published by the USFWS and the National Marine Fisheries Service (NMFS) in November 1996, provides additional policy guidance concerning the preparation and content of HCPs. The USFWS and NMFS published an addendum to the *HCP Handbook* on June 1, 2000 (65 FR 35242) (USFWS and NOAA 2000). This addendum, also known as the Five-Point Policy, provides clarifying guidance for the two agencies in issuing ITPs and for those applying for an ITP under Section 10. The five components addressed in the policy are discussed briefly below:

Biological Goals and Objectives: HCPs must include biological goals (broad guiding principles for the conservation program – the rationale behind the minimization and mitigation strategies), and biological objectives (the measurable targets for achieving the biological goals). These goals and objectives must be based on the best scientific information available and are used to guide conservation strategies for species covered by the plan.

Adaptive Management: The Five-Point Policy encourages the development of adaptive management plans as part of the HCP process under certain circumstances. Adaptive management is an integrated method for addressing biological uncertainty and devising alternative strategies for meeting biological goals and objectives. An adaptive management strategy is essential for HCPs that would otherwise pose a significant risk to the Covered Species due to significant information gaps.

Monitoring: Monitoring is a mandatory element of all HCPs under the Five-Point Policy. As such, an HCP must provide for monitoring programs to gauge the effectiveness of the plan in meeting the biological goals and objectives, and to verify that the terms and conditions of the plan are being properly implemented.

Permit Duration: Under existing regulations, several factors are used to determine the duration of an ITP, including the duration of the applicant's proposed activities and the expected positive and negative effects on Covered Species associated with the proposed duration. Under the Five-Point Policy, the USFWS will also consider the level of scientific and commercial data underlying the proposed operating conservation program, the length of time necessary to implement and achieve the benefits of the operating conservation program, and the extent to which the program incorporates adaptive management strategies.

Public Participation: Under the Five-Point Policy guidance, the USFWS announced its intent to expand public participation in the HCP process to provide greater opportunity for the public to assess, review, and analyze HCPs and associated documentation (e.g., National Environmental Policy Act [NEPA] review). As part of this effort, the USFWS has expanded the public review process for most HCPs from a 30-day comment period to a 60-day period.

1.3.2 Federal 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 to reach a decision that reflects NEPA's mandate to strive for harmony between human activity and the natural world. Although the requirements of the ESA and NEPA overlap considerably, the scope of NEPA exceeds the ESA by considering impacts of a Federal action on non-wildlife resources, such as water quality, air quality and cultural resources.

Issuance of an ITP is a Federal action subject to compliance with the National Environmental Policy Act (NEPA). Therefore, the USFWS will prepare and provide for public review an Environmental Assessment (EA) to evaluate the potential environmental impacts of issuing an ITP and approving the implementation of the proposed Kawailoa HCP. The purpose of the EA is to determine if ITP issuance and HCP implementation will significantly affect the quality of the human environment. If the USFWS determines significant impacts are likely to occur, a comprehensive Environmental Impact Statement (EIS) for the proposed action will be prepared and distributed for public review; otherwise, a Finding of No Significant Impact (FONSI) will be issued. The USFWS will not make a decision on ITP issuance until after the NEPA process is complete.

1.3.3 Federal 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.*). A list of birds protected under MBTA implementing regulations is provided at 50 CFR §10.13. 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)."

The MBTA provides no process for authorizing incidental take of MBTA-protected birds (USFWS and NMFS 1996). However, if the HCP is approved and USFWS issues an ITP to the Applicant, the terms and conditions of that ITP will also constitute a Special Purpose Permit under 50 CFR §21.27 for the take of the Newell's shearwater, Hawaiian stilt, Hawaiian coot, Hawaiian moorhen, and Hawaiian duck and Hawaiian short-eared owl under the MBTA. Therefore, subject to the terms and conditions to be specified in the ITP, if issued, any such take of the six listed bird species also will not be in violation of the MBTA. However, because the MBTA provides for no incidental take authorization, other MBTA-protected birds that are not protected by the ESA and that may be adversely affected by the proposed wind facility will not be covered by any take authorization.

To avoid and minimize impacts to MBTA-protected species, Kawailoa Wind Power LLC has incorporated design and operational features based on the Wind Turbines Guidelines Advisory Committee Recommendations (2010). This document aims to guide policy issues and provides science-based technical advice on how best to assess and prevent adverse impacts to wildlife and their habitats related to land-based wind energy facilities. Specific site development and construction best management practices (BMPs) that have been adopted by Kawailoa Wind Power to avoid and reduce the potential for impacts to MBTA-protected species are detailed in Table 5-1.

1.3.4 Federal National Historic Preservation Act (16 U.S.C. 470-470b, 470c-470n)

USFWS issuance of an ITP under ESA Section 10(a)(1)(B) is considered an "undertaking" covered by the Advisory Council on Historic Preservation and must comply with Section 106 of the National Historic Preservation Act (NHPA) (36 CFR §800). The undertaking is defined as the land-use activity that may proceed once an ITP is issued to an Applicant. Section 106 requires USFWS to assess and determine the potential effects on historic properties that would result from the proposed undertaking and to develop measures to avoid or mitigate any adverse effects. Accordingly, USFWS must consult with the Advisory Council on Historic Preservation, the State Historic Preservation Officer (SHPO), affected Tribes, the applicant, and other interested parties, and make a good-faith effort to consider and incorporate their comments into project planning.

The USFWS will determine the "area of potential effects" associated with the proposed undertaking, which is usually defined as the geographic area where the undertaking may directly or indirectly change the character or use of historic properties included in or eligible for inclusion in the National Register of Historic Places. The USFWS generally interprets the area of potential effects as the specific location where incidental take may occur and where ground-disturbing activities may affect historic properties. The USFWS, in consultation with the SHPO, must make a reasonable and good-faith effort to identify undiscovered historic properties. The USFWS also determines the extent of any archeological investigations that may be required; however, the cost of NHPA compliance rests with the Applicant.

1.3.5 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 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 Incidental Take 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.

To qualify for an ITL, the following must occur:

- The Applicant minimizes and mitigates the impacts of the take to the maximum extent practicable (i.e., implements a Habitat Conservation Plan [HCP]).
- The Applicant guarantees that adequate funding for the HCP will be provided.
- The Applicant posts a bond, provides an irrevocable letter of credit, insurance, or surety bond, or provides other similar financial tools, including depositing a sum of money in the endangered species trust fund created by §195D-31, or provides other means approved by BLNR, adequate to ensure monitoring of the species by the State and to ensure that the applicant takes all actions necessary to minimize and mitigate the impacts of the take.
- The plan increases the likelihood that the species will survive and recover.
- The plan takes into consideration the full range of the species on the island so that cumulative impacts associated with the take can be adequately assessed.
- The activity permitted and facilitated by the license to take a species does not involve the use of submerged lands, mining or blasting.
- The cumulative impact of the activity, which is permitted and facilitated by the license, provides net environmental benefits.
- The take is not likely to cause the loss of genetic representation of an affected population of any endangered, threatened, proposed or candidate plant species.

Section 195D-4(i) directs DLNR to work cooperatively with Federal agencies in concurrently processing HCPs, ITLs and ITPs. Section 195D-21 deals specifically with HCPs and its provisions are similar to those in Federal regulations. According to this section, HCPs submitted in support of an ITL application shall:

- Identify the geographic area encompassed by the plan; the ecosystems, natural communities, or habitat types within the plan area that are the focus of the plan; and the endangered, threatened, proposed, and candidate species known or reasonably expected to be present in those ecosystems, natural communities, or habitat types in the plan area.
- Describe the activities contemplated to be undertaken within the plan area with sufficient detail to allow the department to evaluate the impact of the activities on the particular ecosystems, natural communities, or habitat types within the plan area that are the focus of the plan.
- Identify the steps that will be taken to minimize and mitigate all negative impacts, including without limitation the impact of any authorized incidental take, with consideration of the full range of the species on the island so that cumulative impacts associated with the take can be adequately assessed; and the funding that will be available to implement those steps
- Identify those measures or actions to be undertaken to protect, maintain, restore, or enhance the ecosystems, natural communities, or habitat types within the plan area; a schedule for implementation of the measures or actions; and an adequate funding source to ensure that the actions or measures, including monitoring, are undertaken in accordance with the schedule.
- Be consistent with the goals and objectives of any approved recovery plan for any endangered species or threatened species known or reasonably expected to occur in the ecosystems, natural communities, or habitat types in the plan area.

- Provide reasonable certainty that the ecosystems, natural communities, or habitat types will be maintained in the plan area throughout the life of the plan in sufficient quality, distribution, and extent to support within the plan area those species typically associated with the ecosystems, natural communities, or habitat types, including any endangered, threatened, proposed and candidate species known or reasonably expected to be present in the ecosystems, natural communities, or habitat types within the plan area.

- Contain objective, measurable goals, the achievement of which will contribute significantly to the protection, maintenance, restoration or enhancement of the ecosystems, natural communities, or habitat types; time frames within which the goals are to be achieved; provisions for monitoring (such as field sampling techniques), including periodic monitoring by representatives of the department or the ESRC, or both; and provisions for evaluating progress in achieving the goals quantitatively and qualitatively.

- Provide for an adaptive management strategy that specifies the actions to be taken periodically if the plan is not achieving its goals.

In addition to the above requirements, all HCPs and their actions authorized under the plan should be designed to result in an overall net benefit to the threatened and endangered species in Hawai'i (Section 195D-30).

Section 195D-25 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. The Applicant has met with the ESRC several times during the preparation of this HCP.

Following preparation of the plan, the proposed plan and the application must be made available for public review and comment no less than 60 days prior to approval. If the plan is approved by BLNR, participants in the plan shall submit an annual report to the department within 90 days of each fiscal year ending June 30, that includes a description of activities and accomplishments, analysis of the problems and issues encountered in meeting or failing to meet the objectives set forth in the HCP, areas needing technical advice, status of funding, and plans and management objectives for the next fiscal year (§195D-21).

1.3.6 Hawai'i Revised Statutes, Chapter 343

Chapter 343, Hawaii Revised Statutes (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, HRS). Kawailoa Wind Power LLC will comply with Chapter 343 for any actions conducted under this Habitat Conservation Plan as required by law.

Because the project is being permitted pursuant to the State's HRS Chapter 201N Energy Facility Siting Process, an Environmental Impact Statement (EIS) is being prepared for the project with the Department of Business, Economic Development and Tourism (DBEDT) as the accepting authority. The Draft Environmental Impact Statement Preparation Notice (EISPN) was released for public comment on September 23, 2010. Following the end of the 30-day public review period for the EISPN, Kawailoa Wind Power LLC incorporated comments on the EISPN into a Draft Environmental Impact Statement (DEIS), which was released for public comment on February 23, 2011. The DEIS described and discussed the likely direct, indirect, and cumulative impacts of the proposed project, as well as mitigation measures. The public comment period for the DEIS will lasted for 45-days as provided by law. A Final Environmental Impact Statement (FEIS) that incorporates and responds to all comments on the DEIS was submitted to the DBEDT for review and accepted on June 27, 2011.

1.4 Project Description

1.4.1 Project History

First Wind obtained a lease from Kamehameha Schools for approximately 4,200 ac (1,700 ha) of land within the former Kawailoa Plantation for the project area. Four temporary 60-meter guy wire-supported met towers were installed on the property between August and December 2009 to collect wind resource data. One met tower was dismantled and moved to a new location in June 2010 and was then removed in September 2010. Another met tower was removed in January 2011. There are currently two temporary met towers on site. The project was granted Temporary Use Approvals by the City and County of Honolulu's Department of Planning and Permitting on August 10, 2008, September 18, 2009, and April 21, 2010. A Power Purchase Agreement is being negotiated with HECO. An Interconnect Requirements Study (IRS) with HECO is ongoing.

1.4.2 Project Design and Components

The Kawailoa Wind Power wind energy generation facility will consist of 30 WTGs, each with its own turbine pad (i.e., an associated work area used for component laydown during construction, and for maintenance during operations). Each turbine site will consist of:

- a pad-mounted transformer
- a power distribution panel
- a turbine tower: The towers proposed are approximately 328 ft (100 m) in height. The proposed rotor blade lengths are approximately 166 ft (50.5 m). Thus, the maximum height of the turbines from tower base to highest blade tip will be 493 ft (150.5 m).
- a gravel access drive and buffer area
- an area roughly 200 ft (61 m) in radius surrounding each turbine site that will be temporarily disturbed during construction of the turbine components
- a poured concrete foundation area of approximately 2,800 ft^2 (260 m^2),
- a search plot area up to 9.9 ac.: The search plot will extend out up to 370 ft radius (113 m), depending on topography, and will be managed long term to maintain short stature vegetation to facilitate downed wildlife searches.

The turbines will be arranged in several arrays along the ridge tops within the project area (Figure 1-1).

Up to two permanent met towers will be erected during construction and remain for the duration of the project and each will consist of:

- a lattice unguyed tower 328 ft (100 m) tall
- a search plot area up to 1.96 ac, extending out to 165 ft radius (50 m) that will be managed long term to maintain short stature vegetation to facilitate downed wildlife searches

Other project components include: an operations and maintenance (O&M) building, Battery Energy Storage System (BESS) enclosure, two interconnection facilities and one electrical substation.

The single-story O&M building will:

- house operation personnel, wind generating facility controls, and maintenance equipment and spare parts
- will be 7,000 ft^2 (650 m^2) and have a maximum height of 30 ft (8 m)
- be surrounded by a temporary 1.4 ac. laydown area

The electrical substation will:

- feed electricity into an existing HECO electrical transmission line
- have a maximum footprint of approximately of 1.4 acre (60,000 square feet)
- have free standing steel structures up to a maximum height of 50 ft.

The proposed BESS enclosure will:

- consist of an approximately 14,040 ft^2 (1,304 m^2) building roughly 25 ft (7.6 m) high to house the components of the BESS and the HECO Control Room

The two interconnection facilities will:
- each have a control house and communication tower occupying 40,000 ft^2 (3716 m^2)

The communications towers will:

- have up to two antennae mounted on each tower. The communications tower located at the substation (see inset for Figure 1-1, will be up to 150 ft (46 m), while the other will be approximately 50 - 60 ft (15.3 - 18.2 m) tall.
- The remaining antennae will be installed offsite at two other existing communication towers at Mount Kaʻala on State conservation land currently leased by Hawaiian Telcom (Figure 1-3). One tower is located near the existing Hawaiian Telcom communications building, roughly 8 mi (12.9 km) from the Kawailoa project area. The second new microwave facility is located at the existing Hawaiian Tel repeater antenna on a nearby ridge. Communications equipment will be installed on existing lattice structures at both off-site locations.
- Access to, as well as radar and communications activities within the Mt. Kaʻala area are managed by the multi-agency Kaʻala Joint Use Coordination Committee (JUCC), which includes representatives from the U.S. Armed Services. A Conservation District Use Permit will also be required for the mounting of the antennae.

Electricity generated by the WTGs will be transformed to 23 kV, collected through a network of underground and overhead collection circuits and delivered to an electrical substation. At the substation, the voltage will be transformed to 46 kV and delivered to two interconnection facilities or "switchyards," both of which will be connected to existing 46 kV transmission lines which cross the site and are owned and maintained by Hawaiian Electric Company. The 50 MW switchyard will be connected to the 46 kV Waialua-Kuilima transmission line, and the 20 MW switchyard will be connected to the 46 kV Waialua-Kahuku transmission line via a new 46 kV overhead connector line. The higher-voltage 46 kV connector lines will be installed on approximately 60-foot-high poles, as specified by HECO, and will be spaced at an average interval of approximately 250 - 350 ft (76 – 107 m). No new transmission lines will be constructed as part of the project. A total of 4.0 miles (6.4 km) of overhead lines will be erected on 45-ft (13.7 m) high wooden utility poles spaced 200 – 300 ft (61 – 91 m) apart. An additional 7.2 miles (11.6 km) of line will be underground (Table 1-1). Any underground collection cables will be buried in trenches and backfilled to finish grade. Disturbed areas will be revegetated following excavation and burying of cables.

The project will have a permanent footprint of 22.0 ac. (including existing access roads) after disturbing approximately 335 ac. during construction; 259 ac. of the disturbed area are likely to remain under long term vegetation management due to the maintenance of search plot areas under turbines and permanent met towers for downed wildlife monitoring (Table 1-1). Figure 1-1 shows the layout of the various project components, within a series of corridors which cumulatively represent the maximum extent of the project footprint. The footprint was developed based on the distribution of wind resources and other site constraints such as topography and military flightlines. Since the development of the project footprint, the location of a few of the project components were revised (such as the location of the proposed overhead lines) and now extend beyond the limits of the footprint presented. However, these areas were already included in the botanical and wildlife studies conducted and the analyses of the potential impacts of this project also include these areas (CH2M Hill 2011a, b).

<u>1.4.3 Purpose and Need for Kawailoa Wind Power Project</u>

The purpose of the proposed Kawailoa Wind Power project is to provide an alternative energy source on Oʻahu that is renewable. The Hawaiian Islands are largely dependent on imported petroleum, with over 90% of its energy needs supplied from fossil fuels brought from outside of the State (Global Energy Concepts LLC 2006; Rocky Mountain Institute 2008). Approximately $2 billion to $3 billion worth of oil is imported to the State annually (S.B. 2474, S.D. 3, H.D. 2). Oʻahu in particular consumes the vast majority of the State's electricity, but generates little electricity from renewable sources. Furthermore, fossil fuel pricing has been historically volatile; fuel prices are subject to fluctuation based on supply and demand conditions, as well as political concerns that can affect the long term availability of world supply. Reducing the proportion of energy that comes from fossil fuel would also buffer the system from the energy cost fluctuations that accompany volatile oil prices**.**

In an effort to reduce imports and oil consumption, the State developed Hawai'i's Renewable Portfolio Standards (S.B. 2474, S.D. 3, H.D. 2) and HRS §269-92, which established renewable energy portfolio standards for Hawai'i's electric utilities. According to the renewable portfolio standards established in HRS §269-92, each electric utility company that sells electricity for consumption in the State shall establish a renewable portfolio standard of:

(1) 10% of its net electricity sales by December 31, 2010
(2) 15% of its net electricity sales by December 31, 2015
(3) 20% of its net electricity sales by December 31, 2020

In January 2008, the State of Hawai'i and the U.S. Department of Energy (DOE) signed an agreement to establish the Hawai'i Clean Energy Initiative (HCEI), which strives to have 70% clean, renewable energy for electricity and transportation by 2030. This goal has the potential of reducing Hawai'i's current crude oil consumption by 72% (State of Hawai'i and USDOE 2008).

To meet the goals of energy independence and sustainability, renewable energy alternatives need to be developed in Hawai'i. Several wind energy facilities are already operating in the State and new facilities are currently being proposed (Table 1-4). The proposed Kawailoa Wind Power project will help the State move toward these goals.

Table 1-4. Existing and Potential Wind Energy Facilities throughout Hawai'i.

Facility Name	Operator	Energy Generated	Island
Lalamilo Wind Farm replacement (P)	Hawaii Electric Light Company	N/A	Hawaii
Pakini Nui	Tawhiri Power, LLC	20.5 MW	Hawaii
Upolu Point	Hawi Renewable Development	10.5 MW	Hawaii
Auwahi Wind Project (P)	Auwahi Wind Energy LLC	21 MW	Maui
Kaheawa Wind Power (KWP)	First Wind	30 MW	Maui
Kaheawa Wind Power (KWP) II (P)	First Wind	22 MW	Maui
Kahuku Wind Power	First Wind	30 MW	Oahu
Kawailoa Wind (P)	First Wind	70 MW	Oahu
Na Pua Makani (P)	Oahu Wind Partners LLC	25 MW	Oahu
Unknown (P)	Castle & Cooke	300 MW	Lanai
Kauai Wind Power (P)	UPC Kaui Wind Power	10.5 – 15 MW	Kauai
(P) = Potential wind facility DBEDT (2011)			

Furthermore, reducing the consumption of fossil fuel for energy generation would also benefit the environment in a number of ways. The most important of these is the reduction in air pollutant emissions associated with the combustion of fossil fuels, such as carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_X). These gases are known to contribute to various undesirable environmental effects, including global warming and acid rain. Additionally, it has been shown that these gases are detrimental to human health and the health of other living organisms. According to the U.S. Department of Energy (DOE), a "single 1.5 MW wind turbine displaces 2,700 metric tons of

CO_2 per year compared with the current U.S. average utility fuel mix” (Wind Turbine Guidelines Advisory Committee 2010). Wind energy technology also reduces water use (U.S. Department of Wind Energy 2008). Additional emission reductions will stem from the elimination of the need to transport petroleum fuels from distant ports to the island.

1.5 List of Preparers

This HCP was prepared by Ling Ong, Jaap Eijzenga, Tiffany Thair, Carolyn Unser, Jason Balmut and John Ford of SWCA Environmental Consultants. Reviewers include Dave Cowan of First Wind, and the input and guidance provided by Sandee Hufana and Scott Fretz of DLNR, Aaron Nadig, Megan Laut and Patrice Ashfield of USFWS, as well as members of the ESRC is gratefully acknowledged.

2.0 DESCRIPTION OF HABITAT CONSERVATION PLAN

2.1 Purpose of this HCP

The construction and operation of the Kawailoa Wind Power wind energy generation facility could potentially adversely impact six Federally listed species and one State-listed species that are known or presumed to fly in the vicinity of the project area. These species have the potential to collide with the turbine towers, or be struck by the rotors, resulting in injury or mortality. These species also may collide with guy wires supporting any of the temporary met towers, with the permanent unguyed met towers, with communication towers, with the overhead collection lines, or may also be harmed by the operation of vehicles or heavy equipment during construction or operations. Of the seven species, six are birds: Newell's shearwater or ʻaʻo, Hawaiian duck or koloa maoli, Hawaiian stilt or aeʻo, Hawaiian coot or ʻalae keʻokeʻo, Hawaiian common moorhen or ʻalae ʻula, and the State-endangered Hawaiian short-eared owl or pueo. The seventh species is a mammal, the endangered Hawaiian hoary bat or ʻopeʻapeʻa.

These species are protected under the ESA, as amended, or as a State-listed species in the case of the Hawaiian short-eared owl. Because of the documented presence of these species at or near the proposed facility and the anticipated take in connection with construction and operation of the proposed project, the Applicant has filed an application for an ITP in accordance with Section 10(a)(1)(B) of the ESA and an ITL pursuant to HRS Chapter 195-D. This HCP has been prepared to fulfill application requirements for these permits. Upon issuance of the ITP and ITL, Kawailoa Wind Power LLC will be authorized for the incidental take of a limited number of individuals of these Covered Species in connection with the otherwise lawful construction and operation of the proposed Kawailoa Wind Power facility.

The purpose of this HCP also includes the following:

1. To make the most supportable determinations as to the potential impact that the wind energy generation facility could have on each of these listed species.
2. To discuss alternatives to the proposed facility and its design, in terms of these impacts.
3. To propose appropriate efforts to minimize, mitigate, and monitor these potential impacts to the maximum extent practicable.
4. To ensure funding for the completion of these efforts.
5. To provide for adaptive management and adjustment of the above measures as determined during implementation of the HCP.

2.2 Scope and Term

This HCP seeks to offset the potential impact of the proposed wind energy generation facility on the Covered Species with measures that protect and provide a net benefit to these species islandwide and statewide. The Applicant anticipates a 20-year project life, throughout which this HCP would be in effect. With monitoring and review by the USFWS and DLNR, the provisions for adaptive management will allow for the mitigation of project impacts to be adjusted appropriately. Accordingly, this HCP includes provisions for post-construction monitoring and adaptive management to allow flexibility and responsiveness to new information over the life of the project. Monitoring and adaptive management will be coordinated with USFWS and DLNR.

2.3 Surveys and Resources

The following sources were used in the preparation of this HCP:

- General information on the project description and the site's physical environmental setting were summarized from the Environmental Impact Statement Preparation Notice (CH2M Hill 2010), Draft Environmental Statement (CH2M Hill 2011a) and Final Environmental Statement (CH2M Hill 2011b).
- Information on endangered species interaction with wind turbines at the operating Kaheawa facility on Maui

- Surveillance radar and audio-visual sampling occurred at two locations within the project area in summer and fall 2009 (Cooper et al. 2011a, Appendix 3a) and in summer 2011 (Cooper and Sanzenbacher 2011, Appendix 3b).
- Monthly on-site and off-site avian surveys were conducted by SWCA biologists between October 2009 and February 2011 (SWCA 2010a, Appendix 4). Bat activity was also monitored on site with Anabat detectors between October 2009 and April 2011 (Appendix 4) and is on-going.
- Biological assessments of the project area (including flora and fauna) were conducted by Hobdy in February 2010 and August 2010 (Hobdy 2010a, 2010b, Appendix 1a, b). Hobdy also conducted biological surveys at the proposed off-site microwave facility sites (Hobdy 2010c, Appendix 10).
- A wetland assessment was conducted by SWCA on July 1, 8 and 9, 2010, and on September 2010 (SWCA 2010b, Appendix 2).
- An invertebrate survey of the two off-site microwave facility sites was conducted by SWCA biologists on August 14, 2010 to inventory the endangered Hawaiian snails (*Achatinella* spp.) and other native invertebrates present (SWCA 2010c, Appendix 12).

In addition to site-specific surveys, USFWS and DLNR provided unpublished information, data and reports to ensure that all available resources could be considered and evaluated in the preparation of this HCP. Continued coordination with USFWS and DLNR biologists greatly contributed to the preparation of this HCP.

3.0 ENVIRONMENTAL SETTING

3.1 Location, Vicinity, & Climate

The proposed Kawailoa Wind Power facility is located within an approximately 4,200-acre (1,700 hectare) property at Kawailoa in the northern portion of the Island of O‘ahu, Hawai‘i (Figure 1-1). The proposed project is situated east of Hale‘iwa town and south of Waimea Valley in the District of Waialua. It is bounded on the east by military and agricultural lands, and on the west by a rural residential area. The northern boundary abuts conservation land, including Waimea Valley, and additional agricultural land is located to the south. The project area encompasses portions of five parcels (TMKs 6-1-005:001, 6-1-006:001, 6-1-007:001, 6-2-009:001, 6-2-011:001), which are all owned by Kamehameha Schools and designated as an Agricultural District. The project area is accessed by Kawailoa Road or Ashley Road via Kamehameha Highway (Highway 83).

Nearby urban areas include the residential communities of Kawailoa, Hale‘iwa (to the south), and Pūpūkea (beyond Waimea Bay to the north). Pūpūkea is 5.2 mi (8.4 km) to Kawailoa Rd and Kamehameha Hwy intersection. Hale‘iwa is the nearest commercial center, located approximately 1.9 miles (3.1 km) from the project area (Hale‘iwa to Kawailoa Rd /Kamehameha Hwy intersection).

Notable nearby land uses within the vicinity include:

- Kawailoa Training Area: The largest U.S. military training area on O‘ahu, covering 23,348 acres (U.S. Army Environmental Command 2008)
- Kawailoa Refuse Transfer Station
- Waimea Valley: Roughly 1,875-acre valley owned by the Office of Hawaiian Affairs and managed by Hi‘ipaka, a non-profit organization which operates Hawaiian-based recreational and educational activities (http://waimeavalley.net/default.aspx)
- Drum Road: A military access road running along the west slope of the Ko‘olau Range and across the Schofield Plateau (SWCA 2008)

Local climatic conditions at the site are characteristic of lowland areas on the windward side of O‘ahu, with relatively constant temperatures and persistent northeast trade winds. Average monthly temperatures in the area range from 67.3 °F (19.6°C) in January to 76.6 °F (24.8°C) in August (Western Regional Climate Center 2005b). Annual mean precipitation in the area ranges from 22.5 inches (57.2 cm) near the makai (seaward) portion of the project area to slightly over 56 inches (142.2 cm) near the mauka (inland) portion of the project area (Western Regional Climate Center 2005a). Prevailing northeasterly trade winds in the area generally blow from 12.3 to 15.7 miles/hour (AWS Truewind 2004).

3.2 Topography and Geology

The topography of O‘ahu is characterized by broad central valleys in the interior portions and tall, steep slopes on the coastal areas as a result of erosion from wind, rain and sea (Moore 1964; Polhemus 2007). The two mountain ranges, Ko‘olau Mountain Range in the east and the Wai‘anae Mountain Range in the west, are roughly parallel and oriented on a northwest to southeast axis. The project area consists of various ridges gently sloping toward the ocean that are dissected by several small gulches (Hobdy 2010a). Named gulches within the project area include: Ka‘alaea, Kawailoa, Laniākea, and Loko Ea. Elevations range from 200 ft (61.0 m) at the western makai portion of the project area to approximately 1,280 ft (390.1 m) at the eastern mauka side of the project area.

O‘ahu, 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). O‘ahu is mostly composed of the heavily eroded remnants of two large Pliocene shield volcanoes Wai‘anae and Ko‘olau (Juvik and Juvik 1998). The extinct Ko‘olau and Wai‘anae Volcanoes were formed about 2.2 to 2.5 million years ago and 2.7 to 3.4 million years ago, respectively (Juvik and Juvik 1998; Lau and Mink 2006).

The project area is located on the Schofield Plateau, an alluvial fan of erosional unconformity that formed when lava flows from the Ko‘olau Volcano banked against the eroded slope of the Wai‘anae

Volcano (Macdonald et al. 1983). 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 is present in the southern portion of the project area.

3.3 Soils

Various soil types developed throughout the Island of Oʻahu as the basaltic lavas and volcanic ash from the volcanoes 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 shown in Figure 3-1.

The three primary soil types underlying the project area are Helemano silty clay, 30-90% slopes; Wahiawa silty clay, 3-8% slopes; and Leilehua silty clay, 2-6% slopes. The soils in the gulches are of the Rough Mountainous Lands and Rock Lands Series (Foote et al. 1972). According to the NRCS National Hydric Soils List, none of the soils in the project area are considered hydric (NRCS 2010).

Two soil types occur at the communication facility sites: Helemano silty clay, 30-90% slopes and Kemoo silty clay, 30-70% slopes (Foote et al. 1972). These soils are not considered hydric (NRCS 2010).

3.4 Hydrology, Drainage and Water Resources

3.4.1 Surface water

Hydrologic processes in Hawaiʻi are highly dependent on the climatic and geological features, and stream flow is influenced by rainfall and wind patterns. Permeable underlying rock may cause some streams on Oʻahu to have lengthy dry reaches under natural conditions. The majority of the perennial streams on Oʻahu are located in the windward Koʻolau Mountains which produce a larger amount of orographic precipitation compared to the leeward side (Polhemus 2007). The project area is located within six watersheds of the Waialua region on narrow east-west trending lands. The six watersheds from north to south are the: Waimea, Keamanea (includes Kaʻalaea and Laniākea), Kawailoa, Lokoea, and Anahulu. Within these watersheds are several streams, ponds, and wetlands (DAR 2008, DLNR 2011). The Jurisdictional Wetland Boundary Determination in Appendix 2 provides additional detail on these resources (SWCA 2010b).

- Waimea: The Waimea River and its four tributaries – ʻElehāhā, Kaiwikoʻele, Kamananui, and an unnamed tributary - flow near the northern boundary of the project area and discharge into Waimea Bay. Only the unnamed tributary of the Waimea River and the Waimea River mainstream occur within the project parcels. Waimea River is a jurisdictional perennial waterbody and the unnamed tributary is non-perennial probable jurisdictional stream.
- Keamanea: The Kaʻalaea Stream and its tributaries are non-perennial non-jurisdictional areas within the project area. The Laniākea Stream and its major tributaries are non-perennial probable jurisdictional areas within the project area.
- Kawailoa: The Kawailoa Stream and its major tributaries are non-perennial probable jurisdictional areas within the project area.
- Lokoea: The Lokoea Stream is a perennial probable jurisdictional area within the project area.
- Anahulu: The Anahulu River runs near the southern portion of the project area and discharges into Waialua Bay. The jurisdictional Anahulu River has two perennial tributaries, Kawai Nui and Kawai Iki Streams, which join the mainstream immediately mauka of the eastern boundary of the project area. Each of these tributaries is diverted once, supplying water to the Kawai Nui Ditch System (DAR 2008; SWCA 2008). There are several reservoirs associated with the ditch system. Two are located on Anahulu River at 967.6 ft (295 m) and 780.64 ft (238 m) (SWCA 2008).

A former Hawaiian fishpond, ʻUkoʻa Pond, occurs seaward and outside of the project parcels near the intersection of Kawailoa Drive and Kamehameha Highway. The extent of this basal, spring-fed pond

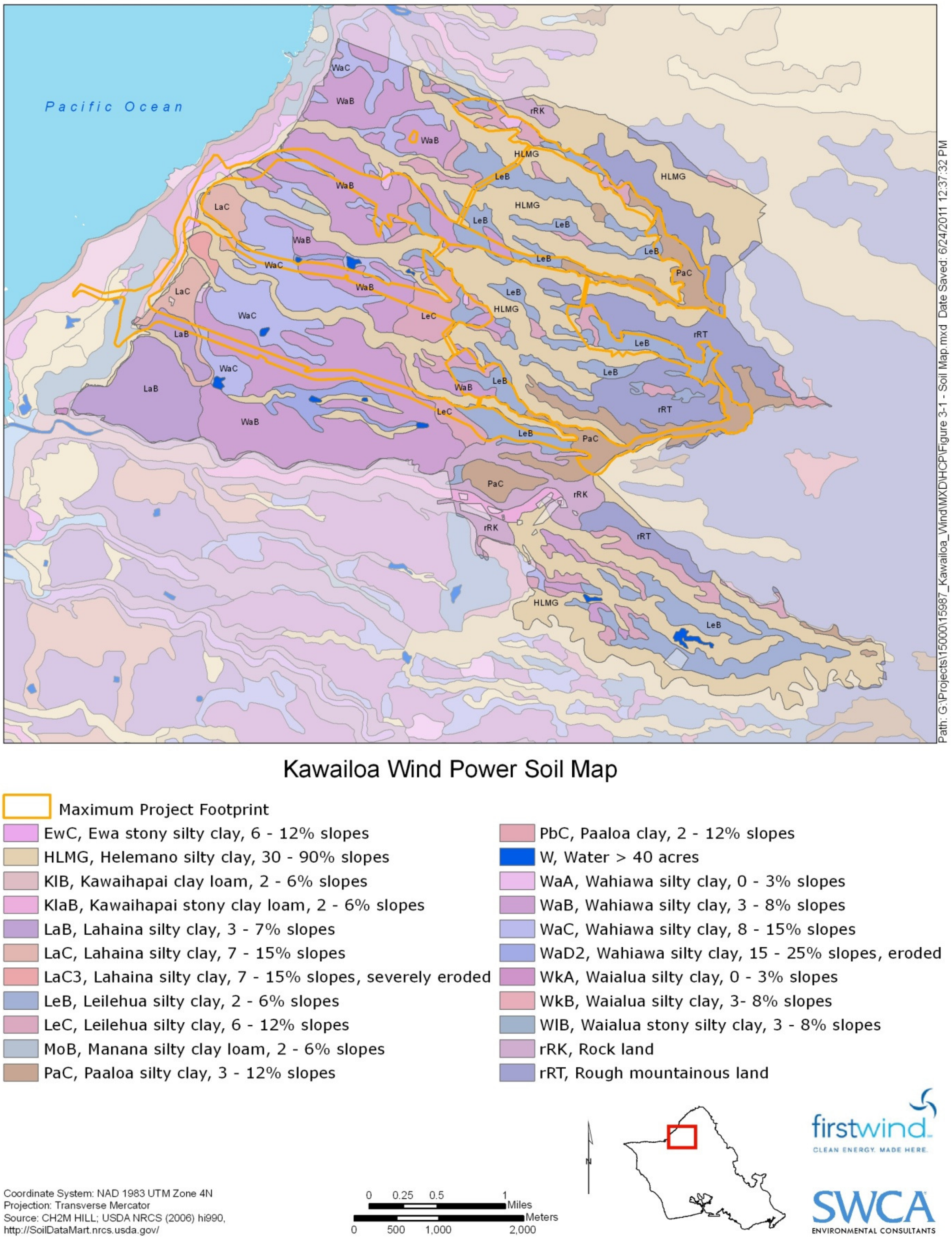


Figure 3-1. Soil Types within the Project Area.

was reduced due to dumping and filing within the old Kawailoa Landfill (Elliott and Hall 1977; Miller et al. 1989). Lokoea is both the name of the waterway that historically drained ʽUkoʽa Pond to the sea at Haleʽiwa Harbor (Miller et al. 1989) and of the influent intermittent gulch above the pond.

Table 3-1. Streams within the Kawailoa project area.

Stream	DAR Watershed	Perennial /Intermittent	Total Length
Waimea	Waimea	Perennial	64.4 mi (103.6 km)
Kaʽalaea	Kaʽalaea	Non-perennial	5 mi (8 km)
Kawailoa	Kawailoa	Non-perennial	9.2 mi (14.9 km)
Laniākea	Laniākea	Non-perennial	7.2 mi (11.6 km)
Loko ea	Lokoea	Perennial	2.2 mi (3.5 km)
Anahulu	Anahulu	Perennial	64.6 mi (103.9 km)
Source: DAR (2008); SWCA (2008, 2010b).			

3.4.2 Flooding

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 project area is almost entirely within Flood Zone D where analysis of flood hazards has not been conducted and flood hazards are undetermined. Near the mouths of several streams (Kawailoa, Laniākea, Lokoea, and Anahulu) the land is identified as Flood Zone X, an area defined as having less than 0.2% annual risk of flood inundation. The proposed mountaintop Mount Kaʽala communications sites are in an area designated by FEMA as unstudied, and therefore has not been classified for flood hazard.

3.4.3 Groundwater

Oʽahu has a vast amount of groundwater, which supplies most of the domestic water supply (Macdonald et al. 1983; Lau and Mink 2006). The project area is located over the north hydrologic sector of the Kawailoa aquifer system (as designated by DLNR 2010). The Kawailoa aquifer system is within the central Oʽahu groundwater flow system (Oki 1998). Groundwater in the Kawailoa aquifer system is thought to drain northwest toward the Waimea coast.

The northern aquifer on the Island of Oʽahu includes three sub-aquifers: Mokulēʽia in the Waiʽanae formation, as well as the Waialua and Kawailoa in the Koʽolau formation. These areas are underlain by a deep wedge of sedimentary caprock that creates thick basal lenses (Hunt 1996). However, the Hawaiʽi Stream Assessment (CWRM 1990) notes that the Kawailoa System, which encompasses the Anahulu River, lacks an effective caprock. This absence of a caprock boundary allows free movement of the groundwater to the ocean (Oki et al. 1999).

In the late 1970s, the USFWS Division of Ecological Services biologists used orthophoto quadrangle maps and spot field checks to map wetlands in Hawaiʽi as a part of the National Wetlands Inventory (NWI) Program according to the Cowardin et al. (1979) classification system. According to the USFWS definition, several wetland types are located within the project area including: Freshwater Pond (PUBH, PUBHh, PUBHx), Riverine (R4SBCx), Freshwater Emergent Wetland (PEM1Cx), and Freshwater Forested/Shrub Wetland (PFO3C) (SWCA 2010b).

SWCA biologists conducted a wetland assessment in the project area to identify any wetlands or other waters subject to U.S. Army Corps of Engineers (USACE) jurisdiction under Section 404 of the Clean Water Act. No wetlands meeting the three established criteria of hydrophilic vegetation, soils, and water regime were found to occur within the areas to be affected by construction and operation of the proposed wind power facility or off-site communications facility (SWCA 2010b, Appendix 2).

3.5 Environmental Contaminants

A phase I Environmental Site Assessment has not yet been prepared for the proposed wind farm area. Operation of the facility will require the use of several materials that require special handling and storage (e.g., mineral oil, hydraulic oil, waste oil, and cleaner/degreaser). More detailed information on these materials will be provided in the EA.

3.6 Land Use Designations

Under The State Land Use Law (Act 187), Hawai'i Revised Statutes Chapter 205, all lands and waters in the State are classified into one of 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 (Hawai'i Administrative Rules, Title 13, Chapter 5).

All of the project area is designated as an Agricultural District (Figure 3-2). Lands to the north and mauka of the project area are designated as Conservation. Lands within a Conservation District are typically utilized for protecting watershed areas, preserving scenic and historic resources, and providing forest, park, and/or beach reserves (subsection 205-2[e] HRS). The communication facility equipment is located on existing towers within a conservation district in the DLNR Mount Ka'ala Natural Area Reserve.

Kawailoa is located in the North Shore Sustainable Communities Plan (NSSCP) area. The NSSCP is one of eight geographically oriented plans intended to guide public policy, investment, and decision-making through 2020. Land use maps within the NSSCP area depict the project area as Agriculture (Helber Hastert & Fee Planners 2009).

In addition, land use is dictated by the Land Use Ordinance 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. 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).

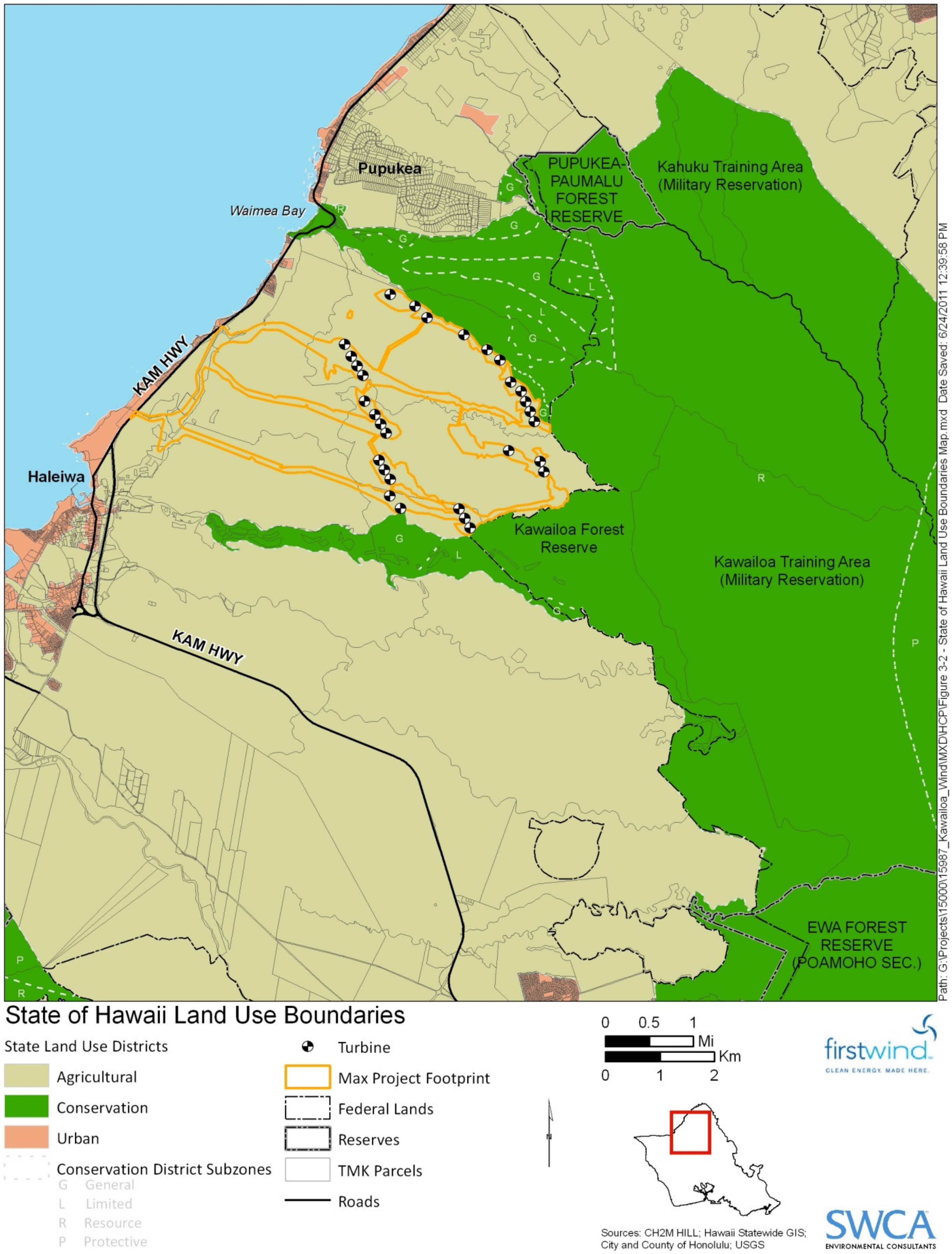


Figure 3-2. **State of Hawai'i Land Use Boundaries Map**.

3.7 Flora

3.7.1 Flora Within the Project Area

Botanical surveys of the project area were conducted by Robert Hobdy in February (Hobdy 2010a) and August 2010 (Hobdy 2010b). Hobdy walked multiple routes throughout the property and more intensively examined areas most likely to support native plants (e.g., gulches, steep slopes, and rocky outcrops). Hobdy recorded approximately 183 plant species within the project area in February (Hobdy 2010a) and an additional 40 species during the survey in August (Hobdy 2010b). 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. No portion of the Kawailoa Wind Power project area has been designated as critical habitat for any listed plant species.

The vegetation in the project area is a mixture of aggressive weedy species that have taken over since the abandonment of sugar cane agriculture. Guinea grass (*Urochloa maxima*) is the most abundant species on the property, forming deep growth on all the ridge tops and in many of the gulches (Hobdy 2010a, b). Other common species include: common ironwood (*Casuarina equisetifolia*), albizia (*Falcataria moluccana*), Formosan koa (*Acacia confusa*), koa haole (*Leucaena leucocephala*), Padang cassia (*Cinnamomum burmanni*), Java plum (*Syzygium cumini*), strawberry guava (*Psidium cattleianum*), cork bark passion flower (*Passiflora suberosa*) and swamp mahogany (*Eucalyptus robusta*). All of these species are non-native to the Hawaiian Islands (Hobdy 2010a, b).

Although the project area is believed to have been forested with a variety of native trees, shrubs, ferns, and vines in Pre-Contact times, few native species persist in the project area today. The lack of native species is attributed to years of agricultural activities and invasion by non-native plant and animal species (Hobdy 2010a, b). Significant remnants of native vegetation occur on steep slopes of the gulches in the upper parts of the property. Thirty native plant species were identified in the project area, of which 13 are endemic to the Hawaiian Islands (found only in Hawaiʻi). Seven species that were introduced by Polynesians also occur in the project area (Hobdy 2010a, b). Table 3-2 lists native plant species recorded in the project area by Hobdy (2010a, b).

Table 3-2. Native Hawaiian plants observed in the project area.

Scientific Name	Hawaiian & Common Names	Status[1]
FERNS		
DENNSTAEDTIACEAE (Bracken Family)		
Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) R.M. Tryon	kilau	E
DICKSONIACEAE (Dicksonia Family)		
Cibotium chamissoi Kaulf.	hāpuʻu	E
GLEICHENIACEAE (False Staghorn Fern Family)		
Dicranopteris linearis (Burm.f.) Underw.	uluhe	I
LINDSAEACEAE (Lindsaea Fern Family)		
Sphenomeris chinensis (L.) Maxon	palaʻā	I
NEPHROLEPIDACEAE (Sword Fern Family)		
Nephrolepis exaltata (L.) Schott	niʻaniʻau	I
POLYPODIACEAE (Polypody Fern Family)		
Lepisorus thunbergianus (Kaulf.) Ching	pākahakaha	I
PSILOTACEAE (Whisk Fern Family)		

Scientific Name	Hawaiian & Common Names	Status[1]
Psilotum nudum (L.) P. Beauv.	moa	I
MONOCOTS		
ASPARAGACEAE (Asparagus Family)		
Pleomele halapepe St. John	halapepe	E
CYPERACEAE (Sedge Family)		
Carex meyenii Nees	--------------	I
Carex wahuensis C.A. Meyen	--------------	E
Cyperus polystachyos Rottb.	--------------	I
PANDACEAE (Screwpine Family)		
Freycinetia arborea Gaud.	ʽieʽie	I
POACEAE (Grass Family)		
Chrysopogon aciculatus (Retz.) Trin.	pilipili ʽula	I
DICOTS		
ASTERACEAE (Sunflower Family)		
Bidens sandvicensis Less	koʽokoʽolau	E
EBENACEAE (Ebony Family)		
Diospyros sandwicensis (A.DC.) Fosb.	lama	E
ERICACEAE (Heath Family)		
Leptecophylla tameiameiae (Cham. & Schlect.) C.M. Weiller	pūkiawe	I
FABACEAE (Pea Family)		
Acacia koa A. Gray	koa	E
Vigna marina (J. Burm.) Merr.	nanea	I
GOODENIACEAE (Goodenia Family)		
Scaevola gaudichaudiana Cham.	naupaka kuahiwi	E
LAURACEAE (Laurel Family)		
Cassytha filiformis L.	kaunaʽoa pehu	I
MENISPERMACEAE (Moonseed Family)		
Cocculus orbiculatus (L.) DC.	huehue	I
MYOPORACEAE (Myoporum Family)		
Myoporum sandwicense A. Gray	naio	
MYRTACEAE (Myrtle Family)		
Metrosideros polymorpha Gaud. var. *polymorpha*	ʽōhiʽa	E
OLEACEAE (Olive Family)		
Nestegis sandwicensis (A. Gray) Degener, I. Degener & L. Johnson	olopua	E
ROSACEAE (Rose Family)		
Osteomeles anthyllidifolia (Sm.) Lindl.	ʽūlei	I
RUBIACEAE (Coffee Family)		
Psychotria mariniana (Cham. & Schlectend) Fosb.	kōpiko	E
Psydrax odorata (G. Forst.) A.C. Smith & S.P. Darwin	alaheʽe	I

Scientific Name	Hawaiian & Common Names	Status[1]
SANTALACEAE (Sandalwood Family)		
Santalum freycinetianum Gaud. var. *freycinetianum*	‘iliahi	E
SAPINDACEAE (Soapberry Family)		
Dodonaea viscosa Jacq.	‘a‘ali‘i	I
STERCULIACEAE (Cacao Family)		
Waltheria indica L.	‘uhaloa	I
THYMELAEACEAE (‘Akia Family)		
Wikstroemia oahuensis (A. Gray) Rock.	‘akia	E
(1) E= endemic (native only to Hawai‘i); I = indigenous (native to Hawai‘i and elsewhere).		
Source: Hobdy (2010a, b).		

Following construction, Kawailoa Wind Power LLC intends to stabilize the project area using suitable ground cover. Where practical, native species will be used to stabilize bank slopes along constructed access roads or cut and fill slopes within the project area, as recommended by Hobdy (2010a). Although native species may be re-introduced, the primary goal of the revegetation will be to immediately stabilize soil and prevent erosion following construction. Kawailoa Wind Power will also replant an equivalent or greater number of native trees in the vicinity of the project to replace any native trees that may be removed during construction (see Section 7.9). No critical habitat for any plant species have been designated within the Kawailoa project area.

3.7.2 Flora at Off-site Microwave Facility Locations

Hobdy conducted a botanical survey of the Mount Ka‘ala off-site microwave facility sites in August 2010. He surveyed the two 0.1 acre (0.04 ha) sites of the communication towers on the ridge top, as well as a 30 ft (9 m) buffer downslope of the tower sites. No State- or Federally listed endangered, threatened or candidate plant species were observed during the survey, nor were any species considered rare throughout the Hawaiian Islands (Hobdy 2010c). A total of 63 plant species were recorded; 30 non-native and 33 native species. The non-native vegetation was limited to the two communication towers sites on the ridge top which were previously cleared and have been maintained in this condition for over 30 years. The native vegetation was mostly limited to the buffer outside and downslope of the proposed microwave facility sites (Hobdy 2010c). A complete list of the plant species documented at the Mount Ka‘ala site is included in Appendix 10.

Nine plant specieshave critical habitat designations that encompass the tower sites. The plant species are *Alsinidendron trinerve, Cyanea acuminate, Cyanea longiflora, Diplazium molokaiense, Hedyotis parvula, Labordia cyrtandrae, Phyllostegia hirsute, Tetramolopium lepidotum* ssp*. lepidotum, and Viola chamissoniana* ssp*. chamissoniana.* None of the plant species with designated critical habitat that encompass the tower sites are present on-site (See Appendix 10) at the two tower locations and no impacts to these plant species are expected.

Any vegetation that would be disturbed at the off-site microwave facility sites consists of non-native species common throughout O‘ahu and the main Hawaiian Islands. However, no impacts to flora are anticipated as the communication equipment will be installed on the two existing towers and ground disturbance is expected to be minimal.

3.8 Wildlife

3.8.1 Surveys Conducted

Wildlife occurring on or flying over the project area has been investigated through a combination of pedestrian surveys (Hobdy 2010a, b; Appendix 1a, b), visual bird surveys (SWCA 2010a; Appendix 4), nocturnal radar surveys (Cooper et al. 2011; Appendix 3), and the use of bat detection devices (SWCA 2010a; Appendix 4). Botanical surveys and a one-time avian survey were conducted at the off-site microwave facility sites (Hobdy 2010c; Appendix 10). A mollusc survey was also conducted at the off-site microwave facility sites (SWCA 2010c; Appendix 12). Endangered molluscs have only been documented in recent times in native forests at elevations greater than 400 m (1,312 ft) on O'ahu (USFWS 1992). As the project site is lower in elevation and dominated by non-native vegetation, these snails are not expected to be found at the project site. Thus, no mollusc survey was conducted at the project site.

3.8.1.1 Radar surveys

Nocturnal radar surveys were conducted on site in an effort to identify seabirds that may potentially transit the project area during crepuscular and night periods from 1800-2100 h and 0400-0600 h. Surveys were conducted in June and October 2009 and June 2011. Radar surveys were conducted at four locations to provide representative coverage of the project site. The summer surveys coincide with the incubation periods of the Hawaiian petrel and Newell's shearwater and the fall surveys coincide the fledgling periods for both species. Criteria used to identify possible shearwaters/petrels consisted of radar targets moving at airspeeds greater than 30 mi/h, of the appropriate size, flying inland or seaward only (not parallel to shore) and exhibiting directional flight (Cooper et al. 2011).

3.8.1.2 Bird and Bat surveys

Point counts, playbacks and driving transects were conducted on and off-site to maximize the possibility of documenting native birds on-site and at nearby water bodies.

SWCA began conducting avian point count surveys in the project area in October 2009 (Appendix 4). A total of 29 point count stations (Figure 3.3) were surveyed from October 2009 to February 2011. A 1 km buffer around potential turbine locations was created and an "airspace envelope" developed around each turbine string (Figure 3-3). All flight observations occurring at point count stations within the 1 km airspace envelope were considered to be within the possible area of turbine interaction and were deemed "on-site." Point count stations outside the airspace envelope were considered to be "off-site." Point count stations were located to sample representative habitats within the project area, close to potential turbine locations. Additional point counts were also added at water bodies in the vicinity of the project area, to document waterbird activity at the nearby water bodies. The months during which individual point counts were sampled varied over the course of the year, depending on the proposed turbine configuration which changed over time. Two to nine 200 m radius point count stations were surveyed during each session. Sessions were conducted in the morning (0600 – 1100 h), and evening (1400 – 1930 h). Each point count lasted 15 minutes per station. Point counts at the nearby water features were chosen in an effort to gain a better understanding of the activity patterns of the threatened and endangered species covered by the HCP, as well as to document the arrival and activity patterns of non-listed migratory bird species.

Playbacks of moorhen calls at the ponds (P01-P07) were also conducted from the end of May 2010 to the end of September 2010. Playbacks consisted of playing chick distress calls for 30 sec, followed by 30 seconds of silence, then 30 seconds of moorhen territorial calls followed by another 30 seconds of listening for a response. The calls chosen were calls that are most likely to elicit a response from nearby moorhen (DesRochers et al. 2006, 2008). These calls were recorded from James Campbell Wildlife Refuge and were obtained from http://ase.tufts.edu/biology/labs/reed/res-pub-suppl.html. Playbacks

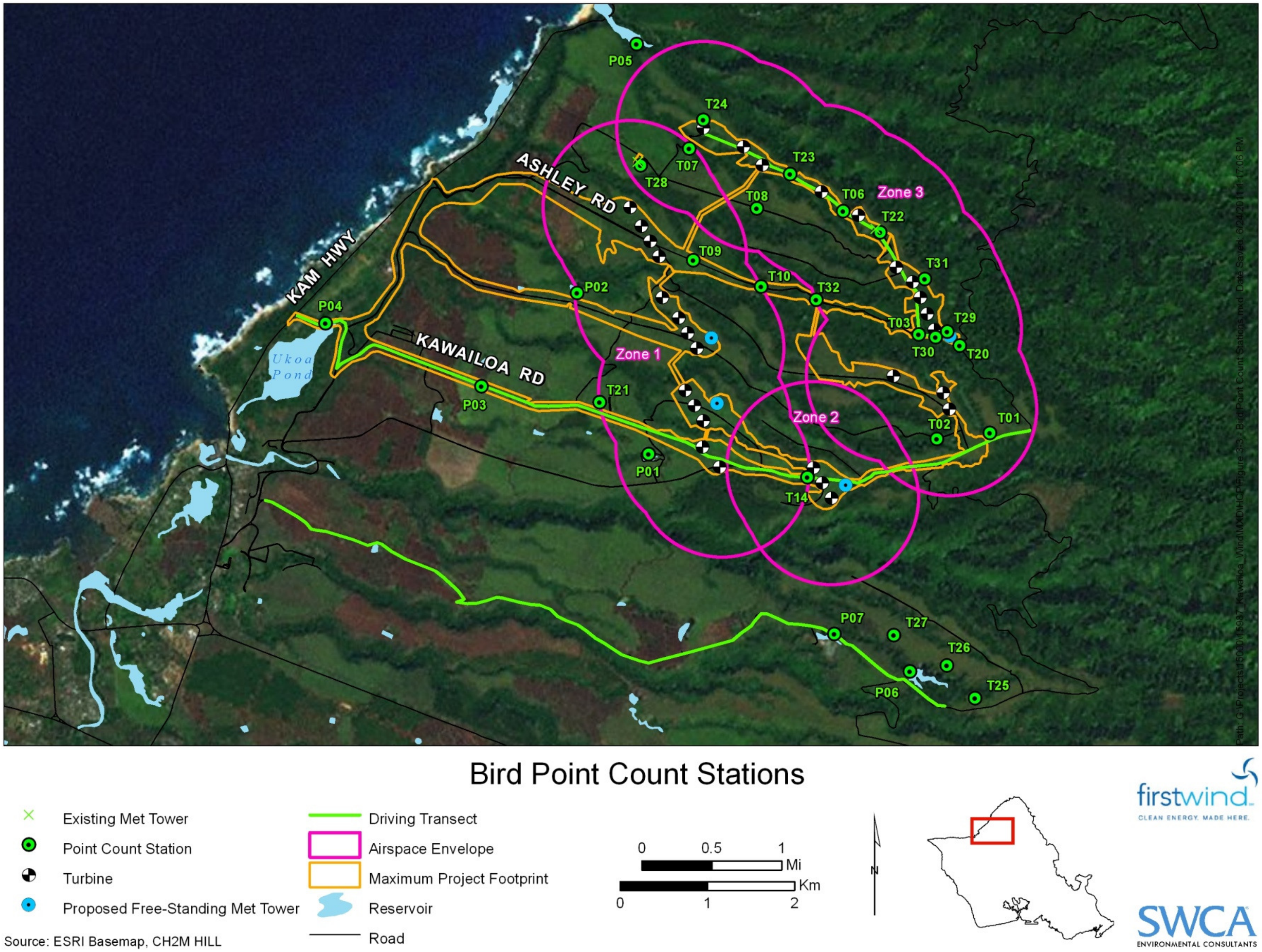


Figure 3-3. Bird Point Count Stations.

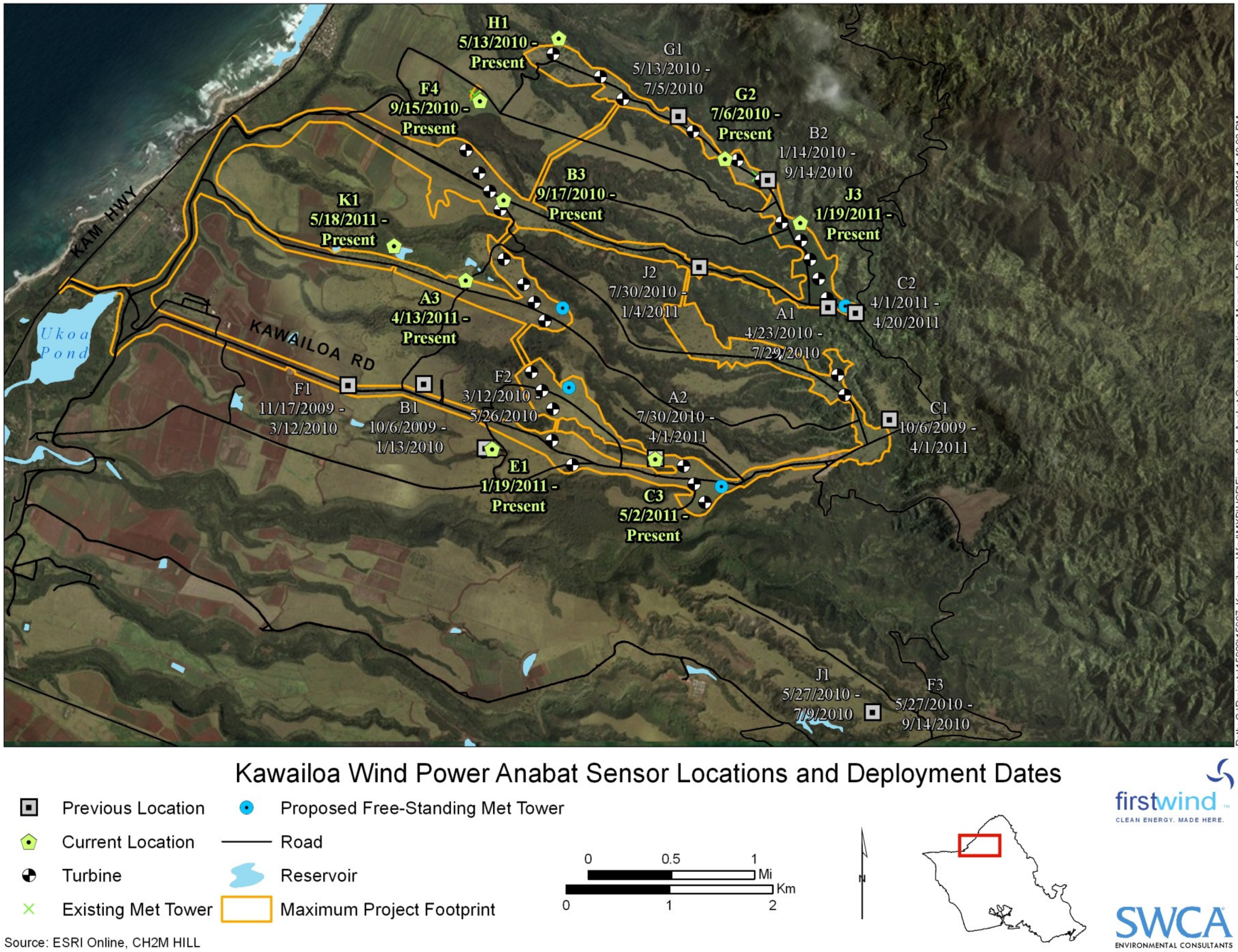


Figure 3-4. Anabat Locations.

have been shown to increase detection by 30% on O‘ahu (DesRochers et al. 2008). Due to time constraints, point counts were shortened to 13 minutes (2 mins playback + 13 mins point count observations) when playbacks were conducted.

To increase the probability of detecting waterbirds, driving transects were conducted between April and August 2010. As sightings of waterbirds primarily occurred near the ponds, driving transects were conducted between ponds, between P07 and P06, and from P04 to P01 to document waterbird activity between ponds. Transects were also conducted along parts of the turbine string that were accessible by road, from T29 to T24 and P01 to T01. The vehicle was driven at speeds between 5 miles per hour (mph) and 15 mph and occurrences of all native birds (waterbirds and owls) were recorded.

Incidental sightings of all native birds were also recorded while biologists were on-site from October 2009 to February 2011. For more detail on the bird survey methods, please see Appendix 4.
To quantify bat activity in the project area, two to eight Anabat detectors (Titley Electronics, NSW, Australia) were deployed at various locations at Kawailoa Wind Power from October 2009 to April 2011 (Figure 3-4) and are on-going. Anabat detectors record any ultrasonic sounds emitted by bats. 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 to increase the coverage of the area sampled at the project site.

3.8.2 Non-Listed Wildlife Species

Summary of Bird Observations

A total of 26 bird species were detected on-site, three were native species and one a winter migrant. The native species were the threatened Newell’s shearwater (presumably detected during radar surveys), the black-crowned night heron and the Hawaiian duck-mallard hybrid and the one winter migrant, the Pacific golden-plover. An additional eight species were observed at nearby ponds and in the vicinity of the project area; native birds included the endangered Hawaiian coot, the endangered Hawaiian moorhen and the great frigatebird. The black-crowned night heron, the frigate bird and pacific golden plover are non-listed native or migratory birds protected by the Migratory Bird Treaty Act. The remaining species were introduced species.

Table 3-3 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, biogeographical status of each species throughout Hawai‘i, State and Federal listing status, indication of whether the observed species is protected by the MBTA, and indication of the species being detected on-site, off-site, or both. Key avian species (i.e., waterbirds and shorebirds) that are not Federally or State-listed, but occur on-site or in the vicinity of the project area, are discussed below.

Table 3-3. Bird Species at the Project Site, Nearby Ponds and Vicinity.

E= endemic; I = indigenous, V = visitor, NN = non-native permanent resident; *E* = Endangered, *T* = threatened

Common Name	Scientific Name	Status[1]	MBTA	On site	Off-site	Others
Newell’s shearwater	*Puffinus auricularis newelli*	E, *T*	X	X[1]		
Great frigatebird	*Fregata minor*	I	X			X (Waimea Valley)
Cattle egret	*Bubulcus ibis*	NN	X	X	X	

[1] Based on radar data, not confirmed by visual assessment.

Common Name	Scientific Name	Status[1]	MBTA	On site	Off-site	Others
Black-crowned night heron	*Nycticorax nycticorax*	I	X	X	X	
Mallard	*Anas platyrhynchos*	NN	X		X	
Hawaiian duck-mallard hybrids	*Anas* sp.	E	X	X[1]	X[1]	
Muscovy	*Cairina moschata*	NN			X	
Domestic duck	*Anas platyrhynchos domestica*	NN			X	
Domestic geese	*Ana anser domesticus*	NN			X	
Gray francolin	*Francolinus pondicerianus*	NN		X	X	
Black francolin	*Francolinus francolinus*	NN		X	X	
Domestic chicken	*Gallus gallus*	NN		X	X	
Common peafowl	*Pavo cristatus*	NN		X		
Hawaiian coot	*Fulica alai*	E, *E*	X		X	
Hawaiian moorhen	*Gallinula chloropus sandvicensis*	E, *E*	X		X	
Pacific golden-plover	*Pluvialis fulva*	V	X	X	X	
Spotted dove	*Streptopelia chinensis*	NN		X	X	
Zebra dove	*Geopelia striata*	NN		X	X	
Barn owl	*Tyto alba*	NN	X	X	X	
Skylark	*Alauda arvensis*	NN				X (Opaeula Road)
Red-vented bulbul	*Pycnonotus cafer*	NN		X	X	
Red-whiskered bulbul	*Pycnonotus jocosus*	NN		X	X	
Japanese bush-warbler	*Cettia diphone*	NN		X	X	
White-rumped shama	*Copsychus malabaricus*	NN		X	X	
Red billed leothrix	*Leiothrix lutea*	NN		X	X	
Japanese white-eye	*Zosterops japonicus*	NN		X	X	
Common myna	*Acridotheres tristis*	NN		X	X	
Red-crested cardinal	*Paroaria coronata*	NN		X	X	

[1] Presumed, see section 3.8.4.3 Hawaiian Duck

Common Name	Scientific Name	Status[1]	MBTA	On site	Off-site	Others
Northern cardinal	*Cardinalis cardinalis*	NN	X	X	X	
House finch	*Carpodacus mexicanus*	NN	X	X	X	
Common waxbill	*Estrilda astrild*	NN		X	X	
Red avadavat	*Amandava amandava*	NN		X	X	
Nutmeg mannikin	*Lonchura punctulata*	NN		X		
Chestnut munia	*Lonchura malacca*	NN		X		
	Total species			**26**	**28**	**2**

3.8.2.1 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; Hawaii 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 Hawaiʽi, this species is considered a nuisance by aquaculture farmers. A total of six sightings of the native black-crowned night heron have been recorded on-site (two during point count surveys, three incidental sightings and one sighting during driving transects). All sightings were of single birds in flight. Birds were observed in flight at the ponds in the area (P01 and P02) or flying near the lower met tower on Kawailoa Road (T21) or in the area between the met tower and P01 (Figure 3-3). No birds have been observed foraging at the irrigation ponds on-site. No birds were observed flying within the rotor swept zone (RSZ) of the proposed turbine.

Thirteen observations of the black-crowned night heron were recorded (nine during point count surveys and four incidental sightings) off-site at the adjacent water bodies. Flock size ranged from one to two birds with an average of one bird. This species was observed in flight at ponds P03, P04 and P05. None were observed at P06 or P07. The black-crowned night heron is also frequently seen foraging (i.e., not in flight) at P04 and P05 (Figure 3-3). The black-crowned night heron was present on-site or off-site for all months of the year except January and February. Based on observations, the black-crowned night heron is likely present on-site and in the vicinity year round. As no birds were recorded within the rotor swept zone of the turbines, night-herons are expected to be at very low risk of colliding with project components. No irrigation ponds will be impacted by the construction of the project thus no foraging habitat will be lost and no waterbodies will be created by the project (see section 5.3) and will not attract the night-heron to the site. No impacts to the local population of night-herons are anticipated.

The cattle egret was introduced to Hawaiʽi from Florida for insect control in the mid 20^{th} 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 Oʽahu, large concentrations of this species can be found at Pearl Harbor, Kāneʽohe 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; Hawaii Audubon Society 2005; USFWS 2005a). Cattle egrets were observed rarely on-site but were common at the adjacent water bodies and at the farmland farther seaward of the project site.

3.8.2.2 Other Birds

For centuries, migratory ducks, geese and other waterfowl have wintered on the Hawaiian Islands.

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). 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, recreational development), invasive plants, non-native animals (predation, disease and competition), human disturbance, and environmental contaminants (Engilis and Naughton 2004).

The USFWS developed the *U.S. Pacific Islands Regional Shorebird Conservation Plan* over concerns of declining shorebird populations and loss of habitat (Engilis and Naughton 2004). This plan identifies three shorebird species of primary importance in Hawai'i: the Hawaiian stilt, Pacific golden-plover, and bristle-thighed curlew (*Numenius tahitiensis*). The only permanent resident shorebird, the Hawaiian stilt, is discussed in Section 3.8.4.2b. The other two species are of primary importance because Hawai'i supports a substantial amount of Pacific golden-plovers 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. The wandering tattler is considered a species of importance and the ruddy turnstone is a species of secondary importance (Engilis and Naughton 2004).

The Pacific golden-plover is the only shorebird that was detected utilizing the project area during the avian surveys conducted by Kawailoa Wind Power LLC and SWCA. Data suggests that these birds arrive in the vicinity of the project area in August and leave in May. No birds were recorded at flight altitudes within the rotor swept zone of the proposed turbines and are not expected to be at very low risk of colliding with project components. The creation of roads and open spaces during project construction and the maintenance of the search plots is likely to marginally benefit the pacific golden plover by creating more usable habitat. No impacts to the population of Pacific golden plovers that utilize the site is anticipated.

No frigate birds were observed over the site either during systematic surveys or within incidental sightings. The one observation was of a bird flying in Waimea valley. Given that these birds can be expected to fly over the site very rarely, they are anticipated to be a low risk of collision with project components. No impacts to the local population of frigate birds are anticipated.

3.8.2.3 Invertebrates

Hobdy specifically searched for the endangered Blackburn's sphinx moth (*Manduca blackburni*) within the project area. No moths or their larvae were observed (Hobdy 2010a, b). As stated in Section 3.8.1, endangered molluscs have only been documented in recent times in native forests at elevations greater than 400 m (1,312 ft) on O'ahu (USFWS 1992). As the project site is lower in elevation and dominated by non-native vegetation, these snails are not expected to be found at the project site. Thus, no mollusc survey was conducted within the project area.

3.8.2.4 Mammals

The Hawaiian hoary bat is the only terrestrial mammal native to Hawai'i; this species is discussed in Section 3.8.4.4. Several non-native mammals have been observed on the Kawailoa Wind Power project area incidental to avian surveys. Feral pigs (*Sus scrofa*) are common throughout the project area. Domestic dogs (*Canis familiaris*) were reported and the area is regularly used by hunters with dogs. Rats (*Rattus* spp.) and small Indian mongoose (*Herpestes auropunctatus*) were also observed. Although not seen, it is likely that feral cats (*Felis catus*) and mice (*Mus domesticus*) occur on site (Hobdy 2010a, b). A feral cat colony used to occur at the gated entrance to Kawailoa Road.

<u>3.8.3 Wildlife at Off-site Microwave Facility Locations</u>

Only four species of non-native birds were observed or heard during the one-time survey of the off-site microwave facility sites (Hobdy 2010c). These include the Japanese bush warbler (*Cettia* *diphone*), red-vented bulbul (*Pycnonotus cafer*), the Japanese white-eye (*Zosterops japonicas*) and house finch (*Carpodacus mexicanus*). Another non-native bird that also would occur here is the red-billed leiothrix (*Leiothrix lutea*). Thus, birds that frequent the Mt. Ka'ala sites are non-native species common to altered rural environments on O'ahu. Based on historical data, the following native birds may also occur: the O'ahu 'amakihi (*Hemignathus flavus*) and the 'apapane (*Himantione sanguinea*). Much rarer occurrence would be the endangered O'ahu 'elepaio (*Chasiempis ibidis*) and the the 'i'iwi (*Vestiaria coccinea*), which is listed as State endangered on O'ahu (DLNR 1990; Hobdy 2010c).

No State- or Federally listed candidate, threatened, or endangered molluscs or species of concern were found within the off-site microwave sites (Appendix 12). One species of native snail was found at the Hawaii Telcom site and seven native species at the Repeater station. Six native species were also found enroute to the Repeater station, of which *Kaala subrutila*, an endemic mollusc, may be assessed for candidate species listing in the near future (C. King, DOFAW, personal communication, see Table 3-4). Many of the native species found were common at the sites and the majority of the native snail diversity was found on native plants along the edges of each site (Table 3-4). Terrestrial species were found in the leaf litter and aboreal species were present on the foliage on trees and shrubs. Only two non-native mollusc species (*Oxychilus alliarius* and *Deroceras laeve*) were found during the survey. *O. alliarius* is known to feed on other molluscs and represents a potential ecological threat to native molluscs at Mt. Ka'ala. The invasive slug *D. laeve* competes with other molluscs and is also considered a treat to native ecosystems in Hawai'i. For more details see Appendix 12.

Although not observed during the survey, DOFAW has clarified that an additional native mollusc species (*Achatinella mustelina*) was historically found on olomea (*Perrottetia sandwicensis*) adjacent to the existing facilities, and a population is present approximately 50 meters away from the Hawaiian Telcom building site; *A. mustelina* is a Federally-listed species (USFWS 1992).

One bird the Oahu elepaio (*Chasiempis sandwichensis ibidis*), an invertebrate the Hawaiian picture-wing fly (*Drosophila substenoptera*) have critical habitat designations that encompass the tower sites. The Oahu elepaio designated critical habitat is unoccupied. None of the larval host plants for the fly; *Cheirodendron platyphyllum* ssp. *platyphyllum*, *C. trigynum* ssp. *trigynum*, *Tetraplasandra kavaiensis*, and *T. oahuensis*, are present on-site at the tower locations and no impacts to these species are expected.

As outlined by the 2003 critical habitat rule: existing man-made features and structures within the boundaries of the mapped units, such as buildings; roads; aqueducts and other water system features, including but not limited to pumping stations, irrigation ditches, pipelines, siphons, tunnels, water tanks, gauging stations, intakes, reservoirs, diversions, flumes, and wells; existing trails; campgrounds and their immediate surrounding landscaped area; scenic lookouts; remote helicopter landing sites; existing fences; telecommunications equipment towers and associated structures and electrical power transmission lines and distribution and communication facilities and regularly maintained associated rights-of-way and access ways; radars; telemetry antennas; missile launch sites; arboreta and gardens, heiau (indigenous places of worship or shrines) and other archaeological sites; airports; other paved areas; and lawns and other rural residential landscaped areas do not contain, and are not likely to develop, primary constituent elements and are specifically excluded from designation under this rule.

The Mt. Ka'ala off-site communications location is an existing infrastructure and excluded from critical habitat designation, and impacts are not anticipated to indirectly affect nearby habitat containing the primary constituent elements.

3.8.4 Listed Wildlife Species

Only one Federally listed species could be resident within the Kawailoa Wind Power project area. The endangered Hawaiian hoary bat has been documented flying within the project area during the radar surveys and bat activity, as evaluated using bat detectors, is higher between March and November. It is possible that the tree-roosting Hawaiian hoary bat roosts on site particularly during the months when bats are more frequently detected. The presumed Hawaiian duck-mallard hybrid has been documented utilizing ponds within the "airspace envelope" of the turbines in Zone 1 (see Fig. 3-3).

Radar studies in 2009 and 2011 have detected a low number of targets exhibiting flight speeds and flight patterns that fit the "shearwater-like" category. This suggests that the individuals are likely to be Newell's shearwaters though no visual identification of these targets were obtained. It is therefore assumed that a small number of Newell's shearwaters transit the Kawailoa Wind Power project during the seabird breeding season. No portion of the project area has been designated as critical habitat for any listed species. Several Federally listed endangered and threatened bird species have been observed at nearby water bodies and individuals of these species may occasionally transit through the airspace of the proposed Kawailoa Wind Power facility. Hawaiian duck-mallard hybrids, Hawaiian coot and Hawaiian moorhen have been observed at the nearby water bodies. The Hawaiian moorhen occurs regularly at the stream at Waimea Valley (P05). A Hawaiian coot was observed once foraging at P03. No Hawaiian stilts have been observed on site or at any of the nearby water bodies during the year-long survey. One State-listed endangered species, the Hawaiian short-eared owl, has not been observed at the Kawailoa Wind Power project area, but could potentially be present as suitable habitat is available.

The proposed WTGs, on-site communication towers, met towers, overhead collection lines associated with the Kawailoa Wind Power project would potentially present collision hazards to the listed bird and bat species. These species may also collide with the two off-site antennae mounted on existing towers. Lighting some of these structures pursuant to Federal Aviation Administration (FAA) regulations may increase the risk of avian collisions. Table 3-5 lists the Federally and State-listed species with potential to be adversely impacted by operation of the Kawailoa Wind Power project and for which Federal or State authorization of incidental take is being sought.

3.8.4.1 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.

Based on data collected in the 1990's the population of Newell's shearwater was estimated to be approximately 84,000 breeding and non breeding birds, with a possible range of 57,000 to 115,000 birds (Ainley et al. 1997). Radar studies on Kaua'i showed a 63% decrease in detections of shearwaters between 1993 and 2001 (Day et al. 2003a). More recently, Holmes (Planning Solutions Inc. 2010) suggest a 75% population decrease between 1993 and 2008, based on radar surveys and Save Our Shearwater (SOS) data. This puts the 2008 total population estimate on the order of 21,000 birds. The largest breeding population of Newell's shearwater occurs on Kaua'i (Telfer et al*.* 1987; Day and Cooper 1995, Ainley et al*.* 1995, 1997; Day et al*.* 2003a). Breeding also occurs on Hawai'i Island (Reynolds and Richotte 1997; Reynolds et al*.* 1997; Day et al. 2003a) and almost certainly occurs on Moloka'i (Pratt 1988; Day and Cooper 2002). Recent radar studies suggest the species may also nest on O'ahu in small numbers (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 (Spencer/First Wind, pers. comm.).

Newell's shearwaters typically nest on steep slopes vegetated by uluhe fern (*Dicranopteris linearis*) undergrowth and scattered 'ōhi'a (*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 irregularly to feed the chick. The closely related Manx shearwater (*Puffinus puffinus*) is fed every 1.2-1.3 days (Ainley et al. 1997). Newell's shearwaters arrive at and leave their burrows during darkness and birds are seldom seen

Table 3-4: List of Species Recorded at Each Location along the Transect in Each Site.

Location	Family	Species found	Native?	Occurrence (T=Terrestrial, A=Aboreal)	Relative Abundance
Hawaii Telcom Station	Zonitidae	*Oxychilus alliarius*	No	T	abundant
	Succineidae	*Succinea* spp.	Yes	UNKNOWN	highly abundant
Repeater Station	Succineidae	*Succinea* spp.	Yes	UNKNOWN	highly abundant
	Succineidae	*Catinella rotundata*	Yes	A	abundant
	Succineidae	*Catinella* sp.	Yes	A	common
	Agriolimacidae	*Deroceras laeve*	No	T & A	rare
	Achatinellidae	*Tornatellininae* spp.	Yes	A	common
	Achatinellidae	*Pacificellinae* spp.	Yes	A	common
	Achatinellidae	*Auriculellinae* spp.	Yes	A	common
	Achatinellidae	*Tornatellidinae* spp.	Yes	A	abundant
~50 m before Repeater Station (on trail)	Succineidae	*Succinea* spp.	Yes	UNKNOWN	highly abundant
	Succineidae	*Catinella rotundata*	Yes	A	abundant
	Achatinellidae	*Tornatellininae* spp.	Yes	A	abundant
	Achatinellidae	*Tornatellidinae* spp.	Yes	A	abundant
	Helicarionidae	*Philonesia* spp.	Yes	T & A	rare
	Helicarionidae	*Kaala subrutila*	Yes	T & A	rare

Table 3-5. Federally or State-listed Species with Potential to be Impacted by the Kawailoa 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
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			

near land during daylight hours. During the day, adults remain either in their burrows or at sea some distance from land.

First breeding occurs at approximately six years of age, after which breeding pairs produce one egg per year. A high rate of non-breeding is found among experienced adults that occupy breeding colonies during the summer breeding season, similar to some other seabird species (Ainley et al. 2001). It was estimated by Ainley et al. (2001) that 46% of all active burrows produced an egg. No specific data exist on longevity for this species, but other shearwaters may reach 30 years of age or more (Bradley et al. 1989; del Hoyo et al. 1992).

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 (NESH Working Group 2005).

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 wingbeat pattern of Newell's shearwater is somewhat similar to that of the Hawaiian petrel.

<u>Current Threats to the Newell's Shearwater</u>

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, collision with powerlines and other anthropogenic structures, and fallout of juvenile birds associated with disorientation from urban lighting (Ainley et al. 1997; Mitchell et al. 2005; Hays and Conant 2007).

<u>Occurrence of Newell's Shearwater in the Project Area and Off-site Communication towers</u>

Cooper et al. (2011, Appendix 3a) conducted 10 nights of surveillance radar and audiovisual sampling at the Kawailoa Wind Power project area in summer and fall 2009 to sample representative seabird passage rates over the site for use in estimating the risk of seabird take resulting from collisions with turbines and met towers. Supplementary radar surveys were conducted in June 2011 for 16 nights to measure passage rates over the north-eastern most turbine string (Cooper and Sanzenbacher 2011, Appendix 3b). Two new areas were sampled for five nights each to increase radar coverage of the project site. Sites sampled in 2009 were also resampled for three nights each. The 2011 data shows similar passage rates to those measured in 2009 both at the new sites and the resampled sites.

All three surveys found an extremely low number of targets exhibiting flight speeds and flight patterns that fit the "shearwater-like" category. The mean movement rate across all nights and all sites for 2009 and 2011 was 0.66 shearwater-like targets/h (Cooper and Sanzenbacher 2011, Appedix 3b).

No visual identification of these targets were possible for both the 2009 and 2011 surveys; however, Cooper et al. (2011) suggests that the individuals were more likely to be Newell's shearwaters than Hawaiian petrels due to the timing of movements and the available literature indicating that Newell's shearwaters but not Hawaiian petrels occur on O'ahu. 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 and go to about 60 min after sunset (Day et al. 2003b). Additionally, Cooper et al. (2011) indicated that the fall radar data were highly likely to include an unknown proportion of plovers (thus conservatively inflating movement rates used in the shearwater fatality models) based on observations of Pacific golden-plovers during fall sampling, the difficulty of separating plover targets from shearwater targets on radar, and the higher movement rates observed in fall when lower numbers of shearwaters are expected to occur. Due to the high possibility of high target contamination in the fall, the passage rates of Newell's shearwaters were modeled based on summer movement rates only resulting in an annual movement rate of 804 bird passes/year over the entire site. For more details please see Appendix 3a, b.

The Newell's shearwater has not been confirmed as a nesting species on O'ahu (Ainley et al. 1997) as no nesting colonies have been found. There have been infrequent incidental reports of downed fledglings in the last 50 years (roughly one a decade) for the Island of O'ahu (Cooper et al. 2011). Assuming the detected birds were Newell's shearwaters, then their observed behavior of flying to and from the Ko'olau Range suggests that at least a small number of these birds are at least 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 Kawailoa Wind Power project area lies within the primary corridor used by these few birds as they move between their prospective nesting areas and the ocean. Observations of Newell's shearwaters in the Hawaiian Islands indicate that approximately 75% of shearwaters will fly at or below turbine height (Cooper et al. 2011).

No radar studies were conducted at the off-site microwave facility sites because the proposed antennae will mounted on existing towers, the antennae are not expected to significantly increase the collision risk of any Covered Species if they should happen to transit the tower location.

3.8.4.2 Waterbirds

Four of the Covered Waterbird species, the Hawaiian duck, Hawaiian coot, Hawaiian moorhen and Hawaiian stilt, 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 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.

3.8.4.2a 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 Hawaiian duck is a small, mottled brown duck with emerald green to blue patches on their wings (speculums). Males are typically larger, have distinctive dark brown chevrons on the breast feathers, an olive-colored bill, and bright orange feet. Females are slightly smaller and lighter in color (Evans et al. 1994; USFWS 2005a). Compared to feral mallard ducks, Hawaiian ducks are more cryptic and about 20 to 30% smaller (Uyehara et al. 2007).

The historical range of the Hawaiian duck includes all the main Hawaiian Islands, except for the Islands of Lāna'i and Kaho'olawe. Hawaiian ducks 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 Hawaiian duck alleles from the population on the island (Browne et al. 1993). 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 unpub). 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. Approximately 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.

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). No suitable habitat for Hawaiian duck occurs on the Kawailoa Wind Power project area.

Breeding occurs year-round, although the majority of nesting occurs from March through June (USFWS 2005). 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).

<u>Current Threats to the Hawaiian Duck</u>

Hybridization with mallards is the largest threat to the Hawaiian duck. Reintroduction of pure Hawaiian ducks to O‘ahu is being contemplated, although for pure Hawaiian ducks to continue to exist 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 at 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 reintroduction will occur, but it is possible that reintroduction could occur during the 20-year life of the proposed project.

In addition to hybridization concerns, Hawaiian ducks are predated by mongoose, feral cats, feral dogs, and possibly rats (Engilis et al. 2002). Black-crowned night herons, largemouth bass (*Micropterus salmoides*), and bullfrogs have been observed to take ducklings (Engilis et al. 2002). 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 incidental observations of nēnē or Hawaiian goose (*Branta sandvicensis*) in flight at the Kaheawa Wind Power facility on Maui indicate this species is capable of exhibiting deliberate avoidance of wind turbines under prevailing conditions (Kaheawa Wind Power 2008a).

Occurrence of the Hawaiian Duck in the Project Area and Off-site Communication Towers

Ducks resembling Hawaiian ducks (but likely to be hybrids) have been seen flying over Zone 1 of the Kawailoa Wind Power project area (see Appendix 4 Figure 1). A total of 10 sightings of the Hawaiian duck-mallard hybrids have been recorded on-site (five during point count surveys, four incidental sightings and one sighting during driving transects). Flock sizes ranged from one to 15 birds with an average size of four birds. Similar to the black-crowned night heron, birds were observed in flight at the ponds in the area (P01 and P02) or flying near the lower met tower on Kawailoa road (T21) or in the area between the met tower and P01. However, one incidental sighting was also reported along the road between T28 and T07 (Appendix 4 Figure 2). No flocks were seen within the altitude of the rotor swept zone (RSZ) of the proposed turbine (approximately 50 m altitude or above).

Thus, while flying over the Kawailoa Wind Power project area, ducks may be vulnerable to colliding with the WTGs, and met towers. The risk is probably highest in Zone 1 and likely negligible in Zone 2 and 3, given that no waterbird activity (ducks or otherwise) was observed in these zones. Passage rates of ducks were only applied to Zone 1 and the estimated passage rate area is 0.054 birds/ha/hr. The passage rate of ducks in Zone 2 and 3 is presumed to be zero (SWCA 2010a; Appendix 4).

There are no open water features near the proposed location of the off-site communication towers, and waterbirds have not been historically documented at Mt. Kaʽala (DLNR 1990). In addition, none of the listed waterbird species have been observed at the site (Hobdy 2010c; Steve Mosher pers. comm.)

Because of the hybridization of Hawaiian ducks with feral mallards, it is questionable whether any pure Hawaiian ducks are resident on the Island of Oʽahu (Browne et al. 1993; Uyehara et al. 2007; USFWS 2005a). Given the dispersal capabilities of the species, it is possible for pure Hawaiian ducks to occasionally fly over from Kauaʽi. However, genetic research in 2007 showed presence of several Hawaiian ducks at James Campbell National Wildlife Refuge, and a bird struck by a plane at Honolulu International Airport in 2005 was found to be Hawaiian duck (Wright 2008). Therefore, take coverage is being requested for Hawaiian ducks in the event that genetic analysis of downed ducks on site result in the assessment of take of a pure Hawaiian duck. Take coverage is also requested in the event that pure Hawaiian ducks are reintroduced to the Island of Oʽahu during the project permit duration.

3.8.4.2b 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, West Indies, to southern South America and also the Hawaiian Archipelago (Robinson et al. 1999). Hawaiian stilt and black-necked stilt are part of a superspecies complex of stilts found in various parts of the world (Pratt et al. 1987; 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 winter rainfall and variation in 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).

Oʽahu 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 Nuʽupia Ponds in Kāneʽohe (USFWS 2005a). The Kiʽi 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 Kiʽi 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 Kiʽi 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 Kiʽi Unit has on-going control programs for mongoose, feral cats, rats, cane toads (*Bufo marinus*), and bullfrogs (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 wind turbines in the United States. One black-necked stilt fatality 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 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, the Vicinity and Off-site Communication towers

No Hawaiian stilts were seen flying over the proposed Kawailoa Wind Power facility during the avian point count surveys conducted by SWCA or Hobdy (SWCA 2010; Hobdy 2010a, b). No stilt have been observed occupying the waterbodies that were surveyed. Two irrigation ponds occur within the 1 km airspace envelope around the lowest turbine string (Zone 1) that may potentially be attractive to Hawaiian stilt occasionally. No other coastal wetlands are present within the airspace envelope of the turbine strings. Waimea River is a perennial stream, and is within the airspace envelope of the upper most turbine sting (Zone 3), however, stilt are not expected to be present in Waimea River as they require early successional marshlands for nesting and foraging (USFWS 2005a). However, because of the known dispersal capabilities of these birds (Reed et al. 1998), it is expected that individual stilts can fly over the Kawailoa Wind Power project area on a very irregular basis while moving between wetlands or islands.

There are no open water features near the communication sites; therefore, no waterbirds are expected. There are no open water features near proposed location of the off-site communication towers, and waterbirds have not been historically documented at Mt. Kaʽala (DLNR 1990). In addition, none of the listed waterbird species have been observed at the sites (Hobdy 2010c; Steve Mosher pers. comm.)

3.8.4.2c Hawaiian Coot

Population, Biology and Distribution of the 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. 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 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, 2005a; unpubl. data). Population fluctuations in these areas are attributed to seasonal rainfall and variation in 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 11.8 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 year round depending on rainfall. Hawaiian coots will 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 of bullfrogs and marine toads, 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, although in these cases standing or ponded water within the project area was an attractant (Erickson et al. 2001).

Occurrence of the Hawaiian Coot in the Project Area, the Vicinity and Off-site Communication towers

One observation of the Hawaiian coot was made at an adjacent waterbody, P03, in September 2010 (Figure 3.3). This individual was foraging in the pond when observed and did not take flight. The individual was of the rare color morph, with a red frontal shield instead of white. Only 1-3% of the Hawaiian coot has the red frontal shield like the American coot, *Fulica americana* (Engilis and Pratt 1993). This individual was not present when subsequent observations were made later in September. Two irrigation ponds also occur within the 1 km airspace envelope around the lowest turbine string (Zone 1) and may be attractive to Hawaiian coot occasionally. No other coastal wetlands are present within the airspace envelope of the turbine strings. Waimea River is a perennial stream, and is within the airspace envelope of the upper most turbine string (Zone 3), however, coot are not expected to be present in Waimea River as they are primarily a species of the coastal plains (USFWS 2005a). Hawaiian coots are known to disperse between islands and coupled with the one-time observation of a foraging coot at P03, there is potential for coots to occasionally fly over the lower elevations of Kawailoa Wind Power project area if moving between foraging sites or islands. No suitable habitat for Hawaiian coot occurs on the Kawailoa Wind Power project area.

There are no open water features near proposed location of the off-site communication towers, and waterbirds have not been historically documented at Mt. Kaʻala (DLNR 1990). In addition, none of the listed waterbird species have been observed at the site (Hobdy 2010c; Steve Mosher pers. comm.)

3.8.4.2d Hawaiian Moorhen

Population, Biology and Distribution of the Hawaiian Moorhen

The Hawaiian moorhen is an endemic, non-migratory subspecies of the cosmopolitan common moorhen (*Gallinula chloropus*). It is believed that the subspecies 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 moorhen 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 moorhen was recorded at the Kiʻi Unit of the James Campbell NWR (USFWS unpubl. data).

In Hawaiʻi, moorhen 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 on the Kawailoa 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 inches (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 also as 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 moorhen, however, 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 (Hötker et al. 2006); none in the United States. This is despite the fact that common moorhen 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, the Vicinity and Off-site Communication towers

No Hawaiian moorhens were detected during the year of avian point count surveys on the Kawailoa Wind Power project area. However, Hawaiian moorhen have been seen regularly at nearby water bodies and may potentially be attracted to the two irrigation ponds within the airspace envelope of the lower turbine string (Zone 1). Hawaiian moorhen were observed in flight only once in December, where two individuals were made a short flight 7 m below the stream bank at P05. A total of three individuals have been seen/heard at P05 and have responded to moorhen call playbacks on three occasions. These moorhen are likely resident at P05. Hawaiian moorhen were also seen at two locations at Ukoa pond during a site visit by SWCA biologist on November 30, 2010. Hawaiian moorhen have not been seen at any of the other water bodies and moorhen playbacks have not elicited any response in any of these areas.

A total of 10 moorhen are also resident in the lotus ponds in Waimea Valley (Laurent Pool, Conservation Land Specialist, Waimea Valley, pers. comm.; see Appendix 4 Figure. 2). Three moorhen adults and two chicks were seen by SWCA biologists on a visit conducted on 4/23/10. However, Hawaiian moorhen are not expected to be present in the upper reaches of Waimea River, within the airspace envelope of Zone 3, due to the lack of suitable habitat. It is very unlikely that Hawaiian moorhens regularly fly over the Kawailoa Wind Power project area; however, given their ability to fly and their occurrence at Waimea Valley, it is possible that individual Hawaiian moorhens will very occasionally fly over the project area, especially the lower elevation portion.

There are no open water features near proposed location of the off-site communication towers, and waterbirds have not been historically documented at Mt. Ka‘ala (DLNR 1990). In addition, none of the listed waterbird species have been observed at the site (Hobdy 2010c; Steve Mosher pers. comm.)

3.8.4.3 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 extant owl native to Hawai‘i and 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 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 owl 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 Hawai‘i 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. Nests are constructed by females and consist of simple scrapes in the ground lined with grasses and feather down. 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 Kaua'i 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, O'ahu, and Kaua'i 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 extinction 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 Kaheawa Wind Power facility on Maui, with one turbine related fatality reported since the start of project operations. 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 (Spencer/First Wind, pers. comm.). At Wolfe Island, Ontario, it was observed that short-eared owls were most vulnerable to colliding with turbine blades during predator avoidance and during aerial flight displays (Stantec Consulting Ltd. 2007). Short-eared owl on O'ahu 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 Communication towers

Hawaiian short-eared owls were not detected at the Kawailoa Wind Power project area or at the nearby water bodies. Because these owls are active during daytime and crepuscular periods, it seems probable that they would have been detected during the avian point counts if resident on-site. Regurgitated owl pellets of rodent hair and bones were observed on a trail on a grassy ridgetop in the upper part of the site (Hobdy 2010a) and numerous pellets have been found during the monitoring of the met towers at Kawailoa (SWCA, personal observations). However, it is probable that these belong to the barn owl (*Tyto alba*) which does occur on site. Despite these observations, as suitable grassland habitat does occur at the project site, the Hawaiian short-eared owl may occasionally be present.

No Hawaiian short-eared owls were seen during the wildlife surveys at the Mt. Ka'ala microwave facility sites. It has not been historically documented at Mt. Ka'ala (DLNR 1990).

3.8.4.4 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. Both sexes have a coat of brown and gray fur. Individual hairs are tipped or frosted with white (Mitchell et al*.* 2005).

The species has been recorded on Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i, but no historical population estimates or information exist for this subspecies. Population estimates for all islands in the State in the recent past have ranged from hundreds to a few thousand bats (Menard 2001). It is thought that the islands of Kaua'i and Hawai'i support the largest populations (Mitchell et al. 2005). The Hawaiian hoary bat is believed to occur primarily below an elevation of 4,000 ft (1,220 m). This subspecies 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 'ōhi'a, hala (*Pandanus tectorius*), coconut palms (*Cocos nucifera*), kukui (*Aleurites moluccana*), kiawe (*Prosopis pallida*), avocado (*Persea americana*), mango (*Mangifera indica*), shower trees (*Cassia javanica*), pūkiawe *(Leptecophylla tameiameiae*), and fern clumps; they are also suspected to roost in eucalyptus (*Eucalyptus* spp.) and Sugi pine (*Cyrptomeria japonica*) stands. Hawaiian hoary bats have been known to use both native and non-native habitats for feeding and roosting (Mitchell et al. 2005). The vegetated areas within the project area for the wind farm site consist mostly of agricultural land, alien grassland and forest. The forest habitat is fairly homogenous and comprised of non-native, invasive species, including stands of albizia, ironwood and eucalyptus trees; these trees may provide roosting habitat for bats. Bat activity has been detected in essentially all habitats, including in clearings, along roads, along the edges of tree lines, in gulches, and at irrigation ponds; monitoring to date indicates that bats use all of these features for travelling and foraging. The species has been rarely 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) core range habitat sizes of 84.3 ac (34.1 ha; n=14) for males and 41.2 ac (16.7 ha; n=11) for a female bat (Bonaccorso, F. 2011. pers. comm. (USGS. May 3, 2011). 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. Female core ranges overlapped with male ranges. Bats typically feed along a line of trees, forest edge or road and a typical feeding range stretches around 300 yds (275 m). Bats will spend 20 to 30 mins hunting in a feeding range before moving on to another (Bonaccorso 2011).

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 different elevations indicate that altitudinal movements 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. In the winter, bat occurrences increase in high elevation areas (above 5,000 ft or 1,525 m) especially from January through March (Menard 2001; Bonaccorso 2011).

Hawaiian hoary bats feed on a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes and termites (Whitaker and Tomich 1983). They appear to prefer moths ranging between 0.6 and 0.89 inches (16 to 20 mm) in size (Bellwood and Fullard 1984; Fullard

2001). Koa moths (*Scotorythra paludicola*), which are endemic to the Hawaiian islands and use koa (*Acacia koa*) as a host plant (Haines et al. 2009), are frequently targeted as a food source (Gorresen/USGS, pers. comm.). Prey is located using echolocation. Water courses and edges (e.g., coastlines and forest/pasture boundaries) appear to be important foraging areas (Grindal et al. 1999, Francl et al. 2004, Brooks and Ford 2005, Morris 2008, Menzel et al. 2002). In addition, the species is attracted to insects that congregate near lights (USFWS 1998; Mitchell et al. 2005, Belwood and Fullard 1984). They begin foraging either just before or after sunset depending on the time of year (USFWS 1998; Mitchell et al. 2005).

<u>Current Threats to the Hawaiian Hoary Bat</u>

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). Roost trees are not expected to be limiting as the Hawaiian hoary bat roost in a variety of native and non-native trees (see above), many of which are abundant and some non-native species are considered invasive (such as kiawe and eucalyptus).

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 U.S. At the Kaheawa Wind Power facility on Maui, two Hawaiian hoary bat fatalities have been observed since the start of project operations. The fatalities occurred in September 2008 and April 2011.

<u>Occurrence of the Hawaiian Hoary Bat in the Project Area and Off-site Communication towers</u>

Two to nine Anabat detectors have been deployed at various locations on the Kawailoa Wind Power project area beginning in October 2009 (Figure 3-4). These studies are presently on-going, with detectors being moved to new locations from time to time to increase the area sampled. Anabat detectors detect the presence of bats by recording ultrasonic sounds emitted by bats during echolocation.

A total of 2,466 detector nights were sampled from October 2009 to January 2011 at 19 locations (Appendix 4). During this period, bat activity over the entire site occurred at an average of 0.12 bat passes/detector night. The bat activity rates on site were divided into higher and lower activity periods. Higher activity periods were months with an average bat activity greater than 0.1 passes/detector night. Lower activity periods were months with an average of less than 0.1 passes/detector night. The higher activity period for Kawailoa Wind Power was between the months of March to November with an average activity rate of 0.15 passes/detector night for that period (Figure 3-5). February was excluded as a month with higher bat activity as 95% of the call sequences were detected on February 28. June and October were included in the higher bat activity period as these months are bracketed by months that are considered “higher activity”. (Figure 3-5). The low activity period occurs during the months of December through February with an average activity rate of 0.045 passes/detector night (Figure 3-5, Appendix 4). The data suggest that bat activity increases from March through November and is lowest or absent in the winter. Bat calls are also distributed throughout the night (Fig. 3-6). The overall detection rates at Kawailoa Wind Power are approximately five times lower than the detection rates at Hakalau National Wildlife Refuge (0.66 passes/detector night) (Bonaccorso, USGS unpublished report) but are ten times the rates at Kaheawa Wind Pastures and Kahuku Wind Power, both of which have an activity rate of approximately 0.01 bat passes/detector night (SWCA 2010d).

At Kawailoa Wind Power, bats may roost in the trees present in the area and bat activity has been detected in essentially all habitats, including clearings, along roads, along the edges of tree lines, in gulches and at irrigation ponds. Monitoring to date indicates that bats use all of these features for travelling and foraging.

The actual number of bats represented by the detections made by the Anabat detectors on the Kawailoa Wind Power site is not known. Bat activity rates are not necessarily indicative of the number of bats (Kunz et al. 2007) as Anabat detectors cannot differentiate between many bats passing the detector once and one bat passing the detector multiple times. Thus, the higher activity rates observed at Kawailoa Wind Power could be due to an increase in bat numbers in the area or an increase in usage of the area by the same number of individuals or a combination thereof. The reported bat activity rates are also relative, rather than absolute measures of bat activity at the site. While the Anabats were placed in a variety of locations and vegetation types to ensure good representation of the site, these Anabats were not randomly placed at each location but situated in spots sheltered from wind, along roads or edges of vegetation to maximize the probability of detecting a bat. Hence the average bat activity over the Kawailoa Wind Power site is likely to be much less than the measured rate.

Cooper et al. (2011) visually observed two Hawaiian hoary bats on-site incidental to the seabird radar survey in June 2009, but no bats in October 2009. Those observations translated to an estimated summer occurrence rate of 2 bats in 84 25-min observation sessions (i.e. 0.057 bats/h or approximately 0.68 bats/night (assuming 12 hrs of night)). Both bats were flying at an altitude of ≤5 m (Cooper et al. 2011). In June 2011 only one bat was recorded in 16 nights of observations (0.010 bats/h or 0.12 bats/night).

Given these results, it is presumed that a number of Hawaiian hoary bats forage over the Kawailoa Wind Power project area on a somewhat regular, though possibly seasonal, basis. These bats may also roost in the area.

No surveys for Hawaiian hoary bats were conducted at the microwave facility sites. Given the native forest that surrounds the microwave facility sites, bats may be expected to forage in the area at least occasionally.

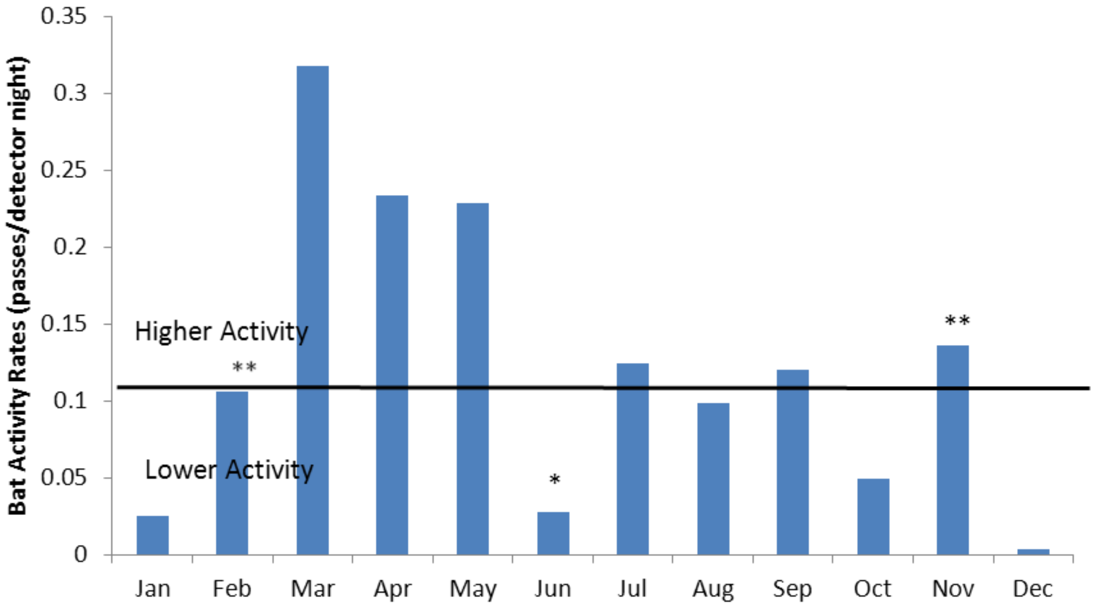


Figure 3-5. Distribution of Bat Passes Over Survey Period.
Higher activity month = 0.1 passes/detector night or greater; Lower activity month= less than 0.1 passes/detector night

*the drop in June was probably due to the low sampling effort for that month (37 detector nights) which occurred due to operator error and equipment shortage

**the increases in November and February were due to a large number of calls recorded in one night (on November 15, 30 of 49 call sequences were recorded in a span of 30 minutes; on February 28, 36 of 39 call sequences were recorded in a span of 1.5 hrs)

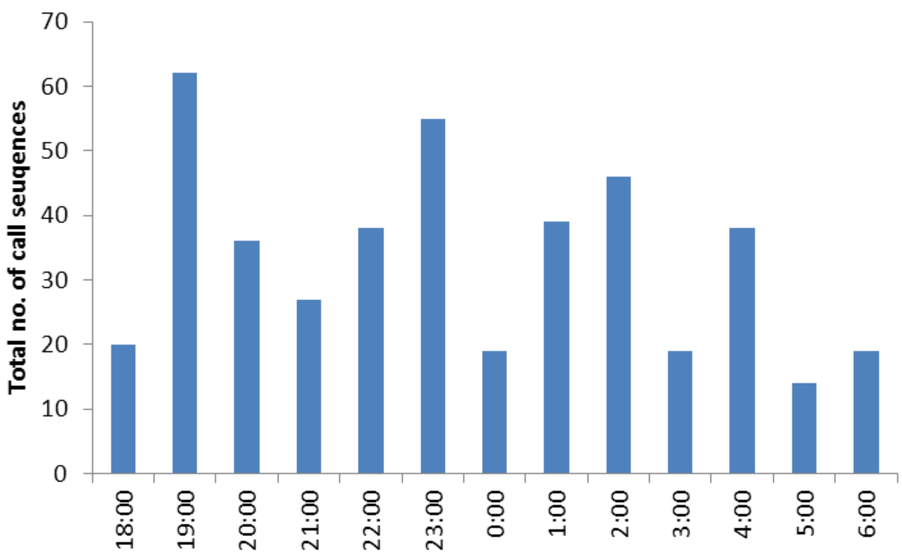


Figure 3-6. Time Distribution of All Bat Calls Detected.

4.0 BIOLOGICAL GOALS AND OBJECTIVES

The final addendum to the *Handbook for Habitat Conservation Planning and Incidental Take Permitting Process* (USFWS and NOAA 2000) is a five-point policy guidance for the HCP process. The addendum outlines the importance of defining biological goals. These broad, guiding principles clarify the purpose and direction of an HCP's operating conservation program. Biological objectives are also integral to the HCP process to achieve the different components of the biological goals. The objectives are more measurable than the goals and may include: species or habitat indicator, location, action, quantity/state, and timeframe needed to meet the objective (USFWS and NOAA 2000).

Kawailoa Wind Power LLC has met with local representatives of the USFWS and Hawai'i DLNR to discuss potential adverse impacts to the seven listed species, measures to practicably minimize the potential for adverse impacts, and biological goals and objectives. Where the potential for impacts is unavoidable, this HCP provides means to minimize and mitigate any adverse impacts to the listed species that may occur, and to provide a net conservation benefit.

Based on on-going surveys conducted on the project area, as well as records of species known to exist at adjacent areas, the proposed project is expected to directly or indirectly impact seven Federally or State-listed species. The proposed wind energy facility in Kawailoa is anticipated to directly or indirectly impact individuals, but will have only minor, negligible, or impacts on the amount or quality of terrestrial habitat for these species. For this reason, the goals and objectives of this HCP are species-based, rather than habitat-based.

Specific biological goals and objectives of this HCP are to:

- Minimize and mitigate, to the maximum extent practicable, the effects of take caused by the wind energy generation facility.
- Increase the knowledge and understanding of the seven Federally and State-listed species' occurrence and behavior in the project vicinity.
- Adhere to goals of the existing recovery plans for any of the seven listed species, considering the most recent updated information and goals.
- Provide a net conservation benefit to each of the seven species.

5.0 ALTERNATIVES

The proposed project design (Proposed Action) and the need for the project is described in Section 1.4. Because of siting requirements and existing constraints for each of the project components (for example, turbine spacing and setbacks from adjacent military land uses), this represents the only identified feasible alternative for the Project. Although additional micro-siting may occur, this will be within the limited area of the project envelope as defined, and thus any changes will fall within the range of impacts described for the Proposed Action. Alternatives considered for the project include a No-Action Alternative and a Communications Site Layout Alternative as described below.

5.1 No-Action ("No Build") Alternative

The "no-action" alternative is a "no build" alternative that would mean a commercial wind energy generation facility would not be constructed and operated by Kawailoa Wind Power LLC. Kawailoa Wind Power LLC is a business entity created for this sole purpose, with a majority partner that is a leader in the wind power industry. Thus, a "no build" alternative is contrary to the Applicant's fundamental purpose and objective. The "no build" scenario also fails to serve the purpose, intent, and requirements of Act 95 (S.B. 2474, S.D. 3, H.D. 2, signed by Governor Linda Lingle on June 2, 2004), which establishes renewable energy portfolio standards for Hawai'i's electric utilities. Act 95 requires each electric utility to establish a renewable portfolio standard of 8% by the end of 2005, 10% by the end of 2010, 15% by the end of 2015, and 20% by the end of 2020. The "no build" alternative, then, does not support the State of Hawai'i's desire to develop viable renewable energy sources, or Kawailoa Wind Power LLC's business plan to contribute to these goals.

The no-build scenario would result in no take and no change in the status of the listed species and no implementation of any mitigation measures. There would be no changes to the site or to existing habitats, nor any potential for collision with wind turbines or project infrastructure. Without the proposed mitigation measures, there would be no contributions to recovery efforts, and no further study or habitat protection funded by the project. In view of the fact that these are expected to provide a net benefit to the species, the "no-build" scenario does not have the potential for a net positive effect on the covered species.

Lastly, the "no build" scenario would maintain the status quo of O'ahu's electric energy production, its dependence on imported oil and the emissions thereof. The broad economic and environmental benefits of a second commercial wind energy generation facility would be foregone.

5.2 Alternative Communications Site Layout

As described in Section 1.4, the project includes installation of up to eight microwave dish antennae in four different locations to provide a dedicated communication link between the wind farm and the HECO substations in Waialua and Wahiawā. Up to four antennae would be installed on two new towers at the Kawailoa wind farm site. The remaining antennae would be installed on existing structures at two different Hawaiian Telcom communication sites, both located on the north slope of Mt. Ka'ala.

In the event agreements cannot be made to use the existing off-site structures, a new tower will be installed in an area adjacent to the existing structure at each site under this alternative. No changes will occur at the Kawailoa wind farm site. The tower constructed adjacent to the Hawaiian Telcom building will be a 30-foot lattice steel tower supporting up to two antennae, which will be connected via waveguide cable to radio equipment inside the building. At the repeater site, a 20-foot lattice tower with up to two antennae will be constructed. Similar to the tower on the wind farm site, these will both have concrete foundations approximately 144 ft^2 in area. The antennae, approximately 11 ft (3.4 meters) in diameter, will be mounted horizontally on the towers.

Access to, as well as radar and communications activities within the Mt. Ka'ala area are managed by the multi-agency Ka'ala Joint Use Coordination Committee (JUCC), which includes representatives from the U.S. Armed Services. A Conservation District Use Permit will also be required for the erection of the towers.

All avoidance and minimization measures listed in Section 5.3 will be followed with the alternative communications site layout.

To minimize direct impacts of clearing on native mollusc species, additional mollusc surveys will be conducted, in coordination with USFWS and DOFAW staff, before any vegetation clearing or trimming at either site. No trimming of vegetation along the trails is anticipated. No vegetation will be cleared if the endangered *Achatinella* species are detected. If *Achatinella* species are detected at the location of the proposed towers, the towers will not be erected. Leaf litter will be collected before the area is graded and distributed to the surrounding area to allow any native snails in the leaf litter to move on to undisturbed ground. In addition, measures to minimize the potential for introduction of non-native invasive ant species will be implemented, as described in section 5.3. If a helicopter is used to deliver construction materials, it will remain 100 ft (30.5 m) agl to avoid the impact of rotor wash on any *Achatinella* species that may be present in the vicinity. A post-construction report will be submitted to USFWS and DOFAW within a month of the installation of the off-site communications towers.

One bird the Oahu elepaio (*Chasiempis sandwichensis ibidis*), an invertebrate the Hawaiian picture-wing fly (*Drosophila substenoptera*) and nine plant species have critical habitat designations that encompass the tower sites. The plant species are *Alsinidendron trinerve*, *Cyanea acuminate*, *Cyanea longiflora*, *Diplazium molokaiense*, *Hedyotis parvula*, *Labordia cyrtandrae*, *Phyllostegia hirsute*, *Tetramolopium lepidotum* ssp. *lepidotum*, and *Viola chamissoniana* ssp. *chamissoniana*. The Oahu elepaio designated critical habitat is unoccupied. None of the larval host plants for the fly; *Cheirodendron platyphyllum* ssp. *platyphyllum*, *C. trigynum* ssp. *trigynum*, *Tetraplasandra kavaiensis*, and *T. oahuensis*, or plant species with designated critical habitat that encompass the tower sites are present on-site at the tower locations and no impacts to these species are expected.

As outlined by the 2003 critical habitat rule: existing man-made features and structures within the boundaries of the mapped units, such as buildings; roads; aqueducts and other water system features, including but not limited to pumping stations, irrigation ditches, pipelines, siphons, tunnels, water tanks, gauging stations, intakes, reservoirs, diversions, flumes, and wells; existing trails; campgrounds and their immediate surrounding landscaped area; scenic lookouts; remote helicopter landing sites; existing fences; telecommunications equipment towers and associated structures and electrical power transmission lines and distribution and communication facilities and regularly maintained associated rights-of-way and access ways; radars; telemetry antennas; missile launch sites; arboreta and gardens, heiau (indigenous places of worship or shrines) and other archaeological sites; airports; other paved areas; and lawns and other rural residential landscaped areas do not contain, and are not likely to develop, primary constituent elements and are specifically excluded from designation under this rule.

The Mt. Ka‘ala off-site communications location is an existing infrastructure and excluded from critical habitat designation, and impacts are not anticipated to indirectly affect nearby habitat containing the primary constituent elements.

The construction of the towers is not expected to increase the requested take for any of the Covered Species. Studies have shown that only 1% of Newell's shearwaters (n = 688 birds; B. Cooper/ABR, 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, and that the towers are substantially less than 60 ft tall, the likelihood of a seabird flying at such low altitudes and colliding with the microwave towers is considered to be remote.

There are no open water features near the proposed location of the microwave towers, and waterbirds have not been historically documented at Mt. Ka‘ala (DLNR 1990). In addition, none of the listed waterbird species have been observed at the site (Hobdy 2010c; Steve Mosher pers. comm.). Therefore, the erection of additional microwave towers is not expected to increase the risk of waterbird fatality for the project.

Potential for short-eared owls to collide with the microwave towers is also considered negligible because these structures will be immobile and stationed in cleared sites. The towers should be readily visible to, and avoidable by, owls. Likewise, the potential for bats to collide with the microwave towers is considered to be negligible because they will be immobile and should be readily detectable by the bats through echolocation.

5.3 Avoidance and Minimization Measures

The analysis of project design alternatives supports the conclusion that the Proposed Action is preferred when all impacts on the human and natural environment are considered. Because complete avoidance of risk to the listed species is impossible under the Proposed Action, the Applicant has incorporated several measures to avoid and minimize the risk of listed and other wildlife species that may be adversely impacted by the project, and to minimize impact on the human environment. These measures include, but are not necessarily limited to:

- Using "monopole" steel tubular turbine towers rather than lattice towers. Tubular towers are considerably more visible than lattice towers and should reduce collision risk.

- The use of unguyed instead of guyed permanent met towers for the project site

- Marking guy wires on temporary met towers with high visibility bird diverters made of spiraled PVC and twin 12-inch white poly vinyl marking tape to improve the visibility of the wires

- Utilizing a rotor with a significantly slower rotational speed (range of 6 – 16 rpm) compared to older designs (28.5 – 34 rpm). This increases the visibility of turbine blades during operation and decreases collision risk.

- Placement of all new power collection lines underground as far as practicable to minimize the risk of collision with new wires; overhead collection lines will be fitted with marker balls to increase visibility where appropriate. All overhead collection lines will be spaced according to Avian Power Line Interaction Committee (APLIC) guidelines to prevent possible electrocution of native species. Species most at risk are those likely to perch on power poles or lines (APLIC 2006). Only one species is identified to be at risk at Kawailoa Wind Power, the Hawaiian short-eared owl. Using the barn owl as a surrogate species, the horizontal spacing will be more than 20 inches (51 cm) to accommodate the wrist-to-wrist distance of the owl. If a vertical arrangement is chosen, a vertical spacing of more than 15 inches (38 cm, head-to-foot length) will be used (APLIC 2006). Any jumper wires will be insulated.
- Overhead collection lines will be parallel to tree lines whenever possible. Overhead lines spanning the gulches will be fitted with marker balls to increase their visibility to Covered Species and minimize risk of collisions.

- Improving drainage in areas as needed to eliminate the accumulation of standing water after periods of heavy rain to minimize potential of attracting waterbirds to the site.

- Where feasible, minimizing night-time construction activities to avoid the use of lighting that could attract seabirds and possibly bats.

- Use of minimal on-site lighting at buildings and using shielded fixtures that will be utilized only on infrequent occasions when workers are at the site at night. Onsite lighting will be fitted with motion-sensors, automatic shut-off timers or similar devices to limit lighting to periods when personnel are actively working.

- Clearing of trees above 15 ft in height for construction between June 1 and September 15 will not occur as it is the period when non-volent Hawaiian hoary bat juveniles may occur in the project area.

- Low wind speed curtailment will be implemented once the project is operational to reduce the risk of bat take: 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 suggests 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) to 5 m/s. Two years of research conducted by Arnett et al. (2009, 2010) found that bat fatalities were reduced by an average of 82% (95% CI: 52–93%) in 2008 and by 72% (95% CI: 44–86%) in 2009 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.

Based on data collected to date, the curtailment will initially occur during months of March to November, which is when bat activity has been relatively higher (see Section 3.8.4.8). Low wind speed curtailment will be implemented at night by raising the cut-in speed of the project's wind turbines to 5m/s. Curtailment will be for the duration of the night (from sunset to sunrise). Curtailment will also be extended if fatalities are found outside the initial proposed curtailment period with direction from USFWS and DLNR. Curtailment may also be modified with the approval of DOFAW and USFWS if site-specific data demonstrate a lack of bat activity during certain periods, or if experimental trials are conducted that demonstrate that curtailment is not reducing collision risk at the project during the entire curtailment period.

- A speed limit of 15 mph will be observed while driving on site, to minimize collision with species listed in the HCP, in the event they are found to be utilizing habitat on site or injured.

- 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 owls are seen or heard, and resumed when it is apparent that the young have fledged or other confirmation that nesting is no longer occurring.

- Measures will also be implemented to avoid impacts to native molluscs at the off-site antennae locations. The antennae will be mounted on existing towers. A limited amount of tree trimming may be required during installation and ongoing maintenance, to provide adequate line-of-sight between the antennas. A helicopter will be used to transport the antennae to the repeater station to minimize the need for vegetation trimming along the access trail, and helicopters will remain 100 ft agl to avoid impacts from downwash. In addition, all vegetation trimming activities will be directed by USFWS and DOFAW staff to minimize the potential for impacts to native vegetation. Because native vegetation at the site could potentially support native mollusc species (including at least one Federally and State listed species, see Section 3.8.3), additional mollusc surveys will be conducted before any vegetation trimming at either site, also be approved by USFWS and DOFAW staff. If the endangered *Achatinella* spp. are detected during the surveys, no vegetation will be trimmed and the detections will be reported to USFWS and DOFAW. If no *Achatinella* are detected, then vegetation will be trimmed by hand. A post-construction report will be submitted to USFWS and DOFAW within a month of the installation of the antennae at the off-site communications towers. Post-construction report will include alternative selected, survey methodology, results of surveys and success of minimization avoidance measures. The agencies, USFWS and DOFAW, will maintain final approval for successful implementation.

- To minimize the potential for introduction of non-native invasive ant species at either of the Hawaiian Telcom sites, baseline surveys of ant fauna will be conducted before and following installation of the antennas, in coordination with DOFAW staff. In addition, all materials and vehicles will be inspected for the presence of ants before transport to the site. With implementation of these measures, impacts to native invertebrate species will be insignificant. If new species of ants are detected in the post-construction survey, and are attributed to the construction work, control measures will be implemented to remove the new species from the area. A post invasive species monitoring report will be submitted to USFWS and DOFAW one month after the six month monitoring period. Report will include survey methodology, results of surveys and success of minimization avoidance measures. The agencies, USFWS and DOFAW, will maintain final approval for successful implementation.

The following avoidance and minimization measures pertain to mitigation measures inmplemented for the Covered Species. These measures will be included in any management plans developed for the Covered Species:

- All ungulate fences built to implement mitigation measures for the Covered Species will have a barbless top-strand of wire to prevent entanglements of the Hawaiian hoary bat on barbed wire.

- In areas where Hawaiian waterbirds have been observed, nest searches will be conducted by a qualified biologist prior to any work being conducted and after any subsequent delay in work of three or more days (during which birds may attempt nesting).

- If a nest is discovered work will cease within a 150ft of the nest, for a minimum of seventy days (10 weeks); if a nest with chicks/ducklings is discovered, work will cease for a minimum of 49 days (7 weeks). These guidelines are intended to protect chicks/ducklings, and may be shortened if monitoring is conducted often enough to note when chicks/ducklings have fledged (usually five to six weeks after hatching). Work should not begin in the area until two weeks after chicks/ducklings have fledged.

- If an endangered Hawaiian waterbird is found in the project's action area during on-going work, then all activities within 50-ft of the bird will cease; work may continue after the bird leaves the area of its own accord. If a bird is seen in a similar location for more than two consecutive days, project managers should contact the USFWS for specific guidance.

5.3.1 USFWS Guidelines

In recognition of the growing wind energy industry in the United States, the Wind Turbine Guidelines Advisory Committee, headed by USFWS, has released *Wind Turbine Guidelines Advisory Recommendations* (2010) which provides recommendations intended to minimize impacts to all wildlife and their habitats related to land-based wind energy projects including those covered under ESA and MTBA. The guidelines are not required by statute to be followed. Kawailoa Wind Power LLC has complied with these guidelines to the maximum extent practicable with regards to site development, turbine design, and operations. Table 5-1 below lists the BMPs provided in the *Guidelines* relating to site development and turbine design and operation and discusses how the Applicant plans to comply with these recommendations. It should be noted that these recommendations relate to all wildlife, whether or not they are protected under the ESA or MBTA, and the benefits of following these recommendations, where applicable, extend beyond the implementation of this HCP.

Table 5-1. Comparison of Kawailoa Wind Power with Site Development and Construction BMPs Outlined in the Wind Turbine Guidelines Advisory Committee Recommendations (2010).

Wind Turbine Guidelines Advisory Committee Recommendations	Proposed Kawailoa Wind Power Project
Minimize, to the extent practicable, the area disturbed by pre-construction site monitoring and testing activities and installations.	The area disturbed during pre-construction has been kept to a minimum. The largest areas that have been cleared have been for the erection of the met towers which required the cutting of trees and mowing the grassy understory. Native trees were left standing in the met tower clearing as far as practicable. These areas were also cleared as it is required by DOFAW and USFWS that the area under the met tower be searchable for downed wildlife that may collide with the towers.

Wind Turbine Guidelines Advisory Committee Recommendations	**Proposed Kawailoa Wind Power Project**
Avoid locating wind energy facilities in areas identified as having a demonstrated and unmitigatable high risk to birds and bats.	On-site surveys indicate that the risk to listed bird species is low, as only the Hawaiian duck-mallard hybrid has been documented using and transiting over the site infrequently. Radar surveys have documented very low passage rates of Newell's shearwater-like targets over the project site. Site-specific surveys indicate that the project area is not located along any of the daily movement flyways used by wetland birds or seabirds. The site is consistently a location of high visibility with high cloud ceilings. The project area has shown some level of bat activity. It is likely that some individuals use the area seasonally and low wind speed curtailment will be implemented during high activity periods to reduce the risk of take to bats (see section 5.4). It is expected that the project will reduce the risk to listed species as much as possible while achieving the basic project purpose.
Use available data from State and Federal agencies, and other sources (which could include maps or databases), that show the location of sensitive resources and the results of Tier 2 and/or 3 studies to establish the layout of roads, power lines, fences, and other infrastructure.	Available data from State and Federal agencies (including critical habitat, forest and waterbird habitat, and NWI) were utilized to ensure project components avoid sensitive resources.
Use native species when seeding or planting during restoration.	Vegetation that will be removed from the project area during construction will be replaced with appropriate non-invasive vegetation to ensure stable cover. Some areas may be planted with native vegetation. Native trees will be replanted in the vicinity of the project to compensate for the removal of any native trees during construction (see Section 7.9)

Wind Turbine Guidelines Advisory Committee Recommendations	Proposed Kawailoa Wind Power Project
To reduce avian collisions, place low and medium voltage connecting power lines associated with the wind energy development underground to the extent possible, unless burial of the lines is prohibitively expensive (e.g., where shallow bedrock exists) or where greater adverse impacts to biological resources would result: - Overhead lines may be acceptable if sited away from high bird crossing locations, to the extent practicable, such as between roosting and feeding areas or between lakes, rivers, prairie grouse and sage grouse leks, and nesting habitats. To the extent practicable, the lines should be marked in accordance with Avian Power Line Interaction Committee (APLIC) collision guidelines. - Overhead lines may be used when the lines parallel tree lines, employ bird flight diverters, or are otherwise screened so that collision risk is reduced. - Above-ground low and medium voltage lines, transformers and conductors should follow the 2006 or most recent APLIC "Suggested Practices for Avian Protection on Power Lines."	This recommendation is being followed. APLIC guidelines for overhead collection lines have been followed (see Section 5.3 above).
Avoid guyed communication towers and permanent met towers at wind energy project sites. If guy wires are necessary, bird flight diverters or high visibility marking devices should be used.	All communication towers and permanent met towers will be unguyed.
Use construction and management practices to minimize activities that may attract prey and predators to the wind energy facility.	Trash will be placed in closed containers to minimize the attraction of introduced predators to the site.
Employ only red, or dual red and white strobe, strobe-like, or flashing lights, not steady burning lights, to meet Federal Aviation Administration (FAA) requirements for visibility lighting of wind turbines, permanent met towers, and communication towers. Only a portion of the turbines within the wind project should be lighted, and all pilot warning lights should fire synchronously.	Most or all of the turbines will likely be lit with medium intensity, red-pulsating, synchronized lights in accordance with FAA aviation safety guidance and as requested by the military for the Kawailoa Wind Power site. Kawailoa Wind Power will request the maximum flash interval to minimize lighting impact. White strobe lights do not conform to FAA guidance.

Wind Turbine Guidelines Advisory Committee Recommendations	Proposed Kawailoa Wind Power Project
Keep lighting at both operation and maintenance facilities and substations located within half a mile of the turbines to the minimum required: - Use lights with motion or heat sensors and switches to keep lights off when not required. - Lights should be hooded downward and directed to minimize horizontal and skyward illumination. - Minimize use of high-intensity lighting, steady-burning, or bright lights such as sodium vapor, quartz, halogen, or other bright spotlights.	On-site lighting at buildings will be minimal and shielded fixtures will be utilized on infrequent occasions when workers are at the site at night (see Section 5.3).
Establish non-disturbance buffer zones to protect sensitive habitats or areas of high risk for species of concern identified in pre-construction studies. Determine the extent of the buffer zone in consultation with USFWS and State, local and tribal wildlife biologists, and land management agencies (e.g., U.S. Bureau of Land Management (BLM) and U.S. Forest Service [USFS]), or other credible experts as appropriate.	No sensitive habitats or areas of high risk for species of concern were identified during pre-construction studies.
Locate turbines to avoid separating bird and bat species of concern from their daily roosting, feeding, or nesting sites if documented that the turbines' presence poses a risk to species.	The turbines are located upland of any known water bodies and are not expected to impede water bird movement. The turbines are also situated at a low enough elevation so as not to encroach on any potential Newell's shearwater nesting sites. Bats may forage around the turbines but the turbines are not expected to separate them from their normal feeding or roosting sites.
Avoid impacts to hydrology and stream morphology, especially where Federal or State-listed aquatic or riparian species may be involved.	The proposed project is not expected to impact hydrology, stream morphology, or any aquatic or riparian species.
Although it is unclear whether tubular or lattice towers reduce risk of collision, when practical use tubular towers or best available technology to reduce ability of birds to perch and to reduce risk of collision.	Tubular towers will be utilized for the turbine towers. The towers will not have external platforms or ladders.

Wind Turbine Guidelines Advisory Committee Recommendations	Proposed Kawailoa Wind Power Project
Minimize the number and length of access roads; use existing roads when feasible.	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.
Minimize impacts to wetlands and water resources by following all applicable provisions of the Clean Water Act (33 USC 1251-1387) and the Rivers and Harbors Act (33 USC 301 et seq.); for instance, by developing and implementing a storm water management plan and taking measures to reduce erosion.	No wetlands occur on the project area (see Appendix 2). All applicable provisions of the Clean Water Act (33 USC 1251-1387) and the Rivers and Harbors Act (33 USC 301 et seq.) will be followed.
Reduce vehicle collision risk to wildlife by instructing project personnel to drive at appropriate speeds, be alert for wildlife, and use additional caution in low visibility conditions.	A wildlife education and observation program (WEOP) will be conducted for all regular on-site staff (Appendix 6). 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, the possibility of downed wildlife being present on roads, and the possibility of Hawaiian short-eared owls flying across roads. A 15 mph speed limit will be enforced (see Section 5.3). These types of personnel will be instructed to contact the Site Environmental Compliance Officer immediately if they detect any downed wildlife on-site.
Instruct employees, contractors, and site visitors to avoid harassing or disturbing wildlife, particularly during reproductive seasons.	The WEOP will educate employees, contractors, and site visitors to avoid contact with Covered Species.

Wind Turbine Guidelines Advisory Committee Recommendations	Proposed Kawailoa Wind Power Project
Reduce fire hazard from vehicles and human activities (instruct employees to use spark arrestors on power equipment, ensure that no metal parts are dragging from vehicles, use caution with open flame, cigarettes, etc.).	Wind turbines are not generally susceptible to wildfires, and grass and other flammable materials are kept well back from the base of the tower as a matter of regular maintenance. However, consistent with the requirements of the Honolulu Fire Department, an appropriate access road for fire apparatus would provide access to within 150 feet of all onsite facilities and buildings. In addition, The O&M Building and BESS would be supported by an external fire hydrant, supplied from two water tanks with a total capacity of approximately 1260,000 gallons. Interior areas would include accessible fire extinguishers. In addition human-caused fire hazards will be minimized using through fire prevention training of all employees and contractors, use of hotwork permit procedures for all spark-inducing work, the establishment of work site requirements for fueling, smoking, flammable/combustible liquid storage, and vehicle safety routes. A local emergency response communication protocol will be established.
Follow Federal and State measures for handling toxic substances to minimize danger to water and wildlife resources from spills.	All activities will comply with the SPCC rule.
Reduce the introduction and spread of invasive species by following applicable local policies for noxious weed control, cleaning vehicles and equipment arriving from areas with known invasive species issues, using locally sourced topsoil, and monitoring for and rapidly removing noxious weeds at least annually.	This recommendation is being followed, see Section 7.8. The site will be surveyed for noxious weeds annually in cooperation with the Department of Agriculture (DOA). Appropriate measures as recommended by the DOA will be taken if noxious weeds are found.
Utilize pest and weed control measures as specified by county or State requirements, or by applicable Federal agency requirements (such as Integrated Pest Management) when Federal policies apply.	This recommendation is being followed, see Section 7.8.

6.0 POTENTIAL IMPACTS

Generation of electrical energy from wind is a renewable, clean, environmentally friendly technology. It reduces greenhouse gas emissions and water use in electricity generation. At the same time, the potential for wind energy turbines to adversely affect birds and bats is well-documented in the continental United States (e.g., Horn et al. 2008; Kunz et al. 2007; Kingsley and Whittam 2007; Kerlinger and Guarnaccia 2005; Erickson 2003; Johnson et al. 2003a, 2003b). In the State of Hawai'i, wind-powered generation facilities are relatively new; thus, few studies have been conducted to document the direct or indirect impact of wind energy facilities on wildlife.

Kaheawa Wind Power LLC has been conducting post-construction monitoring to document downed wildlife at the Kaheawa Pastures Wind Energy Generation Facility on Maui since operations began in June 2006 (Kaheawa Wind Power 2008a, 2008b, 2009, 2010). This information offers some insight into the potential impacts of wind turbines on Hawaiian wildlife, as well as the accuracy of pre-operational take estimates. Since the start of operations in 2006, Kaheawa Wind Power has documented take of three listed species: three adult Hawaiian petrel, nine full-grown nēnē, and two Hawaiian hoary bats (Kaheawa Wind Power LLC 2008a, 2008b, 2009, 2010; Spencer/First Wind, pers. comm.). Although 1-2 fatalities annually were predicted for Newell's shearwater, no fatalities have been documented to date. Other documented fatalities of native birds include white-tailed tropicbirds, great frigate birds and Hawaiian short-eared owls.

6.1 Impacts to Birds

Erickson et al. (2001) estimated that an average of 2.19 bird fatalities occur per wind turbine annually in the mainland United States. This equated to an annual mortality of approximately 33,000 birds given the number of turbines in operation at the time (Erickson et al. 2001). Based on 12 wind projects in the U.S., the National Wind Coordinating Collaborative (2004) estimated an average annual avian fatality rate of 2.3 birds per turbine. Though avian fatality rates differ by region, projects in California presently account for the highest wind-related avian mortality in North America. Certain types of birds in certain settings seem to have a higher risk of collision with wind energy facilities than others. When abundant in open country, as in California, raptors (hawks, eagles, falcons and owls), have had comparatively high fatality rates, though passerines as a class generally comprise the majority of fatalities at wind facilities nationwide (Erickson et al. 2001; NWCC 2004; Kingsley and Whittam 2007). Although some impacts to avian species may occur as a result of habitat alteration and disturbance or operation of vehicles, most fatalities at wind facilities are attributed to collisions with wind turbine rotors, met towers, or guy wires (Kerlinger and Guarnaccia 2005).

Numbers of 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, communication towers, powerlines, 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.

The studies conducted to date at the Kaheawa Pastures Wind Energy Generation Facility suggest that avian mortality resulting from the proposed Kawailoa Wind Power project may occur at a lower rate than has occurred at facilities in the continental U.S. It is expected that individuals of non-listed bird species will occasionally be killed through collision with the proposed wind turbines and met towers. In general, potential exists for individuals of any bird species in the project area (see Table 3-2) to collide with project components, although that potential seems greater for birds that regularly fly well above ground (e.g., bulbuls) than for those that usually remain low or concealed in vegetation (e.g., white-rumped shama).

6.2 Impacts to Bats

The number of bat fatalities at wind energy facilities has often exceeded the number of avian fatalities. Studies in the continental U.S. have shown that annual fatality rates vary by region with an average of 1.2 bat fatalities per turbine in the Pacific Northwest and Rocky Mountains, 1.7 bat fatalities per turbine (0.1 – 7.8 bats per turbine) in the Upper Midwest, and as many as 46.3 bat fatalities per turbine (range 15.54 – 69.6 bats per turbine) in certain areas of the eastern U.S. (Johnson 2005). Differences are likely due to differences in local habitat conditions and population sizes of the most susceptible species. Facilities studied in the eastern U.S. where fatalities are highest are primarily located along forested ridge tops as opposed to open areas, and where migratory tree-roosting species are most numerous (Cryan and Barclay 2009). Bat fatality rates are also greater at facilities with taller turbines (Barclay et al. 2007). Geographic and topographic differences may also be factors. Most of the recorded bat fatalities in the U.S. (83.2%) are members of migratory tree-roosting species. Hoary bats (of which the Hawaiian hoary bat is a subspecies) are the most frequently (45.5%) recorded fatalities (Johnson 2005; Cryan and Brown 2007; Arnett et al. 2008).

Bats are active in the continental U.S. from April to November, but available evidence indicates that bat mortality at wind facilities peaks in late summer and fall (August through September), coinciding with mating and migration. Increased bat fatalities also tend to occur during periods of low wind speed (< 13.5 mph or 6 m/s) and passing weather fronts (Nicholson et al. 2005; Arnett et al. 2008). In contrast, observed bat collision mortality during the breeding season is rare (Johnson et al. 2003b). Similar to birds, bats are also known to collide with tall, man-made structures (Johnson 2005).

The high number of fatalities of migratory tree-roosting bats at some wind energy facilities has stimulated a cooperative research effort to explore how and why bats contact turbines (Arnett et al. 2008). Although the causes of bat fatalities at turbines remain unclear (Cryan and Barclay 2009), several possible explanations have been proposed. Research has suggested that some fatalities may result from mating behaviors that center on the tallest trees in a landscape (Cryan 2008; Cryan and Barclay 2009). Some bats may be attracted to audible sound, ultrasound, light, and movement of wind turbine structures (Horn et al. 2008) or bats may be attracted to turbines as potential feeding, roosting, flocking and mating opportunities (Cryan and Barclay 2009). However, research on the ultrasonic sound emissions of various turbines found that ultrasonic emissions attenuated at short distances from the turbine and there was no evidence of unusual ultrasonic emissions that would attract bats (Szewczak and Arnett 2006). It has been suggested that tree bats may come in close proximity to blades to feed on insects that gather around turbines (Cryan and Barclay 2009). Other theories speculate that migratory behavior, such as stopovers, are responsible for observed fatality rates (Johnson 2005; Cryan and Brown 2007) or that forest edges produced by access roads create favorable foraging habitat (Horn et al. 2008). Few of these hypotheses have been tested. Baerwald et al. (2008) documented that some bats killed at wind turbines suffered from pulmonary hemorrhaging (i.e., barotrauma) caused by a rapid reduction in air-pressure near the edges and tips of moving blades.

6.3 Estimating Project-related Impacts

Construction and operation of the Kawailoa Wind Power project will create the potential for Federally and State-listed bird and bat species to collide with wind turbines, temporary and permanent met towers, communications towers, overhead lines and cranes used for construction of the turbines. The potential for each listed species to collide with project components was assumed based on detection of the species during on-site baseline surveys (discussed in Section 3.0) and the proposed project design. Fatality estimate models for birds were developed to incorporate rates of species occurrence, observed flight heights, encounter rates with turbines and met towers, and considered the ability of birds to detect and actively avoid project components. The ability of birds to detect and avoid turbines was then varied in the models to create a range of probabilities of mortality for each species on an annual basis. Ranges of expected mortality constitute the "direct take" expected from construction and operation of Kawailoa Wind Project. Fatality estimates for bats were based on published data correlating bat activity rates with bat fatality.

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 an adult bird killed by collision could have been tending to eggs, nestlings, or dependent fledglings or an adult bat could have been tending to dependent juveniles. The loss of these adults will then also lead to the loss of the eggs or dependent young. Loss of eggs or young will be "indirect take" attributable to the proposed project. Methods for determining indirect take are described in detail in section 6.3.2.

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 using habitat in the project area is the Hawaiian hoary bat, which could roost in trees on 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 July to August. The Hawaiian short-eared owl, which has not been observed on-site to date, may also roost in low vegetation or nest on the ground within the property. Regular breeding on site is considered highly unlikely because no sightings have been documented during the year-plus-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 to avoid potential for harm to non-volent juvenile bats (see Section 5.3). As Hawaiian short-eared owls breed year round, it is not possible to time clearing activities to completely avoid the potential for conflict with nesting owls. To minimize the risk of interference, vegetation clearing will be suspended when indications of nesting by adult Hawaiian short-eared owls are seen or heard, and resumed when it is apparent that the young have fledged or other confirmation that nesting is no longer occurring (see Section 5.3).

Estimated annual mortality resulting from the Kawailoa Wind Project for each of the species addressed in this HCP is provided below. Also included for each species is an estimate of indirect take based on expected level of direct take. As discussed in Section 8.2 (Monitoring), the amount of direct take attributed to the project (total direct take) will be determined annually. Total direct take will be assessed using observed direct take (actual individuals found during post-construction monitoring) and an estimate of unobserved direct take based on results from searcher efficiency and carcass removal results. This will account for individuals that may be killed but that are not found during the monitoring effort for various reasons, including heavy vegetation cover and scavenging. 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; an estimator proposed in Huso (2008, 2010), is 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

A detailed protocol of how monitoring will be performed at Kawailoa Wind Power is provided in Section 8.2 and Appendix 7. A detailed protocol of how searcher efficiency and carcass removal rates will be quantified during the post-construction monitoring effort is also provided in Appendix 7 and methods for calculating total direct take is presented in Appendix 9.

6.3.1 Take Levels

In addition to providing an estimate of direct and indirect take for each species covered by this HCP, each section below identifies the number of individuals of each species for which take authorization is sought through acquisition of a Federal ITP and State of Hawai'i ITL. Because of a very low level of observed bird activity at Kawailoa Wind Power for the Covered Species in the HCP, the mortality modeling provides very low estimated rates of direct take. To account for the stochasticity of take over time, where take in any given year take may be higher or lower than the expected long term average, one-year, five-year, and 20-year take limits are proposed (e.g., take for Species A could be authorized as three individuals in any given year but not more than five individuals total every five years and not more than 10 individuals for 20 years). Short term take limits (one-year and five-year limits) also provide benchmarks for the monitoring of take and will enable mitigation efforts to be tailored to respond to more immediate events. Twenty-year limits, however, are believed to be a better reflection of the long term amount of take expected.

For each species, the annual baseline level of take was estimated based on the expected average annual mortality identified through the modeling using the most reasonable expectations of avoidance for each species, rounded up to the nearest whole integer, and then adjusted to account for expected levels of unobserved direct take. For example, Newell's shearwater mortality is expected to occur at an average rate of approximately 0.12 adults per year. To arrive at the annual baseline level of take to be authorized, this was first rounded up to 1 adult per year (i.e., almost 8x). Then, based on assumptions concerning unobserved direct take, it was expected that the discovery of 1 shearwater mortality in a given year could lead to an assessment of total direct take for that year of 2 shearwaters. So, while the modeling suggests that shearwater mortality will occur at a rate of roughly one adult bird every seven years, it cannot be known if or in what years mortality will occur. Because of this and because of assumptions concerning unobserved direct take, it is necessary to have the annual baseline take authorization for Newell's shearwater allow the total direct take of a minimum of 2 adult birds in any given year. The 5-year and 20-year Baseline levels, being of a longer term duration, however, more closely reflect the expected annual average mortalities.

Computed "take" for each Covered Species will be classified as Tier 1 and Tier 2. For bats, an additional higher tier, Tier 3, was added to account for the uncertainty surrounding the susceptibility of non-migrating Hawaiian hoary bats colliding with turbines. The continental subspecies of hoary bats is most susceptible to turbine collisions during their fall migration period (see Section 6.2) but the same migration behavior does not occur in Hawaii (see Section 6.3.6), thus the take levels encompass a wider range to accommodate the possible differences in susceptibility.

Requested take at Tier 1 is the baseline amount requested to be authorized by the ITP/ITL for the life of the project. A Tier 2 or 3 (Higher or greater) rate of take would be that which exceeds the Tier 1 limit. In this HCP, a Tier 2 take limit may be up to twice the Tier 1 requested take limit. For bats, the Tier 3 requested take limit is three times greater than Tier 1. Exceeding the five- or 20-year take limit for Tier 1 for any Covered Species would indicate that the rate of take has moved to Tier 2 or Tier 3 (in the case of bats). At this point, the Applicant will also consult with DLNR and USFWS to implement adaptive management strategies. Exceeding only the one-year limit will not move take to a higher tier, but will be used as "early warnings" to spur investigation into why a higher annual rate of take is occurring and whether steps may be able to be taken to reduce future take.

6.3.2 Monitoring of Take Levels

The monitoring protocol will be finalized with the approval of USFWS and DOFAW before the start of project operations. The proposed monitoring protocol for estimating take at Kawailoa Wind Power is presented in Appendix 7 and 9. Currently, intensive monitoring is proposed for the first three years of project operations and systematic monitoring for one year at 5-year intervals, starting at Year 5. Take levels will be calculated on a yearly basis, and based on the number of years that intensive or systematic monitoring have occurred, 5-year and 20-year take projections will be made to determine which take tier the project is currently in. If take appears to be occurring unevenly or if adaptive management measures are in place to reduce take levels, Kawailoa Wind Power may be required to extend the length of the intensive/systematic monitoring periods to obtain a more accurate long term average at the direction of USFWS and DOFAW.

6.3.3 Estimating Indirect Take

The amount of indirect take assigned to a fatality will be determined based on the presumed breeding status of the taken individual and potential productivity as discussed below. The estimates of indirect take derived in this section provide examples based on the best information currently available, which may change as new information emerges. Any new adjustments that result in additional take not previously analyzed, will require amendment of the permit. Breeding status is assigned as follows:

1. Species with a defined breeding season (Newell's shearwater, Hawaiian stilt and Hawaiian hoary bat):
    a. If an adult is found during breeding season, and if an estimate of the average breeding rate of the species (percent of adult population breeding in a given year) is available, the average population breeding rate will be used to determine the probability that the adult was breeding.
    b. If an adult is found during breeding season, and if an estimated breeding rate is not available for the species, the adult will be assumed to have been breeding.
    c. If an adult is found outside of the breeding season, the adult will be assumed to have been non-breeding.
    d. Immatures will be assumed to be non-breeding regardless of season.
    e. If age cannot be determined, an individual will be assumed to have been an adult of breeding age.

2. Species for which breeding occurs year-round but have a peak to their breeding season (Hawaiian duck, Hawaiian coot and Hawaiian moorhen):
    a. If an adult is found during peak breeding season, the adult will be assumed to have been breeding.
    b. If an adult is found outside of peak breeding season, it will be assumed there was a 25% chance that the bird was actively breeding.

3. Hawaiian short-eared owl, which is believed to breed year-round with no known peak:
    a. A 16.67% chance of active breeding will be assumed for any adult owl found. This is based on expectation that a pair of owls produces one clutch per year and known length of the breeding period (length of incubation of 1 month plus 1 month of parental care of young till fledging; 2 months breeding / 12 months per year = 0.1666).

Potential productivity ranges widely amongst the species addressed in this HCP. Some species, such as Newell's shearwater, are expected to produce no more than one young per pair per year. Other species, such as Hawaiian duck, can lay clutches of a dozen eggs or more. While not all young hatched from a clutch of eggs can be expected to survive to fledging age much less adulthood, if an incubating female bird was to be killed by collision with a turbine, that fatality may be held indirectly responsible for the loss of the eggs that were viable at the time of collision. On the other hand, if a female was to be killed during the time it was tending to recently fledged young, a reasonable expectation would exist that the number of fledglings lost through loss of parental care would be fewer than the number of eggs in the original clutch because of expected natural losses to predation, disease, starvation, etc. that typically accrue through the breeding period.

The probability of some listed species colliding with a wind turbine also changes with time of year and/or breeding status. For example, Newell's shearwaters have potential to collide with turbines only during the pre-laying and breeding season because outside these periods they remain at sea. Hawaiian hoary bats may preferentially reside at higher elevations during non-breeding periods. Waterbirds often become territorial during the breeding season and are likely less apt to wander away from nesting areas or brooding territories when tending to eggs or chicks, and so may be less susceptible to collisions when actively nesting. These factors were considered in developing how indirect take would be assessed to the proposed project.

Finally, assessments of indirect take must consider parental contributions to care of the eggs and/or young. Male Hawaiian hoary bats exhibit no role in raising of young, so death of a male bat through collision could not lead to indirect take. Males of some of the bird species do contribute significant effort to raising of young; so, if a female of such a species were to be killed during the breeding season, the male of the pair may be capable of successfully raising some of their young, especially if the mortality were to occur when the young were closer to fledging age.

The amount of annual take requested to be authorized in the ITP and ITL for each species is divided into two categories. One category is the number of individuals requested to be authorized to be directly taken and the other consists of the number of individuals that will be assumed to be indirectly taken in terms of eggs, juveniles or fledglings. As described later, the number of individuals of a Covered Species for which take authorization is sought is sometimes greater than the number of individuals of that species actually expected to be taken. For species with very low expected rates of take (such as the Hawaiian duck), only one or a few individuals are expected to collide with the tubines or project components over 20 years. However, the requested take is greater than the expected take to account for the adjustments made due to unobserved direct take and indirect take, where any one carcass 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, after adjustments for searcher efficiency and scavenging rates. The requested take authorization also takes into account the uncertainty that the models may not have completely accounted for all the risk factors, and take may occur at higher rates than expected. This is particularly true for Tier 2 (and Tier 3 for bats) rates of take, which cover take in the unlikely event that the Covered Species are more susceptible to collisions than expected, or to cover take for unusual circumstances such as freak weather events that may result in increased take over a short period of time.

6.3.4 Seabirds

Seabird mortality due to collisions with human-made objects, such as power lines, has been documented in Hawai'i on the Islands of Maui (Hodges 1994) and Kaua'i (Telfer et al. 1987; Cooper and Day 1998; Podolsky et al. 1998). At the Kaheawa Pastures Wind Energy Generation Facility on Maui, three Hawaiian petrel mortalities have been observed since operations began in June 2006 (Kaheawa Wind Power LLC 2008a, 2008b, 2009, 2010) but no mortalities have been observed for Newell's shearwater. Modeling of expected impacts to Newell's shearwater for Kawailoa Wind Power was performed by Cooper et al. (2011).

6.3.4.1 Newell's Shearwater

Impacts from Turbines and Met Towers

Pre-construction surveys suggest that Newell's shearwaters are likely to be at risk of collision with the turbines and met towers throughout the project site at Kawailoa Wind Power. The estimated fatality rate for Newell's shearwaters are 0.017 shearwaters/turbine/year (assuming 99% avoidance), 0.084 shearwaters/turbine/year (95% avoidance) and and 0.169 shearwaters/turbine/year (90% collision avoidance rates). For the 30 turbines anticipated on site, the total fatality therefore ranges between 0.50 shearwaters/year (assuming 99% avoidance), 2.52 shearwaters/year (95% avoidance) and 5.04 shearwaters/year (90% collision avoidance rates).

Fatality rates due to Newell's shearwaters striking the met towers are 0.005 birds/tower/year (assuming a 99% avoidance rate), 0.024 birds/tower/year (95% avoidance rate) and 0.047 birds/tower/year (90% avoidance rate).

No Newell's shearwater mortality has been documented at the KWP facility since operations began. However, modeling suggests that for the measured passage rates, at 95% avoidance, approximately three Newell's shearwater fatalities should have occurred already. Since that scenario seems unlikely, given that no carcasses have been found, a 99% avoidance rate was assumed for Kawailoa Wind Power. Thus, the estimated average fatality rate at a 99% avoidance level for all turbines is estimated at 0.50 shearwaters/year. Fatality at the (up to) two permanent met towers is estimated at 0.01 shearwaters/year at the 99% avoidance rate. The total expected fatality for the turbines and met towers combined is calculated to be 0.51 shearwaters/year. However, this estimated fatality may still be inflated as during the radar survey, it was evident that some of the targets observed on radar were likely not to be Newell's shearwater but other seabirds or shorebirds that have similar flight speeds and sizes, such as the Pacific golden-plover, black-crowned night heron or white-tailed tropic bird (Appendix 3; Day et al. 2003b). Coupled with the uncertainty over whether the species still breeds on the Island of O'ahu, Kawailoa Wind Power proposes to assume that approximately only one quarter of the targets are Newell's shearwater and projects a mortality rate of 0.13 shearwaters/year for all turbines and met towers on site.

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 met towers that will be onsite, but will have a smaller profile. The construction phase is expected to last less than a year, with cranes on-site for only four to six months. Assuming that the cranes have an equal or lesser probability of a bird strike as a met tower the take is calculated to be 0.0025 birds per crane (0.005 (take/yr for met tower) x 0.5 years = 0.0025 birds). This also conservatively assumes that the cranes will be onsite during the breeding season for the Newell's shearwater and there is a nesting colony on Oahu. Given the modeled low rate, potential for Newell's shearwaters to collide with construction cranes is considered unlikely and no additional take is requested.

Potential for shearwaters to collide with the on-site communication towers, off-site antennae and utility poles also exists. These structures, except for one of the communications tower, are 60 ft tall or less. Studies have shown that only 1% of Newell's shearwaters (n = 688 birds; B. Cooper/ABR, pers. comm.) fly below 60 ft and for the one communications tower that is 150 ft tall, it is expected that 25% of all Newell's shearwater will fly below 150 ft (n = 688 birds; B. Cooper/ABR, pers. comm.). 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 low altitudes and colliding with any of the communication towers, antennae, and utility poles related to the project is considered to be remote.

The possibility of Newell's shearwater colliding with overhead lines is also considered remote. On Kaua'i, take associated with 1145 miles of transmission, distribution, and secondary lines in 2008 was estimated to be 15.5 breeding adults, and 63 non-breeding or immature Newell's shearwaters (Planning Solutions et al. 2010). Kaua'i is estimated to host 75% of the total population of Newell's shearwater population, which is estimated at 21,250 breeding and non-breeding birds in 2008 (Planning Solutions et al. 2010). This amounts to 0.067 mortalities per year per mile of power line. Most of the remaining birds are believed to nest on Hawai'i and Maui, but some birds could potentially be nesting on Oahu (Appendix 3). If 1% of the Newell's shearwater population still uses Oahu (approximately two hundred individuals which is likely an overestimate), the total mortality for the 4 miles of proposed overhead lines at Kawailoa would be 0.07 Newell's shearwaters over 20 years. With a total of 2995 miles of transmission and distribution lines on Oahu, the fallout rates associated with power line strikes alone, assuming 1% of the population utilizing this area would be expected to be 2.67 birds per year for the entire island.

To our knowledge, no seabird mortality (or mortality of any other listed species) has been recorded at the two existing off-site communication facilities, although we also are not aware that any systematic mortality monitoring has been conducted at these locations. Because the proposed antennae will mounted on existing towers, the antennae are not expected to significantly increase the collision risk of any Covered Species if they should happen to transit the tower location.

Therefore, none of these structures were as assumed to be a potential source of take of Newell's shearwater and the amount of take to be authorized 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 attributed to the on-site construction cranes, on-site communication towers or off-site antennae, associated overhead cables or utility poles, the take will be assessed as part of the project and Kawailoa Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site and through the methods proposed in Section 7.3.

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 (15 mph) will be established 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 take modeling.

Therefore, for this HCP, 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 0.13 shearwaters/year.

Indirect Take and Take Limits

Adult and immature shearwaters are most likely to collide with turbines or associated structures while commuting between nesting and feeding grounds during the non-breeding pre-laying period (April to May), and breeding periods which consist of the incubation and chick-feeding periods (June to October), and the fledging period (October to November). Newell's shearwaters are not expected to fly across the project area at other times of year. Based on the above, indirect take would be applied to any direct take of adult shearwaters from June through October. Indirect take would not be assessed to adult shearwaters found at other times of year or to immature shearwaters. Both shearwater parents care for their eggs and chicks. As little information is available for Newell's shearwaters on nestling growth and development or adult visitation rates, it is assumed that both parents are necessary throughout the breeding season for successfully fledging a chick.

Not all Newell's shearwaters visiting a nesting colony breed. It was estimated by Ainley et al. (2001) that 46% of all active burrows produced an egg. Moreover, most non-breeding birds and failed breeders leave the colony for the season by August (Ainley et al. 2001). Therefore, it appears there would be a 46% chance that an adult shearwater taken from June 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 as identified in Table 6-1 below, indirect take would be assessed at the rate of 0.46 eggs or chicks per adult taken between May and August, and 1.00 chick per adult taken in September through October (life history data presented can also be found in Appendix 5). These are conservative adjustments because this assumes that a chick will definitely perish if either parent dies at any time through October. When chicks are close to fledgling, it is likely that some will survive even with the death of a parent, similar to other seabirds such as the Hawaiian petrel (Simons and Hodges 1998).

Table 6-1. 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	Apr-May	--	0	--	0.00
Adult	Jun-Aug	1	0.46	1.0	0.46 eggs/chicks
Adult	Sept-Oct	1	1	1.0	1 chick
Adult	Nov-May	--	0.00	--	0.00
Immature	All year	--	0.00	--	0.00

Because of adjustments to account for unobserved direct take, any one Newell's shearwater 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, with total direct take then likely to be rounded up to two to three birds after adjustments for searcher efficiency and scavenging rates. The amount of adjustment depends on the search protocol in place at the time of the observed take (see Section 8.2.1, Appendix 7 and 9). Therefore, the Applicant suggests the ITP and ITL should allow for a total direct take of up to three Newell's shearwaters and the indirect take of two chicks for any given year for the duration of the project (see below for calculation of indirect take). While the birds taken under "unobserved direct take" would be assumed and, therefore, of unknown age or gender, for the purposes of this HCP it will be assumed that unobserved direct take has an equal probability of occurring anytime between April and November. This period includes the pre-laying period (April to May), the breeding season (June to October) and fledging period (November). It is expected that only adults or immatures will be taken from April to October and only fledglings will be taken in November. Thus the calculated indirect take for an individual lost through "unobserved direct take" is 0.4 chicks based on the distribution of indirect take during that eight month period ([(2 months x 0 chicks) + (3 months x 0.46 chicks) + (2 months x 1 chick) + (1 month x 0 chicks)] / 8 months = 0.42).
As an example, the total direct take of two adults per year (1 observed direct take + 1 unobserved indirect take) could result in an indirect take assessment of 0.4 to 1.4 chicks per year (Table 6-2).

Table 6-2. Calculation of Total Indirect Take for Newell's Shearwater from Observed and Unobserved Direct Take.

Newell's shearwater	Min	Max
Observed indirect take	0	1.0
Unobserved indirect take	0.4	0.4
Total	**0.4**	**1.4**

Rates of take of Newell's shearwaters requested to be authorized by the ITL and ITP through the expected 20-year life of the project are summarized below. The baseline take level is represented by Tier 1. Also provided are tiers accommodating higher rates of take (Tier 2) for purposes of identifying when it would be appropriate or necessary to consider adaptive management practices. See Section 6.3.1 for an explanation of the different take limits and take levels.

Tier 1

Annual average	0.15 adults/immatures and 0.1 chicks	0.25 birds/yr
One-year limit	3 adults/immatures and 2 chicks	
5-year limit	3 adults/immatures and 2 chicks	
20-year limit	3 adults/immatures and 2 chicks	

Tier 2

Annual average	up to 0.3 adults/immatures and 0.2 chicks	0.5 birds/yr
One-year limit	6 adults/immatures and 3 chicks	
5-year limit	6 adults/immatures and 3 chicks	
20-year limit	6 adults/immatures and 3 chicks	

The most recent population estimate of Newell's shearwater was approximately 84,000 breeding and non-breeding birds, with a possible range of 57,000 to 115,000 birds (Ainley et al. 1997). However, based on population modeling, Ainley et al. (2001) calculated an annual population decrease of 6.1%. More recently, Holmes (Planning Solutions et al. 2010) suggest a 75% population decrease between 1993 and 2008, based on radar surveys and SOS data. This puts the 2008 total population estimate on the order of 21,000. The Tier 1 requested take is for five shearwaters over 20 years, resulting in an annual rate of take of shearwaters at 0.4 shearwater/yr which is less than 0.002% of the current estimated Newell's shearwater population. If the five mortalities occur at once, it only constitutes 0.02% of the estimated population. Given these very low percentages, the proposed project is unlikely to result in significant adverse effects to Newell's shearwater at the population level.

Tier 2 requested take totals 9 shearwater over 20 years, resulting in an average annual rate of take at 0.5 shearwaters/yr. This impact is less than 0.004% of the overall population. In the event that that all nine mortalities occur at once, it constitutes 0.04% of the estimated population. Given these very low percentages, take caused by the proposed project would not result in significant adverse effects to Newell's shearwater at the population level.

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). Proposed mitigation measures (Section 7.3) are expected to more than offset the anticipated take and contribute to the species' recovery by providing a net conservation benefit, with the development of new and more effective predator traps or restoration that will enable new colonies to be established and managed. These measures when developed will enable previously unmanaged colonies to be protected, or lay the foundation for the creation of new colonies in areas where threats are low or can be controlled. This is expected to yield improvements in protection, reproductive success and survival over current management methods for the species as a whole, with benefits extending years into the future. For this reason, no significant adverse impacts to the species' overall population, and no significant cumulative impacts to the species are anticipated (see Section 7.3.4 for details).

6.3.5 Hawaiian Waterbirds

6.3.5.1 Hawaiian Duck

Impacts to Hawaiian Duck-Mallard Hybrids from Turbines and Met Towers

Given that few Hawaiian ducks are believed to be resident on the Island of O'ahu (Browne et al. 1993; Uyehara et al. 2007; USFW 2005a), all ducks that resembled pure Hawaiian ducks seen on the project site and in the project vicinity were assumed to be Hawaiian duck-mallard hybrids (see Section 3.8.4.3 for a detailed explanation). Nine such individuals were observed at point counts within the airspace envelope of Zone 1 during the year-long avian survey. This results in an average passage rate of 0.054 individuals/hr/ha over the Zone 1 turbine string. No ducks were observed at Zone 2 or Zone 3, therefore the risk of collision with turbines in Zone 2 and 3 is estimated to be zero. Ducks are only expected to be at risk of collision with the thirteen turbines and up to two permanent met towers in Zone 1.

As no ducks were actually seen at flight altitudes within the RSZ of the proposed turbines, for modeling purposes, 5% of the ducks were assumed to fly within the RSZ in order to estimate fatality rates (see Appendix 4). Therefore, the estimated fatality rate for Hawaiian duck-mallard hybrids entering the RSZ ranges from 0.009 Hawaiian duck-mallard hybrids ducks/RSZ/year (assuming 99% avoidance rates) to 0.05 Hawaiian duck-mallard hybrids ducks/RSZ/year (95% avoidance rates) to 0.094 Hawaiian duck-mallard hybrids ducks/RSZ/year (90% collision avoidance rates). Fatality rates due to Hawaiian duck-mallard hybrids striking the tubular towers of the turbines were at 0.004, 0.018 and 0.036 Hawaiian duck-mallard hybrids/tower/year, assuming 99%, 95% and 90% avoidance rates respectively. Combined, the estimated fatality rate for Hawaiian duck-mallard hybrids at Kawailoa Wind Power were 0.013, 0.065 and 0.130 birds/turbine/year for 99%, 95% and 90% avoidance rates respectively (see Appendix 4).

Fatality rates due to Hawaiian duck-mallard hybrids striking the met towers were 0.002, 0.011 and 0.021 birds/tower/year, assuming 99%, 95% and 90% avoidance rates, respectively (see Appendix 4).

Low mortality of waterbirds has been documented at wind turbines situated coastally 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 show 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). Because of this, an avoidance rate of 99% (99% of the ducks approaching the turbines and met towers successfully avoid them) was used in the modeling to estimate the expected average mortality rate of hybrid Hawaiian ducks resulting from proposed project operations. The estimated average rate of mortality at 99% avoidance is 0.17 ducks/year for all turbines, assuming 13 turbines and two met towers in Zone 1 and no mortality in Zone 2 or 3.

Impacts to Hawaiian Duck-Mallard Hybrids from Other Project Components

Hawaiian duck hybrids frequently fly at altitudes to which the on-site communication towers, overhead collection lines, relocated distribution lines and utility poles on-site would extend (see Appendix 4). Therefore, some potential for ducks to collide with these structures exists. However, as Hawaiian hybrid ducks are primarily diurnal, they are expected to easily avoid the communication towers which would be highly visible during daylight hours. Observations of ducks conducted at wetlands at Kahuku in 2008 and 2009 demonstrated that Hawaiian duck hybrids easily negotiated the overhead powerlines strung across the wetland habitat (SWCA 2010a). 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 communication towers, overhead collection lines, and utility poles on-site is considered negligible.

Some very limited and temporary potential risk 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 relatively brief period. Consequently, potential for hybrid Hawaiian ducks to collide with construction cranes is considered negligible.

No Hawaiian duck hybrids are expected to be present at either offsite communication tower.

Therefore, none of these structures were as assumed to be a potential source of take of Hawaiian duck-mallard hybrids in the mortality modeling performed for the species, and the amount of take expected is based solely on mortality expected to occur as a result of the operation of the WTGs and met towers.

Impacts to Hawaiian Duck-Mallard Hybrids 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 (15 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 estimate and so does not result in an increase in the amount of take expected from the proposed project.

Therefore, for this HCP, it is projected that take of Hawaiian duck hybrids as a result of collision with project components and vehicle strikes will occur at an average rate of 0.17 ducks/year.

Relating Hawaiian Duck-Mallard Hybrid Fatality to the Requested Take for Pure Hawaiian Ducks

Given the dispersal capabilities of the species, it is possible for pure Hawaiian ducks to occasionally fly over from Kaua'i. In addition, genetic research in 2007 showed presence of several Hawaiian ducks at James Campbell National Wildlife Refuge, and a bird struck by a plane at Honolulu International Airport in 2007 was found to be Hawaiian duck (A. Nadig, USFWS, pers comm.). Browne (1993) found absence of pure Hawaiian ducks on Oahu due to extensive hybridization with feral mallards. Uyehara et. al (2007) found a predominance of hybrids on Oahu. An estimated 300 Hawaiian duck-like birds are found on Oahu, but the majority of these, given the genetic evidence, are thought to be hybrids (USFWS 2005a). Mallard control and possible reintroduction of Hawaiian ducks to Oahu may increase the population of Hawaiian ducks on the island within the 20 year life of the project. Given the very high proportion of hybids present on Oahu, it is conservatively assumed that only 10% of the ducks seen may have the potential to be pure Hawaiian ducks, though the proportion of pure Hawaiian ducks to Hawaiian duck-mallard hybrids is expected to be much less as described above. Thus the expected fatality rate of pure Hawaiian ducks is projected to occur at one-tenth the rate of Hawaiian duck-mallard fatalities at 0.017 ducks/year

However, if in the unlikely event a Hawaiian duck mortality is attributed to the on-site construction cranes, Kawailoa Wind Power on-site communication towers or off-site antennae, associated overhead cables or utility poles, the take will be assessed as part of the project and Kawailoa Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site and through the methods proposed in Section 7.3.

<u>Indirect Take and Take Limits of Pure Hawaiian Ducks</u>

It is assumed that adult pure Hawaiian 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 dependent young, and so are not expected to fly over the Kawailoa Wind Power site during those times. It is assumed that pure Hawaiian ducks, like hybrid Hawaiian ducks will breed year round, with a peak in breeding occurring from March to June.

For purposes of assessing indirect take, any adult pure 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 fledglings produced per pair of Hawaiian ducks per nesting attempt is 1.225, see Appendix 5). 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 6-3 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 presented can be found in Appendix 5).

Table 6-3. 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 adjustments made for unobserved direct take, any one 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, which would likely be rounded up to two to four birds after adjustments for searcher efficiency and scavenging rates. The amount of adjustment depends on the search protocol emplace at the time of the observed take (see section 8.2.1, Appendix 7 and 9). While the birds taken under "unobserved direct take" would be assumed, and of unknown age or gender, for the purposes of this HCP it will be assumed that all 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 Hawaiian ducks/Hawaiian duck hybrids 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 two months; three months breeding /12 months per year = 0.25, See Appendix 5). 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).

As an example, the total direct take of two adults per year (1 observed direct take + 1 unobserved indirect take) could result in an indirect take assessment of 0.31 to 1.53 ducklings per year (Table 6-4).

Table 6-4. Calculation of Total Indirect Take for the Hawaiian Duck from Observed and Unobserved Direct Take.

Hawaiian Duck	Min	Max
Observed indirect take	0	1.225
Unobserved indirect take	0.306	0.306
Total	**0.306**	**1.531**

The Applicant suggests the Baseline ITP and ITL should allow for a total direct take of up to four pure Hawaiian ducks and the indirect take of four ducklings in any year of project operation. Rates of take of Hawaiian ducks requested to be authorized by the ITL and ITP through the expected 20-year life of the project are summarized below. The baseline take level is represented by Tier 1. Also provided are tiers accommodating higher rates of take (Tier 2) for purposes of identifying when it would be appropriate or necessary to consider adaptive management practices. See Section 6.3.1 for an explanation of the different take limits and take levels. Note that the level of take expected over the 20-year life of the project was derived by multiplying the expected annual average (0.012) by 20 and rounding up to the nearest whole integer (1). The requested 20-year take authorization is greater than one adult duck to account for unobserved take, and to allow for possible future increases in the pure Hawaiian duck population. A Hawaiian duck/Hawaiian duck hybrid identification key will be used in the identification of downed ducks when it becomes available. USFWS and DLNR will require the Applicant conduct the appropriate genetic analysis for any downed ducks that look like Hawaiian ducks, Hawaiian duck hybrids or female mallards.

Tier 1

Annual average	0.2 adults/immatures and 0.2 ducklings	0.4 birds/yr
One-year limit	4 adults/immatures and 4 ducklings	
5-year limit	4 adults/immatures and 4 ducklings	
20-year limit	4 adults/immatures and 4 ducklings	

Tier 2

Annual average	up to 0.3 adults/immatures and 0.3 ducklings	0.6 birds/yr
One-year limit	4 adults/immatures 4 ducklings	
5-year limit	6 adults/immatures and 6 ducklings	
20-year limit	6 adults/immatures and 6 ducklings	

An estimated 2,000 pure Hawaiian ducks are present on Kaua'i. The Tier 1 requested take is for 8 total birds over 20 years, resulting in an annual average rate of take of 0.4 birds/yr, which would constitute a loss of 0.02% of the population on Kaua'i per year. Mortality at this very low rate is not expected to cause significant negative impacts to the population of pure Hawaiian ducks. This small annual rate of take is also not expected to adversely affect the O'ahu population if reintroduction has already occurred. In the event that all eight ducks get taken at once, it would constitute 0.4% of the population on Kaua'i and would not be expected to cause significant negative impacts to the population of pure Hawaiian ducks. All eight mortalities occurring at once could begin to impact the O'ahu population if reintroduction had already occurred as the initial population is expected to be small. However, the expected small initial population also makes the likelihood of taking eight pure Hawaiian ducks at once that are resident on Oahu extremely unlikely. Regardless, the proposed mitigation at Tier 1 if resident pure Hawaiian ducks are present, is expected to more than offset the anticipated take by increasing the productivity and survival rates of the pure Hawaiian ducks present at the managed wetland (see Section 7.4.1).

Tier 2 requested take totals 12 ducks over 20 years, resulting in an average annual rate of take at 0.6 birds/year which would constitute 0.03% of the Kauaʻi population annually and is also not expected to have significant population level impacts. If 12 ducks get taken at once, it would constitute 0.6% of the population on Kauaʻi and is still not expected to cause significant negative impacts to the population of pure Hawaiian ducks. All 12 mortalities occurring at once could begin to impact the Oʻahu population if reintroduction has already occurred. However, the expected small initial population also makes the likelihood of taking 12 pure Hawaiian ducks at once that are resident on Oahu extremely unlikely. Regardless, the proposed mitigation at Tier 2 is expected to more than offset the anticipated take by increasing the productivity and survival rates of the pure Hawaiian ducks on at the managed wetland (see Section 7.4.2). For these reasons, no adverse impacts to the species' overall population are anticipated.

6.3.5.2 Hawaiian Stilt

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. However, because Hawaiian stilts have historically occurred in the Kawailoa area, it is assumed that the project would be at some risk of taking this species, however small. For the purposes of this HCP, 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 0.17 stilts/year lost through interaction with turbines, met towers, on-site communication towers, and overhead cables, utility poles and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

No Hawaiian stilt are expected to be present at either offsite communication tower.

However, if in the unlikely event a stilt mortality is attributed to the off-site antennae, the take will be assessed as part of the project and Kawailoa Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site and through the methods proposed in Section 7.3.

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 Kawailoa 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 (Appendix 5). However, based on the information in 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 four, while average number of fledglings produced per pair of Hawaiian stilts is 0.9, see Appendix 5). 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 assumed likely to survive even with the loss of one parent (Robinson et al. 1999). Based on these assumptions, as indicated in Table 6-5 below, the amount of indirect take assessed for each direct adult stilt mortality is 0.45 during the breeding season (life history data presented can be found in Appendix 5).

Table 6-5. 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

Because of adjustments made for 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 two to four birds after adjustments for searcher efficiency and scavenging rates. The amount of adjustment depends on the search protocol in place at the time of the observed take (see Section 8.2.1, Appendix 7 and 9). While the birds taken under "unobserved direct take" would be assumed, and therefore, of unknown age or gender, for the purposes of this HCP it will be assumed that all Hawaiian stilts taken through "unobserved direct take" will be adults. In addition, because stilt could be flying through the project area at any time of year, the likelihood of the 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). As an example, the total direct take of two adults per year (1 observed direct take + 1 unobserved indirect take) could result in an indirect take assessment of 0.53 fledglings per year (Table 6-6).

Table 6-6. Calculation of Total Indirect Take for the Hawaiian Stilt from Observed and Unobserved Direct Take.

Hawaiian Stilt	Min	Max
Observed indirect take	0	0.45
Unobserved indirect take	0.075	0.075
Total	**0.075**	**0.525**

Rates of take of Hawaiian stilt requested to be authorized by the ITL and ITP through the expected 20-year life of the project are summarized below. The baseline take level is represented by Tier 1. Also provided are tiers accommodating higher rates of take (Tier 2) for purposes of identifying when it would be appropriate or necessary to consider adaptive management practices. As with Hawaiian duck, 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. See Section 6.3.1 for an explanation of the different take limits and take levels.

Tier 1

Annual average	0.4 adults/immatures and 0.2 fledglings	0.6 birds/yr
One-year limit	4 adults/immatures and 2 fledgling	
Five-year limit	6 adults/immatures and 3 fledglings	
20-year limit	8 adults/immatures and 4 fledglings	

Tier 2

Annual average	up to 0.6 adults/immatures and 0.3 fledglings	0.9 birds/yr
One-year limit	4 adults/immatures and 2 fledglings	
5-year period	8 adults/immatures and 4 fledglings	
20-year limit	12 adults/immatures and 6 fledglings	

Oahu supports 35-50% of the State's stilt population with approximately 450 to 700 birds present on the island. However, Hawaiian stilts readily disperse between islands and constitute a homogenous metapopulation (Reed et al. 1998). Currently, the population of Hawaiian stilts is considered to be stable to increasing (Service 2005) and is estimated to be between 1,200 to 1,600 birds (Griffin et al. 1989; Engilis and Pratt 1993, Hawaii Biodiversity and Mapping Program 2007). Tier 1 requested take is for 12 total birds over 20 years, resulting in an annual rate of take of stilts at 0.6 birds/yr which constitutes no more than 0.01% of the estimated population annually on O'ahu and is not expected to significantly impact the population of the stilt on the island. In the event that all 12 stilt mortalities occur at once, it will constitute 1.7% of the resident population or 0.8% of the overall population of

Hawaiian stilt. Regardless, the proposed mitigation (see Section 7.4) is expected to more than offset the anticipated take by increasing the productivity and survival rates of the Hawaiian stilt present at the managed wetland (see Section 7.4.1). 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).

Tier 2 requested take totals 18 stilt over 20 years, resulting in an average annual rate of take at 0.9 stilt/yr which still only constitutes no more than 0.1% of the population on the island annually and is unlikely to significantly impact the population. 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). Mortality of 18 stilts at once would constitute 2.5% of the resident population or 1.1% of the overall population of Hawaiian stilt. Regardless, the proposed mitigation for Tier 2 is expected to more than offset the anticipated take by increasing the productivity and survival rates of the Hawaiian stilt present at the managed wetland (see Section 7.4.2). For these reasons, no adverse impacts to the species' overall population are anticipated.

6.3.5.3 Hawaiian Coot

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 (see Section 3.8.2.5). No coots were observed flying through the project area during the avian surveys but one Hawaiian coot was observed foraging once in a nearby waterbody (see Section 3.8.4.5). The Hawaiian coot was absent in subsequent observations. Because the coot was not observed in flight, mortality modeling for this species would result in a projected rate of take of zero. Since the Hawaiian coot presumably took flight to arrive and depart from the pond, Hawaiian coots may occasionally occur in or near the airspace envelope of the turbines. Therefore, 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 0.17 coots/year resulting from interactions with turbines, met towers, on-site communication towers, associated overhead cables, utility poles and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

No Hawaiian coot are expected to be present at either offsite communication tower.

However, if in the unlikely event a Hawaiian coot mortality is attributed to the off-site antennae, the take will be assessed as part of the project and Kawailoa Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site and through the methods proposed in Section 7.3.

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 dependent young, and so are not expected to fly over the Kawailoa Wind Power project area 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 (Appendix 5). 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, Appendix 5). 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 6-7 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 presented can be found in Appendix 5).

Table 6-7. 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 adjustments made for 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, which likely would be rounded up to two to four birds after adjustments for searcher efficiency and scavenging rates. The amount of adjustment depends on the search protocol emplace at the time of the observed take (see section 8.2.1, Appendix 7 and 9). While the birds taken under "unobserved direct take" would be assumed, and therefore, of unknown age, for the purposes of this HCP 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).

As an example, the total direct take of two adults per year (1 observed direct take + 1 unobserved indirect take) could result in an indirect take assessment of 0.15 to 0.6 chicks per year (Table 6-8).

Table 6-8. Calculation of Total Indirect Take for the Hawaiian Coot from Observed and Unobserved Direct Take.

Hawaiian Coot	**Min**	**Max**
Observed indirect take	0	0.45
Unobserved indirect take	0.15	0.15
Total	**0.15**	**0.6**

Rates of take of Hawaiian coot requested to be authorized by the ITL and ITP through the expected 20-year life of the project are summarized below. The baseline take level is represented by Tier 1. Also provided are tiers accommodating higher rates of take (Tier 2) for purposes of identifying when it would be appropriate or necessary to consider adaptive management practices. As with the hybrid Hawaiian duck and Hawaiian stilt, 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. See Section 6.3.1 for an explanation of the different take limits and take levels.

Tier 1

Annual average	0.4 adults/immatures and 0.2 fledglings	0.6 birds/yr
One-year limit	4 adults/immatures and 2 fledgling	
Five-year limit	6 adults/immatures and 3 fledglings	
20-year limit	8 adults/immatures and 4 fledglings	

Tier 2

Annual average	up to 0.6 adults/immatures and 0.3 fledglings	0.9 birds/yr
One-year limit	4 adults/immatures and 2 fledglings	
5-year limit	8 adults/immatures and 4 fledglings	
20-year limit	12 adults/immatures and 6 fledglings	

Island-wide population, based on bi-annual waterbird counts conducted by DOFAW, suggests that the population is stable and is estimated at between 2,000 and 3,000 individuals. O'ahu supports between 500 and 1,000 coots, or up to 33% of the State population. Hawaiian coots readily disperse between islands and constitute a homogenous metapopulation. The Tier 1 requested take is for 12 total birds over 20 years, resulting in an annual rate of take of coots at 0.6 birds/yr which constitutes no more than 0.06% of the estimated population on O'ahu annually and is not expected to significantly impact the population of the coots on the island. In the event that all 12 coot mortalities occur at once, it will constitute 1.2% of the resident population or 0.4% of the overall population of Hawaiian coot. Regardless, the proposed mitigation (see Section 7.4) is expected to more than offset the anticipated take and contribute to the species' recovery by increasing the productivity and survival rates of the Hawaiian stilt present at the managed wetland (see Section 7.4.1). 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).

Tier 2 requested take totals 18 coot over 20 years, resulting in an average annual rate of take at 0.9 stilt/yr which still only constitutes no more than 0.2% of the population annually on the island. 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 take of 18 coot mortalities would constitute 1.8% of the resident population or 0.6% of the overall population of Hawaiian coot. Regardless, the proposed mitigation for Tier 2 is expected to more than offset the anticipated take and contribute to the species' recovery by increasing the productivity and survival rates of the Hawaiian stilt present at the managed wetland (see Section 7.4.2). For these reasons, no adverse impacts to the species' overall population are anticipated.

6.3.5.4 Hawaiian Moorhen

Hawaiian moorhens were never detected at Kawailoa Wind Power during the year long avian point count survey but do occur in the nearby waterbodies. However, Hawaiian moorhen are also thought to be at very low risk of collision with turbines because of their sedentary habits (see Section 8.3.2.6). 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 0.17 moorhens/year as a result of collision with turbines, met towers, on-site communication towers, associated overhead cables, utility poles and other associated structures, as well as mortality due to construction related fatalities and vehicular strikes.

No Hawaiian moorhen expected to be present at either offsite communication tower.

However, if in the unlikely event a Hawaiian moorhen mortality is attributed to the off-site antennae, the take will be assessed as part of the project and Kawailoa Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site and through the methods proposed in Section 7.3.

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 Kawailoa Wind Power project area during those times. Hawaiian moorhen have been documented to breed year round with the peak breeding period between March and 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 (Appendix 5). 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, see Appendix 5). 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 6-9 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 presented can be found in Appendix 5).

Because of adjustments made for 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 which likely would be rounded up to two to four birds after adjustments for searcher efficiency and scavenging rates. The amount of adjustment depends on the search protocol emplace at the time of the observed take (see Section 8.2.1, Appendix 7 and 9). While the birds taken under "unobserved direct take" would be assumed, and of unknown age, for the purposes of this HCP 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 6-9. 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

As an example, the total direct take of two adults per year (1 observed direct take + 1 unobserved indirect take) could result in an indirect take of 1.03 chicks (Table 6-10).

Table 6-10. Calculation of Total Indirect Take for the Hawaiian Moorhen from Observed and Unobserved Direct Take.

Hawaiian Moorhen	Min	Max
Observed indirect take	0	0.65
Unobserved indirect take	0.38	0.38
Total	**0.38**	**1.03**

In addition to the anticipated take by the project, predator trapping poses some risk of harassment due to capture (see Section 7.4.3), and could result in injury or mortality to the Covered waterbird species and is accounted for in Section 6.3.5.4. Moorhen are attracted to traps (DesRochers et al. 2006) and moorhen on O'ahu have been documented entering live traps (DesRochers et al. 2006; Nadig/USFWS, pers. comm.). USFWS recommends additional take of not more than ten Hawaiian moorhen annually in the form of harassment due to capture. The trapping at 'Uko'a pond is anticipated to last five years and a total of take of 50 individuals in the form of harassement is also requested. No risk of injury or mortality is anticipated from this harassment and the conservation strategy to implement wetland management including a predator control program will result in an overall increase in the baseline number of individuals of the endangered Hawaiian moorhen. Therefore,_the implementation of live trapping will have beneficial effects through the control of nonnative predators and increased productivity of Hawaiian moorhen. As a beneficial effect no further mitigation would be required for the potential capture of Hawaiian moorhen.
However, if the implementation of mitigation measures causes a waterbird capture that does result in mortality or injury, the take will be assessed as part of the 18 birds (Tier 2 total) estimated for injury or mortality as part of the Kawailoa Wind Power project.

Rates of take of Hawaiian moorhen requested to be authorized by the ITL and ITP through the expected 20-year life of the project are summarized below. The baseline take level is represented by Tier 1. Also provided are tiers accommodating higher rates of take (Tier 2) for purposes of identifying when it would be appropriate or necessary to consider adaptive management practices. As with the duck, stilt, and coot, 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. See Section 6.3.1 for an explanation of the different take limits and take levels.

Tier 1

Annual average	0.4 adults/immatures and 0.2 fledglings	0.6 birds/yr
One-year limit	4 adults/immatures and 2 fledgling	
Five-year limit	6 adults/immatures and 3 fledglings	
20-year limit	8 adults/immatures and 4 fledglings	
20-year Take for Harassment	50 individuals	

Tier 2

Annual average	up to 0.6 adults/immatures and 0.3 fledglings	0.9 birds/yr
One-year limit	4 adults/immatures and 2 fledglings	
5-year limit	8 adults/immatures and 4 fledglings	
20-year limit	12 adults/immatures and 6 fledglings	
20-year Take for Harassment	50 individuals	

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) and the actual population is expected to be larger. The Tier 1 requested take is for 12 total birds over 20 years, resulting in an annual rate of take of moorhen at 0.6 birds/yr which constitutes no more than 0.2% of the known estimated population annually on O'ahu and is not expected to significantly impact the population of the moorhen on the island. If 12 moorhen mortalities occur at once, it will constitute 3.5% of the known resident population. Regardless, the proposed mitigation (see Section 7.4) is expected to more than offset the anticipated take and contribute to the species' recovery by by increasing the productivity and survival rates of the Hawaiian moorhen present at the managed wetland (see Section 7.4.1). 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).

Tier 2 requested take totals 18 moorhen over 20 years, resulting in an average annual rate of take at 0.9 stilt/yr which still only constitutes no more than 0.3% of the known estimated population on the island annually. This rate of take is still unlikely to impact the State population even with its potentially small size. Hawaiian moorhen are rarely seen flying, preferring to swim or walk (Bannor and Kiviat 2002). Moorhens in Hawai'i 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 1983). The likelihood of 18 moorhen mortalities occurring at once would constitute 2.4% of the known resident population. The proposed mitigation for Tier 2 is expected to more than offset the anticipated take and contribute to the species' recovery by increasing the productivity and survival rates of the Hawaiian moorhen present at the managed wetland (see Section 7.4.2). For these reasons, no adverse impacts to the species' overall population are anticipated.

6.3.6 Hawaiian Short-eared Owl

No Hawaiian short-eared owls were seen or heard during the avian point count surveys conducted over 12 months at the Kawailoa Wind Power project area (see Section 3.8.2.7). Post-construction monitoring data from North America suggest the species has a low vulnerability to collision with wind turbines (see Section 3.8.2.7).

Hawaiian short-eared owls generally fly low over the ground, preferring open pastures and grasslands away from most structures (Wiggins et al. 2006). This behavior is typical of short-eared owls observed at the operating Kaheawa Wind facility on Maui (Spencer/First Wind, pers. comm.). The potential for short-eared owls to collide with wind turbines seems to be greatest when birds are performing aerial breeding displays or if the birds need to avoid some aerial predator. The lack 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. Further, 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.

Potential for short-eared owls to collide with on-site and off-site project components including the permanent, un-guyed met tower, communication towers, antennae, overhead collection 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.

However, if in the unlikely event a Hawaiian short-eared owl mortality is attributed to the on-site construction cranes, on-site communication towers or off-site antennae, associated overhead cables or utility poles, the take will be assessed as part of the project and Kawailoa Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site and through the methods proposed in Section 7.3.

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, and are believed to nest in the vicinity. Since project operations began in 2006, one fatality has been documented due to a turbine collision and one from a vehicular collision (Kaheawa Wind Power LLC, 2008a, 2008b, 2009, 2010). One carcass was also incidentally found under MECO transmission lines in 2009. The low number of recorded fatalities at a site where the species has considerable exposure to collision hazards, suggests that the risk of collision at the Kawailoa Wind Power facility is very low.

All overhead collection lines (including associated hardware and equipment) will be spaced according to APLIC (2006) guidelines, and fitted with insulated jumpers (see Section 5.2) to minimize the risk of electrocution-related mortalities.

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 (15 mph) will be enforced on project roadways to minimize potential for vehicle strikes to harm short-eared owls.

Given that no Hawaiian short-eared owls have been observed on site, it is possible that no Hawaiian short-eared owl fatalities will be realized during the life of the Kawailoa Wind Power project. However, as suitable habitat for hunting does seem to be present, the risk of collision cannot 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. For the purposes of this HCP, it is assumed that the proposed project will on average result in the loss of 0.2 Hawaiian short-eared owl/year. This equates to one owl every five years. This mortality rate includes loss due to interaction with turbines, met towers, on-site communication towers, off-site antennae 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 (see Appendix 5). 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 6-11 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 presented can be found in Appendix 5).

Table 6-11. 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

Because of adjustments made for 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 and rounded up to two to four birds after adjustments for searcher efficiency and scavenging rates. The amount of adjustment depends on the search protocol emplace at the time of the observed take (see Section 8.2.1, Appendix 7 and 9). While the birds taken under "unobserved direct take" would be assumed, and of unknown age, for the purposes of this HCP it will be assumed that all Hawaiian short-eared owls taken through "unobserved direct take" will be adults Similar to the calculation for indirect take above, the indirect take assessed for "unobserved direct take" will be 0.95 owlets per adult.

As an example, the total direct take of two adults per year (1 observed direct take + 1 unobserved indirect take) could result in an indirect take of 1.9 chicks (=0.95+0.95).

Rates of take of Hawaiian short-eared owl requested to be authorized by the ITL and ITP through the expected 20-year life of the project are summarized below. The baseline take level is represented by Tier 1. Also provided are tiers accommodating higher rates of take (Tier 2) for purposes of identifying when it would be appropriate or necessary to consider adaptive management practices. The expected 20-year rate was derived by multiplying 0.2 owls/year by 20 years and rounding up to the nearest whole integer. See Section 6.3.1 for an explanation of the different take limits and take levels.

Tier 1

Annual average	0.2 adults/immatures and 0.2 owlets	0.4 birds/yr
One-year limit	4 adults/immatures and 4 owlets	
Five-year limit	4 adults/immatures and 4 owlets	
20-year limit	4 adults/immatures and 4 owlets	

Tier 2

Annual average	up to 0.3 adults/immatures and 0.3 owlets	0.6 birds/yr
5-year period	6 adults/immatures and 6 owlets	
20-year period	6 adults/immatures and 6 owlets	

No population numbers for Hawaiian short-eared owl are available for the Island of O‘ahu or any of the other Hawaiian Islands. The Tier 1 requested take is for 8 total birds over 20 years, resulting in an annual rate of take of owls at 0.4 birds/yr, this is unlikely to cause a significant impact on the Hawaiian short-eared owl population on O‘ahu. Given that short-eared owls do not congregate in large numbers, the likelihood of all 8 owl mortalities occurring at once is unlikely. Given that the population numbers are unknown, this may impact the resident population on the island but such take would not be expected to affect the status of the species on other islands. However, the Applicant's proposed mitigation for the anticipated take (see Section 7.4) will also 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 which when implemented should mitigate for the requested take by increasing adult survival and productivity.

Tier 2 requested take totals 12 owls over 20 years, resulting in an average annual rate of take at 0.6 owls/yr. However, realization of take at higher levels is considered extremely unlikely to occur because Hawaiian short-eared owls have not been seen at the Kawailoa Wind Power site over the course of 12 months of surveys. These rates of take are also unlikely to cause a significant impact on the Hawaiian short-eared owl population on O‘ahu. Given that short-eared owls also do not congregate in large numbers, the likelihood of all 12 owl mortalities occurring at once is extremely remote. However, if it were to occur, the take could impact the resident population on the island but such take would not be expected to affect the status of the species on other islands. The proposed mitigation for the Higher take levels will contribute to a greater understanding of the species' occurrence and status, which which when impelemted should mitigate for the requested take at Tier 2 by increasing adult survival and productivity.

6.3.7 Hawaiian Hoary Bat

Based on surveys conducted to date, the Hawaiian hoary bat occurs within the project area with higher activity recorded from March to November (Appendix 4, section 3.2.3.8). Bats also occur in very low numbers at the Kahuku Wind Power facility (SWCA 2010d) and there has been one other confirmed sighting of a Hawaiian hoary bat at Pūpūkea on the North Shore of O‘ahu in 2002 (Menard/TNC, pers. comm.). Two observed direct takes of the Hawaiian hoary bat have occurred at KWP since the beginning of project operations.

6.3.7.1 Impacts of the Facility on Bat Habitat

Hawaiian hoary bats have been known to use both native and non-native habitats for feeding and roosting (Mitchell et al. 2005). The vegetated areas within the maximum project footprint for Kawailoa Wind Power consist mostly of agricultural land, alien grassland, shrubland and forest. The alien forest habitat at Kawailoa Wind Power is fairly homogenous, with stands of albizia, ironwood and eucalyptus trees, all of which are considered invasive species in Hawai‘i (see Section 3.7.1.). At Kawailoa Wind Power, bats may roost in the trees present in the area and bat activity has been detected in essentially all habitats, including clearings, along roads, along the edges of treelines, in gulches and at irrigation ponds. Monitoring to date indicates that bats use all of these features for travelling and foraging. The construction of Kawailoa Wind Power will result in the loss of about 5.6 ac of land to permanent structures such as buildings, met towers, turbines and riser poles (Table 1-1). An additional 16.4 ac of land is expected to be altered by road widening or creation of access roads to turbine pads (Table 1-1). Up to 9.9 ac and 1.9 ac of land will be cleared around each turbine and permanent met tower respectively (to a possible maximum of about 305 ac for all 30 turbines and 4 met towers) to establish searchable plots for the monitoring of downed wildlife. Of the 305 ac total approximately 259 ac is likely to be cleared and maintained; the remainder of the search areas will likely remain undisturbed due to steep topography. These search plots will be maintained as short stature shrubs and grasses to maximize the probability of finding downed wildlife and will result in the conversion of approximately 44 ac of agricultural land, 64 ac of shrubland, 130 ac of alien forest and 21 ac of grassland to mowed or otherwise maintained clearings. These habitats contain mostly invasive tree, shrub and grass species (see Section 3.7.1). Only the clearing of alien forest has the potential to affect the roosting of Hawaiian hoary bats in the area. However, the total population of bats on Oʻahu is believed to be small (USFWS 1998), and alien roost trees are plentiful; thus roost trees in alien forests are probably not a limiting factor for the species on Oʻahu (see Section 3.8.4.4). The alien forest habitat in the vicinity of Kawailoa Wind Power is fairly homogenous, and does not vary significantly in composition or structure between adjacent patches (L. Ong/SWCA personal observations). For these reasons, it is expected that any bats displaced by the clearing of alien forest would readily find alternate roost sites in surrounding undisturbed forest. Although bats may use the alien forest trees on the site for roosting, the loss of 130 ac of alien forest constitutes only 1.0% of the total lowland forest (alien and native) available in the project area and vicinity[1]. The clearing of an additional 5.6 ac of land for permanent structures and 16.4 ac of land for road widening may also result in the additional loss of alien forest. Although the exact location of the roads and buildings have not been finalized, alien forest habitat loss (versus the amount of agricultural, grassland and shrubland lost) is expected to be less than 50% of the 22 ac. total for roads and structures. This additional small loss is also not expected to reduce the availability of roost trees to the Hawaiian hoary bat. Moreover, the conversion of some of the alien forest habitat to open spaces, and the addition of edges and corridors due to road creation and improvements will result in the creation of foraging habitat. Bat activity has been detected in similar types of clearings around the current temporary met towers, and along edges and roads at the project site (see above and Section 3.8.4.4). Therefore, these changes in the habitat mosaic (forest to open areas) are not expected to adversely affect the Hawaiian hoary bat but may result in changes in the patterns of use within the area (roosting versus foraging). Furthermore, the clearing of trees will not occur during the pupping season from June 1 to September 15 to avoid take of non-volant juveniles (Section 5.3).

In summary, the total population of bats on Oʻahu is believed to be small (USFWS 1998), and roost trees in alien forests are probably not a limiting factor for the species on Oʻahu (see Section 3.8.4.4). For these reasons, no net habitat loss is expected for the Hawaiian hoary bat, as the roosting habitat is not expected to be limiting in the area, and is further offset by the creation of foraging habitat due to increased availability of open spaces, edges and corridors. The construction and operation of Kawailoa Wind Power is not expected to result in significant bat habitat loss or significantly displace any bats or negatively impact bat foraging and roosting behavior on site. The only impacts from the project are anticipated to be due to the take of individuals by collisions with the project components and are addressed in the following section.

Scattered native trees, notably koa, are present in small numbers intermixed within the alien forest, and an equivalent or greater number of these trees will be replanted in the vicinity to replace the trees lost due to clearing. This will result in the creation of some native tree habitat which may also be used by bats in the future (see Section 7.9).

6.3.7.2 Calculating Direct Take

Extensive monitoring of bat activity at existing wind farms on the continental U.S. (see Section 3.8.4.4 and 6.2) has shown that bats are most susceptible to collisions with turbines during the fall migration season. In recent years, bat fatality studies have focused exclusively on a three month window (July

[1] The area analyzed includes vegetation bounded by Waimea Valley to the north, Kawailoa Gulch to the south, the coastline to the west and lowland forest which extends to an elevation of 1,600 ft to the east. The total area is 19,150 ac, of which 11,290 ac is designated conservation land, 7,553 ac agricultural land and 307 ac, urban land.

through September) when most bat fatalities occur. Studies on documented bat fatalities outside this season are few and fatality rates appear to be minimal (Gruver 2002; Nicholson et al. 2003; Johnson et al. 2003a; Fiedler 2004). Several studies have also shown a positive relationship between the total number of bat passes/detector night (recorded primarily during the Fall migration season) with the estimated total fatalities/turbine/year (Kunz et al. 2007; Baerwald and Barclay 2009).

Data from Kunz et al. (2007) show that the estimated number of bat fatalities/turbine/year is generally equivalent to the number of bat passes/detector night on site (see Table 6-12). A similar relationship was detected by Baerwald and Barclay (2009), where bat activity rates of migratory bats (of which the continental hoary bat is one) measured during the Fall migration season, were positively correlated with fatality rates occurring at tall turbines (turbine **towers** 65 m or taller). The number of bat fatalities ranged widely from 1.7 to 13.5 times the number of migratory bat passes/detector night (see Figure 6-1). The lowest bat activity rate recorded at their sampled sites was 0.78 ± 0.12 passes/detector night. This rate is more than five times greater than the rate recorded at Kawailoa Wind Power during the higher activity periods (see Section 3.8.4.4).

Therefore, using the Baerwald and Barclay (2009) study as a guide, bat fatality rates at tall turbine sites with low bat activity were examined in order to develop an estimate of expected direct take of Hawaiian hoary bat for Kawailoa Wind Power. The two sites (sites 8 and 9 in Figure 6.1) with bat activity (less than 2 bat passes/detector night, Figure 6-1) most closely approaching that measured at Kawailoa also had bat activity rates that most closely matched adjusted bat fatality rates (i.e., in the range close to 1.7 times rather than 13.5 times). A similar trend is also seen in Table 6-12 with data summarized by Kunz et al. (2007). Sites with the lowest bat activity had a low ratio of fatality to activity, while sites with higher activity rates have more variable ratios of activity to fatality.

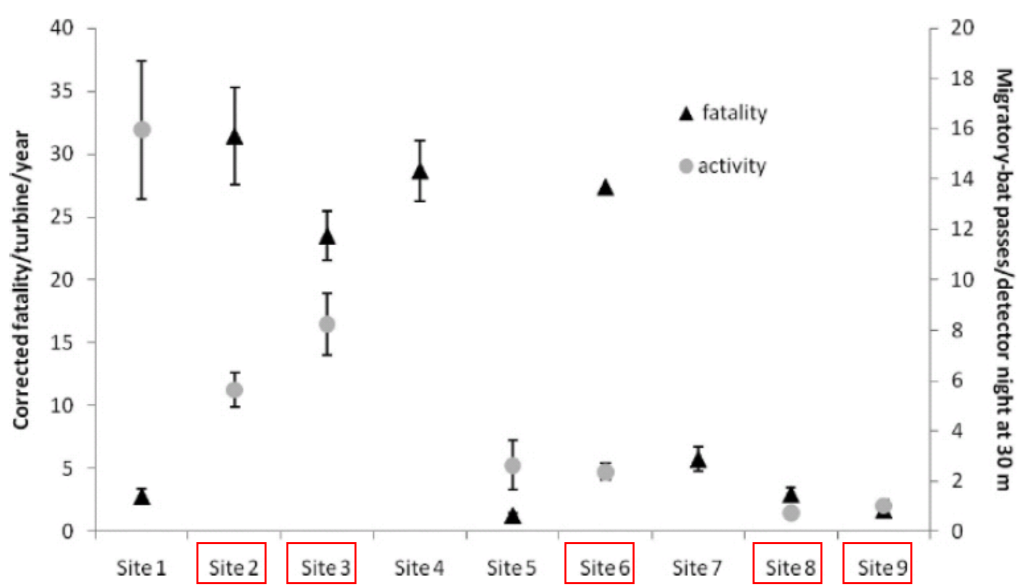


Figure 6-1. Mean ± SE Activity of Migratory Bats at 30 m and Corrected Bat Fatalities/Turbine/Year Across Sites in Southern Alberta, Canada.
Heights of turbine towers varied: sites 1 and 5 = 50 m; sites 2, 3, 4, and 7 = 65 m; site 6 = 67 m; site 8 = 80 m; and site 9 = 84 m. Note: not all sites have activity and fatality rates e.g., site 4.
Source: Baerwald and Barclay 2009.
Sites with tall turbines (65 m towers or taller) with activity and fatality rates.

Table 6-12. Fatality Rates and Bat Activity Indices at Five 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	Sep to Oct 2003, May to Sep 2004	10.2	34.9	42	Jain 2005
Buffalo Ridge, MN	15 June-15 Sep 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.

In applying these studies to estimating the expected fatality rate of Hawaiian hoary bats at Kawailoa Wind Power, a few limitations need to be recognized:

1) 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 activity rates holds for individual species.

2) For the Kunz et al. (2007) data set, echolocation calls were recorded at different heights at some sites and only at ground level at others.

3) The echolocation call data for all the above studies were collected after the wind energy facilities were constructed. It is unclear whether preconstruction bat pass data, such as is available for the Kawailoa Wind Power project area, 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 roosting bats (*Lasiurus*), 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.

4) Most of these studies focused on migratory bat fatalities associated with their fall migration, which occurs on a continental scale. During the fall migration, thousands of migrating bats can traverse an area in a single night. This phenomenon does not occur in Hawai‘i. Therefore, the Hawaiian hoary bat may be less vulnerable to turbines on the Hawaiian Islands because it does not migrate long distances or congregate in large numbers (Cryan and Barclay 2009).

Take estimates for Hawaiian hoary bat for the Kawailoa Wind Power project are calculated with the following assumptions:

1) that changes in landscape and construction of turbines will not attract bats to the area

2) that post-construction bat activity will remain the same as the measured pre-construction bat activity

3) the number of bat fatalities/turbine/year is positively correlated with the number of bat passes/detector night which is measured during the higher activity period for the site

(Section 3.8.4.4). This activity period is considered analogous to the peak bat activity recorded at wind farm sites during the fall migration period on the continental U.S. (as demonstrated by Kunz et al. 2007 and Baerwald and Barclay 2009).

In an effort to minimize bat fatalities, low wind speed curtailment (LWSC) will also be implemented from the start of project operations (see Section 5.3) for the peak months of March through November when bat activity is relatively higher (see Section 3.8.4.4). LWSC reduced bat fatalities by an average of 82% in 2008 and 72% in 2009, during a 2-year study in Pennsylvania (Arnett at al. 2010, see Section 5.3). The expected fatality at Kawailoa with low wind speed curtailment assumed a conservative 70% reduction in fatalities during the implementation of LWSC.

As discussed in Section 3.2.3.8, the Anabat detectors used on-site resulted in measurement of an average of 0.15 passes/detector night during the higher activity periods (from March through November). Bat fatality at Kawailoa Wind Power was estimated using bat activity to fatality ratios ranging from 1:0.5 to 1:1.5 to encompass the uncertainty surrounding the susceptibility of resident Hawaiian hoary bats to turbine collisions as compared to their mainland counterparts. A ratio of 1:0.5 assumes that the Hawaiian hoary bat is somewhat less susceptible to turbine collisions than mainland bats due to factors such as a lack of long-distance mass migration behavior, though a much shorter distance altitudinal shift may occur on O‘ahu (see Section 3.8.4.4). Ratios of 1:1 and 1:1.5 assume that Hawaiian hoary bats are as susceptible to turbine collisions as the continental subspecies.

The expected bat fatalities based on the different assumed ratios are presented in Table 6-13. As an example when a 1:0.5 ratio is assumed, a bat activity rate of 0.15 passes/detector night results in 0.075 fatalities/turbine/yr, or 45 fatalities for 30 turbines over 20 years (=0.15 x 0.5 x 30 x 20). A 70% reduction in fatality due to LWSC is then applied resulting in an expected take of 13.5 bats for 30 turbines over the life of the project (=45 x [1-0.7]).

Table 6-13. Direct Take Calculations Based on LWSC and Activity.

	Bat Activity:Fatality per Turbine		
	1:0.5	1:1	1:1.5
Expected direct take	45.0	90.0	135.0
Expected direct take with LWSC (70% reduction in fatality)	13.5	27.0	40.5

Potential for bats to collide with met towers, on-site communication towers, off-site antennae, 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 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. No downed bats have been found during the weekly searches of the four guyed temporary met tower at the Kawailoa Wind Power project area. Weekly searches began in October 2009 and are ongoing. These search plots have been regularly mowed since the plots were established. In addition, of 64 wind turbines studied at Mountaineer Wind Energy Center on the Appalachian Plateau in West Virginia, bat fatalities were recorded at operating turbines, but not at the one turbine that remained non-operational during the study period. This supports the assumption that stationary structures such as met towers and cranes should not result in bat fatalities (Kerns et al. 2005).

However, if in the unlikely event a bat mortality is attributed to the on-site construction cranes, on-site communication towers or off-site antennae, associated overhead cables or utility poles, the take will be assessed as part of the project and Kawailoa Wind Power LLC will mitigate for that loss at a level commensurate with any take recorded on-site and through the methods proposed in Section 7.3.

6.3.7.3 Calculating Indirect Take

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 bat activity data collected to date collected at Kawailoa Wind Power also suggest that this may be occurring (Section 3.8.4.4). Even though LWSC curtailment will be implemented during the peak activity months, the risk of take is probably still greater during these months than during the months when bat activity is low or presumed absent and LWSC is not implemented. Therefore, it is conservatively assumed that bats are most likely to collide with turbines during the peak activity period from May through November, which encompasses most of the breeding season (see below).

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 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 lactating female bats found during the months of April through August is 1.8 juveniles per adult female as indicated in Table 6-14 below (life history data presented can be found in Appendix 5).

Table 6-14. Calculating Indirect Take for the Hawaiian Hoary Bat.

Hawaiian hoary bat	Season/ Breeding Condition	Average no. of juveniles per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect take (A*B*C)
Female	Lactating	1.8	1.0	1.00	1.80
Female	Not lactating	--	0.0	--	0.00
Male	All year	--	0.0	0.00	0.00
Immature	All year	--	0.0	--	0.00

As with the other species addressed in this HCP, the DLNR and ESRC have recommended that annual take limits allow for at least one **observed** take a year. Because of adjustments for unobserved direct take, any one 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 one, which will likely be rounded up to four bats during the years when intensive monitoring occurs (see Appendix 7), after adjusting for searcher efficiency and scavenging. Existing literature on adjusting for 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; Kaheawa Wind Power 2010). During years of less intensive monitoring effort, any one Hawaiian hoary bat found to have collided with a project component in a year may result in a total direct take of up to eight bats.

While the other bats taken under these scenarios would be assumed and, therefore, of unknown age or gender, for the purposes of this HCP 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 most likely would be flying through the project area from March through November, spanning a period of nine months, the likelihood of a female bat having dependent young is assumed to be 11%. This is based in the information that Hawaiian hoary bats have one brood a year, and are expected to be to have dependent young one month out of the nine months (parental care of one month after birth; NatureServe 2008) present on site. Further, parental care is limited to a period June thoruhg September. Consequently, indirect take will be assessed to bats lost through “unobserved direct take” at the rate of 0.1 juveniles/bat (0.5 x 0.11 x 1.8 = 0.10).

As an example, indirect take assessed to a total direct take of 4 bats (1 observed direct take + 3 unobserved direct takes) is assumed to be no more than 2.1 juveniles (Table 6-15).

Rates of take of Hawaiian hoary bat requested to be authorized by the ITL and ITP through the expected 20-year life of the project are summarized below. The baseline take level is represented by Tier 1. Tier 1 rates approximates a bat activity to fatality ratio of 1:0.5. Two tiers with higher rates of take than Tier 1 are also proposed (Tier 2 and Tier 3) with bat activity to fatality ratios approximating 1:1 to 1:1.5, respectively (see Table 6-13 above). See also Section 6.3.1 for an explanation of the different take limits and take levels.

Table 6-15. Calculation of Total Indirect Take for the Hawaiian Hoary Bat from Observed and Unobserved Direct Take.

Hawaiian Hoary Bat	Min	Max
Observed indirect take	0	1.8
Unobserved indirect take	0.3 (=0.10x3)	0.3 (=0.1x3)
Total	**0.3**	**2.1**

Tier 1

Annual average	0.8 adults/immatures and 0.4 juveniles	1.2 bats/yr
One-year limit	8 adults/immatures and 4 juveniles	
Five-year limit	16 adults/immatures and 8 juveniles	
20-year limit	16 adults/immatures and 8 juveniles	

Tier 2

Annual average	1.6 adults/immatures and 0.8 juveniles	2.4 bats/yr
One-year limit	16 adults/immatures and 8 juveniles	
5-year limit	24 adults/immatures and 12 juveniles	
20-year limit	32 adults/immatures and 16 juveniles	

Tier 3

Annual average	2.4 adults/immatures and 1.2 juveniles	3.6 bats/yr
One-year limit	24 adults/immatures and 12 juveniles	
5-year limit	32 adults/immatures and 16 juveniles	
20-year limit	48 adults/immatures and 24 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 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 Islands of Hawai'i and Kaua'i (Menard 2001). No breeding bats have been recorded on O'ahu and based on published literature, the bats found on O'ahu are thought to be migrant or vagrant (USFWS 1998) though bat activity data at Kawailoa Wind Power suggests that some bats may reside on O'ahu (see Section 3.8.4.4). Species recovery is also currently focused on the Islands of Hawai'i and Kaua'i as recommended by the Recovery Plan for the Hawaiian Hoary Bat (USFWS 1998).

The Tier 1 requested take is for 24 total bats over 20 years, resulting in an annual rate of take at 1.2 bats/yr. This low rate of take is unlikely to adversely affect the population on O'ahu (if present) and evern less likely to impact the status of the species on other islands (such as Hawai'i and Kaua'i) where populations are assumed to be more robust. Given that bats are expected to be migrant or vagrant, or if a small resident population is present on the island, it is very unlikely that all 24 bat mortalities will occur at once. If this occurs, it could impact the local resident population, but if the bats are migrant or vagrant, it is unlikely to affect the population as a whole. However, the Applicant's proposed mitigation which will occur on O'ahu (see Section 7.6.1) is expected to offset the anticipated take occurring on the island, and contribute to the species' recovery by increasing the productivity and survival rates of Hawaiian hoary bats utilizing the restored wetland or forest (see Section 7.6.2), regardless of whether they are resident, migrant or vagrant. For these reasons, no adverse impacts to the species' overall population are anticipated.

Take at Tier 2 (48 bats total or 2.4 bats/yr) or 3 (72 bats total or 3.6 bats/yr) could only occur and impact the O‘ahu population, if a resident population is present and is much larger than anticipated (likely to at least be in the hundreds). This would in turn imply that the populations on the Islands of Hawai‘i and Kaua‘i, where bats are known to breed and are detected more frequently, could be larger, and thus the somewhat higher average yearly take is not expected to impact the status of the species as a whole. The Tier 2 and Tier 3 rates of take could impact the resident population on O‘ahu, in the very unlikely event that all the mortality occurs at once (48 bats for Tier 2 and 72 bats for Tier 3). However, the Applicant's proposed mitigation for the anticipated take (see Section 7.6) which is being implemented on O‘ahu is expected to offset the take at the required tier and ultimately contribute to the species' recovery by increasing the productivity and survival rates of Hawaiian hoary bats utilizing the restored wetland or forest (see Section 7.6.2). For these reasons, no adverse impacts to the species' overall population are anticipated.

6.4 Cumulative Impacts to Listed Species

Take for the Covered Species has been authorized for projects occurring on O‘ahu, Maui and Kaua‘i through HCPs and Safe Harbor Agreements (SHAs) (Table 6-16). Under the Federal Endangered Species Act (16 U.S.C. 1531-1544) HCPs are required to minimize and mitigate the effects of the incidental take to the maximum extent practicable. In addition to the above requirements, the State of Hawaii requires that all HCPs and their actions authorized under the plan should be designed to result in an overall net benefit to the threatened and endangered species in Hawai‘i being authorized for incidental take (Section 195D-30). Under a SHA, 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.

In addition to the take that has already been authorized (Table 6-16), the proposed Na Pua Makani wind facility project on Oahu, the Kaheawa Wind Power II and Auwahi Wind Project on Maui and Kaua‘i Wind Power project on Kaua‘i (Table 1-4) also have the potential to result in incidental take of, and contribute to cumulative impact to, the Covered Species. However, it is expected that if the HCPs for any or all of the potential projects are approved, the impacts and mitigation measures will resemble those discussed for Kawailoa Wind Power, where the proposed mitigation measures are expected to offset the anticipated take and provide a net benefit to the species.

At a broader scale, Kawailoa Wind Power represents one of many projects that can be expected to occur on the Islands of O‘ahu, Maui and Kaua‘i. O‘ahu, Maui and Kaua‘i have experienced increasing human population growth and real estate development, and those 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 Kawailoa Wind Power are among the few that are implementing measures to offset take and provide a net benefit to the affected species. In general, it is assumed that future development projects will be conducted in compliance with all applicable local, State, and Federal environmental regulations.

Table 6-16. Current and Pending Take Authorizations for the Covered Species on O‘ahu, Maui and Kaua‘i through Habitat Conservation Plans and Safe Harbor Agreements.

Applicant	Permit Duration	Location	Species and Total Take Authorization
Kahuku Wind Power	05/27/2010-05/27/2030	Kahuku, O‘ahu	Newell’s shearwater (12 adults, 6 chicks) Hawaiian duck (12 adults, 12 ducklings) Hawaiian stilt (12 adults, 6 chicks) Hawaiian coot (12 adults, 6 chicks) Hawaiian moorhen (12 adults, 8 chicks) Hawaiian short-eared owl (12 adults, 12 owlets) Hawaiian hoary bat (18 adults, 14 juveniles)
Kaheawa Wind Power	01/30/2006-01/30/2026	Mā‘alaea, Maui	Newell’s shearwater (40 individuals) Hawaiian hoary bat (20 individuals)
Kaheawa Wind Power II	Pending	Mā‘alaea, Maui	Newell’s shearwater (5 adults, 3 chicks)[1] Hawaiian hoary bat (9 adults, 6 juveniles)[1]
Auwahi Wind Energy	Pending	‘Ulupalakua Ranch, Maui	Hawaiian hoary bat (19 adults, 8 juveniles)[1]
Kaua‘i Island Utility Cooperative (KIUC)	2011-2015	Kaua‘i	Newell’s shearwater (625 individual mortalities, 275 non-lethal injuries)
Chevron SHA	09/23/2005-09/23/2011	Kapolei, O‘ahu	Hawaiian stilt Hawaiian coot

6.4.1 Seabirds (Newell’s Shearwater)

Currently, take for Newell’s shearwater has been authorized on O‘ahu, Maui and Kaua‘i (Table 6-16). Mitigation for Kahuku Wind Power on Oahu consists of colony-based management on Maui or Kaua‘i. The colony based management is expected to consist of erecting a cat and mongoose-proof fence around an identified colony, eradicating the cats and mongoose within and trapping for rats to protect the nesting seabirds within. Social attraction and artificial burrows could also be used to enhance the colony numbers by attracting seabirds to a managed site, safe from predation. The predator exclusion and trapping is expected to increase adult and juvenile survival and also increase the overall productivity of the colony within the protected area and offset the requested take and provide a net benefit to the species by contributing knowledge to new management techniques for the species such as social attraction.

Mitigation for take of Newell’s shearwater at Kaheawa Wind Power and the pending Kaheawa Wind Power II project also consists of colony-based management using social attraction and artificial burrows to attract seabirds to an already protected site on Maui. The protection of the Newell’s shearwaters is expected to increase productivity and survival within the protected colony which will offset the requested take for the two projects. Net benefit is expected as this will be the first viable Newell’s colony on Maui that will be managed and the colony is expected to show net growth (versus a declining population at most unmanaged colonies) with the protection provided.

Mitigation by KIUC for their Short-term Seabird HCP, is comprehensive. It consists of implementing the Save our Shearwaters (SOS) Program which rehabilitates downed seabirds, colony-based management and research and additional take monitoring. The SOS Program rescues and rehabilitates downed seabirds that would otherwise have died, primarily as a result of powerline collisions and light attraction. It provides a significant conservation benefit to these seabirds, which supplements KIUC’s main mitigation effort of implementing colony-based management. Seabird colony management will occur at Limahuli Valley and Hono o Na Pali Natural Area Reserve. The measures that will be implemented at Limahuli Valley include ungulate-proof fencing, ungulate

[1] pending project approval

removal, feral cat removal, rodent control, alien plant control, and monitoring the breeding success of the seabirds. Measures to be implemented at Hono o Na Pali Natural Area Reserve include cat-trapping, rodent control, barn owl removal and monitoring of breeding success of the seabirds. Research initiatives include a two-year auditory survey to locate additional breeding colonies and updating at-sea seabird population estimates. Funds will also be provided to implement an appropriate monitoring program. These measures are expected to benefit the seabirds by increasing productivity and survival at the protected colonies and are expected to offset the requested take for KIUC. The research will also enhance the knowledge of the population size of the seabirds and their collision rates with overhead utility lines. The research is expected to better inform the threats that the seabirds face both at sea and on land.

Take authorization for this species may also be requested by Na Pua Makani on Oahu and Kaua'i Wind Power on Kaua'i (Table 1-4).

The proposed mitigation measures described for Newell's shearwater from the various HCPs are expected to produce a measurable net benefit in the form of off-setting the requested take and result in an increase in the species' population by increasing productivity and survival rates of birds through predator control and other management measures such as fencing and ungulate control and supplementary programs such as SOS. The research and development of new management techniques proposed by the different projects (such as the development of a self-resetting cat trap by Kawailoa Wind Power) will also improve effectiveness of the management of the seabird colonies. The research and development will also have far-reaching effects beyond the mitigation measures implemented by any of the project applicants. All the improved management measures will be available to be utilized by most parties involved in the management of Newell's shearwater colonies once developed. This is expected to result in better protection and greater reproductive success and adult survival for many colonies, including those that are currently unmanaged. For these reasons, no significant adverse impacts to the species' overall population, and no significant cumulative impacts to the species, are anticipated.

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

Currently, only the Kahuku Wind Power facility has been authorized to take the Hawaiian duck, Hawaiian stilt, Hawaiian coot, or Hawaiian moorhen on O'ahu. Take authorizations for this project are shown in Table 6-16. No observed take of waterbirds has been recorded at Kahuku since the project began operating in May 2010. Take authorization for these Federally listed waterbirds is assumed for Na Pua Makani on Oahu and Kaua'i Wind Power on Kaua'i (Table 1-4).

The most important causes of decline of Hawaiian waterbirds are 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 Kawailoa Wind Power project will 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 Kawailoa Wind Power exists.

Kahuku Wind Power is conducting wetland management consisting of predator control and vegetation management for waterbird mitigation. These measures are expected to increase waterbird productivity and survival at the managed site and are expected to offset the requested take for Kahuku Wind Power. The mitigation measures are also expected to result in the production of waterbird fledglings in excess of the take requested by Kahuku Wind Power, thereby providing a net conservation benefit (SWCA 2010d). The proposed mitigation measures are expected to produce a measurable net benefit in the form of a marginal increase in the species' population by increasing productivity and survival rates of birds through predator control and other management measures such as fencing and ungulate control. Similar mitigation measures are being implemented by Kawailoa Wind Power and assumed for Na Pua Makani and Kaua'i Wind Power on Kaua'i (if constructed). For these reasons, no significant adverse impacts to the species' overall population, and no significant cumulative impacts to the Federally listed waterbirds, are anticipated.

6.4.3 Hawaiian Short-eared Owl

Currently, the only authorized take of Hawaiian short-eared owls is at Kahuku Wind Power. Over the 20-year project life, Kahuku Wind Power is authorized to take eight owls and four owlets (Table 6-16). No observed take of Hawaiian short-eared owls has been recorded at Kahuku since construction of the project began in May 2010. Take authorization for this species is also assumed for Na Pua Makani on Oahu (Table 1-4).

Loss and degradation of habitat, predation by introduced mammals, and disease threaten Hawaiian short-eared owls. Hawaiian short-eared owls appear particularly sensitive to habitat loss and fragmentation, as they require relatively large tracts of grassland and are ground nesters. Ground nesters 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 vulnerable to predation by rats, cats, and the small Indian mongoose (Mostello 1996; Mitchell et al. 2005). Trauma (apparently from vehicular collisions), emaciation and infectious disease (pasteurellosis) (Thierry and Hale 1996) also cause 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 Kawailoa Wind Power, exists.

However, Kawailoa Wind Power has proposed mitigation measures for the species that will contribute to the rehabilitation of injured owls and/or a greater understanding of the species' occurrence and status as well as management measures to aid in the recovery of the species. These measures should result in an overall net conservation benefit for the species by rehabilitating owls that would otherwise have died or by increasing adult survival or productivity due to the management measures. Similar mitigation measures are being implemented for Kahuku Wind Power and are assumed for Na Pua Makani. For these reasons, no significant adverse impacts to the species' overall population are expected, and no significant cumulative impacts to the species are anticipated.

6.4.4 Hawaiian Hoary Bat

Currently, only the Kahuku Wind Power facility has been authorized to take Hawaiian hoary bats on O'ahu (Table 6-16). Take authorization for this species is assumed for Na Pua Makani on O'ahu. Kaheawa Wind Power is authorized for Hawaiian hoary bat take on Maui. Take authorizations for Kaheawa Wind Power II and Auwahi Wind Power on Maui are assumed (Table 1-4).

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. Research was the main component of Kaheawa Wind Power mitigation due to the need to help determine some basic life history parameters and identify effective management measures. Kahuku Wind Power, Kaheawa Wind Power II and Auwahi Wind Energy will mitigate for bats by restoring forest habitat to increase the amount of foraging, breeding and roosting habitat. The acreage to be restored is based on the estimated core territory area size of a bat, which is considered the minimum habitat requirement for a bat. All projects are restoring acreages commensurate with their impacts on Hawaiian hoary bat. The forest restoration will consist of ungulate fencing, removal of ungulates, removing or managing invasive species and conducting native forest restoration activities. These restorations are expected to compensate for the requested take of the Hawaiian hoary bat by the three projects. The Auwahi Wind Energy forest restoration is also expected to create a travel corridor between two forest reserves (Kula Forest Reserve and Kanaio Forest Reserve) and the Auwahi Forest Restoration Project, which will reduce habitat fragmentation and genetic concerns and provide a net benefit to the species (Tetra Tech EC LLC 2011). Kawailoa Wind Power's proposed mitigation for the anticipated take of Hawaiian hoary bat will also contribute to restoration of native bat habitat (either wetland or forest) with a research component and are anticipated to have similar benefits. Similar mitigation measures are assumed Na Pua Makani on Oahu, and Kaua'i Wind Power on Kaua'i. Therefore, there are no anticipated cumulative impacts to the Hawaiian hoary bat.

7.0 MITIGATION MEASURES

7.1 Selection of Mitigation Measures

Kawailoa Wind Power is coordinating with biologists from USFWS, DOFAW, First Wind, SWCA, and members of the ESRC to identify and select appropriate mitigation measures to compensate for the take of seven federally and/or State-listed species to the maximum extent practicable during operation of the Kawailoa Wind Power project. The criteria used for determining the most appropriate mitigation measures include:

1. The level of mitigation should (at least) be commensurate with the currently anticipated take.
2. Mitigation should be species-specific and, to the extent practicable, location or island specific.
3. Mitigation measures should be practicable and capable of being done given currently available technology and information.
4. Mitigation measures should have measurable goals and objectives that allow success to be assessed.
5. Should be flexible to adjust to changes in the level of take according to new information during project operation.
6. Should be consistent with or otherwise advance the strategies of the respective species' draft or approved recovery plans.
7. Mitigation measures that serve to directly "replace" individuals that may be taken (e.g., by improving breeding success or adult and juvenile survival) are preferred, though efforts to improve the knowledge base for poorly documented species also have merit, particularly when the information to be gained can benefit future efforts to improve survival and productivity.
8. Off-site mitigation measures to protect breeding or nesting areas for birds, and roosting areas for bats, located on otherwise unprotected private land are preferred over those on public land, and sites on State land are preferred by USFWS over those on Federal land.
9. Measures to decrease the level of take resulting from a private activity unrelated to the project are generally considered the responsibility of the other party and are not preferred as mitigation (e.g., rescue/rehabilitation of downed seabirds outside the project area as a result of disorientation by outdoor lights not related to the proposed project).
10. Alternate or supplemental mitigation measures should be identified for future implementation if the level of take is found to be higher (or lower) as a result of monitoring.

Federally and/or State-listed species considered to have potential to be incidentally taken during operation of the Kawailoa Wind Power project include the Newell's shearwater, Hawaiian duck, Hawaiian stilt, Hawaiian coot, Hawaiian moorhen, Hawaiian short-eared owl, and Hawaiian hoary bat. 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.

Rates of incidental take for all species discussed in this document have been tiered to encompass a range of possible take scenarios. These take tiers were previously defined in Section 6.3.1. Initial yearly mitigation efforts are designed to compensate for take at the 20-year Tier 1 take level. Later in the project, total adjusted take as estimated through post-construction monitoring will be used to determine which tier take is occurring at and the necessary levels of mitigation to be commensurate with the requested take of the required tier.

The primary goal of the proposed mitigation measures is to directly increase populations of the listed species to aid their recovery. However, for some species adequate information to implement such measures may be lacking, in which case the proposed mitigation can include funding of research aimed at increasing knowledge of distribution, status, and threats to the species and the populations on O‘ahu in particular. The purpose of these contributions is to facilitate future State, Federal, and private conservation actions and management efforts directed at the species' recovery. Measures intended to increase population sizes will generally be aimed at restoring native habitat used by Covered Species or decreasing predation pressure through exclusion or removal of predators from known breeding areas. Decreasing predation pressure is expected to increase adult and juvenile survival, leading to increased productivity, and thus compensate for any individuals that may be taken incidentally by the project.

It is possible that individuals of Covered Species will be taken before mitigation measures have allowed for increases in productivity. This would result in a lag between the time of incidental take and the intended replacement, possibly resulting in a loss of productivity by the species over that time. Therefore, the proposed levels of mitigation are also intended to compensate for loss of productivity by incidentally taken, sexually mature adult over a possible lag-period, which is the time from which the take occurs till the time an adult is protected from predation or the extra fledgling produced reaches adulthood. Conversely, it is also possible that mitigation measures would allow for increases in productivity by the Covered Species before any incidental take occurs, and credit would thus be accrued that could be used to offset future take.

Take will be considered to have exceeded Tier 1 take limits and occurring at Tier 2 levels when the 5-year take limits for Tier 1 are exceeded within five years of if the 20-year take limit for Tier 1 is exceeded at any time. For bats, which have an additional tier of take above Tier 2 (i.e. Tier 3), take will be considered to be occurring at Tier 3 levels when the 5-year take limits for Tier 2 are exceeded within five years of if the 20-year take limit for Tier 2 is exceeded at any time. The Applicant will promptly coordinate with USFWS and DLNR if Tier 2 rates of take are identified in order to implement adaptive management plans and adjust mitigation efforts accordingly. Sections 6.3.2 - 6.3.6 identify the rates of take that will be considered above Tier 1 (Tier 2 or above) for each species. A summary of mitigation efforts proposed by Kawailoa Wind Power for the species addressed in this HCP is identified in Table 7-1 below and the proposed funding structure in Appendix 8.

Table 7-1. Mitigation Measures for Different Tiers of Proposed Take.

Species	Proposed Mitigation by Measured Take Level	
	Tier 1	Tier 2 or Above
Seabirds	Development and testing of self-resetting cat trap, efficacy testing and implementation at a Newell's shearwater colony on Kaua'i.	Contribution to a restoration fund for predator control, social attraction and translocation of Newell's shearwaters to Kaho'olawe.
Waterbirds	Predator control, fencing, and vegetation maintenance at 'Uko'a Pond or other site for five years plus MOA between First Wind and landowner for long-term commitment to management of pond for waterbirds. Subsequent mitigation efforts to meet Tier 1 requested take as required.	Additional mitigation efforts at 'Uko'a Pond or at additional wetlands.
Hawaiian short-eared owl	Upfront contribution of $12,500 for research and rehabilitation and up to a maximum of $25,000 to implement management strategies if/as they becomes available.	Additional funding of $6,250 for research and rehabilitation and up to a maximum of $12,500 to implement management strategies.
Hawaiian hoary bat	Restoration of wetland or forest habitat to increase foraging capacity and provide additional roost trees. Research to evaluate the efficacy of wetland or forest mitigation.	Tier 2 and Tier 3: Additional restoration of wetland or forest habitat to increase foraging capacity and provide additional roost trees.

7.1.1 Re-Allocation of Funds and Commitment to Provide Necessary Mitigation

The goal of the habitat conservation program (minimization, mitigation, and monitoring) is to minimize incidental take and compensate for the incidental take of each species that does occur, plus provide a net conservation benefit, as measured in biological terms. This is typically achieved by allocating adequate funding to ensure the implementation of mitigation measures. The mitigation measures chosen should be cost effective relative to alternative measures, and identified as high priority for the recovery of the species. All mitigation measures will be chosen with the concurrence of DOFAW and USFWS.

The overall expenditure at the Tier 1 is not expected to exceed a total of $7.2925 million, but the budgeted amounts are estimates and are not necessarily fixed. Kawailoa Wind Power will provide the required conservation measures in full, even if the actual costs are greater than anticipated. One way of accomplishing this is that past, current or future funds allocated to a specific Covered Species may be reallocated where necessary to provide for the cost of implementing conservation measures for another Covered Species, and funding for any individual Covered Species is not limited to those amounts estimated in Appendix 8. Funding reallocation for one species to another will not impede the implementation of mitigation measures for either species. Kawailoa Wind Power also recognizes the cost of implementing habitat conservation measures in any one year may exceed that year's total budget allocation, even if the overall expenditure for the conservation program stays within the total amount budgeted over the life of the project. Accomplishing these measures may, therefore, require funds from future years to be expended or likewise unspent funds from previous years to be carried forward for later use. For practical and commercial reasons, such reallocation of funds among years may require up to 18 months lead time in order to meet revenue and budgeting forecast requirements. However, if reallocation between species or budget years are not sufficient to provide the necessary conservation, Kawailoa Wind Power will nonetheless be responsible for ensuring that the necessary conservation is provided.

7.2 General Measures

7.2.1 Wildlife Education and Observation Program (WEOP)

A wildlife education and observation program (WEOP) will be implemented 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. A draft plan for the WEOP is attached in Appendix 6.

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, the possibility of downed wildlife being present on roads, and the possibility of Hawaiian short-eared owls flying across roads. Personnel will be instructed to contact the Site Environmental Compliance Officer immediately if they detect any downed wildlife on-site.

7.2.2 Downed Wildlife Protocol

The protocol for the recovery, handling, and reporting of downed wildlife will follow that developed for Kaheawa Pastures Wind Energy Generation Facility (Kaheawa Wind Power LLC 2006), Kahuku Wind Power (SWCA 2010d), or other protocols approved by USFWS and DLNR. 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 this HCP). A Hawaiian duck/Hawaiian duck hybrid identification key will be used in the identification of downed ducks when it becomes available. If morphological features are inconclusive and there is reasonable uncertainty regarding the status of the duck incidentally taken, USFWS and DLNR may request the applicant conduct the appropriate genetic analysis.

Any State or Federally listed species found dead or injured in the project area will be handled in accordance with the approved protocol. Injured State or Federally listed species will be photographed from a discrete distance and monitored until collection by an authorized individual. The O'ahu Wildlife Program manager at DLNR and Fish and Wildlife Biologist at USFWS will be notified within 24 hours by phone and written notification will be provided within three calendar days upon discovery of any injured or dead Covered Species (including ESA and MBTA). All (covered and non-covered) species will be documented in accordance with approved protocols; collections will be made only by staff personnel permitted by USFWS and DLNR to handle and salvage wildlife. Injured individuals or carcasses will be handled according to guidelines in Appendix 11 of the HCP.

7.3 Newell's Shearwater

Although providing mitigation on O'ahu for most species would be preferred, this approach is not likely to be the most productive for Newell's shearwater recovery. No discrete nesting colonies are known from O'ahu, and locating any small and likely scattered breeding populations, if any exist, would take considerable effort. Combined with additional threats, including high fallout potential due to heavy urbanization on O'ahu, this makes conservation efforts on a scale that is within the scope of this project impractical and likely ineffective in terms of contribution to recovery. Therefore, with the concurrence of ESRC, USFWS and DLNR, mitigation for the possible take of Newell's shearwater by the Kawailoa Wind Power project will be either focused on improving existing management measures or implementing colony-based management at a chosen breeding colony on Maui, Kaua'i, or elsewhere to provide a net benefit and maximize contributions to the recovery goals of the species.

Major threats to the recovery of Newell's shearwaters include: 1) introduced predators, mainly cats (*Felis catus*) which can prey on adults, eggs and fledglings; 2) feral ungulates, mainly pigs (*Sus scrofa*), which degrade habitat and may trample burrows; and 3) artificial lighting, which may disorient fledglings and increase their risk of collision with artificial structures (Mitchell et al. 2005; NESH Working Group 2005). According to models by Ainley et al. (2001) based on best estimates of breeding effort and success, the population had an annual decrease of 3.2%. However, their models predicted an annual population decrease of 6.1%when anthropogenic variables affecting mortality of Newell's shearwaters (e.g. light attraction, power line collision, predation) were included. Holmes (Planning Solutions, Inc. 2010) suggests a 75% population decline between 1993 and 2008 based on radar studies and SOS data. Predation on adult Newell's shearwaters, as well as on Hawaiian petrels, an endemic, endangered seabird with similar breeding strategy, has been documented (Simons 1983; Ainley et al. 2001). In Haleakalā National Park, Hodges and Nagata (2001) identified predation as accounting for 41% of total terrestrial mortality (adults, fledglings, and eggs) of Hawaiian petrels in cases where 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). Human-related causes (road-kills, collapsed burrows, collision with structures) accounted for 49% of all mortalities, with natural causes accounting for the remaining 10%. Data on the different causes of mortality for Newell's shearwaters is absent, but it is expected that the causes of Newell's shearwater mortality are generally similar to those of the Hawaiian petrel due to their similar reproductive strategies and the pervasiveness of these threats.

In addition to reducing the threats to existing colonies, the Recovery plan for Newell's shearwater (USFWS 1983) identifies the establishment of additional nesting colonies as a key step in the recovery of the species. Newly established colonies should be at managed sites where predation pressure is reduced and situated in areas where light attractant problems are minimal. New seabird colonies have been successfully established worldwide for a range of surface nesting and burrowing seabird species. Visual and audio social attraction and translocation of chicks or even eggs have been used successfully in establishment of new colonies or re-establishment of previously extirpated colonies of seabirds. Chick translocation has been successfully implemented for at least ten shearwater and petrel species (Gummer 2003; Miskelly and Taylor 2004; Bell et al. 2005; Priddel et al. 2006; Miskelly et al. 2009). Important considerations when translocating highly philopatric seabirds are to ensure habitat quality at the release site, and that translocated birds imprint on the release site (Numata 1996) and a source colony needs to be available and accessible. Natural colony formation does occur within philopatric seabird species, usually by first-time breeders visiting unoccupied potential breeding sites. However, potential breeding sites may not be visited by such pioneering individuals, whose occurrence is much rarer in endangered species. In addition, species or populations that are not expanding or are even in decline are less likely to seek out alternative breeding sites (Taylor 2000a, 2000b). Therefore, translocation of chicks or eggs is an important tool in establishing new colonies in protected, predator free habitats for species in serious decline (such as the Newell's shearwater), whose current nesting habitat is threatened and difficult to protect.

7.3.1 Tier 1 Mitigation

For Tier 1, mitigation measures will support the development of improved traps for predators and in subsequent utilization at a Newell's shearwater colony on Kauaʻi or Maui. Kauaʻi is where the largest portion of the species' population is found, and where action is most likely to result in benefits to the species. DOFAW and USFWS have been working since 2002 to identify breeding colonies of Newell's shearwaters and Hawaiian petrels on Kauaʻi.

Development of a Self-Resetting Cat Trap and Deployment at a Newell's Shearwater Colony

The development of a more efficient cat trap is consistent with the one of the recovery milestones identified by in the *Recovery Plan for the Hawaiian Petrel and Newell's Shearwater* (USFWS 1983) and the 5-Year Work Plan for Newell's Shearwater (NESH Working Group 2005). The recovery plan states that one of the primary management objectives for the two species are: "Developing efficient predator control methods and techniques for use in and around isolated nesting sites." The Newell's Shearwater (NESH) Working Group developed a 5-Year Work Plan for Newell's Shearwater (NESH Working Group 2005) which outlines specific recovery objectives for the Newell's Shearwater that can be met within five years. The first recovery objective is also to "Minimize adult/breeder mortality and maximize fledgling production by developing and implementing effective predator control methods in colonies".

Goodnature Limited (http://www.goodnature.co.nz/), a New Zealand based company is currently seeking funding to develop a self-resetting cat trap. The funding is anticipated to result in a trap that specifically targets cats while excluding sensitive species. The trap will dispatch the cats humanely and then will self reset multiple times so that the traps are active again without human intervention. The prototype will be commercially available 12 months after the funding is received (see Appendix 15 for a timeline). These traps will be tested in a location where cats are common in Hawaii, to demonstrate the effectiveness and efficiency of the trap above conventional traps. Concurrently, a Newell's seabird colony will be identified and a pilot study will be designed where these traps are deployed to provide localized control of cats over an area where birds are known to be breeding. The study will be designed by Goodnature Limited and Kawailoa Wind Power will be responsible for the implementation of the study by the first Newell's shearwater breeding season after the trap becomes commercially available. The cat trap will be deployed for one breeding season and based on modeling of a reduction from medium to mild predation (HT Harvey and Associates 2011), the cat trap deployment is expected to result in a 10% increased breeding probability, 7.5% increased breeding success and 1.5 - 2.5% increase in survival of adults and subadults that are protected within the trapped area from cats. Modeling shows that within one year, for 20 active burrows protected, the reduction of cat predation could potentially result in the additional survival of 0.5 adults, 4.1 juveniles and 2 fledglings. For 30 burrows, the accrual after one season is expected to be 0.8 adults, 6.1 juveniles and 2.9 fledglings (HT Harvey and Associates 2011). The preferred location for the seabird colony is Kauaʻi, but Maui may be selected with USFWS and DOFAW concurrence. Seabirds colonies currently under consideration include, but are not limited to, Wainiha Valley, Limahuli Valley and Hono O Na Pali on Kauaʻi, or Makamakaʻole and a potential seabird colony at Upper Kahakuloa Valley on Maui.

7.3.2 Mitigation for Tier 2 Rates of Take

Take will be considered to be occurring at Tier 2 levels when the 5-year take limits for Tier 1 are exceeded within five years of if the 20-year take limit is exceeded at any time. Tier 2 mitigation will consist of contributing to a restoration fund for predator control, social attraction and translocation of Newell's shearwaters.

Contributing to a Restoration Fund for Predator Control and Translocation or Social Attraction of Newell's Shearwater

If at the time when Tier 2 rates of take are determined, Kawailoa will contribute to a restoration fund for predator control, social attraction and translocation of Newell's shearwaters. Kahoʻolawe has been identified as a potential site where Kawailoa Wind Power would contribute $200,000 to the restoration fund. Kaho'olawe and its surrounding waters were under control of the U.S. Navy from 1941 to 1994. Over fifty years of use as a live-fire training area have significantly impacted the landscape, although there were efforts to remove unexploded ordinance. Kaho'olawe and its surrounding waters were conveyed back to the State of Hawai'i in 1994, and since then, Kaho'olawe and the waters within two nautical miles of its shores have been designated as a reserve, and the State of Hawai'i has established the Kaho'olawe Island Reserve Commission (KIRC). The commission is committed to environmental and cultural restoration of Kaho'olawe, and with funding and partnership with various groups. With respect to the restoration of seabird colonies, KIRC identifies two main efforts in its 2010 report: the eradication of invasive mammals and the removal of marine debris. Feral cats are rampant on Kaho'olawe, and have ravaged the island's seabird population. In partnership with USFWS and Island Conservation, the development of an operational and management plan is underway, and a feasibility study to remove invasive mammals has been completed. The contributions by Kawailoa Wind Power to predator control at the site and the eventual translocation of Newell's shearwater to a managed area within Kaho'olawe are expected to aid in establishing a new Newell's shearwater seabird colony within Maui Nui.

7.3.3 Additional Research to Improve Avoidance and Minimization Measures at Tier 2 Rates of Take

If Tier 2 rates of take are found to occur, the Applicant will conduct on-site investigations in an effort to determine the cause(s) of the unexpectedly higher levels of take, and to identify and implement measures, where practicable, to reduce take levels. On-site investigations would include, but will not necessarily be limited to, additional surveys using radar, night-vision, thermal imaging, or newer state-of-the-art technologies, as appropriate, to document bird movements and behavior during periods when collisions are believed to be occurring, and particularly to determine whether certain turbines, seasonal or other site-specific conditions account for greater mortality. Investigations would also include experimental changes in project operations that will not cause further incidental take. Measures to reduce and minimize further take would include, but will not be limited to, implementing permanent changes in project operation or moving structures that cause a disproportionately high amount of take. Determining the appropriateness of any such measures will take into account costs and practicability and at the direction of USFWS and DOFAW. Measures will only be implemented with the approval of USFWS and DOFAW.

7.3.4 Measures of Success

Mitigation efforts provided by Kawailoa Wind Power will contribute to Newell's shearwater habitat protection or restoration and colony enhancement and thus will provide a net benefit to, and aid in the recovery of the species.

Development of the Self Resetting Cat Trap

Mitigation will be deemed successful if the self-resetting cat trap is successfully developed and is demonstrated to successfully function in the field at a Newell's shearwater colony for one breeding season, is more efficient and effective in dispatching cats than conventional traps, with no adverse impact to the seabirds. With the low requested take at Tier 1, the proposed mitigation measures of the development of a self resetting cat trap and its implementation at a seabird colony as part of a pilot study, are expected to produce a net benefit in the form of an increase in the species' population by increasing productivity and survival rates. As stated above, the pilot study will result in an immediate increase in adult and subadult survival at the colony as well as increased reproductive output, above the unmanaged state. While the area managed is anticipated to be small, trap development as outlined in Section 7.3.1 is expected to more than compensate for the requested take at Tier 1. A more effective cat trap for Newell's shearwater predator management will help to meet a milestone identified as necessary for the recovery of the species, and the eventual implementation at additional colonies will increase survival and reproduction. The new trap is anticipated to have far reaching benefits beyond the mitigation measures implemented by the Applicant. The development of the trap will enable managers to conduct predator control at sites that are currently not suitable for trapping because of their remoteness and the intensive labor required to maintain a trapping grid. It is anticipated that the cat trap will be less labor intensive to operate and more effective than the cat traps currently available (current cat traps, once sprung, are inactive and need to be manually reset by a person) and will be utilized extensively by most parties involved in the management of Newell's shearwater colonies once developed. This is expected to yield improvements in protection, reproductive success and survival over current management methods, for many currently unmanaged colonies, with benefits extending years into the future.

Contributing to a Restoration Fund for Predator Control and Translocation or Social Attraction of Newell's Shearwater

The contribution to a restoration fund that includes predator trapping and translocation of Newell's shearwater to create a new colony will help to meet a milestone identified as necessary for the recovery of the species. The new colony will be established at a site that is managed for predators and where birds are at low risk from fallout due to powerline collisions and light attraction. The establishment of a new colony is expected to help increase the population of Newell's shearwaters and may also contribute to a range expansion of the species.

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

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. The estimated cost for each proposed measure is presented in Appendix 8.

Measures intended to increase waterbird population sizes have been generally aimed at reducing or eliminating predation through exclusion (i.e., fencing) and eradication of predators from an enclosed breeding area. Garrettson and Rohwer (2001) found that lethal predator control using professional trappers was an effective way to increase waterfowl production; average nest success was nearly twice as high at trapped sites than at untrapped sites. Nest success of several dabbling ducks was also determined to be higher under predator management (by trapping, shooting, or lethal baiting) than at sites without predator management, although this relationship varied with climatic conditions (Drever et al. 2004). Long term removal of feral mink (*Mustela vison*) via trained animals also resulted in an increase in the breeding densities of four waterfowl species compared to densities in control areas (Nordström et al. 2002).

Proposed mitigation for the take of waterbirds by operation of the Kawailoa Wind Power project will focus on predator control and vegetation maintenance at a wetland site on O'ahu that has regular waterbird activity or have a history of importance for waterbirds 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, ITT site at Kawainui Marsh, ʻUkoʻa Pond, Heʻeia Marsh and Pouhala Marsh. James Campbell Wildlife Refuge is a National Wildlife Refuge and has been excluded as a mitigation option at the request of USFWS. Both Hamakua and Pouhala marshes are State Wildlife Sanctuaries, but are excluded because they currently have sufficient funding to provide maximum protection and nesting habitat for the listed waterbirds. Heʻeia Marsh is severely degraded and will require significant habitat restoration work including intensive mangrove removal before the area can be used by the listed waterbirds. It is, therefore, excluded as a mitigation option at this time. Waterbirds occur intermittently at both ʻUkoʻa Pond and Kawainui ITT site, but nesting has not been documented at either site. Restoration work is planned, and it is expected that both sites will provide habitat in need of protection in the near future. ʻUkoʻa Pond is located on land owned and managed by Kamehameha Schools (which also owns the site of the proposed wind farm), whereas the Kawainui ITT site is owned and managed by the State of Hawaii. Since ʻUkoʻa Pond is located on private land, it is considered a site of higher priority. In addition, the much smaller Kawainui ITT site is located adjacent to an urban area and a busy intersection, and the waterbirds there may be more vulnerable to vehicular collisions than at ʻUkoʻa pond.

ʻUkoʻa Pond is identified as a supporting wetland on Oʻahu in the Draft Revised Recovery Plan for Hawaiian Waterbirds (USFWS 2005). One of the downlisting criteria for the four endangered waterbird species is that 75% of the supporting wetlands are protected and managed according to the practices outlined in the recovery plan. A management plan for ʻUkoʻa Pond has existed since 1999, and was recently updated in 2011. The most recent plan identifies the long-term goals that the land owner Kamehameha Schools has for ‘Uko‘a Pond. ‘Uko‘a Pond is considered as a site with potential to be

a) a cultural resource center for students and the community;
b) an active site for environmental education;
c) a haven for native wildlife; and
d) an attraction for Hawai‘i residents and visitors.

‘Uko‘a Pond spans about 150 acres total, and is located just north of Haleiwa, about 2 miles from the project site. This inland wetland is one of the very few historic wetlands on O‘ahu with great potential for restoration. A 1999 management plan lists presence of all four listed waterbird species, but during more recent surveys only Hawaiian moorhen and stilt were observed (N. Whitehead, K.S. ecologist, pers. comm.). Restoration activities outlined in the management plan include vegetation removal and control, fencing to keep out dogs, pigs, and cattle, predator control to reduce densities of cats, mongoose, and rats, and monitoring. Initial vegetation removal and partial fencing will be completed prior to implementation of mitigation (N. Whitehead, K.S., ecologist, pers. comm.).

Mitigation efforts, will include fencing, predator control, weed control, and monitoring, will be directed at increasing productivity of all four listed waterbird species, 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. A long-term banding, nest monitoring and resighting study will also be used to quantify productivity and mitigation success. The take of adults or subadults at Kawailoa 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 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.

Given that Hawaiian duck, Hawaiian coot and Hawaiian moorhen have extended breeding periods in Hawaii, it is anticipated that mitigation efforts for direct and indirect take of Hawaiian duck, Hawaiian coot, and Hawaiian moorhen at Kawailoa Wind Power will mostly result in same breeding year replacement by fledglings. These three species all reach maturity at year 1 and since same-year replacement is anticipated, no productivity would be lost by take of these species (fledglings will have matured by the next breeding season). However, Hawaiian stilts mature at Year 2. Therefore, for this species, one year of productivity is added into the mitigation requirements to account for one year of lag in replacing adults with fledglings. However, should the replacement of adults of any of the covered waterbird species occur only in the subsequent breeding season, one year of loss of productivity will be added to the mitigation requirement. The number of fledglings required to be produced to compensate for Tier 1 rates of take of the four waterbird species is listed in Table 7-5 and is based on same-year replacement of take by fledglings.

Monitoring of waterbird reproductive success and population size will also be funded to quantify the success of the mitigation measures. Monitoring is 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 will be determined in consultation with biologists at USFWS, DOFAW, and Kawailoa Wind Power. Consultation is necessary to ensure that the proposed management actions for waterbirds on O‘ahu satisfy the mitigation criteria required of Kawailoa 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. Coordination will also be required with the landowner (Kamehameha Schools) to ensure that the proposed activities are compatible with their overall vision of restoring the ecological and hydrological functions of the wetland, while preserving historical farming practices and providing an educational benefit (Kalani Fronda/Kamehameha Schools pers comm.). Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

Mitigation targets have been identified based on the "Tier 1" and "Tier 2" take levels. On-site post-construction monitoring will be used to determine whether waterbird take is occurring at Tier 1 or Tier 2 levels. Initial mitigation is intended to compensate for take occurring at Tier 1 level as described in Section 7.4.1. If post-construction monitoring shows that take is occurring in excess of Tier 1 level, adjustment to mitigation efforts will be made as described below (Sections 7.4.2 and 7.4.3).

Table 7-2. Annual Fledgling Production Requirements for Tier 1 Take of Listed Waterbird Species Based on Same-year Replacement of Take by Fledglings[1].

Species	Tier 1 take level			Average annual fledgling production requirement	Total 20-year requirement
Hawaiian stilt	20-year take limit	adults	8		
		fledglings	4		
	annual average	adults	0.4	0.80[2]	
		fledglings	0.2	0.20	
	loss of productivity**			0.19[3]	
	Total fledglings required per year			**1.19**	
	Total fledglings required (20 years)				**24 (=23.8)**
Hawaiian coot	20-year take limit	adults	8		
		fledglings	4		
	annual average	adults	0.4	0.8[2]	
		fledglings	0.2	0.20	
	Total fledglings required per year			**1.00**	
	Total fledglings required (20 years)				**20**
Hawaiian moorhen	20-year take limit	adults	8		
		fledglings	4		
	annual average	adults	0.4	0.80[2]	
		fledglings	0.2	0.20	
	Total fledglings required per year			**1.00**	
	Total fledglings required (20 years)				**20**

[1] Mitigation for the Hawaiian duck will consist of culling of feral ducks and mallards that present a hybridization risk to the pure Hawaiian duck
[2] Annual survival of Hawaiian stilt, Hawaiian coot and Hawaiian moorhen fledgling to adulthood = 0.50
[3] Annual productivity for Hawaiian stilt is 0.47 fledglings per adult

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 Tier 1 rate but one is taken at a Tier 2 rate, Tier 1 mitigation will be adjusted to compensate for the Tier 2 rate of take. This is 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. This concept is discussed in Section 7.4.5.

7.4.1 Tier 1 Mitigation

Mitigation for the Tier 1 level of take of the four waterbirds at ʻUkoʻa Pond will consist of a five year plan of fencing and managing a smaller unit of wetland (40 ac) within ʻUkoʻa pond. The size of the unit to be managed was based on factors such as fence alignment, topography, location of open water bodies and other factors as well as the likelihood of achieveing mitigation obligations with a set timeframe. This 40 ac unit is currently overgrown by invasive species particularly water hyacinth (*Eichhornia crassipes*) and bulrush (*Schoenoplectus* varieties) but is still connected to a small body of open water (Kamehameha Scools, unpublished data). There is a source of flowing water nearby due to a previously capped well and the area is close to an access point where equipment and materials to manage the site can be staged. The removal of the invasive vegetation is likely to increase the amount of open water available and should be attractive to waterbirds. The overall goals of the restoration and management of the 40 ac unit is to attract waterbirds to the managed site and provide immediate protection from predators through fencing and predator control to encourage breeding and increase productivity. Partnerships between Kawailoa Wind Power, Kamehameha Schools and a third party contractor will be developed for the management of the site. The details of the management plan are still being discussed with the third party contractor. The third party contractor will submit a work plan that will be approved by USFWS and DOFAW before the commencement of the work. Kawailoa Wind Power will also be responsible for ensuring that ʻUkoa pond is managed for the permit term of the project (via partnerships or otherwise). Partnerships are currently being developed between Kawailoa Wind Power and Kamehameha Schools to ensure the long-term management of ʻUkoa pond when mitigation activities are completed. Components of the plan that Kawailoa Wind Power proposes to fund include:

- A one-time contribution of $77,000 towards the construction of a fence around the 40 ac unit (Year 1);
- $30,000 for costs associated with permitting for fence construction (Year 1);
- $30,000 for four years of fence maintenance (Year 2 to 5);
- $110,000 for four years of predator trapping and ungulate removal by a qualified contractor or personnel approved by USFWS and DLNR (Year 2 to 5);
- $80,000 for five years for monitoring of the management effort (Year 1 to 5);
- $85,000 for vegetation removal in the first two years;
- $150,000 for replanting of native flora in the first two years;
- $120,000 for four years of weed control (Year 2 to 5) and
- $24,000 for the biological oversight of third-party contractor work if necessary

The total funding allocated to the management efforts amounts to approximately $706,000. Following permit issuance a Waterbird Management Plan for the proposed area will be drafted within six months of permit issuance, to address the components of wetland management and will be approved by the USFWS and DOFAW before implementation. This wetland management as outlined in the Plan will be conducted for 20 years or the life of the Permit. At a minimum the Plan will include:

- Measures for invasive plant control and percentage of open water to remain unvegetated over the 20 years.
- Hawaiian duck hybrid management;
- Invasive rat, cat, dog, pig, and mongoose control;
- Fence maintenance; and
- Criteria to address any botulism outbreak in the wetland.

A timeline for predator control, vegetation maintenance, and monitoring of waterbird populations and reproductive activity, is proposed below:

a. Completion of a perimeter fence to keep out ungulates and dogs one year from permit issuance. Hog wire mesh with graduated vertical spacing (small mesh at the bottom and larger at the top) will be used to keep ungulates and dogs out.

b. Predator trapping and baiting will begin during the first breeding season after fence construction and vegetation removal and will be funded for four years. Predator trapping for dogs, cats and mongoose will be conducted year round using traps, leg holds, and/or snares. The trapping design will be approved by USFWS and DOFAW. Traps will be placed along the perimeter of the fences. Leg holds and snares will 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 for rats will be deployed year-round following protocols set forth by the Department of Agriculture. All ungulates and dogs will be removed by the end of Year 2.

c. Regular monitoring for mammalian predators, ungulates and dogs will be conducted and any ungulates or dogs detected within the fenced area will be removed as soon as possible and breaches in the fence repaired within a month.

d. Vegetation removal of invasive species and replanting with native plants will be completed in the first two years.

e. Vegetation maintenance (beginning the year after fence completion and continuing for four years) will be conducted to further remove and prevent invasive species from encroaching on waterbird nesting habitat and to enhance available nesting habitat where possible.

f. Monitoring of reproductive activity and waterbird populations will establish a baseline and quantify the effectiveness of the predator and vegetation control methods (that are implemented after fence installation). Monitoring of reproductive activity and bird resightings will be conducted weekly from May through September for stilt and year round for the other Covered Species of waterbirds as nests are discovered. Total bird counts including specification of life stages, and the tracking of productivity of individual nests or broods to fledging will be conducted the maximum extent practicable. Banding of chicks or juvenile birds annually will be used to facilitate this, by qualified personnel with the appropriate banding and endangered species permits.

The predator control, vegetation maintenance and monitoring will be performed by a qualified contractor or personnel approved by DLNR and USFWS. After five years of management, the number of fledglings or adults accrued for the Covered waterbird species will be reviewed, and if they are at least one more than required to compensate for the Tier 1 requested take, the required mitigation will be considered fulfilled. Productivity and survival rates will be calculated annually, based on the results from the weekly mornitoring and resighting data. This standard applies to the Hawaiian coot, Hawaiian stilt and Hawaiian moorhen. Currently, as few pure Hawaiian ducks are believed to exist on O‘ahu due to hybridization (see Section 3.8.4.3), mitigation for Hawaiian ducks may consist of removal of feral ducks, mallards and Hawaiian duck hybrids at ‘Uko‘a pond. Removals will be coordinated with and directed by DOFAW and USFWS. However, in the event duck hybrids are exterminated and pure Hawaiian ducks are reintroduced, mitigation will consist of increasing survival and productivity rates of the pure Hawaiian ducks present.

Currently only Hawaiian stilts and Hawaiian moorhen are occasionally observed at ‘Uko‘a Pond, and none of the four waterbird species have in recent years been observed nesting at the site. Therefore baseline population and productivity is zero. In the absence of a baseline population it is difficult to predict the number of birds that will become established at Ukoa Pond within the project life, but birds are expected to respond rapidly to the newly available nesting and foraging habitat. Hamakua Marsh, located on the windward side of Oahu, and similar to ‘Uko‘a Pond, characterized as seasonal floodplain and influenced by high tidal events, is used as a basis for the estimate of expected bird densities and fledgling production at Ukoa Pond. Between 2005 and 2009 the 22 acre Hamakua Marsh produced an average of 2.2 coot fledglings, 36.6 moorhen fledglings, and 11 stilt fledglings annually (SWCA 2010d). Considering the fact that the total habitat area at Ukoa Pond will be approximately double that of Hamakua Marsh, it is expected that the total number of fledglings produced over the project life will meet the mitigation requirements of Tier 1. Annual fledgling production rates at ‘Uko‘a Pond after habitat restoration and implementation of predator control measures is expected to be double that at Hamakua marsh and be approximately 4.4 coot, 65 moorhen, and 22 stilt fledglings, assuming the species composition at both sites are similar. Over four years the total accurual is expected to result in 17 coot, 260 moorhen and 88 stilt fledglings. The number of fledglings accrued, particularly for Hawaiian moorhen and Hawaiian stilt, are expected to far exceed the required number of fledglings required for Tier 1 as outlined in Table 7-2. Hamakua marsh has an unusually large number of moorhen at the site that are thought to displace the Hawaiian coot from nesting (Misaki pers comm., DOFAW 2010), therefore, if the species composition at ‘Uko‘a pond is more balanced, the Hawaiian coot fledglings accrued are expected to compensate for the Tier 1 requested take as well. Consequently, 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 one species more than another in order to achieve the required number of fledglings to meet the Tier

1 requested level of take. In addition, mitigation will be continued till the required mitigation is achieved for the Hawaiian stilt, Hawaiian coot and Hawaiian moorhen.

If Tier 1 requirements have not been met through the management of 40 acres at ʻUkoaʻ Pond, additional funding (estimated up to $272,000 for four years, for predator control, monitoring, fence maintenance and weed control) will be provided by the Applicant for additional mitigation measures until the Tier 1 requested take for the Hawaiian coot, Hawaiian stilt and Hawaiian moorhen are met (see Appendix 8 Funding Matrix). This may also result in an extension of management past the 20-year term of the ITP/ITL. The design and scope of each year's effort will be directed by USFWS and DLNR in coordination with Kawailoa Wind Power and Kamehameha Schools. Coordination is necessary to ensure that the proposed management actions funded by Kawailoa Wind Power satisfy the mitigation criteria required of Kawailoa Wind Power by both DLNR and USFWS.

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, Kawailoa Wind Power, with approval from 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 Hawaiʻi could include water level control, disease prevention and monitoring of environmental contaminants (USFWS 2005a).

It is possible that bat mitigation (as described below in Section 7.6.1) may also include wetland restoration at ʻUkoʻa pond. If this occurs, the area proposed for wetland restoration will increase by another 40 acres and is likely exceed that required for Tier 1 mitigation for waterbirds. If the wetland restoration area is increased to accommodate bat mitigation, it is anticipated that the additional restored areas will also attract waterbirds. Therefore, the management measures outlined above (fencing, trapping, vegetation maintenance and monitoring) will correspondingly be increased to ensure that the entire restored area is also managed for waterbirds. Monitoring of waterbird productivity will document any mitigation accrued above the Tier 1 level.

<u>7.4.2 Mitigation for Tier 2 Rates of Take</u>

Take will be considered to be occurring at Tier 2 levels when the 5-year take limits for Tier 1 are exceeded within a five year period, or if the 20-year take limit is exceeded at any time. If a Tier 2 rate of take occurs for any of the waterbird species, no additional mitigation will be provided if the number of fledglings or adults accrued for that Covered species are is commensurate with the requested take at Tier 2 plus a net conservation benefit for the species. . If this is not the case, mitigation actions will first be increased at ʻUkoʻa Pond. Activities will include intensifying the trapping effort or implementing additional vegetation management. If increased efforts at ʻUkoʻa Pond are not sufficient to increase adult survival or produce enough fledglings to be commensurate with the requested take at Tier 2, and achieve a net conservation benefit for the species at the measured take levels, Kawailoa Wind Power LLC 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 by DLNR and USFWS. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

<u>7.4.3 Mitigation Measures for Waterbirds as a Covered Activity</u>

Predator trapping poses some risk of harassment due to capture, and could result in injury or mortality to the Covered waterbird species and is accounted for in Section 6.3.5.4. Moorhen are attracted to traps (DesRochers et al. 2006) and moorhen on Oʻahu have been documented entering live traps (DesRochers et al. 2006; Nadig/USFWS, pers. comm.). USFWS recommends additional take of not more than ten Hawaiian moorhen annually in the form capture. The trapping at ʻUkoʻa pond is anticipated to last five years and a total of take of 50 individuals in the form capture is also requested. Minimal risk of injury or mortality is anticipated from this capture and the conservation strategy to implement wetland management including a predator control program will result in an overall increase in the baseline number of individuals of the endangered Hawaiian moorhen. Therefore, the implementation of live trapping will have beneficial effects through the control of nonnative predators and increased productivity of Hawaiian moorhen. As a beneficial effect no further mitigation would be required for the potential capture of Hawaiian moorhen. However, if the implementation of mitigation measures causes a waterbird capture that does result in mortality or injury, the take will be assessed as part of the 18 birds (Tier 2 total) estimated for injury or mortality as part of the Kawailoa Wind Power project.

7.4.4 Measures of Success

Funding will be provided annually by the Applicant as outlined in the plan. Mitigation measures will be considered successful if

1. The first annual payment is paid before the commercial operation date.
2. Subsequent yearly funding is provided by June 1 of each year.
3. Tier 1 mitigation commences within the first year of the project operations unless circumstances beyond the control of Kawailoa Wind Power prevent it from happening. In the event of unforeseen delays, the Applicant, at the direction of DLNR and USFWS will by a specified time period 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 allocated funding will be used to conduct alternate mitigation measures at the same site or at an alternate site instead. The alternate mitigation measures will be decided by DLNR and USFWS.
4. Upon entering a Tier 2 rate of take, annual funding will increase within six months of the determination. Funding will be disbursed in a similar manner as Tier 1 funding with subsequent yearly payments provided before June 1 each year.
5. Mitigation will be deemed successful if the number of fledglings and adults accrued exceed the requested take for the required tier for the Hawaiian coot, Hawaiian stilt and Hawaiian moorhen and result in a net benefit for the three Covered species over the entire permit term as measured in annual increments and based upon banding and resight studies. 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 wetland restoration, a reduction in introduced predator populations, and will have contributed to the recovery of the species.

7.5 Hawaiian Short-eared Owl

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 Hawaii 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 basline studies.

Mitigation targets have been identified based on the levels of take identified as "Tier 1" or "Tier 2." 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 the level as described in Section 7.5.1. If post-construction monitoring shows that take is actually occurring in excess of Tier 1, adjustment to mitigation efforts will be made as described below (Sections 7.5.2 and 7.5.3). The estimated cost for each proposed measure is presented in Appendix 8.

7.5.1 Tier 1 Mitigation

Mitigation for possible take of the Hawaiian short-eared owl by Kawailoa Wind Power will consist of two parts: funding research or 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 and provide a net benefit.

7.5.1.1 Funding for Owl Rehabilitation or Research

Prior to the start of operations, Kawailoa Wind Power will contribute a total of $12,500 to appropriate programs or facilities for research or rehabilitation of owls. Three alternatives for rehabilitation or research are identified below and selection approved by USFWS and DOFAW.

<u>Alternative 1 Owl Rehabilitation on O'ahu</u>

The Aloha Animal Hospital regularly receives injured Hawaiian short-eared owls on O'ahu. A need identified by the veterinarian, Dr. Fujitani of Aloha Animal Hospital, to facilitate the rehabilitation of Hawaiian short-eared owls was the construction of a flight cage to house the owls prior to release. Flight cages allow for birds to exercise their flight muscles prior to release (Greene et al. 2004). The selection of this alternative is contingent upon finding a suitable site to construct the flight cage, as Aloha Animal Hospital currently does not have the space required. The facility that houses the flight cage will need to have qualified rehabilitators to provide the required husbandry and ensure that the owls continue to receive regular veterinary care.

<u>Alternative 2 Owl Rehabilitation on the Island of Hawai'i</u>

The Hawaii Wildlife Center, located on the Island of Hawai'i, is a facility that will be dedicated to the rescue and recovery of native wildlife in the State of Hawaii (http://www.hawaiiwildlifecenter.org/mission-statement.htm). A key component of this facility is a wildlife response and care unit that will provide medical and husbandry care for sick, injured and orphaned native wildlife, including those affected by natural and man-made disasters. Individuals that are successfully treated will be returned back to the wild. This center is currently under construction and is still fundraising to complete the facility. Needs identified by Linda Elliot (founder, president and center director) for the rehabilitation of raptors were funding to complete the outdoor aviaries in the recovery yard (each outdoor aviary is estimated to cost $2,500 to build) and funding for facilities such as the intake/exam room, laboratory, holding room or food preparation areas. This facility when completed will have the capacity to rehabilitate native raptors from the entire Hawaiian Archipelago. The Hawaiian short-eared owl is one of two native raptors in the State, the other being the Hawaiian hawk, or i'o (*Buteo solitarius*).

<u>Alternative 3 – Funding for Basic Research</u>

If funding is allocated to 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. Research may be conducted on the Island of O'ahu, or other islands based on feasibility.

<u>Expected Outcomes From Funding Research or Rehabilitation</u>

The allocation of funds to research and/or rehabilitation will be determined by DLNR and USFWS and will be used for whatever management or research activity is deemed most appropriate at the time.

The rehabilitation efforts of injured owls are anticipated to offset any impact that the wind facility may have on the local population. If research is funded, it is anticipated that the research conducted will result in an increased understanding of the habitat requirements and life history characteristics of Hawaiian short-eared owl populations, leading to the development practicable management strategies and possibly help with the recovery of the Hawaiian short-eared owl on O'ahu.

7.5.1.2 Funding of Management Actions

When practicable management actions that will aid in the recovery of Hawaiian short-eared owl populations are identified on O'ahu, Kawailoa Wind Power will provide additional funding of $12,500 up to a maximum of $25,000 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 deemed appropriate to compensate for the Tier 1 requested take (adjusted for take already mitigated for in the rehabilitation program) and also provide a net benefit to the species.

7.5.2 Mitigation for Tier 2 Rates of Take

Take will be considered to be occurring at Tier 2 levels when the 5-year take limits for Tier 1 are exceeded within five years of if the 20-year take limit is exceeded at any time. If monitoring indicates a Tier 2 level of take, Kawailoa Wind Power will provide additional funding of $6,250 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. Additional support for owl rehabilitation on O‘au or other islands may be provided if identified. 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 $6,500 up to a maximum of $12,500 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 deemed appropriate to compensate for the requested take at a Tier 2 tier and also provide a net benefit to the species.

7.5.3 Measures of Success

The success of the mitigation efforts will be determined as follows:

1. Funding for owl research will be considered successful if Kawailoa Wind Power contributes $12,500 to an appropriate program to support owl research and rehabilitation before the beginning of operations; and if Kawailoa Wind Power contributes within 5 years from the beginning of operations, $12,500 up to $25,000 to fund management measures. Criteria for the success of the management measures will be determined when the protocols for the chosen management measures are developed.
2. Reports will be obtained from the funded owl rehabilitation center on the number of Hawaiian short-eared owls rehabilitated each year.
3. Mitigation at a Tier 2 tier will be considered successful if Kawailoa Wind Power contributes an additional an additional $6,250 for research and $6,500 up to a maximum of $12,500 to fund management measures within 6-months of the determination of Tier 2 take. Criteria for the success of the management measures will be determined when the protocols for the chosen management measures are developed.

7.6 Hawaiian Hoary Bat

Mitigation targets have been identified based on the tiered levels of increasing take ranging from Tier 1 to Tier 3. On-site monitoring during operations will be used to determine the tier at which Hawaiian hoary bat take is occurring. Mitigation is initially intended to compensate for take at the Tier 1 level as described in Section 6.5.1. If monitoring shows that take is actually occurring in excess of Tier 1 level, adjustment to mitigation efforts will be made as described below (Section 7.6.2 and 7.6.3). The estimated cost for each proposed measure is presented in Appendix 8.

USFWS and DOFAW have recently required that upland forest restoration be provided as compensation for bat take at the rate of 40 ac. per pair of bats (one male and one female) (A. Nadig, USFWS, personal communication). This requirement applies to wind projects that typically have a 20-year permit term. However, it is also recognized that restoring wetlands can also greatly improve foraging habitat and can also be beneficial to bats. Moreover, restoration and management of existing habitats has the potential to provide broader ecological benefits such as reducing fragmentation or invasive species threats while also increasing the carrying capacity of the local bat population.

Proposed mitigation for Kawailoa Wind Power consists of restoring wetland habitat or native forest to improve foraging resources available to bats and to provide additional roost trees, along with a complimentary research project that supports the efficacy of the mitigation method selected. The rationale and proposed methods for wetland or forest restoration are described below.

Wetland Restoration

Wetland restoration has been shown to increase bat activity for the hoary bat and other species (Grindal et al. 1999; Francl et al. 2004; Brooks and Ford 2005) on the mainland. In Hawaii, prime bat foraging habitat is likely to be a greater limiting factor than roost-site limitations (O'Farrell pers comm., see Appendix 14), as the species has been recorded roosting in a variety of native and non-native trees (Mitchell et al. 2005) and there is no shortage of available roost trees on the island. Bat home ranges have the potential to contract with improved foraging resources (Kunz and Lumsden 2003) and existing data shows that core ranges of Hawaiian hoary bats are very variable and can be much smaller than the short-term average of 84.3 ac for males (n=14) and 41.2 ac (n=11) for females on the Island of Hawaii (Bonaccorso, F. 2011. pers. comm., USGS. May 3, 2011, see Section 3.8.4.4). Current research shows that male Hawaiian hoary bat core areas do not appear to overlap but female core areas may overlap with male core areas. Sample sizes are small, however, and individuals were tracked only for two weeks. Belwood and Fullard (1984) also reported groups of up to 8 Hawaiian hoary bats foraging in a small area (approximately 1.3 ac) around the incandescent lights at Kokee State Park (150th Air National Guard Station), Kauaʻi, with each bat defending its foraging airspace within the small area; demonstrating that, while territorial, Hawaiian hoary bats can forage in close proximity to each other.

Brooks and Ford (2005) showed that for hoary bats and large bodied bats in general, open canopy habitats which included open uplands, reservoirs, large ponds and beaver meadows had ten times more bat activity than closed canopy habitats (vernal pools and streams, Figure 7-1). Moreover, Grindal et al (1999) also demonstrated that bat activity levels were significantly greater in riparian (lake) than upland habitat (mixed conifer, spruce or fir depending on elevation). The hoary bat was among the species sampled in the study. Commuting and foraging activity for bats in general were ten to 40 times greater in riparian than upland habitats respectively. The results were consistent over an elevational gradient (540 - 1800m) (Figure 7-2).

Data collected at small irrigation ponds in the vicinity of Kawailoa Wind Power, though limited, show similar trends (Table 7-3). These ponds are open canopy and are small bodies of open water (1 - 4 ac). The average activity rate at these small ponds is seven-fold that occurring in other vegetated areas (1.25 passes/detector night vs. 0.18 passes/detector night; data weighted by detector nights).

Table 2. Average number of search phase and feeding buzz echolocation call sequences per 20-minute ultrasonic survey by species and habitat and analysis of variance results comparing call activity between open- and closed-habitat types, Quabbin Reservoir watershed, MA, 2003 and 2004. SC = search call; FB = feeding buzz.

		Open-canopy habitats					Closed-canopy habitats			Analysis of variance[1]	
Bat species	Call activity	Open uplands	Reservoir	Large pond	Beaver meadow	Mean	Vernal pool	Stream	Mean	F	p
Big brown bat	SC	9.7	4.6	9.6	4.0	6.5	0.1	2.0	1.1	8.4	0.092
	FB	0.6	0.1	0.9	0.8	0.6	0.0	0.1	0.1	5.6	0.168
Eastern red bat	SC	1.7	4.6	8.7	3.8	4.7	0.7	0.7	0.6	87.4	< 0.001
	FB	0.1	0.5	1.1	0.4	0.5	0.1	0.0	0.1	4.0	0.261
Hoary bat	SC	1.3	9.5	3.2	1.7	3.9	0.1	0.6	0.4	88.4	< 0.001
	FB	0.0	0.1	0.0	0.0	< 0.1	0.0	0.0	0.0	[2]	
All large-bodied bats	SC	12.7	18.9	21.0	9.4	15.5	0.6	3.3	2.0	29.2	0.012
	FB	0.7	0.7	2.0	1.3	1.2	0.1	0.1	0.1	17.2	0.033
Little brown bat	SC	0.5	5.0	19.2	13.3	9.5	13.5	1.0	7.3	< 1.0	> 0.500
	FB	0.3	0.7	7.1	6.6	3.7	5.8	0.1	3.0	1.3	> 0.500
Northern myotis	SC	0.4	0.0	0.2	0.0	0.2	0.8	0.5	0.7	11.6	0.057
	FB	0.1	0.0	0.0	0.0	< 0.1	0.1	0.1	0.1	10.0	0.075
Unidentified *Myotis*	SC	0.2	0.4	0.6	1.0	0.6	3.8	1.8	2.8	3.3	0.336
	FB	0.0	0.0	0.0	0.1	< 0.1	0.4	0.3	0.4	8.0	0.097
All *Myotis*	SC	1.0	5.4	19.9	14.3	10.2	18.0	3.3	10.7	< 1.0	> 0.500
	FB	0.3	0.7	7.1	6.7	3.7	6.3	0.5	3.4	< 1.0	> 0.500
All species	SC	15.9	29.4	46.8	24.8	29.2	19.0	7.7	13.4	10.1	0.073
	FB	1.0	1.4	9.1	7.9	4.9	6.3	0.6	3.5	5.3	0.177

[1]Repeated measures (years), analysis of ranks; comparison of closed-versus open-canopy habitat classes.
[2]No analysis performed, no observations in one habitat class.

Figure 7-1. Hoary Bat and Large-Bodied Bat Activity at Open- and Closed-Canopy Habitats (figure from Brook and Ford 2005)

Fig. 1. Commuting activity levels (mean + 1 SE) of bats in riparian and upland habitat over three elevational zones. Means with different letters are significantly different ($p < 0.05$).

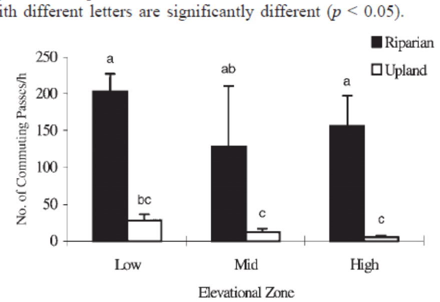


Fig. 2. Foraging activity levels (mean + 1 SE) of bats in riparian and upland habitat over three elevational zones. Means with different letters are significantly different ($p < 0.05$).

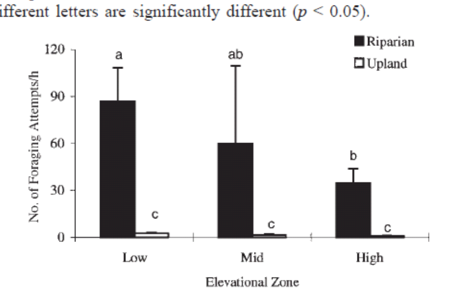


Figure 7-2. Bat Activity Levels Between the Uplands and Riparian Areas (figure from Grindal et al. 1999)

Table 7-3. Comparison of Activity Rates from March 1 – June 7 2011 at Ponds and Other Vegetated Habitats at Kawailoa Wind Power and Vicinity. Anabats highlighted in gray were deployed at the irrigation ponds.

Anabat	Passes	Detector Nights	Activity Rate (passes/detector night)
A2	10	31	0.32
A3	8	56	0.14
B3	2	84	0.02
C1	0	31	0.00
C2	12	19	0.63
C3	1	37	0.03
E1	101	92	1.10
F4	38	99	0.38
G2	22	98	0.22
H1	19	89	0.21
J3	1	95	0.01
K1	31	14	2.21

Based on existing data from other sites and in the vicinity of ‘Uko‘a pond (the proposed wetland restoration site), it is expected that the foraging activity rates at a restored wetland will increase by seven to ten-fold above that occurring at forests in the area (Brooks and Ford 2005, Grindal et al 1999, Table 7-3). Hence, it is proposed that wetland restoration which will create high quality foraging habitat, will be five times more beneficial to foraging bats than forest restoration and that as a rough metric, 1 ac. of wetland is equivalent to 5 ac. of forest.

This wetland restoration proposal has received considerable support from Dr. Michael J. O'Farrell (O'Farrell Biological Consulting LLC; Email: mike@mammalogist.org; Website: www.mammalogist.org, Appendix 14), the bat expert Kawailoa Wind Power has consulted with and who estimates that this project will have a high probability of success based on his long-term observations in the field of *Lasiurus* species on the mainland and work on numerous published and technical reports (O'Farrell et al. 2004; Bradley et al. 2005; Williams et al. 2006; O'Farrell et al. 2000; Gannon et al. 2004; O'Farrell 2006a, 2006b, 2007, 2009; see website above for a complete curriculum vitae).

Forest Restoration

Alternatively, if mitigation at ‘Uko‘a Pond is unacceptable or infeasible then Kawailoa Wind Power proposes to implement native forest restoration to improve or create additional foraging habitat for the Hawaiian hoary bat, while retaining and planting more native roost trees in the chosen area.

Based on input provided by USFWS and DOFAW, they have recently required that upland forest restoration be provided as compensation for bat take at the rate of 40 ac. per pair of bats (one male and one female). This is based on the reasoning that the core range habitat for a male bat is approximately 80 ac. (mean male core area : 84.3 ac, n=14) and 40 ac. for a female bat (mean female core area = 41.2 ac, n=11). Current research shows that male bat core areas do not appear to overlap but female core areas may overlap with male core areas (Bonaccorso, F. 2011. pers. comm., USGS. May 3, 2011). Hence, in an 80 ac. forest, USFWS has reasoned that one pair of bats may be found. Furthermore, as Hawaiian hoary bats are conservatively estimated to live 10 years, for a 20 year project like Kawailoa Wind Power, up to two pairs of bats may use the area. Hence per USFWS recommendations the compensation for a pair of bats is calculated to be 40 ac. (80 ac. for a pair of bats/ 2 lifespans = 40 ac.).

Research

Because of the lack of life history information on the Hawaiian hoary bat, research is also 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."

7.6.1 Tier 1 Mitigation

Mitigation for the Hawaiian hoary bat by Kawailoa Wind Power was developed through discussions with USFWS, DLNR, and bat experts, 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 measures consisting of:

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 by DLNR, USFWS and ESRC;
4. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.
5. Monitoring to verify increased use of restored and managed habitats;
6. Research to verify increased health, survivorship and/or productivity of local bats as a result of using the restored and managed habitats.

7.6.1.1 Research on Bat Habitat Utilization and Bat Interactions at Kawailoa Wind Power

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. The Applicant will 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 Kawailoa Wind Power and the vicinity. Survey protocols will be developed prior to start of project operations, in consultation with HBRC, with approval by USFWS and DLNR. Up to 12 anabat detectors will be deployed at Kawailoa Wind Power and the vicinity.

The Applicant will continue to survey for and monitor Hawaiian hoary bats within and in the vicinity of the Kawailoa Wind Power site. 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. These on-site surveys are also expected to advance avoidance and minimization strategies that wind facilities in Hawai'i and elsewhere can employ in the future to reduce bat fatalities. Surveys will be conducted during years when systematic fatality monitoring is conducted, (i.e., during the first three years and at five year intervals thereafter, or as otherwise determined under the Adaptive Management provisions), to

1. Correlate observed activity levels with any take that is observed. Thermal imaging or night vision technology will be used to assist acoustic monitoring as trends are detected. The use of additional techniques and technologies will also be considered.
2. Determine seasonal and nightly peak bat activity periods on-site.
3. Determine if bats are being attracted to the wind facility by comparing post-construction data with pre-construction activity levels.

Incidental bat observations will also be recorded under the WEOP (Section 7.2 and Appendix 6).

7.6.1.2 Implementation of Management Measures

The Tier 1 requested take equates to roughly 10 pairs of bats (10 males and 10 females) after accounting for juvenile survival rates.

Wetland Alternative

Kawailoa Wind's preferred mitigation is to provide wetland restoration at 'Uko'a Pond. Based on input provided by USFWS and DOFAW, they have recently required that upland forest restoration be provided as compensation for bat take by at the rate of 40 ac per pair of bats (one male and one female, see Section 7.6). For wetland restoration, 1 ac of wetland is assumed to have the foraging potential of 5 ac of forest (see Section 7.6 under Wetland Restoration), thus the wetland area for restoration is calculated to be 80 ac (40 ac x 10 pairs / 5 ac, see Section 7.6). In addition to the restoration of 80 ac of the 'Uko'a pond wetland, Kawailoa Wind Power proposes to restore 40 ac of adjacent forest buffer to provide day and night roosts as part of Tier 1 mitigation. Baseline studies documenting bat activity, and relative bat numbers (by visual surveys and mist netting) will be established one year prior to the restoration of the pond.

'Uko'a wetland is surrounded by a thick canopy layer averaging 20-30 feet in height. The canopy is dominated by Chinese banyan (*Ficus microcarpa*), date palm (*Phoenix dactylifera*), kiawe (*Prosopis pallida*), Manila tamarind (*Pithecellobium dulce*), paperbark, Christmas berry, and Java plum (*Syzygium cumini*). The interior of the wetland is dominated by California bulrush (*Schoenoplectus californicus*), California grass (*Urochloa mutica*), neke fern (*Cyclosorus interruptus*), saltmarsh bulrush (*Bolboschoenus maritimus paludosus*), 'ahu'awa haole (*Cyperus involucratus*), and juncus (*Juncus polyanthemos*). Throughout the interior, there are also pockets of small shrubs and trees, dominated by paperbark and sourbush. The ground layer is dominated by 'ae'ae (*Bacopa monnieri*) and giant duckweed (*Spirodela polyrhiza*). Along the Kawailoa Road boundary of the wetland, the composition is almost completely water hyacinth. A small body of open water exists in the middle of the pond.

Wetland restoration to improve bat foraging habitat will consist of five components

1) Removal of invasive vegetation to re-create bodies of open water.
2) Control and removal of alien vegetation in the wetland interior to allow for the natural recruitment of native species that are already present. Suitable areas will replanted with native vegetation if necessary.
3) Managing 40 ac. of trees around the periphery of the pond by the selective removal of alien trees and replanting to provide night roosts and potentially day roosts. Alien trees that have been frequently documented as suitable roost trees will be retained in consultation with bat experts in Hawaii. Tree replantings will consist of native or non-invasive species that will grow well in the soil type and moisture regime of the area, and are also species that are documented as suitable roost trees for the Hawaiian hoary bat.
4) Fencing of the restored wetland and forested area.
5) Removal of the ungulates within the restored and forested area.

The removal of invasive vegetation and allowing the establishment of native emergent vegetation around the periphery of open water is expected to create edge habitat rich in foraging potential. The restoration of edge habitat should provide a sufficient foraging base to increase the carrying capacity of the local area (O'Farrell pers comm., Appendix 14). The availability of nearby roost trees should also enhance the quality of the habitat, by providing roost trees in close proximity to a high quality foraging habitat. Hence, the restoration of 'Uko'a pond is considered to have a high potential to increase the quality of foraging habitat for the local bat population in the area. By increasing forage biomass and providing additional roost opportunities use of the area by Hawaiian hoary bats is expected to increase and also improve reproductive success through improved foraging opportunities. This hypothisis will be evaluated through a research project outlined below.

As stated in Section 4.7.1, 40 ac of wetland will be restored as mitigation for waterbirds. If the wetland restoration area is increased to 80 ac to accommodate bat mitigation, the additional restored areas will also attract waterbirds. Therefore, the management measures outlined in Section 7.4.1 for waterbirds (fencing, trapping, vegetation maintenance and monitoring) will correspondingly be increased to ensure that the entire restored area is also managed for waterbirds. Monitoring of waterbird productivity will document any mitigation accrued above the Tier 1 level.

Research and Monitoring Accompanying Wetland Restoration

In addition to the implementation of habitat restoration measures, research will be conducted to investigate whether increasing and improving foraging habitat for the Hawaiian hoary bat in wetland areas results in an increased reproductive success or increased survival of adults or juveniles. The study will be designed by Kawailoa Wind Power, together with bat experts, and a detailed plan for the various aspects of the bat management will be written within three months of the issuance of the permit and an agreed upon baseline will be measured prior to the clearing of the vegetation. This Hawaiian Bat Research and Monitoring Plan for Kawailoa Wind Power will be approved by DLNR and USFWS before implementation. The study will be conducted by a primary investigator and a minimum of two technicians.

Bat detectors will also be placed within the portion of the pond identified for restoration one year prior to restoration to document baseline levels of bat activity rates. Concurrently, mist-netting and visual surveys will be conducted to census and capture bats to determine the age, sex and breeding status of bats utilizing the unrestored area. Tagging of bats and radio telemetry will also be conducted to gather life history information such as home range size and contribute to a population or density estimate for the mitigation site.

Telemetry, assessing bat activity, mist-netting, visual surveys will be conducted for three years post-restoration, and at subsequent five-year intervals. Research will quantify the success of the mitigation and components of the research could consist of documenting increasing bat activity from pre- to post-restoration, to support that wetland restoration improves foraging habitat for bats and results in greater survival and increased productivity. Documenting increased numbers of bats caught in mist-nets or seen during visual surveys will demonstrate that the restoration at ʻUkoʻa Pond has increased the number of individuals utilizing ʻUkoʻa Pond. If the pregnant bats or juveniles caught increase over time, this will also demonstrate that increased reproductive success is occurring at the restored wetland, as compared to baseline (pre-restoration) levels. Telemetry will provide information on home range sizes and time spent by individuals feeding and roosting at the restored site. All these data will be used to determine if the increase in survivorship and productivity at the wetland have been sufficient to compensate for the requested take in Tier 1. Due to the small amount of information currently available about the basic biology of the Hawaiian hoary bat, the exact metric or combination thereof, to be used to determine the effectiveness of the mitigation, will an integral part of the research that will have to be fulfilled as part of the mitigation.

If after 5 years of wetland restoration, the monitoring data and results from the research described above show that the mitigation measures are insufficient to mitigate for take occurring at Tier 1, additional mitigation measures will be implemented to compensate for the deficit. Mitigation measures will consist of additional forest or wetland restoration. However, if other methods for improving bat habitat are available at that point in time, these alternative management strategies will also be considered. The most appropriate mitigation measure to be implemented will be determined by DLNR and USFWS using the best available science and expertise. Mitigation measures may be extended beyond the term of the ITL/ITP if necessary to compensate for the requested take. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

Reforestation Alternative

Alternatively, if wetland restoration is not selected, then Kawailoa Wind Power proposes to restore forest habitat to increase habitat available to bats. Based on the current recommendations of USFWS and DOFAW, 400 ac. of native forest will restored, and restoration measures will include fencing, ungulate control, removal of invasive species and replanting of native species. The actual acreage to be restored may be modified with the approval of DOFAW and USFWS if future research indicates that 400 acres is likely to be either insufficient or excessive. Literature shows that hoary bats and *Lasiurus* species in general, prefer to forage along edges and gaps (e.g., Morris 2008; Hein et al. 2009; Menzel et al. 2002). It is therefore proposed that during restoration, the removal of alien species and the selective replanting of native species be used to create edge and gaps within the restored area. Mitigation for bats will be deemed successful if bat activity rates are greater in the restored forest in comparison to the unrestored forest.

Possible locations for native forest restoration and management on O'ahu include forests currently managed by Kamehameha Schools or at Waimea valley, managed by Hi'ipaka LLC, a native Hawaiian non-profit organization. On Maui possible locations include native habitat plant restoration and management at Kahikinui Forest Reserve, managed by DOFAW or on private land owned by Ulupalakua Ranch. Other areas for forest restoration on O'ahu, Maui or other islands will be considered as necessary and the final location for forest restoration and management will be will be determined in consultation with DLNR, USFWS and bat experts. Mitigation can be conducted on Maui only if the bats on Maui and O'ahu are determined to be genetically similar and not distinct sub-populations. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

It is anticipated that the measures 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. Other sites may be chosen if they are determined to be more appropriate for the implementation of the mitigation measures, or if the originally identified mitigation measure does not come to fruition within three years from the start of project operations, with approval from USFWS and DOFAW. Funds will be directed toward whatever management or research activity is deemed most appropriate at the time with the concurrence of USFWS and DOFAW.

Research and Monitoring Accompanying Forest Restoration

In addition to the implementation of restoration measures, research will be conducted to investigate whether increasing and improving roosting and foraging habitat for the Hawaiian hoary bat in forested areas results in an increased productivity or increased survival of adults or juveniles. The study will be designed by Kawailoa Wind Power, together with bat experts and a detailed plan for the various aspects of the bat management will be written within three months of the issuance of the permit and an agreed upon baseline will be measured prior to the clearing of the vegetation. This Hawaiian Bat Research and Monitoring Plan for Kawailoa Wind Power will be approved by DLNR and USFWS before implementation. The study will be conducted by a primary investigator and a minimum of two technicians.

Bat detectors will also be placed within the area identified for restoration one year prior to restoration to document baseline levels of bat activity rates. Concurrently, mist-netting and visual surveys will be conducted to census and capture bats to determine the age, sex and breeding status of bats utilizing the unrestored area. Tagging of bats and radio telemetry will also be conducted to gather life history information such as home range size and contribute to a population or density estimate for the mitigation site.

Telemetry, assessing bat activity, mist-netting, visual surveys will be conducted for three years post-restoration, and at subsequent five-year intervals. Research will quantify the success of the mitigation and components of the research could consist of documenting increasing bat activity from pre- to post-restoration, to support that forest restoration improves roosting foraging habitat for bats and results in greater survival and increased productivity. Documenting increased numbers of bats caught in mist-nets or seen during visual surveys will demonstrate that the forest restoration has increased the number of individuals utilizing the restored forest. If the pregnant bats or juveniles caught increase over time, this will also demonstrate that increased reproductive success is occurring at the restored forest. Telemetry will provide information on home range sizes and time spent by individuals feeding and roosting at the restored site. All these data will be used to determine if the increase in survivorship and productivity at the restored forest have been sufficient to compensate for the requested take in Tier 1. Due to the small amount of information currently available about the basic biology of the Hawaiian hoary bat, the exact metric or combination thereof, to be used to determine the effectiveness of the mitigation, will an integral part of the research that will have to be fulfilled as part of the mitigation.

7.6.2 Mitigation for Tier 2 Rates of Take

Take will be considered to be occurring at Tier 2 levels when the 5-year take limits for Tier 1 are exceeded within five years of if the 20-year take limit is exceeded at any time. Similarly, take will be considered to be occurring at Tier 3 levels when the 5-year take limits for Tier 2 are exceeded within five years of if the 20-year take limit for Tier 2 is exceeded at any time. If a Tier 2 or Tier 3 rate of take occurs, additional research to investigate the reasons for the increased rate of take will be conducted, and additional measures to reduce the take will be implemented if possible. Additional mitigation measures will also be implemented to mitigate for the increased take.

7.6.2.1 Additional Research at Kawailoa Wind Power

In the event that take exceeds the threshold for Tier 1, Kawailoa Wind Power will review the fatality records in an effort to determine whether measures in addition to LWSC can be implemented that will reduce or minimize take. If causes cannot be readily identified Kawailoa 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 fatalities are occurring
3. using thermal imaging or night vision equipment to document bat behavior
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. These data may also be used to refine LWSC criteria, such as revising the times of year when curtailment is implemented, or if curtailment can be confined to a subset of "problem" turbines. These additional measures will be implemented by Kawailoa Wind Power with the concurrence of USFWS and DLNR.

7.6.2.2 Additional Bat Habitat Management Measures for Tier 2 or Tier 3

Wetland restoration or forest restoration using the acreages described above will be conducted to mitigate for take requested at each higher tier (Tier 2 and Tier 3 level). Since the Tier 2 and Tier 3 requested take are multiples of the Tier 1 requested take (Tier 2 requested take is twice that of Tier 1 and Tier 3 requested take is three times; see Section 6.3.7.3 and Table 1-2), the mitigation effort for Tier 2 and Tier 3 will consist of implementing additional mitigation measures (additional forest or wetland restoration) equivalent to the Tier 1 effort upon entering each higher tier.

Wetland Restoration Alternative

If wetland restoration is chosen as the mitigation measure, for each subsequent tier, an additional 80 ac. of wetland restoration and 40 ac. of forest restoration as described in Tier 1 will be added to the on-going mitigation activities. The restoration may be modified depending on the outcome of the research that was conducted in Tier 1. Wetlands to be restored include completing the restoration of the 150 ac ʻUkoʻa pond or conducting the wetland restoration at other locations such as Kawainui Marsh or other wetlands on Oahu.

Forest restoration Alternative

If forest restoration is chosen as the mitigation measure, for each subsequent tier, an additional 400 ac. of forest restoration as described in Tier 1 will be added to the on-going mitigation activities. The actual acreage to be restored may be modified with the approval of DOFAW and USFWS if future research indicates that 400 acres is likely to be either insufficient or excessive.

Possible locations for native forest restoration and management on Oahu include forests currently managed by Kamehameha Schools or at Waimea valley, managed by Hi'ipaka LLC, a native Hawaiian non-profit organization. On Maui. possible locations include native habitat plant restoration and management at Kahikinui Forest Reserve, managed by DOFAW or on private land owned by Ulupalakua Ranch on Maui. Other areas for forest restoration on Oahu, Maui or other islands will be considered as necessary and the final location for forest restoration and management will be will be determined in consultation with DLNR, USFWS and bat experts. Mitigation can be conducted on Maui only if the bats on Maui and O‘ahu are determined to be genetically similar and not distinct sub-populations. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

Other Alternatives

If at the time of determination of Tier 2 or 3 rates of take, more scientific information is available that indicates that the implementation of measures other than habitat restoration are more important or pressing in aiding the recovery of the Hawaiian hoary bat, Kawailoa Wind Power in concurrence with USFWS and DLNR will direct the specified funds toward whatever management action is deemed most appropriate at the time.

7.6.3 Measures of Success

The success of the mitigation efforts will be determined as follows:

1. On-site research into Hawaiian hoary bat habitat utilization and bat interaction with wind facilities will be considered successful if Kawailoa 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. Research at the either the wetland forest restoration site will be considered successful if the study shows that the restoration increases bat productivity and survival adequate to compensate for the requested take. The study design will be approved by USFWS and DOFAW and the results will be shared with USFWS and DOFAW within nine months of the completion of the study.

3. If wetland restoration is conducted (For Tier 1), mitigation will be considered successful if an increase in bat productivity is observed. If after five years it is determined that the wetland restoration is insufficient to meet Tier 1 obligations, then additional wetland restoration or forest restoration or other newer measures (see section 7.6.1.2) will be conducted to offset the deficit. This may extend the mitigation past the length of the ITP/ITL as necessary.

4. If forest restoration is conducted, mitigation will be considered successful if alien species control and ungulate control within the restored forest is successful and bat productivity or activity rates are greater within the restored forest than in unrestored forest.

5. For Tier 2 and Tier 3 mitigation, which will consist of more wetland or forest restoration, mitigation will be deemed successful based on the same criteria established for the respective mitigation measure in Tier 1, with improvements incorporated as determined by the research conducted in Tier 1.

7.7 Immediate Revegetation to Control Soil Erosion

Re-vegetation will be implemented for erosion control in areas where finished grading results in exposed soil, such as along the edges of turbine pads and along road cuts and fill slopes. In such areas, Kawailoa Wind Power proposes to apply a hydro-seed mixture of annual rye (*Lolium multiflorum*) to establish an initial cover of vegetation. Annual rye grass is expected to provide rapid cover that will gradually die back and allow natural recruitment of neighboring species. To help the rapid establishment of the annual rye and subsequent natural recruitment, all hydroseeded areas will be irrigated as necessary for establishment. Other seed mixes will be considered if they are determined to be more suitable for the terrain and expected climate conditions.

Best efforts will be made to utilize plant materials that have a high likelihood of long-term survival. This phase of the project will be considered successful if it can be demonstrated that >75% of the bare areas, fill slopes, and road cut segments that receive treatment have established cover within one year following treatment. If initial applications appear to be only partially successful, subsequent hand and/or hydro-seeding applications or additional temporary measures (e.g., excelsior, jute or coir matting) may be installed to ensure adequate coverage and erosion control.

7.8 Managing Invasive Species

Kawailoa Wind Power intends to minimize and avoid the introduction of new invasive species to the project area during the proposed wind farm development using the following best management practices. 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 O‘ahu will be washed prior to entering the project area. In addition, Kawailoa Wind Power will ensure that construction materials arriving from outside of O‘ahu 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 will be conducted at a vacant 6.8 acre parcel immediately adjacent to the Barbers Point Harbor, will be leased by Kawailoa Wind Power. Equipment and material arriving through Honolulu Harbor will be inspected and/or cleaned (as appropriate) at a designated location prior to entering the project area. Kawailoa Wind Power will document all inspection and cleaning activities using inspection forms. Kawailoa Wind Power will 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. Furthermore, weed establishment will be limited by minimizing ground disturbance and vegetation removal to the maximum extent practicable. Erosion of the job site and the potential transport of weedy species will be prevented through implementation of storm water runoff Best Management Practices.

At the end of the construction period, areas altered by construction of the project will be surveyed to ensure that no problematic and/or invasive species have been introduced. All areas that are hydroseeded will be monitored for at least six months to ensure removal of any invasive plants that have established from seeds inadvertently introduced as part of the seed mixes. Appropriate remedial actions will be undertaken as needed, at the direction of DLNR and USFWS to facilitate containment or eradication of the target species as soon as possible. Any remedial actions will require the approval of USFWS and DOFAW prior to implementation.

7.9 Replanting of Native Trees

A few native tree species, notably koa, are present on the ridge tops, and some trees may have to be cut down as areas are cleared during the construction phase. Removal of native trees will be kept to the minimum necessary to ensure safe construction and fulfillment of post-construction monitoring requirements. Trees will not be cut during the bat pupping season (see Section 5.3). Kawailoa Wind Power has come to an agreement with the land owner (Kamehameha Schools) that an equal or greater number of native trees will be replanted offsite to compensate for the loss of native trees as a result of construction activities.

8.0 IMPLEMENTATION

8.1 HCP Administration

This HCP will be administered by Kawailoa Wind Power LLC with guidance from the USFWS and DLNR. The schedules for implementation of HCP requirements and reporting requirements are outlined in Appendix 13. Other experts may be consulted as needed, including biologists from other agencies (e.g., U.S. Geological Survey), conservation organizations, consultants and academia. HCP-related issues may also be brought before the ESRC for formal consideration when deemed appropriate by Kawailoa Wind Power, USFWS and DLNR. The Agencies will maintain final approval if an agreement cannot be reached.

Kawailoa Wind Power LLC will meet at least semi-annually with USFWS and DLNR. Additional meetings/conferences may be called by any of the parties at any time to address immediate concerns. The purpose of the regular meetings will be to evaluate the efficacy of monitoring methods, compare the results of monitoring to the estimated take, evaluate the success of mitigation, and develop recommendations for future monitoring and mitigation. Regular meetings will also provide opportunities to consider the need for adaptive management measures. In addition, Kawailoa Wind Power LLC will meet annually with the ESRC to provide updates of monitoring, mitigation, and adaptive management, and to solicit input and recommendations for future efforts. Additional meetings may be requested by the ESRC at any time to address immediate questions or concerns.

8.2 Monitoring and Reporting

Monitoring and reporting by the Kawailoa Wind Power LLC will address both compliance and effectiveness of monitoring and mitigation measures. Compliance monitoring will verify the Applicant’s implementation of the HCP terms and conditions. Annual reports and other deliverables as described below will be provided to USFWS and DLNR to allow them to independently verify that the Applicant has performed all of the required activities and tasks on schedule. Monitoring will document take relative to authorized levels and the success of the HCP’s mitigation program. The monitoring will involve surveys to make sure the authorized level of take is not exceeded, and that minimization and mitigation measures are sufficient and successful. Reporting requirements for Kawailoa Wind Power are outlined in Appendix 13.

8.2.1 Monitoring

The Applicant proposes to document bird and bat injuries and fatalities, including Covered and non-Covered Species, following methods that have been used effectively at other wind energy generation facilities in Hawai‘i and the continental United States. Details of the proposed monitoring protocol are provided in Appendix 7. The actual monitoring protocol will be finalized with final approval of the agencies prior to the start of project operations. Key components include:

- Use of Kawailoa Wind Power technical staff and/or third-party contractors who have been trained by experienced biologists with specialized expertise in conducting wind turbine/bird interaction studies. Additional contingency funds are provided in the event a third party contractor is required for monitoring and will only be used for this purpose.
- Search plots will be cleared and maintained with vegetation of short stature to facilitate searches.
- Carcass removal (CARE) and searcher efficiency (SEEF) trials will be conducted each season using carcasses of different size classes. SEEF and CARE trials will be conducted during the years when intensive searches are underway (see below). Two seasons each year will be addressed because of seasonality of some of the covered species: the winter/spring season (December – May) and summer/fall (June – November). Three size classes have been chosen to represent the size classes of the Covered Species: bat-sized, medium birds (waterbirds and seabirds) and large birds (owls). Carcass removal and SEEF trials will be conducted with sufficient replication to produce scientifically reliable results. These results will provide a basis for estimating unobserved take (see Appendix 7 on the potential study design and Appendix 9

for take calculation) and determining suitable search intervals. The Applicant will all cover costs and responsibilities for acquiring carcasses for trials.

- Intensive searches will be conducted for the first several years under the direction of a qualified biologist after which, the approach may be reduced to a sampling method based on the results obtained up to that point, subject to the approval of DOFAW and USFWS. An example search protocol is presented in Appendix 7. The final search protocol will be reviewed by a qualified researcher that specializes in monitoring and their guidance will be followed. Intensive searches are initially proposed to be conducted for the first three years of project operations. The 3-year time period will begin after the search protocol has been finalized and approved by USFWS and DOFAW. However, intensive searches may continue beyond three years until DOFAW, USFWS and ESRC have agreed that a sufficient basis has been established for reducing search intensity. The intensive years of monitoring are proposed to be subsequently conducted at 5 year intervals at Years 6, 11 and 16. New technologies or search methods may be incorporated under adaptive management in consultation with USFWS and DOFAW if they are demonstrated to increase the efficiency of the monitoring or enable more accurate take estimates to be obtained. Any change in monitoring measures will require the approval of USFWS and DOFAW prior to implementation.

- The search effort during the non-intensive years will be reduced based on results obtained during the intensive search years and subject to approval from USFWS and DOFAW. Similarly, new technologies or search methods may be incorporated under adaptive management in consultation with USFWS and DOFAW if they increase the efficiency of the monitoring. Any change in monitoring measures will require the approval of USFWS and DOFAW prior to implementation.

- The frequency of searches during the intensive search years will ensure that a variety of conditions are included. For example, days after moonless, cloudy or stormy nights are of particular interest, because the wind turbines would be least visible and the risk of collision would presumably be greater, especially during peak fledging periods.
- Incidental observations by on-site staff of bird use, injury and mortality will be documented in accordance with the WEOP and Downed Wildlife Protocol.
- The costs for monitoring and associated vegetation management are broken down as follows:
    - It is estimated that it will require eight full-time staff to conduct on-site HCP compliance at the cost of $475,000/yr, which includes monitoring, vegetation management, reporting and conducting carcass removal trials.
    - Third party quality control of data analysis and the proctoring of SEEF trials will cost $30,000/yr during intensive monitoring years.
    - Equipment for vegetation management (tractors, mowers, weed whackers etc.) is estimated to cost $130,000.
    - Equipment for the monitoring of search plots (truck, ATVs, mule, stakes, Anabats, traps, range finders, GPS, etc.) is estimated to cost $150,000.
    - An additional $25,000/yr is budgeted for supplies (trial carcasses, fuel etc.) and the routine maintenance and operation of equipment.

8.2.2 Reporting

If the monitoring search interval is exceeded, the Applicant will report the event to USFWS and DLNR within a week. If the monitoring search interval is exceeded more than once per season (for reasons other than weather, health or safety), it will be a violation of the permit. The Applicant, DLNR and USFWS may discuss possible adaptive management measures to address and correct the problem and the responsibility lies with the Permittee to correct the problem.

Semi-annual meetings with DLNR and USFWS will be held in March and September to provide brief progress updates and summarize the findings of scavenging, SEEF trials and results of mitigation efforts. Brief quarterly progress reports will be submitted within 30-days for quarters ending March

31, June 30, September 30 and December 31 of each year. Electronic copies of HCP-related data will also be submitted with the progress reports. If necessary, take limits will be reviewed and changed circumstances or adaptive management measures will be discussed with DLNR and USFWS as needed. In addition, should take of a Covered Species occur, DLNR and USFWS will be notified within 24 hours by phone and an incident report will be filed within three (3) business days (Appendix 11).

Annual reports summarizing the results of the three years of intensive monitoring will be prepared and submitted to DLNR and USFWS. These reports will identify: 1) actual frequency of monitoring of individual search plots; 2) results of SEEF and carcass removal trials with recommended statistical analyses if any; 3) directly observed and adjusted levels of take for each species; 4) whether there is a need to modify the mitigation for subsequent years; 5) efficacy of monitoring protocols and whether monitoring protocols need to be revised; 6) results of mitigation efforts conducted as part of the HCP; 7) recommended changes to mitigation efforts if any; 8) budget and implementation schedule for the upcoming year; and, 9) continued evidence of the Applicant's ability to fulfill funding obligations. The annual report will be submitted by August 15 each year along with electronic copies of HCP related data. The report will cover the period from July 1 of the previous year through June 30 of the present year. Agencies will have 30 calendar days to respond to the report, after which a final report incorporating responses to the agencies will be submitted by September 30. The report may also be presented to ESRC as required.

In subsequent years, monitoring may consist of a reduced level of effort, consisting of smaller search plots at a subset of turbines with plots being relocated periodically to sample a variety of locations. The ongoing effort will be supplemented by the WEOP Program, as implemented by on-site staff. Depending upon the findings, the location and focus of the ongoing effort can be modified, with the concurrence of the USFWS and DLNR, to target areas or times of particular interest. A table summarizing the results of incidental observations will be submitted to DLNR and USFWS quarterly (see above for reporting dates). In addition, in accordance with the Downed Wildlife Protocol, biologists at DLNR and USFWS will be notified whenever an MBTA or Covered Species is found dead or injured. The Applicant will confer formally with the USFWS and DLNR following submittal of the annual report to review the results and plan appropriate future mitigation and monitoring measures. Any changes to future mitigation and monitoring will only be made with the concurrence of USFWS and DLNR.

8.3 Adaptive Management Program

According to USFWS policy (see 65 Fed. Reg. 35242 [June 1, 2000]), adaptive management is defined as a formal, structured approach to dealing with uncertainty in natural resources management, using the experience of management and the results of research as an on-going feedback loop for continuous improvement. Adaptive approaches to management recognize that the answers to all management questions are not known and that the information necessary to formulate answers is often unavailable. Adaptive management also includes, by definition, a commitment to change management practices when determined appropriate.

In the case of Kawailoa Wind Power, some uncertainty exists in the proposed project from estimated rates of take to the success of the proposed mitigation measures. Fortunately, because of past studies conducted by many researchers on the effectiveness of predator control upon improving breeding success of the covered seabirds and waterbirds, the potential for success of the mitigation measures proposed for these species is also considered to carry a very low level of uncertainty.

The proposed tiered approach to mitigation was designed to be adaptive because actual rates of take may not match those projected through modeling. Mitigation efforts will increase if monitoring demonstrates that incidental take is occurring above Tier 1 take levels. Any changes in the mitigation measures will be made only with approval from USFWS and DLNR. Regardless of recorded take levels, the avoidance and minimization measures described in Section 5.3 will be employed for the duration of the Kawailoa Wind Power project. The only exception would be if evidence clearly demonstrates that removing the avoidance or minimization measure will not appreciably increase take. For example, if bat take is low and it is proven at other wind facilities that not implementing low wind speed curtailment does not appreciably increase bat take. This could occur due to factors such as bats not foraging at the height of the RSZ, or being less vulnerable to collisions due to the lack of a long distance migration which is when hoary bats on the mainland seem to be most susceptible. Tables illustrating mitigation efforts and adaptive management options are included in Section 7.1.

Monitoring of seabird and waterbird mitigation efforts is intended to inform the Applicant, USFWS, and DLNR whether these efforts are adequately compensating for take. If monitoring reveals that a particular mitigation effort is not achieving the necessary level of success, the Applicant will consult with USFWS and DLNR and require agencies approval to develop and implement a revised mitigation strategy to meet mitigation requirements. As long as take levels remain within the take tiers identified in Section 6.3, any actions performed in response to this adaptive management process would be performed under the mitigation budget established for the project.

If the take of any of the Covered Species exceeds the Tier 1 level of take authorized by the ITP and ITL, but remains within the range identified in Section 6.0 as the Tier 2 rate for that species (or no higher than Tier 3 for bats), the Applicant will increase the mitigation effort for that species as prescribed in Section 7.0. The Applicant will also promptly discuss this situation with USFWS and DLNR to review and approve the total take of that species recorded to date at Kawailoa Wind Power and the mitigation performed to date on behalf of that species, and to identify whether mitigation performed to date has compensated for the higher rate of take or whether changes in mitigation are needed to compensate for the higher rate of take. The Applicant may also consider whether changes in operational practices are needed to reduce levels of take. Any changes to the mitigation efforts will be made only with the approval of USFWS and DLNR, and the Applicant's commitment to fully mitigate for their authorized take level.

8.4 Funding

The HCP includes a habitat conservation program with measures that Kawailoa Wind Power will undertake to monitor, minimize, and mitigate the incidental take of each covered species, plus provide a net conservation benefit, as measured in biological terms. An estimate of the costs of funding the proposed conservation program is presented in Appendix 8 of the HCP. Kawailoa Wind Power will provide the required conservation (monitoring, minimization, and mitigation) measures in full, even if the actual costs are greater than anticipated. For example, although the overall expenditures at the Tier 1 is not expected to exceed a total of $7.2925 million, the budgeted amounts are estimates and are not necessarily fixed. One way of accomplishing this is that past, current or future funds allocated to a specific Covered Species may be re-allocated where necessary to provide for the cost of implementing conservation measures for another Covered Species, and funding for any individual Covered Species is not limited to those amounts estimated in Appendix 8. Kawailoa Wind Power also recognizes the cost of implementing habitat conservation measures in any one year may exceed that year's total budget allocation, even if the overall expenditure for the conservation program stays within the total amount budgeted over the life of the project. Accomplishing these measures may therefore require funds from future years to be expended, or likewise unspent funds from previous years to be carried forward for later use. For practical and commercial reasons, such reallocation of funds among years may require up to 18 months lead time in order to meet revenue and budgeting forecast requirements. However, if reallocation between species or budget years are not sufficient to provide the necessary conservation, Kawailoa Wind Power will nonetheless be responsible for ensuring that the necessary conservation is provided. Funding reallocation for one species to another will not impede the implementation of mitigation measures for either species.

Funding for the implementation of the HCP will be provided by Kawailoa Wind Power as an annual operating expense paid *pari passu* with other operating expenditures (operation and maintenance costs, insurance, payroll, lease payments to the State of Hawaiʻi, audit costs, and agency fee costs) and most importantly, ahead of both debt service to lenders and dividends to equity investors.

Assurances that adequate funding will be available to support the proposed monitoring and mitigation measures will be provided by Kawailoa Wind Power in the form of a bond, letter of credit or similar instrument naming the DLNR as beneficiary. The terms and conditions of such instrument(s) must be finalized before any incidental take of any Covered Species actually occurs.

At a minimum, Kawailoa Wind Power will provide a rolling letter of credit (LC) or bond in the amount of $500,000, which will be available to fund mitigation in the unlikely event of a revenue shortfall or, in the worst case scenario, bankruptcy. The LC will be automatically renewed prior to expiration, unless it is determined to no longer be necessary by the USFWS and DLNR. In the event of a revenue shortfall or bankruptcy, the LC could be drawn upon by DLNR to fund any outstanding mitigation obligations of the project.

8.5 Changed Circumstances Provided for in the HCP

Circumstances may change or occur during the life of the HCP, some of which can be anticipated and planned for. For Kawailoa Wind Power, possible changed circumstances that are anticipated and planned for include: 1) climate change; 2) disease outbreaks in any of the listed species; 3) deleterious change in relative abundance of non-native plant species or ungulates occurring at the mitigation sites for Covered Species; 4) hurricanes or other major storms that may affect the project area and/or mitigation sites; 5) changes in the price of raw materials and labor; 6) the de-listing of any species covered in the HCP; and 7) the listing of one or more species that already occur on-site, or fly over the site, not currently covered in the HCP. Any changes in the mitigation measures implemented for any of the Covered Species due the these scenarios will be performed under the budget established for mitigation expenses in this HCP which includes funding available for the tier of mitigation required, and the Surety Letter of Credit if mitigation actions have not been fully achieved or unmitigated take remains.

The procedures to provide for these scenarios are described below:

1) Global Climate Change Significantly and Negatively Alters Status of the Covered Species

    Kawailoa Wind Power will harness a renewable source of clean energy and is expected to decrease the State of Hawaiʻi's dependence on fossil fuels, and consequently reduce the greenhouse gas emissions by the state. Details on the anticipated reduction of greenhouse gases can be found in the State EIS (CH2M Hill 2011). It should be acknowledged that the operation of Kawailoa Wind Power will directly contribute to mitigating the effects of global warming.

    Global climate change within the life of the project (20 years) has some limited potential to alter the current distribution of vegetation communities utilized by the Covered Species through region-wide changes in weather patterns, sea level, average temperature and levels of precipitation (IPCC 2007). In some instances, climate change may also cause populations of Covered Species to decline. Covered seabird species are likely to be affected through changes in the distribution of their food resources at sea and possible changes in the vegetation at their preferred nesting habitats. Covered waterbird species are most likely to be affected by the loss of wetland habitat due to sea level rise and changes in precipitation. The short-eared owl and Hawaiian hoary bat are not expected to be affected by changes in climate over the life of the project due to their ability to utilize non-native habitats which are unlikely to decrease in availability during that time frame.

    With climate change, hurricanes or storms may occur with greater intensity (Webster et al. 2005; U.S. Climate Change Science Program 2009), which would increase the risk of damage to established mitigation sites. This is discussed in Scenario 4 below. Sea level is predicted to rise approximately 1 m in Hawaiʻi by the end of the 21st Century (Fletcher 2009). Given this, any rise in sea level experienced during the life of the project would likely be less than 1 m. As both seabird and waterbird mitigation sites are more than 1 m above sea level, these sites are unlikely to be impacted by sea level rise while the project is operational.

    Precipitation may decline by 5-10 % in the wet season and increase 5% in the dry season, due to climate change (Giambelluca et al. 2009). This may result in altered hydrology at the waterbird mitigation site and a possible drying of the wetland basins. Other mitigation sites may also be considered for continued mitigation if the existing site is no longer considered suitable wetland nesting habitat for waterbirds. The alternate mitigation site will be chosen with final approval by USFWS and DLNR. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

Vegetation at the seabird mitigation site may also change with decreased precipitation or increased temperatures; however, changes are expected to be small over the lifetime of the project. Should significant changes in vegetation be deemed to be occurring and demonstrated to affect the productivity of the Covered seabird species, other mitigation sites will be considered for continued mitigation, if deemed necessary, and will be chosen in consultation with USFWS and DLNR. In all cases, mitigation efforts will remain commensurate with requested take with a net benefit provided to each Covered Species as required by State law. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

2) Disease Outbreaks in Listed Species

The most prevalent disease for the waterbirds covered in this HCP is avian botulism (USFWS 2005a). Avian botulism is caused by a toxin produced in stagnant water by the anaerobic bacteria *Clostridium botulinum* type C_a. If such outbreaks should occur at the chosen waterbird mitigation site(s), Kawailoa Wind Power will, in coordination with, DLNR and USFWS in implementing measures to prevent or reduce the severity of the outbreaks at the mitigation sites as appropriate.

Newell's shearwater have not been documented to have disease outbreaks but Newell's shearwater fledglings have been found with mild symptoms of avian pox (Ainley et al. 1997; Mitchell et al. 2005; Simons and Hodges 1998). Hawaiian short-eared owls may be susceptible to the "sick owl syndrome," the cause of which has yet to be identified (Mitchell et al. 2005). It is currently not known if the Hawaiian hoary bat is susceptible to any diseases. Disease is considered one of the lesser threats to the persistence of the seabirds, owl and bat covered in the HCP. Should the prevalence of disease increase dramatically and become identified as a major threat to the survival of any of these species by DLNR and USFWS, Kawailoa Wind Power will seek the approval of DLNR and USFWS to determine if changes in monitoring, reporting or mitigation are necessary to provide assistance in documenting or reducing the impact of the disease.

3) Deleterious change in relative abundance of non-native plant species or ungulates occurring at the mitigation sites for Covered Species.

Should the proportion or coverage of non-native plant species or ungulates increase at any mitigation site to a point where it is believed that this change is causing significant habitat degradation or loss of habitat for any of the Covered Species, thereby resulting in a measurable decline of the species at the site, the Applicant will consult with DLNR and USFWS to determine if measures to prevent the further spread of non-native plants or incursion of ungulates are available, practical and necessary. If no such measures are available, mitigation measures for the affected Covered Species may be implemented at another site as determined by DLNR and USFWS.

4) Hurricanes and Storms

Of the species covered in the HCP, the waterbirds may be the most vulnerable to the effects and after-effects of hurricanes and storms. Kawailoa Wind Power will contribute to measures to rehabilitate waterbird habitat within waterbird mitigation sites that are extensively damaged during any hurricane or major storm as allowed by the mitigation budget established under the HCP. Possible contributions to habitat rehabilitation could include removal of debris, aiding in the recreation of nesting islands, contribution to revegetation efforts or rehabilitation of injured Covered Species as deemed necessary. If the habitat destruction due to the hurricane or storm is so extensive as to render the mitigation site unsalvageable or is altered such that it is no longer utilized by nesting waterbirds, and if the same storm also did not similarly damage wetland habitats more proximate to the project area such that project operations continue to pose a risk of causing take of any of the waterbird species, any remaining mitigation will be carried out at another waterbird nesting site, chosen with final approval by USFWS and DLNR. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

Seabirds, such as Newell's shearwater, have been shown to vacate nesting areas in response to approaching intense low-pressure areas and thus adults are unlikely to suffer mortality due to hurricane or storm events. If hurricanes were to occur during the chick-rearing period (e.g., Hurricane 'Iniki in 1992), chicks could suffer mortality as a result of destroyed burrows, uprooted trees, and/or mudslides. However, hurricane-related chick mortality has not been documented (Ainley et al. 1997). If necessary, Kawailoa Wind Power will contribute to measures to rehabilitate seabird nesting habitat within seabird mitigation sites that are damaged during hurricanes or major storms as allowed by the mitigation budget established under the HCP. Possible contributions could include removing of debris, contribution to revegetation efforts or rehabilitation of injured Covered Species as deemed necessary. If the habitat destruction due to the hurricane or storm is so extensive as to render the mitigation site unsalvageable or is altered such that it is no longer utilized by nesting seabirds, and if the same storm does not eliminate all Newell's shearwater activity occurring over the site (through evidence such as a lack of Newell's shearwater targets observed on radar surveys at the site) such that project operations continue to pose a risk of causing take, any remaining mitigation will be carried out at another seabird nesting site, chosen and with final approval by USFWS and DLNR. Mitigation measures will require the approval of USFWS and DOFAW prior to implementation.

It is not known how Hawaiian short-eared owls or Hawaiian hoary bats respond to storms or hurricanes. However, Kawailoa Wind Power will implement changes in monitoring, reporting or mitigation deemed appropriate by DLNR and USFWS if necessary.

5) Changes in the Price of Raw Materials and Labor

   Annual reviews will be performed to analyze the costs in the previous year's budget for mitigation expenses and cumulative costs. Annual expenses for subsequent years will be adjusted to meet projected costs based on previous years' expenditures and cumulative spend to date.

6) De-listing of Covered Species

   Should any of the Covered Species in the HCP be de-listed during the tenure of the permit, Kawailoa Wind Power may choose to consult with USFWS and DLNR to determine whether mitigation measures for the de-listed species can be discontinued. For example, the mitigation provided to date has more than offset the total expected take of that species by the project. However, if take is occurring at Tier 1 or higher, and the ongoing mitigation is necessary to continue offsetting the take of the species, mitigation will continue to be performed in accordance with the HCP.

7) Listing of One or More Species that Already Occur On-site

   In the event that one or more species that occur on-site are listed pursuant to the ESA, Kawailoa Wind Power will evaluate the degree to which the species is (or are) at risk of being incidentally taken by project operations. If take of the species appears possible, Kawailoa Wind Power will then assess whether the mitigation measures already being implemented provide conservation benefits to the newly listed species and if any additional measures are needed to provide a net conservation benefit to the species. Kawailoa Wind Power will then seek coverage for the newly listed species under an amendment to the HCP.

Potential remediation measures to address changed circumstances at the project area or mitigation site(s) are anticipated to improve the overall habitat quality and/or health of the Covered Species following recognition of a changed circumstance. However, these activities also have the potential to impact wildlife and their habitat. Potential impacts from the remediation measures are discussed in the HCP EA.

8.6 Changed Circumstances Not Provided for in the HCP

If changed circumstances occur that were not provided for in Section 8.5, and the HCP is otherwise being properly implemented, the USFWS will not require any conservation and mitigation measures in addition to those provided for in the HCP without the consent of Kawailoa Wind Power.

8.7 Unforeseen Circumstances and "No Surprises" Policy

Unforeseen circumstances are "changes in circumstance surrounding an HCP that were not or could not be anticipated by HCP participants, DLNR and USFWS that result in a substantial and adverse change in the status of a covered species" (USFWS and NMFS 1996). Under the "No Surprises" policy, with a properly implemented HCP (United States Code of Federal Regulations 50 CFR 17.22(b)(5)(iii); Hawaii Revised Statues – Section 195D-23), Kawailoa Wind Power will not be required to commit additional land, water, money or financial compensation, or be subject to additional restrictions on land, water or other natural resources to respond to such unforeseen circumstances beyond what has been already agreed upon in the HCP, without the consent of Kawailoa Wind Power. For the purposes of this HCP, changes in circumstances not provided for in Section 8.5 that substantially alter the status of the Covered Species are considered unforeseen circumstances.

The "No Surprises" policy assurances only apply to species "adequately covered" in the HCP. Species considered to be "adequately covered" are those covered by the HCP that satisfy the permit issuance criteria under the United States Code of Federal Regulations 50 CFR 17.22(b)(2) and Hawaii Statutes – Section 195D-21. The species considered adequately covered in this HCP, and therefore covered by the "No Surprises" policy assurances, include the Newell's shearwater, Hawaiian duck, Hawaiian stilt, Hawaiian coot, Hawaiian moorhen, and Hawaiian hoary bat. The "No Surprises" assurances also apply to the State-endangered Hawaiian short-eared owl as the HCP conditions for the species also satisfy the permit issuance criteria under Hawaii Statutes – Section 195D-21 of the ESA as if the species were listed.

In the event that unforeseen circumstances occur during the term of the Permit and the USFWS and DLNR concludes that any of the Covered Species are being harmed as a result, the agencies may require additional measures of the Permittee where the HCP is being properly implemented only if such measures are limited to modifications of the conservation program for the affected species and maintain the original terms of the HCP to the maximum extent possible. Additional conservation and mitigation measures will not involve the commitment of additional land, water or financial compensation or additional restrictions on the use of land, water or other natural resources otherwise available for development or use under the original terms of the HCP without the consent of Kawailoa Wind Power.

8.8 Notice of Unforeseen Circumstances

The USFWS and DLNR will have the burden of demonstrating that unforeseen circumstances exist, using best available scientific and commercial data. The USFWS and DLNR will notify Kawailoa Wind Power in writing should the USFWS or DLNR believe that any unforeseen circumstance has arisen.

8.9 Permit Duration

The HCP for Kawailoa Wind Power is written in anticipation of the issuance of an ITP and ITL to cover the entire project duration of 20 years.

8.10 Amendment Procedure

Different procedures are present that allow for the amendment to the ITL/ITP. However, the cumulative effect of any amendments must not jeopardize any listed species. USFWS and DLNR must be consulted on all proposed amendments and the amendment procedures are listed below.

8.10.1 Minor Amendments

Informal, minor amendments are permissible without a formal amendment process provided that the change(s) necessitating such amendment(s) does not cause a net adverse effect on any of the four Covered Species that is significantly different from the effects considered in the original HCP. Such informal amendments could include, but are not necessarily limited to, routine administrative revisions, changes to surveying or monitoring protocols that do not decrease the level of mitigation or increase take. A request for a minor amendment to the HCP may be made with written notice to USFWS and DLNR. A public review process may be required for the minor amendment. The amendment will be implemented upon receiving concurrence from the agencies.

8.10.2 Major Amendments

Major amendments are required when the Applicant wishes to significantly modify the project, activity or conservation program already in place. Major amendments are required if the change(s) necessitating such amendment(s) could produce a net adverse effect on any of the Covered Species that is significantly different than any of those considered in the original HCP. For example, a major amendment would be required if the documented level of take exceeds that covered by the HCP's adaptive management program. A major amendment also would be required if another listed species is found to occur in the project area and could be adversely affected by project activities.

A major amendment requires submittal to the USFWS and DLNR of a written application and implementation of all permit processing procedures applicable to an original incidental take permit. The need for a major amendment must be determined at least one year before permit expiration, as a major amendment may require additional surveys and data collection, additional or modified minimization and/or mitigation measures, and/or additional or modified monitoring protocols; a supplemental NEPA evaluation; and additional public review.

8.11 Renewal and Extension

This HCP proposed by Kawailoa Wind Power LLC may be renewed or extended, and amended if necessary, beyond its initial 20-year term with the approval of USFWS and DLNR. Upon expiration, and to the extent permitted by law, the incidental take permits may be renewed without the issuance of a new permit, provided that the permit is renewable, and that biological circumstances and other pertinent factors affecting the Covered Species are not significantly different than those described in the original HCP. To renew the permit, Kawailoa must submit to the USFWS and DLNR, in writing:

- A request to renew the permits;
- Reference to the original permit numbers;
- Certification that all statements and information provided in the original HCP and permit application, together with any approved HCP amendments, are still true and correct, or inclusion of a list of changes;
- A description of what take has occurred under the existing permit; and
- A description of what activities under the original permit the renewal is intended to cover.

If the USFWS and/or DLNR concur with the information provided in the request, they shall renew the permit consistent with their respective permit renewal procedures. If Kawailoa files a renewal request and the request is on file with the USFWS and DLNR at least 180 days prior to the permits' expiration, the permits shall remain valid while the renewal is being processed, provided the existing permit is renewable. Under Federal law, the HCP shall remain valid and in effect while the renewal or extension is being processed, but under State of Hawaiʻi law, the HCP will remain valid and in effect during processing only if the renewal or extension is processed during the original permit term. The permit may not be renewed for levels of take beyond those authorized by the original permit. Kawailoa must have complied with all annual reporting requirements to qualify for a permit renewal.

8.12 Suspension/Revocation

The USFWS or DLNR may suspend or revoke their respective permits if Kawailoa fails to implement the HCP in accordance with the terms and conditions of the permits or if suspension or revocation is otherwise required by law. Suspension or revocation of the permits shall be done in accordance with applicable Federal or State law.

8.13 Other Measures

Issuance criteria under ESA section 10(a)(2)(B) authorize USFWS to obtain such other assurances as may be required that the HCP will be implemented. An Implementing Agreement that specifies the obligations of Kawailoa Wind Power LLC, USFWS, and DLNR with respect to this HCP and stipulates the HCP's terms and conditions in contractual form, which will be signed by all parties (Kawailoa Wind Power LLC, USFWS, and DLNR).

8.14 Permit Transfer

In the event of sale or transfer of ownership of Kawailoa or any of its facilities during the term of the permits, a new permit application, permit fee, and an Assumption Agreement will be submitted to the USFWS and DLNR by the new owner(s). The new owner(s) will commit to all requirements regarding the take authorization and mitigation obligations of this HCP unless otherwise specified in the Assumption Agreement and agreed to in advance by the USFWS and DLNR.

9.0 CONCLUSION

Kawailoa Wind Power looks forward to working with the USFWS, DLNR and the ESRC throughout the approval and long-term implementation of the HCP for the Kawailoa Wind Power project. While the operation of the Kawailoa Wind Power project will aid the State of Hawai‘i in meeting its renewable energy mandate, commercial wind energy generation facilities are not without potential for adverse and unavoidable environmental impacts. Kawailoa Wind Power is committed to making all reasonable efforts to avoid, minimize, mitigate and compensate for these impacts as evaluated and determined through the HCP process and its adaptive management strategy to provide a net benefit to the species.

10.0 LITERATURE CITED

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, edited by A. Poole and F. Gill. 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 Kaua'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). 2006. Suggested Practices for Avian Protection on Power Lines: State of the Art in 2006. Edison Electric Institute, APLIC, and the California Energy Commission. Washington, D.C. and Sacramento, CA.

Arnett, E., W. Erickson, J. Kerns, and J. Horn. 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.

Arnett, E.B., J.P. Hayes, M.M.P. Huso, et al. 2010. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. Austin, TX: Bat Conservation International. www.batsandwind.org/pdf/Curtailment Final Report 5-15-10 v2.pdf

AWS Truewind. 2004. Wind Speed of O'ahu at 50 Meters. Available at: http://www.heco.com/vcmcontent/StaticFiles/pdf/HonoluluCounty_Oahu_SPD50m_19July04.pdf

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.

Baerwald E.F., and R.M.R Barclay. 2009. Geographic variation in activity and fatality of migratory bats at wind energy facilities. *Journal of Mammalogy* 90:1341–1349

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, edited by A. Poole and F. Gill. The Birds of North America, Inc., Philadelphia, PA.

Barclay, R.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.

Bell, M., B.D. Bell, and E.A. Bell. 2005. Translocation of fluttering shearwater (*Puffinus gavia*) chicks to create a new colony. *Notornis* 52, 11-15.

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*. Honolulu: University of Hawai‘i Press.

Bonaccorso, F.J. 2011. Ope‘ape‘a – solving the puzzles of Hawaii's only bat. *Bats* 28(4):10-12.

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.

Bradley, P.V., M.J. O'Farrell, J.A. Williams, J.E. Newmark (eds.). 2005. The revised Nevada Bat Conservation Plan. Nevada Bat Working Group, Reno, NV. 209 pp.

Brisbin, Jr., I.L., and T.B. Mowbray. 2002. American Coot (*Fulica americana*). In *The Birds of North America Online*, edited by A. Poole. 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, edited by A. Poole and F. Gill. Philadelphia, PA.

Brooks, R.T. and W.M. Ford 2005. Bat Activity in a forest landscape of central Massachusettes. *Northeastern Naturalist* 12(4): 447-462.

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. *The 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. *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.

CH2M Hill. 2010. Environmental Impact Statement Preparation Notice, Kawailoa Wind Farm Project, Oahu, Hawaii. Prepared for First Wind LLC. Submitted to DBEDT.

———. 2011a. Draft Environmental Impact Statement Preparation Notice, Kawailoa Wind Farm Project, Oahu, Hawaii. Prepared for First Wind LLC. Submitted to DBEDT.

———. 2011b. Final Environmental Impact Statement Preparation Notice, Kawailoa Wind Farm Project, Oahu, Hawaii. Prepared for First Wind LLC. Submitted to DBEDT.

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.

Cooper, B.A. and P.M. Sanzenbacher 2011. Radar and Visual Studies of Seabirds at the Proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, Summer 2011 . ABR, Inc. Forest Grove, OR. Prepared for First Wind LLC.

Cooper, B.A., P.M. Sanzenbacher, and R.H. Day. 2011. Radar and Visual Studies of Seabirds at the Proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii. ABR, Inc. Forest Grove, OR. Prepared for First Wind LLC.

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 R.M.R. Barclay. 2009. Causes of Bat Fatalities at Wind Turbines: Hypotheses and Predictions. *Journal of Mammalogy* 90(6):1330-1340.

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.

CWRM (Commission on Water Resource Management). 1990. Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources. Report R84. 340 pp. State of Hawai‘i and the National Park Service.

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

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.

———. 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.

———. 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 First Wind 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. *The Auk* 120:669-679.

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

Day, R.H., B.A. Cooper, T.J. Mabee, J.H. Plissner, P.M. Sanzenbacher, and A. E. Oller. In prep. Collision avoidance behavior of Hawaiian Petrels and Newell's Shearwaters in the Hawaiian Islands.

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

———. 2011. Uses of Wind Energy in Hawai'i. Available at: http://hawaii.gov/dbedt/info/energy/renewable/wind. Accessed July 7, 2011.

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

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

DesRochers, D.W., H.K.W. Gee, and J.M. Reed. 2008. Response of Hawaiian Moorhens to broadcast of conspecific calls and a comparison with other survey methods. *Journal of Field Ornithology* 79: 448-457.

DLNR (Department of Forestry and Wildlife). 1990. Mount Ka'ala Natural Area Reserve Management Plan. Natural Area Reserves System Program, State of Hawai'i.

———. 2010. DLNR Aquifers. Honolulu, Hawai'i: DBEDT Statewide GIS Program.

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.

Elliott, M.E., and E.M. Hall. 1977. Wetlands and Wetland Vegetation of Hawai'i. Prepared for The United States Army Corps of Engineers, Pacific Ocean Division, Fort Shafter.

Engilis, Jr., A., and T.K. Pratt. 1993. Status and Population Trends of Hawaii's Native Waterbirds, 1977-1987. *Wilson Bulletin* 105:142-158.

Engilis, Jr., A., K.J. Uyehara, and J.G. Giffin. 2002. Hawaiian Duck (*Anas wyvilliana*). In *The Birds of North America*, No. 694, edited by A. Poole and F. Gill. 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.

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.

Federal Register. 2001. Endangered and Threatened Wildlife and Plants; Reopening of Comment Period and Notice of Availability of the Draft Economic Analysis for Proposed Critical Habitat for the Oahu Elepaio *Federal Register* 69(135):40960- 40962.

Federal Register. 2004. Incidental Take Permit and Habitat Conservation Plan for the Kaua'i Island Utility Cooperative, Hawai'i. *Federal Register* 66(151):42447- 42449.

Fiedler, J.K. 2004. Assessment of bat mortality and activity at Buffalo Mountain windfarm, Eastern Tennessee. Master's thesis, University of Tennessee, Knoxville.

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. Available at: http://www.batcon.org/windliterature.

Fletcher, C.H. 2009. Current Understanding of Global Sea-level Rise and Impacts in Hawai'i. Presentation by the Coastal Geology Group. Available at: http://www.soest.hawaii.edu/coasts/sealevel/FletcherSeaLevel09_web.pps.

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 Lāna'i, State of Hawai'i. U.S. Department of Agriculture, Soil Conservation Service.

Francl, K.E., W.M. Ford and S.B. Castleberry 2004. Bat activity in central Appalachian wetlands. *Georgia Jounal of Science* 62:87-94

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

Gannon, W. L., M. J. O'Farrell, C. Corben, and E. J. Bedrick. 2004. Call character lexicon and analysis of field recorded bat echolocation calls. Pp. 478-484, in Echolocation in bats and dolphins (J. Thomas, C. Moss, and M. Vater, eds.). University of Chicago Press, Chicago, IL. 604 pp.

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.

Giambelluca, T., H. Diaz, and O. Timm. 2009. Climate Variability and Change in Hawai'i. In *Proceedings of the Hawai'i Conservation Conference 2009, Hawai'i in a changing climate: ecological, cultural, economic and policy challenges and solutions.* Honolulu, Hawai'i.

Griffin, C.G., G.J. Shallenberger, and S.I. Fefer. 1989. Hawaii's endangered waterbirds: A resource management challenge. Pages 1165-1175 in *Freshwater Wetlands and Wildlife* (R. R. Shar- itz, and J. W. Gibbons, Eds.). Department of Energy Symposium Series No. 61, United States Department of Energy Office Science and Technical Information, Oak Ridge, Tennessee.

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 Department of Business, Economic Development, and Tourism.

Greene, D.M., M. Engelmann, T.R. Steck. 2004. An Assessment of Cage Flights as an Exercise Method for Raptors. *Journal of Raptor Research* 38(2): 125-132

Grindal S.D., J.L. Morisette, and R.M. Brigham (1999) Concentration of bat activity in riparian habitats over an elevational gradient. Canadian Journal of Zoology 77:972-977

Gruver, J.C. 2002. Assessment of Bat Community Structure and Roosting Habitat Preferences for the Hoary Bat (*Lasiurus cinereus*) Near Foote Creek Rim, Wyoming. Master's thesis, University of Wyoming, Laramie.

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.

Hawaii Audubon Society. 2005. *Hawaii's Birds*: 6th Edition. Waipahu, Hawai'i: Island Heritage.

Hawaii Biodiversity and Mapping Program 2007. University of Hawai'i at Manoa Pacific Biosciences Research Center Center for Conservation Research & Training. Available at http://hbmp.hawaii.edu/metadataexplorer

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.

Hein, C.D., S.B. Castleberry and K.V. Miller. 2009. Site-occupancy of bats in relation to forested corridors. *Forest Ecology and Management* 257:1200-1207.

Helber Hastert & Fee Planners. 2009. North Shore Sustainable Communities Plan. Prepared for the City and County of Honolulu, Department of Planning and Permitting. Public Review Draft dated December 14, 2009.

Hobdy, R.W. 2010a. Biological Resources Survey for the Kawailoa Wind Farm, Kawailoa, Oahu, Hawaii. Prepared for CH2M Hill.

———. 2010b. Biological Resources Survey for the Kawailoa Wind Farm Project, Cane Haul Road, Collector Line Route and 0 & M Building Site, Kawailoa, Waialua, O‘ahu. Prepared for CH2M Hill.

———. 2010c. Biological Resources Survey for the Kawailoa Wind Farm Project, Mount Ka‘ala Microwave Communication Facilities, Mount Ka‘ala, Kamananui, Waialua, O‘ahu. Prepared for CH2M Hill.

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*). Master'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, and 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.

HT Harvey and Associates 2011. Newell's Shearwater Population Modeling. Prepared for First Wind, Environmental Affairs. Unpublished document.

Hunt, C.D. 1996. Geohydrology of Oahu, Hawaii. U.S. Geological Survey Professional Paper 1412-B. 54 pp.

Huso, M. 2008. Statistical properties of fatality estimators. Paper presented at NWCC Research Meeting, Milwaukee, Wisconsin.

———. 2010. An estimator of wildlife fatality from observed carcasses. Environmetrics, n/a. doi: 10.1002/env.1052.

IPCC (Intergovernmental Panel on Climate Change). 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, edited by S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller. Cambridge, United Kingdom and New York: Cambridge University Press.

Jain, A.A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. Master's 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. Available at: http://www.batcon.org/windliterature.

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, and 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.

———. 2003b. What is Known and Not Known About Bat Collision Mortality at Windplants? In *Proceedings of Workshop on Avian Interactions at Wind Turbines*, edited by R.L. Carlton. October 16-17, 2002, Jackson Hole, WY. Electric Power Research Inst., Palo Alto, CA.

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., 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.

Juvik, S.P., and J.O. Juvik. 1998. *Atlas of Hawai'i*, 3rd edition. Honolulu: University of Hawai'i Press. 333 pp.

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

———. 2008a. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan, Year 2 HCP Implementation (July, 2007–June, 2008).

———. 2008b. KWP I and KWP II Acoustic Monitoring of Bat Activity. Unpublished report.

———. 2009. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 3 Annual Report. First Wind Energy LLC, Environmental Affairs, Boston, MA.

———. 2010. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 4 Annual Report. First Wind Energy LLC, Environmental Affairs, Boston, MA.

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. In *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*, edited by E.B. Arnett, pp. 24-95. A Final Report Submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas. Available at: http://www.batcon.org/windliterature. Accessed September 1, 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.

Planning Solutions, Inc., Rana Biological Consulting, Inc. and Ebbin Moser + Skaggs LLP. 2010. Short-term Seabird Habitat Conservation Plan Kaua'i Island Utility Cooperative. Prepared for Kaua'i Island Utility Cooperative.

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. 9 pp.

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.

Kunz T.H., and L.F. Lumsden. 2003. Ecology of cavity and foliage roosting bats. In T. H. Kunz and M. B. Fenton (eds.). *Bat Ecology*, pp. 3–89. Chicago: University of Chicago Press

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, D.C.

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

MacDonald, G.A., A.T. Abbott, and F.L. Peterson. 1983. *Volcanoes in the Sea: the Geology of Hawaii*. 2nd Edition. Honolulu: University of Hawai'i Press.

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. Master's thesis, University of Hawai'i at Mānoa.

Menzel, M.A., T.C. Carter, J.M. Menzel, M.F. Ford, and B.R. Chapman. 2002. Effects of group selection silviculture in bottomland hardwoods on the spatial activity pattern of bats. *Forest Ecology and Management* 162: 209-218.

Miller, J.N., S.S. Armann, S.S.C. Chan-Hui, and J. Chiang. 1989. Ecologically sensitive wetlands on Oahu: groundwater protection strategy for Hawai'i. Environmental Center Water Resources Research Center, University of Hawai'i at Mānoa. Honolulu, Hawai'i. 369 pp.

Mineau, P. 2005. Direct Losses of Birds to Pesticides–Beginnings of a Quantification. Vol. 2. In *Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference*, edited by C.J. Ralph and T.D. Rich, pp. 1065–1070. March 20–24, 2002, Asilomar, California. USDA Forest Service GeneralTechnical Report PSW-GTR-191.

Miskelly, C.M., and G.A. Taylor. 2004. Establishment of a colony of Common Diving Petrels (*Pelecanoides urinatrix*) by chick transfers and acoustic attraction. Emu 104, 205-211.

Miskelly, C.M., G.A. Taylor, H. Gummer, R. Williams. 2009. Translocations of eight species of burrow-nesting seabirds (genera *Pterodroma*, *Pelecanoides*, *Pachyptila* and *Puffinus*: Family Procellariidae). *Biological Conservation* 142, 1965-1980.

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.

Moore, J.G. 1964. Giant Submarine Landsides on the Hawaiian Ridge. U.S. Geological Survey Professional Paper 501-D: 95-98.

Morris, A.D. 2008. Use of Forest Edges by Bats in a Managed Pine Forest Landscape in Coastal North Carolina. MS Thesis, University of North Carolina. 43 pp.

Mostello, C.S. 1996. Diets of the Pueo, Barn Owl, the Cat, and the Mongoose in Hawai'i: Evidence for Competition. Master's thesis, University of Hawaii at Mānoa.

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. Master's thesis, Colorado State University, Fort Collins.

National Wind Coordination Collaborative (NWCC). 2004. Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions. Fact Sheet: 2nd Edition. 7 pp.

NatureServe. 2008. NatureServe Explorer: An Online Encyclopedia of Life. Version 7.0. NatureServe, Arlington, Virginia. Available at: http://www.natureserve.org/explorer. Accessed December 24, 2008.

NESH Working Group 2005. DRAFT Newell's Shearwater Five-year Workplan. Available at: http://state.hi.us/dlnr/DLNR/fbrp/docs/NESH_5yrPlan_Sept2005.pdf.

Nicholson, C.P., R.D. Tankersley Jr., J.K. Fielder, and N.S. Nicholson. 2005. Assessment and prediction of bird and bat mortality at wind energy facilities in the Southeastern United States: Final Report, 2005. Prepared for Tennessee Valley Authority.

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.

NRCS (Natural Resources Conservation Service). 2010. National Hydric Soils List by State (February 2010). Available at: http://soils.usda.gov/use/hydric/lists/state.html. Accessed December 12, 2010.

Numata, M. 1996. Effects of philopatry on the outcome of translocating endangered seabirds. Unpublished report for Postgraduate Diploma in Wildlife Management, University of Otago, Dunedin, New Zealand. 42 pp.

O'Farrell, M.J., C. Corben, and W.L. Gannon. 2000. Geographic variation in the echolocation calls of the hoary bat (*Lasiurus cinereus*). *Acta Chiropterologica*, 2:185-196.

O'Farrell, M.J., J.A. Williams, and B. Lund. 2004. The western yellow bat (*Lasiurus xanthinus*) in southern Nevada. *The Southwestern Naturalist* 49:514-518.

O'Farrell, M.J. 2006a. Final Report, Bat survey at selected water sources and three stationary monitoring sites within the Humboldt-Toiyabe National Forest in the Spring Mountains, Clark County, Nevada. Prepared for USDA Forest Service, Humboldt-Toiyabe SMNRA, Las Vegas, NV.

———. 2006b. Final Report, Long-term acoustic monitoring of bat populations associated with an extensive riparian restoration program in Las Vegas Wash, Clark County, Nevada. Prepared for the Southern Nevada Water Authority.

———. 2007. Final Report 2007, Baseline Acoustic Monitoring of Bat Populations within the Milford Wind Corridor Project Site, Millard and Beaver Counties, Utah. Prepared for CH2M Hill.

———. 2009. Fall 2008 Baseline Report, Acoustic Monitoring of Bat Populations within the Golden West Wind Farm Project Site, El Paso County, Colorado. Prepared for the Walsh Environmental Scientists and Engineers, LLC.

Oki, D.S. 1998. Geohydrology of the Central Oahu, Hawaii, ground-water flow system and numerical simulation of the effects of additional pumpage: U.S. Geological Survey Water-Resources Investigations Report 97-4276.

Oki, D.S., S.B. Gingerich, and R.L. Whitehead. 1999. Hawaii. In *Ground Water Atlas of the United States*, Segment 13, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands: U.S. Geological Survey Hydrologic Investigations Atlas 730-N, p. N12–N22, N36.

Percival, S.W. 2003. Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment. 25 pp.

Planning Solutions, Inc. 2010. Revised Final Environmental Impact Statement Kaheawa Wind Power II Wind Energy Generation Facility, Ukumehame, Maui, Hawaii. April 2010.

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 Kauaʽi. *Colonial Waterbirds* 21:20–34.

Polhemus, D.A. 2007. Biology Recapitulates Geology: the Distribution of Megalagrion Damselflies on the Ko'olau Volcano of O'ahu, Hawai'i. In *Bishop Museum Bulletin in Cultural and Environmental Studies* 3, edited by N.L. Evenhuis and J.M. Fitzsimons, pp. 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, Oʽahu. *ʽElepaio* 65(3):17-21

Pratt, T.K. 1988. Recent observations, March-May 1988. *ʽElepaio* 48:65–66.

Pratt, H.D., P.L. Bruner, and D.G. Berrett. 1987. *The Birds of Hawaii and the Tropical Pacific*. Princeton, NJ: Princeton University Press.

Priddel, D. pers comm., Principal research Scientist, Office of Environment and Heritage, New Zealand.

Priddel, D., N. Carlile, and R. Wheeler. 2006. Establishment of a new breeding colony of Gould's petrel (Pterodroma leucoptera leucoptera) through the creation of artificial nesting habitat and the translocation of nestlings. Biological Conservation 128, 553-563.

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.

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, edited by A. Poole and F. Gill. The Birds of North America, Inc., Philadelphia, PA.

Rocky Mountain Institute. 2008. Policy Recommendations for Hawai‘i’s Energy Future. Prepared for the State of Hawai‘i Department of Business, Economic Development and Tourism.

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.

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., and C.N. Hodges. 1998. Dark-rumped Petrel (*Pterodroma phaeopygia*). In *The Birds of North America*, No. 345, edited by A. Poole and F. Gill. 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.

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.

Stantec Consulting, Ltd. 2007. Environmental Review Report for Wolfe Island Wind Project. Kingston, Ontario.

State of Hawaii and USDOE (U.S. Department of Energy). 2008. Memorandum of Understanding Between the State of Hawaii and the U.S. Department of Energy. Available at: Available at: http://hawaii.gov/dbedt/info/energy/hcei/hawaii_mou.pdf. Accessed November 3, 2008.

SWCA (Environmental Consultants). 2008. Baseline Biological Survey of the Anahulu River and ‘Opae‘ula Stream, O‘ahu, Hawai‘i. Prepared for The Kamehameha Schools Land Assets Division, Endowment Group.

———. 2010a. Kawailoa Wind Power Wildlife Monitoring Report and Fatality Estimates for Waterbirds and Bats (October 2009 – April 2011). Prepared for First Wind LLC.

———. 2010b. Kawailoa Wind Power Jurisdictional Wetland Boundary Determination. Prepared for First Wind LLC.

———. 2010c. Mollusc Survey for the Kawailoa Wind Power Microwave Tower Facilities, Mount Ka‘ala, O‘ahu, Hawai‘i. Prepared for First Wind LLC.

———. 2010d. Kahuku Wind Power Habitat Conservation Plan. Prepared for Kahuku Wind Power LLC for DOFAW. Approved May 27, 2010.

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.

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 pp.

———. 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 pp.

Telfair, II, R.C. 1994. Cattle Egret (*Bulbulcus ibis*). In *The Birds of North America*, No. 113, edited by A. Poole and F. Gill. 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. State of Hawaiʽi Department of Lands and Natural Resources, 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 2011. Draft Auwahi Wind Farm Project Habitat Conservation Plan. Prepared for Auwahi Wind Energy, LLC.

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.

U.S. Army Environmental Command. 2008. Final Environmental Impact Statement, Permanent Stationing of the 2/25th Stryker Brigade Combat Team, Volume 1. Prepared for Headquarter, Department of Army, Washington, DC. Available at: http://the.honoluluadvertiser.com/dailypix/2008/Feb/22/Stryker%20EIS.pdf.

U.S. Climate Change Science Program 2009. Climate and Coasts. In *Proceedings of the Hawaiʽi Conservation Conference 2009, Hawaiʽi in a changing climate: ecological, cultural, economic and policy challenges and solutions.* Honolulu, Hawaiʽi.

U.S. Department of Wind Energy. 2008. 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply. Available at: http://www.20percentwind.org/Final_DOE_Executive_Summary.pdf. Accessed September 5, 2008.

USFWS (United States Fish & Wildlife Service). 1983. Hawaiian Dark-Rumped Petrel and Newell’s Manx Shearwater Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. 57 pp.

———.1992. Recovery Plan for the O’ahu Tree Snails of the Genus *Achatinella*. U.S. Fish and Wildlife Service, Portland, OR.

———. 1998. Recovery Plan for the Hawaiian Hoary Bat *(Lasiurus cinereus semotus*). U.S. Fish and Wildlife Service, Portland, OR.

———. 2002. Oʽahu National Wildlife Refuge Complex. Annual Narrative Report Calendar Year 2002. Honolulu, HI.

———. 2005a. Draft Revised Recovery Plan for Hawaiian Waterbirds, Second Draft of Second Revision. U.S. Fish and Wildlife Service, Portland, OR.

———. 2005b. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, OR.

USFWS and NMFS (National Marine Fisheries Service). 1996. *Habitat Conservation Planning and Incidental Take Permit Processing Handbook*.

USFWS and NOAA (National Oceanic and Atmospheric Administration). 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.

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, and B.D. Dugger. 2008. Wetland Features That Influence Occupancy by the Endangered Hawaiian Duck. *The Wilson Journal of Ornithology* 120(2):311–319.

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.

Western Regional Climate Center. 2005a. Hawaii: Annual Precipitation Summary. Desert Research Institute – Reno, Nevada. Available at http://www.wrcc.dri.edu/COMPARATIVE.html. Accessed May 7, 2010.

———. 2005b. Hawaii: Annual Temperature Summary. Desert Research Institute – Reno, Nevada. Available at: http://www.wrcc.dri.edu/COMPARATIVE.html. Accessed May 7, 2010.

Whitaker, J.O., and P.Q. Tomich. 1983. Food Habits of the Hoary Bat *Lasiurus cinereus* from Hawaii. *Journal of Mammalogy* 64:151-52.

Wiggins, D.A., D.W. Holt, and S.M. Leasure. 2006. Short-eared Owl (*Asio flammeus*). In *The Birds of North America* Online, edited by A. Poole. Ithaca: Cornell Lab of Ornithology. Available at: http://bna.birds.cornell.edu.eres.library.manoa.hawaii.edu/bna/species/062doi:10.2173/bna.62

Williams, J.A., M.J. O'Farrell, and B.R. Riddle. 2006. Habitat use by bats in a riparian corridor of the Mojave Desert in southern Nevada. *Journal of Mammalogy*, 87:1145-1153.

Wind Turbine Guidelines Advisory Committee. 2010. Wind Turbine Guidelines Advisory Committee Recommendations. Available at: http://www.fws.gov/habitatconservation/windpower/Wind_Turbine_Guidelines_Advisory_Committee_Recommendations_Secretary.pdf. Accessed June 21, 2010.

Winter, L. 2003. Popoki and Hawai'i's native birds. *'Elepaio* 63:43-46.

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.

Wright, S. E. 2008. Some significant wildlife strikes to civil aircraft in the United States, January 1990–June 2008. FAA Wildlife Strike Database, U.S. Department of Agriculture, Wildlife Services, Sandusky, Ohio, USA.

Appendix 1a

BIOLOGICAL RESOURCES SURVEY

for the

KAWAILOA WIND FARM

KAWAILOA, OAHU HAWAII

by

Robert W. Hobdy
Environmental Consultant
Kokomo, Maui
February 2010

Prepared for: CH2M HILL

TABLE OF CONTENTS

	page
Introduction ……………………………………………….	3
Site Description ……………………………………………	3
Biological History …………………………………………	3
Survey Objectives ………………………………………..	4
Botanical Survey Report …………………………………..	4
Survey Methods ……………………………………………	4
Description of the Vegetation ……………………………..	4
Discussion and Recommendations ………………………..	5
Plant Species List ………………………………………….	6
Fauna Survey Report ………………………………………	17
Survey Methods ……………………………………………	17
Results …………………………………………………...	17
Mammals …………………………………………………..	17
Birds ………………………………………………………	18
Insects ……………………………………………………..	19
Discussion and Recommendations ……………………….	20
Animal Species List ………………………………………	21
Figure 1 - Bat Survey Locations ………………………….	23
Literature Cited …………………………………………..	24

BIOLOGICAL RESOURCES SURVEY
KAWAILOA WINDFARM

INTRODUCTION

The proposed Kawailoa Wind Farm Project site lies on approximately 4,200 acres of land east of Haleiwa Town, Kawailoa, Waialua District, O'ahu (TMKs 6-1-05:1,6-1-06:1. 6-1-07:1,6-2-09:1, 6-2-11:1). It is adjacent to Waimea Valley on the north and Kawailoa Valley on the south. Below it are agricultural fields and above it are mountainous lands in the Kawailoa Forest Reserve. This document summarizes the results of a biological study that was initiated in fulfillment of environmental requirements of the planning process for this wind farm project.

SITE DESCRIPTION

The project area is a triangular shaped piece of land formerly used for cane production that is now fallow and overgrown with grass and trees. It consists of gently sloping ridges that are dissected by several small gulches. Elevations range from 400 feet at the bottom up to 1,600 feet at the top of the triangle. Soils consist of silty clays of the Wahiawa, Helemano and Leilehua Series on the ridge tops. The soils in the gulches are of the Rough Mountainous Lands and Rock Lands Series (Foote et al, 1972). Rainfall ranges from 40 inches per year at the lower elevations to 75 inches per year at the top (Armstrong, 1983).

BIOLOGICAL HISTORY

In pre-contact times these slopes would have been forested with native 'öhi'a (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees with a dense understory of smaller native trees, shrubs, ferns and vines in great diversity and profusion. Gulches would have had an even denser growth of delicate shade-loving species.

In the late 1800s the area was cleared and converted to sugar cane agriculture. The fields were plowed, burned, harvested and planted in continuous cycles for about 100 years. Some of the broader gulches were used to pasture plantation horses and mules. These uses greatly reduced the numbers and overall diversity of native plants, and these were gradually replaced by increasing numbers of non-native agricultural and pasture plants. A number of tree species were planted along the edges of fields to serve as windbreaks. Other species deemed to be useful or ornamental were also planted in gulches and along ditches. Many of these have proliferated and some have become invasive. Feral pigs have spread throughout the area and have had a negative impact on native vegetation. They also are an important vector for the spread of weed species throughout the forests.

Today, little remains of native plant diversity in the project area. A few native species persist on steep gulch slopes in the upper parts of the property, but most of the area is covered with a few invasive non-native species.

SURVEY OBJECTIVES

This report summarizes the findings of a flora and fauna survey of the proposed Kawailoa Wind Farm Project which was conducted during February, 2010.
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 and its diverse habitats. Areas most likely to harbor native plants such as gulches, steep slopes and 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 the project site is a mixture of aggressive weedy species that have taken over since the abandonment of sugar cane agriculture, but there are significant remnants of native vegetation on steep slopes of the gulches near the top of the site. One non-native species that is truly abundant across the property, Guinea grass (*Panicum maximum*), which forms a sea of deep growth on all the ridge tops and in many of the gulches. Also common and non-native are common ironwood (*Casuarina equisetifolia*), albizia (*Falcataria moluccana*), Formosa koa (*Acacia confusa*), koa haole (*Leucaena leucocephala*), padang cassia (*Cinnamomum burmanni*), Java plum (*Syzygium cumini*), strawberry guava (*Psidium cattleianum*), cork bark passion flower (*Passiflora suberosa*) and swamp mahogany (*Eucalyptus robusta*). All of these species have spread dramatically since the abandonment of sugar cane agriculture.

A total of 183 plant species were recorded during the course of the survey. Of this total, 27 were common native species: kilau (*Pteridium aquilinum* var. *decompositum*), hapu'u (*Cibotium chamissoi*), uluhe (*Dicranopteris linearis*), pala'ā (*Sphenomeris chinensis*), ni'ani'au (*Nephrolepis exaltata*), pakahakaha (*Lepisorus thunbergianus*), moa (*Psilotum nudum*) halapepe (*Pleomele halapepe*), (*Carex meyenii*) no common name, (*Carex wahuensis*) no common name, (*Cyperus polystachyos*) no common name, 'ie'ie (*Freycinetia arborea*), lama (*Diospyros sandwicensis*), pukiawe (*Leptecophylla tameiameiae*), koa (*Acacia koa*), nanea (*Vigna marina*), naupaka kuahiwi (*Scaevola gaudichaudiana*), kauna'oa pehu (*Cassytha filiformis*), 'uhaloa (*Waltheria indica*), huehue (*Cocculus orbiculatus*), 'öhi'a (*Metrosideros polymorpha* var. *polymorpha*), olopua (*Nestegis sandwicensis*), kopiko (*Psychotria mariniana*), alahe'e (*Psydrax odorata*), 'iliahi (*Santalum freycinetianum* var. *freycinetianum*), 'a'ali'i (*Dodonaea viscosa*), 'akia (*Wikstroemia oahuensis)*. None of these are rare species and all but one are known from multiple islands. This one species of halapepe is known only from Oahu but is not uncommon here. Seven species were of Polynesian origin: niu (*Cocos nucifera*), kö (*Saccharum officinarum*), ki (*Cordyline fruticosa*), pa'ihi (*Rorippa sarmentosa*), kukui (*Aleurites moluccana*), 'ihi (*Oxalis corniculata*) and noni (*Morinda citrifolia*). The remaining 149 species were non-native plants that were agricultural weeds, windbreak tree species, forestry plantings or ornamentals.

DISCUSSION AND RECOMMENDATIONS

The vegetation on this large site is dominated by invasive non-native species. Guinea grass, albizia and koa haole occupy the ridge tops. Common ironwood, Formosa koa, Java plum, cork-bark passion flower and swamp mahogany dominate the lower gulches along with many other weeds. Padang cassia and strawberry guava form extremely dense stands in the upper, wetter gulches to the near exclusion of anything else. A fair number of common native trees, shrubs, vines and ferns still occupy the steep slopes of the upper gulches in a few spots.

No federally-listed Endangered or Threatened plant species (USFWS, 2009) were found on the property, nor were any found that are proposed for such status. No special plant habitats or communities were identified.

Due to the lack of any protected species or habitats, there is little of botanical concern with regard to this property and the proposed project which is likely to affect only small areas on ridge tops is not expected to have a measurable negative impact on the botanical resources in this part of O'ahu.

If, however, there is any revegetation planned along road cuts or on the margins of tower pads, it is recommended that some of the native species listed above be selected for propagation and out planting.

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: Conifers, Ferns, Monocots and Dicots. Taxonomy and nomenclature of the conifers and 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.

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			
BLECHNACEAE (Chain Fern Family)			
Blechnum appendiculatum Willd.	palm fern	non-native	rare
DENNSTAEDTIACEAE (Bracken Fern Family)			
Pteridium aquilinum (L.) Kuhn *var. decompositum* (Gaud.) R.M.Tryon	kilau, bracken fern	endemic	rare
DICKSONIACEAE (Dicksonia Family)			
Cibotium chamissoi Kaulf.	hapu'u	endemic	rare
GLEICHENIACEAE (False Staghorn Fern Family)			
Dicranopteris linearis (Burm.f.) Underw.	uluhe	indigenous	uncommon
LINDSAEACEAE (Lindsaea Fern Family)			
Sphenomeris chinensis (L.) Maxon	pala'a	indigenous	rare
NEPHROLEPIDACEAE (Sword Fern Family)			
Nephrolepis brownii (Desv.) Hovencamp & Miyam.	Asian sword fern	non-native	uncommon
Nephrolepis exaltata (L.) Schott	ni'ani'au	indigenous	rare
POLYPODIACEAE (Polypody Fern Family)			
Lepisorus thunbergianus (Kaulf.) Ching	pākahakaha	indigenous	rare
Phlebodium aureum (L.) J. Sm.	rabbit's foot fern	non-native	rare
Phymatosorus grossus (Langsdon&Fisch.) Brownlie	laua'e	non-native	rare
PSILOTACEAE (Whisk Fern Family)			
Psilotum nudum (L.) P. Beauv.	moa	indigenous	rare
PTERIDACEAE (Brake Fern Family)			
Pityrogramma calomelanos (L.) Link	silver fern	non-native	rare
THELYPTERIDACEAE (Marsh Fern Family)			
Christella dentata (Forssk.) Brownsey & Jermy	------------	non-native	rare
Christella parasitica (L.) H. Lev.	------------	non-native	uncommon
CONIFERS			
ARAUCARIACEAE (Araucaria Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Agathis robusta (F.Mueller) F.M. Bailey	Queensland kauri	non-native	rare
Araucaria columnaris (G. Forster) J.D. Hooker	Cook pine	non-native	rare
MONOCOTS			
AMARYLLIDACEAE (Amaryllis Family)			
Hippeastrum striatum (Lam.) H.E. Moore	amaryllis	non-native	rare
ARECACEAE (Palm Family)			
Cocos nucifera L.	niu	Polynesian	rare
Phoenix x dactylifera	phoenix hybrid	non-native	rare
ASPARAGACEAE (Asparagus Family)			
Cordyline fruticosa (L.) A. Chev.	kī, ti leaf	Polynesian	uncommon
Pleomele halapepe St. John	halapepe	endemic	rare
Sanseviera trifasciata Prain	sanseviera	non-native	rare
COMMELINACEAE (Spiderwort Family)			
Commelina diffusa N.L. Burm.	honohono	non-native	rare
CYPERACEAE (Sedge Family)			
Carex meyenii Nees	--------------------	indigenous	rare
Carex wahuensis C.A. Meyen	--------------------	endemic	rare
Cyperus difformis L.	--------------------	non-native	rare
Cyperus polystachyos Rottb.	--------------------	indigenous	rare
Cyperus rotundus L.	nut sedge	non-native	rare
Kyllingia brevifolia Rottb.	kili'o'opu	non-native	rare
ORCHIDACEAE (Orchid Family)			
Phaius tankarvilleae (Banks ex L'Her) Blume	nun's orchid	non-native	rare
Spathoglottis plicata Blume	Phillipine ground orchid	non-native	rare
PANDANACEAE (Screwpine Family)			
Freycinetia arborea Gaud.	'ie'ie	indigenous	rare
POACEAE (Grass Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Andropogon virginicus L.	broomsedge	non-native	uncommon
Axonopus compressus (S.W.) P. Beauv.	broad-leaved carpetgrass	non-native	rare
Axonopus fissifolius (Raddi) Kuhlm.	narrow-leaved carpetgrass	non-native	rare
Chloris barbata (L.) Sw.	swollen fingergrass	non-native	rare
Chloris radiata (L.) Sw.	plush grass	non-native	rare
Cynodon dactylon (L.) Pers.	Bermuda grass	non-native	rare
Eleusine indica (L.) Gaertn.	wiregrass	non-native	rare
Hyparrhenia rufa (Nees) Stapf	thatching grass	non-native	uncommon
Melinis minutiflora P. Beauv.	molasses grass	non-native	uncommon
Oplismenus hirtellus (L.) P.Beauv.	basketgrass	non-native	rare
Panicum maximum Jacq.	Guinea grass	non-native	abundant
Panicum sp.	-------------------	non-native	rare
Paspalum conjugatum Bergius	Hilo grass	non-native	uncommon
Paspalum dilatatum Poir.	Dallis grass	non-native	rare
Paspalum fimbriatum Kunth	Panama grass	non-native	rare
Paspalum scrobiculatum L.	ricegrass	non-native	rare
Paspalum urvillei Steud.	Vasey grass	non-native	rare
Pennisetum polystachion (L.) Schult.	feathery pennisetum	non-native	rare
Pennisetum purpureum Schumach.	Napier grass	non-native	uncommon
Saccharum officinarum L.	sugar cane	Polynesian	rare
Sacciolepis indica (L.) chase	Glenwood grass	non-native	rare
Setaria palmifolia (J. Konig) Stapf	palmgrass	non-native	rare
Setaria parviflora (Poir.) Kerguelen	yellow foxtail	non-native	rare
Sporobolus africanus (Poir.) Robyns & Tournay	smutgrass	non-native	uncommon
Urochloa mutica (Forssk.) T.Q. Nguyen	California grass	non-native	uncommon
ZINGIBERACEAE (Ginger Family)			
Alpinia zerumbet (Pers.) B.L. Burtt & R.M. Smith	shell ginger	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
DICOTS			
ACANTHACEAE (Acanthus Family)			
Asystasia gangetica (L.) T.Anderson	Chinese violet	non-native	rare
Justicia betonica L.	white shrimp plant	non-native	rare
AMARANTHACEAE (Amaranth Family)			
Amaranthus viridis L.	slender amaranth	non-native	rare
ANACARDIACEAE (Mango Family)			
Mangifera indica L.	mango	non-native	rare
Schinus terebinthifolius Raddi	Christmas berry	non-native	uncommon
APIACEAE (Parsley Family)			
Centella asiatica (L.) Urb.	Asiatic pennywort	non-native	rare
Ciclospermum leptophyllum (Pers.) Sprague	fir-leaved celery	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	rare
Ageratum conyzoides L.	maile hohono	non-native	uncommon
Bidens alba (L.) DC	Spanish needle	non-native	uncommon
Conyza bonariensis (L.) Cronq.	hairy horseweed	non-native	uncommon
Crassocephalum crepidioides (Benth.)S.Moore	redflower ragleaf	non-native	rare
Eclipta prostrata (L.) L.	false daisy	non-native	rare
Emilia fosbergii Nicolson	red pualele	non-native	rare
Emilia sonchifolia (L.) DC.	violet pualele	non-native	uncommon
Gamochaeta purpurea (L.) Cabrera	purple cudweed	non-native	rare
Pluchea carolinensis (Jacq.) G.Don	sourbush	non-native	uncommon
Sonchus oleraceus L.	pualele	non-native	rare
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P.Beauv.	African tulip tree	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
BRASSICACEAE (Mustard Family)			
Rorippa sarmentosa (J. Forst. ex DC.) J.F. Macbr	pa'ihi	Polynesian	rare
CARICACEAE (Papaya Family)			
Carica papaya L.	papaya	non-native	rare
CASUARINACEAE (She-oak Family)			
Casuarina equisetifolia L.	common ironwood	non-native	common
CLUSICACEAE (Mangosteen Family)			
Clusia rosea Jacq.	autograph tree	non-native	rare
CONVOLVULACEAE (Morning Glory Family)			
Ipomoea obscura (L.) Ker-Gawl.	-------------------	non-native	rare
Ipomoea triloba L.	little bell	non-native	rare
Merremia tuberosa (L.) Rendle	wood rose	non-native	rare
CUCURBITACEAE (Gourd Family)			
Coccinia grandis (L.) Voigt	ivy gourd	non-native	rare
Lagenaria siceraria (Molina) Standley	long squash	non-native	rare
Momordica charantia L.	balsam pear	non-native	rare
EBENACEAE (Ebony Family)			
Diospyros sandwicensis (A.DC.) Fosb.	lama	endemic	rare
ERICACEAE (Heath Family)			
Leptecophylla tameiameiae (Cham.&Schlect.) C.M. Weiller	pukiawe	indigenous	rare
EUPHORBIACEAE (Spurge Family)			
Aleurites moluccana (L.) Willd.	kukui	Polynesian	uncommon
Chamaesyce hirta (L.) Millsp.	hairy spurge	non-native	rare
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	non-native	rare
Codiaeum variegatum (L.) Blume	croton	non-native	rare
Phyllanthus debilis Klein ex Willd.	niruri	non-native	rare
FABACEAE (Pea Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Acacia confusa Merr.	Formosa koa	non-native	common
Acacia koa A. Gray	koa	endemic	uncommon
Arachis glabrata Bentham	rhizoma peanut	non-native	rare
Bauhinia variegata L.	orchid tree	non-native	rare
Calliandra surinamensis Benthan	powderpuff	non-native	rare
Canavalia cathartica Thouars	maunaloa	non-native	rare
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
Desmanthus pernambucanus (L.) Thellung	slender mimosa	non-native	rare
Desmodium incanum DC.	Spanish clover	non-native	rare
Desmodium sandwicense	Spanish clover	non-native	rare
Desmodium triflorum (L.) DC.	three-flowered beggarweed	non-native	rare
Falcataria moluccana (Miq.) Barneby & Grimes	albizia	non-native	common
Indigofera suffruticosa Mill.	inikö	non-native	rare
Leucaena leucocephala (Lam.) de Wit	koa haole	non-native	common
Macroptilium lathyroides (L.) Urb.	wild bean	non-native	rare
Medicago lupulina L.	black medic	non-native	rare
Medicago polymorpha L.	bur clover	non-native	rare
Mimosa pudica L.	sensitive plant	non-native	uncommon
Neonotonia wightii (Wight & Arnott) Lackey	glycine	non-native	uncommon
Parkia timoriana (A.P. de Candolle) Merrill	drumstick tree	non-native	rare
Peltophorum pterocarpum (A.P. de Candolle) K. Heyne	yellow poinciana	non-native	rare
Stylosanthes fruticosa (Retz.) Alston	shrubby pencilflower	non-native	rare
Vigna marina (J. Burm.) Merr.	nanea	indigenous	rare
GOODENIACEAE (Goodenia Family)			
Scaevola gaudichaudiana Cham.	naupaka kuahiwi	endemic	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
GROSSULARIACEAE (Gooseberry Family)			
Brexia madagascariensis (Lamarck) Ker Gawler	brexia	non-native	rare
LAMIACEAE (Mint Family)			
Salvia officinalis L.	garden sage	non-native	rare
LAURACEAE (Laurel Family)			
Cassytha filiformis L.	kauna'oa pehu	indigenous	rare
Cinnamomum burmanni (Nees) Blume	Padang cassia	non-native	common
Persea americana Mill.	avocado	non-native	rare
LYTHRACEAE (Loosestrife Family)			
Cuphea carthagenensis (Jacq.) Macbr.	tarweed	non-native	rare
MALVACEAE (Mallow Family)			
Malvastrum coromandelianum (L.) Garckey	false mallow	non-native	rare
Melochia umbellata (Houtt.) Stapf	hierba del soldado	non-native	rare
Sida ciliaris L.	red 'ilima	non-native	rare
Sida rhombifolia L.	Cuban jute	non-native	rare
Sida spinosa L.	prickly sida	non-native	rare
Waltheria indica L.	'uhaloa	indigenous	uncommon
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D.Don	Koster's curse	non-native	uncommon
Pterolepis glomerata (Rottb.) Miq.	false meadow beauty	non-native	rare
MELIACEAE (Mahogany Family)			
Melia azedarach L.	pride-of-India	non-native	rare
Toona ciliata M. Roem	Australian red-cedar	non-native	rare
MENISPERMACEAE (Moonseed Family)			
Cocculus orbiculatus (L.) DC.	huehue	indigenous	rare
MORACEAE (Fig Family)			
Ficus microcarpa L.	Chinese banyan	non-native	uncommon
Ficus platypoda (A.Cunn.ex Miq.)A.Cunn.ex Miq.	rock fig	non-native	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Ficus religiosa L.	Bo tree	non-native	rare
Ficus sp.	---------------	non-native	rare
MYRTACEAE (Myrtle Family)			
Corymbia citriodora (Hook.) K.D. Hill & L.A.S.Johnson	lemon gum	non-native	uncommon
Eucalyptus robusta Sm.	swamp mahogany	non-native	common
Eucalyptus rudis Endl.	desert gum	non-native	rare
Melaleuca quinquenervia (Cav.) S.T.Blake	paperbark	non-native	rare
Metrosideros polymorpha Gaud. var. *polymorpha*	'ōhi'a	endemic	uncommon
Psidium cattleianum Sabine	strawberry guava	non-native	common
Psidium guajava L.	common guava	non-native	uncommon
Syzygium cumini (L.) Skeels	Java plum	non-native	common
Syzygium jambos (L.) Alston	rose apple	non-native	rare
NYCTAGINACEAE (Four-o'clock Family)			
Bougainvillea spectabilis Willd.	bougainvillea	non-native	rare
OLEACEAE (Olive Family)			
Nestegis sandwicensis (A. Gray) Degener, I.Degener & L.Johnson	olopua	endemic	rare
ONAGRACEAE (Evening Primrose Family)			
Ludwigia octovalvis (Jacq.) Raven	primrose willow	non-native	rare
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 suberosa L.	cork-bark passion flower	non-native	common
Passiflora subpeltata Ort.	white passion flower	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.	polygala	non-native	rare
PRIMULACEAE (Primrose Family)			
Angallis arvensis L.	scarlet pimpernel	non-native	rare
PROTEACEAE (Protea Family)			
Grevillea robusta A.Cunn.ex R.Br.	silk oak	non-native	uncommon
ROSACEAE (Rose Family)			
Rubus rosifolius Sm.	thimbleberry	non-native	rare
RUBIACEAE (Coffee Family)			
Coffea arabica L.	Arabian coffee	non-native	rare
Morinda citrifolia L.	noni	Polynesian	rare
Posoqueria latifolia (Rudge) J. Roemer & J.A. Schultes	tree jasmine	non-native	rare
Psychotria mariniana (Cham.& Schlectend) Fosb.	kōpiko	endemic	rare
Psydrax odorata (G. Forst.) A.C.Smith & S.P.Darwin	alahe'e	indigenous	uncommon
Spermacoce assurgens Ruiz & Pav.	buttonweed	non-native	rare
SANTALACEAE (Sandalwood Family)			
Santalum album L.	white sandalwood	non-native	rare
Santalum freycinetianum Gaud. var. *freycinetianum*	'iliahi	endemic	rare
SAPINDACEAE (Soapberry Family)			
Dodonaea viscosa Jacq.	'a'ali'i	indigenous	rare
SAPOTACEAE (Sapodilla Family)			
Chrysophyllum mexicanus T. Brandegee	satin leaf	non-native	uncommon
SCROPHULARIACEAE (Snapdragon Family)			
Buddleia asiatica Lour.	dog tail	non-native	rare
THYMELAEACEAE ('Akia Family)			
Wikstroemia oahuensis (A. Gray) Rock	'akia	endemic	rare
URTICACEAE (Nettle Family)			
Cecropia obtusifolia Bertol.	cecropia	non-native	uncommon
VERBENACEAE (Verbena Family)			

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Citharexylum caudatum L.	fiddlewood	non-native	rare
Lantana camara L.	lantana	non-native	uncommon
Stachytarpheta australis Modenke	ōwī	non-native	rare
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain	non-native	rare
Stachytarpheta jamaicensis (L.) Vahl	ōwī	non-native	uncommon
Verbena littoralis kunth	ōwī	non-native	rare
ZYGOPHYLLACEAE (Creosote Bush Family)			
Tribulus terrestris L.	puncture vine	non-native	rare

FAUNA SURVEY REPORT

SURVEY METHODS

A walk-through survey method was conducted in conjunction with the botanical survey. All parts of the project site 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 document any evidence of occurrence of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in the area.

RESULTS

MAMMALS

Five species of mammals were observed during four full days and an evening on the site. Taxonomy and nomenclature follow Tomich (1986).

Feral pig (*Sus scrofa*) – Pigs were common throughout this site. Major trails were found in every gulch and diggings and droppings associated with this species were widespread. Many individuals and family groups were seen.

Mongoose (*Herpestes auropunctatus*) – Mongoose were seen throughout the site, scurrying across roads and trails.

Domestic dog (*Canis familiaris*) – Two lost hunting dogs were seen in the upper part of the site. Pig hunters frequent this area regularly with their dogs.

Rats (Rattus spp.) – One rat was seen running across a road at the site during the evening survey. Rats frequent this type of habitat, feeding on seeds, fruits and herbaceous vegetation.

Hawaiian hoary bat, ‘Ope’ape’a (*Lasiurus cinereus semotus*) – A survey to detect the possible presence of the Endangered Hawaiian hoary bat was conducted on the evening of Feb. 12, 2010. A Batbox IIID detecting device, set to the range they are known to utilize (27,000 to 28,000 hertz) was employed. Surveys were conducted at five locations, four at the top of the site adjacent to the forest and one in the lower southwest corner of the site close to a reservoir (see figure 1). These are locations most likely to have nocturnal flying insect activity that would attract bats if they were in the vicinity. A few faint calls were heard at the first location near the military gate along Drum Road, and a few calls were heard closer at hand at the third location at the highest part of the property. No calls were heard at the other three locations. While this survey provides only a cursory snapshot in time, it does indicate that these bats occur on the site. This finding is consistent with historical and recent bat sightings in the northern Ko’olau Range between Kahuku and Pupukea.

Dense vegetation prevented good visibility of other ground-dwelling mammals, but a significant population of mice (*Mus domesticus*) would be expected, as they are known to frequent this type of habitat. Feral cats (*Felis catus*) are also known to frequent such habitat where they hunt for rodents and birds.

BIRDS

There was moderate avian diversity observed across the breadth of the project site during four full days and one evening of surveys. Seventeen species of birds were recorded, including fifteen non-native birds, one seasonal migrant and one possibly native owl. Taxonomy and nomenclature follow American Ornithologists' Union (2005).

Zebra dove (*Geopelia striata*) – Flocks of these small doves were seen throughout the project area feeding on seeds along roads and in grassy clearings.

Common waxbill (*Estrilda astrild*) – Sizeable flocks of these tiny birds were seen throughout the area feeding on grass seeds in the deep Guinea grass.

Common myna (*Acridotheres tristis*) – Mynas, mostly in pairs, were widespread across the site. They were most often seen in flight.

Japanese bush-warbler (*Cettia diphone*) – These birds were heard calling from underbrush and trees. They are quite secretive and seldom seen.

Kölea, Pacific golden-plover (*Pluvialis fulva*) – Plovers were regularly seen along roads and in clearings where they like to establish territory. These birds are seasonal migrants that spend the fall and winter months in Hawaii and the spring and summer months breeding in the Arctic.

Spotted dove (*Streptopelia chinensis*) – Several of these large doves were seen in flight or perched in trees on the site.

Red-vented bulbul (*Pycnonotus cafer*) – These black birds were seen and their distinctive warbling calls heard throughout most of the site.

Hwamei (*Garrulax canorus*) – These secretive thrushes were heard singing in gulch undergrowth on the site, but were seldom seen.

House finch (*Carpodacus mexicanus*) – Small groups of these finches were seen in trees and shrubbery on the site and heard making their persistent high-pitched calls.

Gray francolin (*Francolinus pondicerianus*) – Several families of these light-brown francolins were seen in the margins of open areas where they feed.

White-rumped shama (*Copsychus malabaricus*) – A few of these white-rumped shama were seen and heard in trees in gulches in the lower part of the property.

Northern cardinal (*Cardinalis cardinalis*) – A few of these cardinals were seen in gulches in the upper part of the property.

Red-crested cardinal (*Paroaria coronata*) – One group of red-headed cardinals was seen in underbrush in the lower part of the site.

Japanese white-eye (*Zosterops japonicus*) – A few pairs of these birds were seen in flight and foraging for insects in trees on the site.

Red avadavat (*Amandava amandava*) – A couple of these birds were seen in a flock of waxbills feeding in the grasslands on the site.

Red-whiskered bulbul (*Pycnonotus jocosus*) – One of these birds was seen in trees in a gulch on the upper part of the site.

(unknown owl species) – Two regurgitated owl pellets of rodent hair and bones were observed on a trail on a grassy ridgetop in the upper part of the site. Owls tend to consume small rodents whole, then regurgitate the indigestible remains in these pellets. The pellets could have come from either a barn owl (*Tyto alba*) or the native pueo (*Asio flammeus sanwichensis*) which both inhabit areas similar to this portion of the site. The pueo is listed as an Endangered species on the island of O'ahu by the State of Hawaii, but is not a federally listed species. The pellets could have come from either owl species, but judging by their size (5-6 cm long x 2.5-3.0 cm wide) they are more likely to have come from the larger of the two species, the introduced barn owl.

A few other non-native bird species might occasionally utilize this property but it is not suitable habitat for Hawaii's native forest birds which occupy native forests at higher elevations beyond the range of mosquitoes and the lethal avian diseases they transmit. No native forest birds were seen even at the highest part of the property.

INSECTS

Insects in general were not tallied, but a search was made for one native sphingid moth, Blackburn's sphinx moth (*Manduca blackburni*), which is listed as an Endangered species (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 primary native host plants are species of 'aiea (*Nothocestrum spp*.) and alternative host plants are tobacco (*Nicotiana tabacum*) and tree tobacco (*Nicotiana glauca*). None of these host plant species were found on the site. No Blackburns' sphinx moth or their larvae were found.

DISCUSSION AND RECOMMENDATIONS

Most of the wildlife observed on the property is non-native and generally unremarkable from an environmental protection standpoint. Feral pigs are common throughout the project area and have had a negative impact on the native vegetation. They have rooted up and destroyed most of the delicate understory species and their ground disturbances have provided seed beds for numerous invasive weeds which now dominate. One native species, however, the Hawaiian hoary bat which was detected near the upper margins of the project site is a federally Endangered species with all of the protections that are associated with this status.

The Hawaiian hoary bat is currently known from the six largest islands, but is considered rare on the island of O'ahu where only a few recent confirmed sightings have been made in the northern Ko'olaus. That it was detected here in the Kawailoa area is thus consistent. One Kahuku resident when queried about these bats mentioned that her son had seen them during the evening on more than one occasion at the Pupukea Boy Scout Camp about 2 ½ miles north of the project area (G.Roberts, personal communication). It makes sense that they would occur in such a rural part of this highly urbanized island.

The Hawaiian hoary bat is a highly mobile creature that is known to move about in response to seasonal temperature changes and insect population spikes. They are solitary (rather than colonial) bats whose roosting sites appear to be opportunistic and ever changing. They have been recorded from almost every conceivable habitat including high and low elevations, forests, pastures, lava flows, bogs and even rural communities. They can occupy one area when flying insects are abundant and be absent when feeding opportunities have moved elsewhere. Thus no critical habitats have been established for them.

None-the-less, the presence of these Endangered flying mammals in the vicinity of proposed wind turbines is of concern and merits consideration as to how to minimize threats to their well being.

No other concerns regarding the wildlife in this project area are anticipated.

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

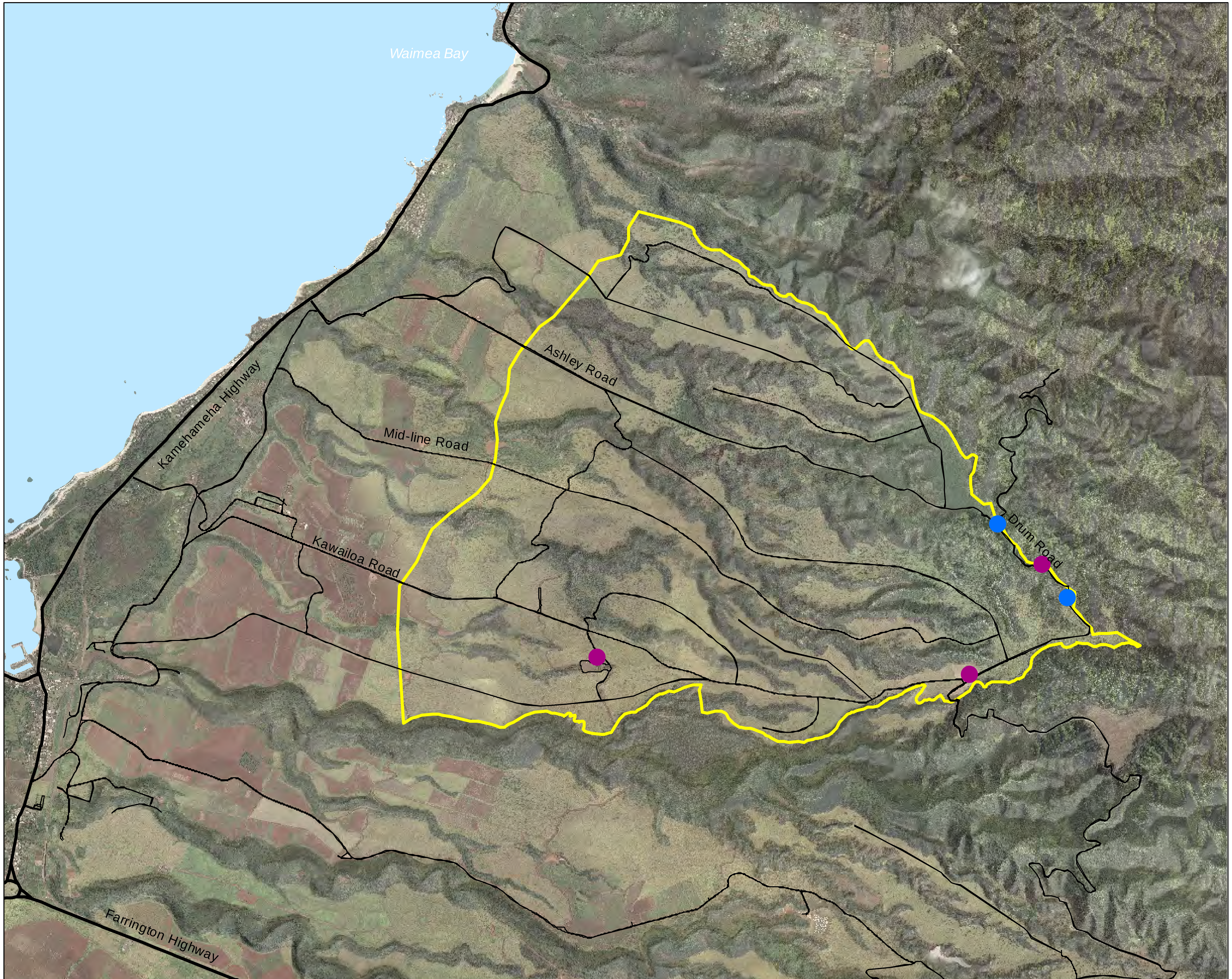
3. Bio-geographical status. The following symbols are used:

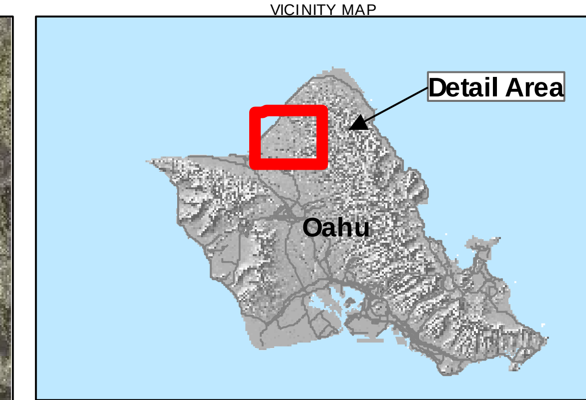
   endemic = native only to Hawaii; not naturally occurring anywhere else in the world.
   indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).
   non-native = all those animals brought to Hawaii intentionally or accidentally after western contact.
   migratory = 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			
Pig	*Sus scrofa*	non-native	common
Mongoose	*Herpestes auropunctatus*	non-native	common
Dog	*Canis familiaris*	non-native	rare
Rat	*Rattus spp.*	non-native	rare
Hawaiian Bat, *Ope'ape'a*	*Lasiurus cinereus semotus*	endemic	rare
BIRDS			
Zebra dove	*Geopelia striata*	non-native	common
Common waxbill	*Estrilda astrild*	non-native	common
Common myna	*Acridotheres tristis*	non-native	uncommon
Japanese bush-warbler	*Cettia diphone*	non-native	uncommon
Kölea, Pacific golden-plover	*Pluvialis fulva*	migratory	uncommon
Spotted dove	*Streptopelia chinensis*	non-native	uncommon
Red-vented bulbul	*Pycnonotus cafer*	non-native	uncommon
Hwamei	*Garrulax canorus*	non-native	uncommon
House finch	*Carpodacus mexicanus*	non-native	uncommon
Gray francolin	*Francolinus pondicerianus*	non-native	rare
White-rumped shama	*Copsychus malabaricus*	non-native	rare
Northern cardinal	*Cardinalis cardinalis*	non-native	rare
Red-crested cardinal	*Paroaria coronata*	non-native	rare
Japanese white-eye	*Zosterops japonicus*	non-native	rare
Red avadavat	*Amandava amandava*	non-native	rare
Red-whiskered bulbul	*Pycnonotus jocosus*	non-native	rare
(unknown owl species)	-------------------------------	?	rare





LEGEND

Bat Survey

- Not Observed
- Observed
- Major Road
- Road
- Survey Boundaries

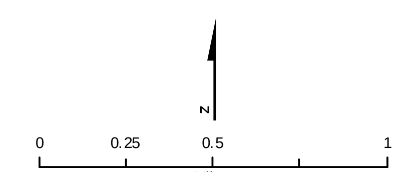


FIGURE 1
Project Location
Kawailoa Wind Farm Project
Flora/Fauna Survey
Oahu, Hawaii

\\NALA\PROJ\FIRSTWINDLLC\398315KAWAILOA\GIS\MAPFILES\FLORAFAUNASURVEY\FIGURE1_PROJECTLOCATION.MXD RMANGAN 3/8/2010 11:49:56

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.

Hobdy, R. 2009. (Biological Survey for a private client in Kahuku).

Palmer, D.D. 2003. Hawai'is Ferns and Fern Allies. University of Hawaii Press, Honolulu.

Roberts, G. 2009 (pers.comm.) Bat sightings at Pupukea, O'ahu.

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. 2009. Endangered and threatened wildlife and Plants. 50 CFR 17.11 & 17.12 (update of 1999 lists).

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 1b

BIOLOGICAL RESOURCES SURVEY

FOR THE

FIRST WIND KAWAILOA WIND FARM PROJECT

CANE HAUL ROAD, COLLECTOR LINE ROUTE

AND O & M BUILDING SITE

KAWAILOA, WAIALUA, O'AHU

By: Robert W. Hobdy
Environmental Consultant
August 2010

For: CH2MHILL

TABLE OF CONTENTS

	page
Introduction	3
Site Description	3
Biological History	3
Survey Objectives	4
Botanical Survey Report	4
Survey Methods	4
Description of the Vegetation	5
Discussion and Recommendations	5
Plant Species List	6-10
Fauna Survey Report	11
Survey Methods	11
Results	11
Mammals	11
Birds Species List	12
Insects	13
Discussion and Recommendations	13
Animal Species List	14-15
Figure 1 - Map of Project area	16
Literature Cited	17

INTRODUCTION

The proposed project lies along a corridor of approximately 4.4 miles running laterally and upward along old cane access roads between the Kawailoa Solid Waste Transfer Station and the west rim of Waimea Valley, TMKs 6-1-05:1, 19, 20, 21, 22 and TMK 6-1-06:1 (por.). It passes along Kawailoa Ranch pastures and through abandoned cane lands. This document summarizes the results of a biological study that was initiated by management in fulfillment of environmental requirements of the planning process for this wind farm.

SITE DESCRIPTION

The project corridor consists of 1.5 miles on the upper coastal plain that was a major cane haul road, 2.9 miles that climbs up the coastal escarpment and ascends gradually, crossing two gulches, and ends on a ridge overlooking Waimea Valley at an elevation of 400 feet. Another few acre area just above Kamehameha Highway near the Ashley Road gate that is planned as an Operations and Maintenance building, rounds out the components of the project.

The soils on the flat ridge tops consist of deep silty clays of the Waialua, Ewa, Helemano, Wahiawa, and Leilehua Series. The soils on the coastal escarpment and in the gulches have rocky outcrops and large amounts of loose stone (Foote et al, 1972). Rainfall averages about 40 inches per year with the bulk falling during the winter months (Armstrong, 1983). Vegetation consists mostly of open grasslands on the ridge tops and dense forests in the gulches.

BIOLOGICAL HISTORY

In pre-contact times these slopes would have been forested with native ′ōhi′a (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees with a dense understory of smaller native trees, shrubs, ferns and vines in great diversity and profusion. Gulches would have had an even denser growth of delicate shade-loving species.

In the late 1800s the area was cleared and converted to sugar cane agriculture. The fields were plowed, burned, harvested and planted in continuous cycles for about 100 years. Some of the broader gulches were used to pasture plantation horses and mules. These uses greatly reduced the numbers and overall diversity of native plants, and these were gradually replaced by increasing numbers of non-native agricultural and pasture plants. A number of tree species were planted along the edges of fields to serve as windbreaks. Other species deemed to be useful or ornamental were also planted in gulches and along ditches. Many of these have proliferated and some have become invasive. Feral pigs have spread throughout the area and have had a negative impact on native vegetation. They also are an important vector for the spread of weed species throughout the forests.

Today, little remains of native plant diversity in the project area. A few native species persist on steep gulch slopes in the upper parts of the corridor, but most of the area is covered with invasive non-native species.

SURVEY OBJECTIVES

This report summarizes the findings of a flora and fauna survey of the proposed Kawailoa Wind Farm Project - Cane Haul Road, Collector Line Route and O & M Building Site which was conducted during July, 2010. 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 on a 100 foot wide corridor along the 4.4 mile route, and within a few acre stretch where the proposed Operations and Maintenance Building is to be situated. Areas most likely to harbor native plants, such as gulches, steep slopes and rocky outcrops, were more intensively examined. Notes were made on species, distribution and abundance as well as on terrain and substrate.

DESCRIPTION OF THE VEGETATION

The vegetation on the project site is a mixture of aggressive weedy species that have taken over since the abandonment of sugar cane agriculture, but there are a few native species that persist in gulches and especially along the rim of Waimea Valley at the upper, eastern edge of the site.

One grass species, Guinea grass (*Megathyrsus maximus*), dominates most of the habitats on the site. Also common are Christmas berry (*Schinus terebinthifolius*), autograph tree (*Clusia rosea*), koa haole (*Leucaena leucocephala*), glycine (*Neonotonia wightii*) and Chinese banyan (*Ficus microcarpa*).

A total of 107 plant species were recorded during the course of the survey. Of this total 7 species were common native species. Two are endemic to Hawaii: Ko'oko'olau (*Bidens sandvicensis*) and ʻakia (*Wikstroemia oahuensis*), and 5 are indigenous in Hawaii as well as to other Pacific islands: pala'ä (*Sphenomeris chinensis*), pilipili'ula (*Chrysopogon aciculatus*), ʻuhaloa (*Waltheria indica*), ülei (*Osteomeles anthyllidifolia*) and alahe'e (*Psydrax odorata*). None of these are rare species and all occur on more than one island. Two species were of Polynesian origin: kukui (*Aleurites moluccana*) and ʻihi (*Oxalis corniculata*). The remaining 98 species were non-native plants that are agricultural weeds, windbreak trees or ornamentals.

DISCUSSION AND RECOMMENDATIONS

The vegetation along this 4.4 mile corridor and within the O & M building site is dominated by non-native species. A small number of common native species are concentrated along Waimea Valley rim on the upper, eastern end of the corridor.

No federally listed Endangered or Threatened plant species (USFWS, 2009) were found on the project corridor, nor were any found that are candidates for such status. No special native plant habitats or communities were identified. Due to the lack of any protected species or habitats, there is little of botanical concern with regard to this project area, 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 landscaping around the O & M Building site it is recommended that some dryland native plants, including the 7 listed above, be used for planting.

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 three groups: Ferns, Monocots and Dicots. Taxonomy and nomenclature 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.

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 Fern Family)			
Sphenomeris chinensis (L.) Maxon	pala'ä	indigenous	rare
POLYPODIACEAE (Polypody Fern Family)			
Phlebodium aureum (L.) J. Sm.	rabbit's foot fern	non-native	rare
Phymatosorus grossus (Langsd. & Fisch.) Brownlie	laua'e	non-native	uncommon
PTERIDACEAE (Brake Fern Family)			
Adiantum hispidulum Sw.	rough maidenhair fern	non-native	rare
THELYPTERIDACEAE (Marsh Fern Family)			
Christella parasitica (L.) H. Lev.	-------------------	non-native	rare
MONOCOTS			
ARECACEAE (Palm Family)			
Phoenix x dactylifera	hybrid date palm	non-native	rare
Washingtonia robusta H. Wendl.	Mexican washingtonia	non-native	rare
ASPARAGACEAE (Asparagus Family)			
Sanseviera trifasciata Prain	sanseviera	non-native	rare
CYPERACEAE (Sedge Family)			
Cyperus rotundus L.	nut sedge	non-native	rare
POACEAE (Grass Family)			
Andropogon virginicus L.	broomsedge	non-native	rare
Axonopus fissifolius (Raddi) Kuhlm.	narrow-leaved carpetgrass	non-native	rare
Chloris barbata (L.) Sw.	swollen fingergrass	non-native	uncommon
Chrysopogon aciculatus (Retz.) Trin.	pilipili ula	indigneous	rare
Digitaria insularis (L.) Mez ex Ekman	sourgrass	non-native	rare
Eleusine indica (L.) Gaertn.	wiregrass	non-native	rare
Melinis minutiflora P. Beauv.	molasses grass	non-native	rare
Oplismenus hirtellus (L.) P. Beauv.	bamboo grass	non-native	rare
Megathyrsus maximus (Jacq.) Simon & Jacobs	Guinea grass	non-native	abundant
Paspalum conjugatum Bergius	Hilo grass	non-native	rare
Urochloa mutica (Forssk.) T.Q. Nguyen	California grass	non-native	rare
DICOTS			
ACANTHACEAE (Acanthus Family)			
Barleria lupulina Lindl.	hophead	non-native	rare
AMARANTHACEAE (Amaranth Family)			
Alternanthera pungens Kunth	Khaki weed	non-native	uncommon
Amaranthus spinosus L.	spiny amaranth	non-native	rare
Amaranthus viridis L.	slender amaranth	non-native	rare
ANACARDIACEAE (Mango Family)			
Schinus terebinthifolius Raddi	Christmas berry	non-native	common

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
APIACEAE (Parsley Family)			
Ciclospermum leptophyllum (Pers.) Sprague	fir-leaved celery	non-native	rare
APOCYNACEAE (Dogbane Family)			
Alstonia sp.	------------------	non-native	rare
ARALIACEAE (Ginseng Family)			
Schefflera actinophylla (Endl.) Harms	octopus tree	non-native	rare
ASTERACEAE (Sunflower Family)			
Bidens alba (L.) DC.	------------------	non-native	uncommon
Bidens sandvicensis Less	ko'oko'olau	endemic	rare
Conyza bonariensis (L.) Cronq.	hairy horseweed	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	uncommon
Verbesina encelioides (Cav.) Benth. & Hook.	golden crown-beard	non-native	rare
BASELLACEAE (Basella Family)			
Anredera cordifolia (Ten.) Steenis	Madeira vine	non-native	rare
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P. Beauv.	African tulip tree	non-native	uncommon
BORAGINACEAE (Borage Family)			
Heliotropium procumbens Mill.	fourspike heliotrope	non-native	rare
BRASSICACEAE (Mustard Family)			
Lepidium virginicum L.	pepperwort	non-native	rare
CACTACEAE (Cactus Family)			
Hylocereus undatus (Haw.) Britton & Rose	night-blooming cereus	non-native	rare
CANNABACEAE (Hemp Family)			
Trema orientalis (L.) Blume	gunpowder tree	non-native	rare
CARICACEAE (Papaya Family)			
Carica papaya L.	papaya	non-native	rare
CASUARINACEAE (She-oak Family)			
Casuarina equisetifolia L.	common ironwood	non-native	uncommon
Casuarina glauca Sieber ex Spreng.	longleaf ironwood	non-native	rare
CLUSIACEAE (Mangosteen Family)			
Clusia rosea Jacq.	autograph tree	non-native	common
CONVOLVULACEAE (Morning Glory Family)			
Ipomoea obscura (L.) Ker-Gawl	-------------------	non-native	rare
Ipomoea triloba L.	little bell	non-native	rare
CUCURBITACEAE (Gourd Family)			
Coccinia grandis (L.) Voigt	ivy gourd	non-native	rare
Cucumis dipsaceus Ehrenb. ex Spach	hedgehog gourd	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Momordica charantia L.	bitter melon	non-native	rare
EUPHORBIACEAE (Spurge Family)			
Aleurites moluccana (L.) Willd.	kukui	Polynesian	rare
Chamaesyce hirta (L.) Millsp.	hairy spurge	non-native	uncommon
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	non-native	uncommon
Chamaesyce prostrata (Aiton) Small	prostrate spurge	non-native	uncommon
Phyllanthus debilis Klein ex Willd.	niruri	non-native	rare
Ricinus communis L.	Castor bean	non-native	uncommon
FABACEAE (Pea Family)			
Acacia confusa Merr.	Formosa koa	non-native	uncommon
Acacia farnisiana (L.) Willd.	klu	non-native	rare
Chamaecrista nictitans (L.) Moench	partridge pea	non-native	rare
Crotalaria incana L.	fuzzy rattlepod	non-native	rare
Crotalaria pallida Aiton	smooth rattlepod	non-native	rare
Desmanthus pernambucanus (L.) Thellung	slender mimosa	non-native	rare
Desmodium incanum DC.	ka'imi clover	non-native	rare
Falcataria moluccana (Miq.) Barneby & Grimes	albizia	non-native	uncommon
Indigofera hendcaphylla Jacq.	creeping indigo	non-native	uncommon
Indigofera suffruticosa Mill.	inikö	non-native	rare
Leucaena leucocephala (Lam.) de Wit	koa haole	non-native	common
Neonotonia wightii (Wight & Arnott) Lackey	glycine	non-native	common
Pithecellobium dulce (Roxb.) Benth.	'opiuma	non-native	rare
Prosopis pallida (Humb. & Bonpl. ex Willd) Kunth	kiawe	non-native	uncommon
Samanea saman (Jacq.) Merr.	monkeypod	non-native	rare
Senna surattensis (N.L.Burm.) H.Irwin & Barneby	kolomona	non-native	rare
LAMIACEAE (Mint Family)			
Hyptis pectinata (L.) Poit.	comb hyptis	non-native	rare
Leonotis nepetifolia (L.) R. Br.	lion's ear	non-native	uncommon
Salvia officinalis L.	garden sage	non-native	rare
MALVACEAE (Mallow Family)			
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	non-native	rare
Malva parviflora L.	cheese weed	non-native	rare
Malvastrum coromandelianum (L.) Garcke	false mallow	non-native	rare
Sida ciliaris L.	red 'ilima	non-native	rare
Sida cordifolia L.	heart-leaved sida	non-native	rare
Sida spinosa L.	prickly sida	non-native	uncommon
Triumfetta semitriloba Jacq.	Sacramento bur	non-native	rare
Waltheria indica L.	'uhaloa	indigenous	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D.Don	Koster's curse	non-native	rare
MELIACEAE (Mahogany Family)			
Melia azedarach L.	pride of India	non-native	uncommon
MORACEAE (Mulberry Family)			
Broussonetia luzonica (Blanco) Bureau	alokon, Phillipine spinach	non-native	rare
Ficus microcarpa L. fil.	Chinese banyan	non-native	common
Ficus platypoda (A.Cunn.ex Miq.)	rock fig	non-native	rare
MYRTACEAE (Myrtle Family)			
Psidium guajava L.	common guava	non-native	rare
Syzygium cumini (L.) Skeels	Java plum	non-native	uncommon
NYCTAGINACEAE (Four-o'clock Family)			
Boerhavia coccinea Mill.	scarlet spiderling	non-native	rare
OXALIDACEAE (Wood Sorrel Family)			
Oxalis corniculata L.	ihi,yellow wood sorrel	Polynesian	rare
PASSIFLORACEAE (Passion Flower Family)			
Passiflora edulis Sims	passion fruit	non-native	rare
Passiflora suberosa	cork bark passion flower	non-native	rare
PHYTOLACCACEAE (Pokeweed Family)			
Rivina humilis L.	coral berry	non-native	rare
PORTULACACEAE (Purslane Family)			
Portulaca pilosa L.	---------------------	non-native	rare
PROTEACEAE (Protea Family)			
Grevillea robusta A. Cunn. ex R. Br.	silk oak	non-native	rare
ROSACEAE (Rose Family)			
Osteomeles anthyllidifolia (Sm.) Lindl.	'ülei	indigenous	rare
RUBIACEAE (Coffee Family)			
Psydrax odorata (G. Forst.) A.C. Smith & S.P.Darwin	alahe'e	indigenous	rare
RUTACEAE (Rue Family)			
Citrus aurantiifolia (Cristmann) Swingle	lime	non-native	rare
SOLANACEAE (Nightshade Family)			
Nicandra physalodes (L.) Gaertn.	apple of Peru	non-native	rare
Solanum seaforthianum Andr.	Brazilian nightshade	non-native	rare
THYMELAEACEAE ('Akia Family)			
Wikstroemia oahuensis (A. Gray) Rock	'akia	endemic	rare
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	non-native	rare
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain	non-native	rare
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain	non-native	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
ZYGOPHYLLACEAE (Creosote Bush Family)			
Tribulus terrestris L.	puncture vine	non-native	rare

FAUNA SURVEY REPORT

SURVEY METHODS

A walk-through survey method was conducted in conjunction with the botanical survey. All parts of the project corridor 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 document any evidence of occurrence of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in the area.

RESULTS

MAMMALS

Six species of non-native mammals were observed during two site visits to the area. Taxonomy and nomenclature follow Tomich (1986).

Horse (*Equus caballus*) – Several horses were pastured along the lower corridor.

Dog (*Canis familiaris*) – A few domestic dogs from nearby properties were seen on the lower corridor.

Cat (*Felis catus*) – Signs of cats were seen along the western end of the corridor near the Kawailoa Solid Waste Transfer Station.

Cattle (*Bos Taurus*) – A few cattle were pastured along the lower corridor.

Pig (*Sus scrofa*) – Feral pig trails and tracks were seen in a gulch on the eastern side of the corridor.

Mongoose (*Herepestes auropunctatus*) – One mongoose was seen on the margin of the corridor during the early evening.

Dense vegetation prevented good visibility of other ground dwelling mammals, but a significant population of mice (*Mus domesticus*) and rats (*Rattus* spp.) would be expected in this type of habitat where they feed on seeds, fruits and herbaceous vegetation.

An evening survey was conducted at two sites along the corridor to see if any Endangered Hawaiian hoary bats were present. A Batbox IIID was employed, set to the frequency of 27,000 Hertz at which these bats are known to use for echolocation. No bat calls were detected at either site using this device. Bats have been detected at higher elevations in the northern Ko'olau Range but were not found at these low elevation sites during this survey.

BIRDS

There was moderate avian diversity observed along the corridor during one full day and an evening. Twelve species of non-native birds were recorded from the area. Taxonomy and nomenclature follow American Ornithologists' Union (2010).

Red-vented bulbul (*Carpodacus mexicanus)* – Bulbuls were quite abundant along the entire corridor.

House finch (*Caropdacus mexicanus*) – House finches were seen in small flocks here and there along the corridor.

Zebra dove (*Geopelia striata*) – These small doves were fairly common along the corridor and in trees.

Spotted dove (*Streptopelia chinensi*s) – Several of these large doves were seen in trees or in flight in the lower part of the corridor.

Common myna (*Acidotheres tristis*) – Several pairs of mynas were seen during the day time and into the early evening.

Northern cardinal (*Cardinalis cardinalis*) – These cardinals were seen and heard in trees in the lower corridor and in gulches.

Nutmeg manikin (*Lonchura punctulata*) – Two flocks of these tiny birds were seen feeding on seeds in the grasslands.

Japanese white-eye (*Zosterops japonicas*) – A few of these tiny green birds were seen and heard twittering in trees in the gulches.

House sparrow (*Passer domesticus*) – A few sparrows were seen in the lower part of the corridor near structures and equipment.

Gray francolin – (*Francolinus pondicerianus*) – A few gray francolins were seen in field margins and heard making their loud, distinctive calls.

White-rumped shama (*Copsychos malabricus*) – Two of these melodius singers were seen and heard in dense forests in gulches.

Red-crested cardinal (*Paroaria coronata*) – One of these bright red-headed cardinals was seen in a tree in the middle of the corridor.

A few other non-native bird species might be expected to utilize the project area, but it is not suitable habitat for Hawai'i's native forest birds which occupy native forests at higher elevations beyond the range of mosquitoes and the lethal avian diseases they transmit. No native birds were seen.

No sightings or signs of any native seabirds such as the wedge-tailed shearwater (*Puffinus pacificus*) or the Threatened Newell's shearwater (*Puffinus newelli*) were detected, and the habitat is not suitable for their nesting burrows. The Newell's shearwaters, however, could fly over this area in the evenings and early morning hours to reach their burrows that are typically located high in the wet forest ridge tops.

INSECTS

Insects in general were not tallied but they were observed and any Endangered and Threatened species were kept in mind. O'ahu has 6 Endangered and Threatened fruit fly species in the genus *Drosophila* and 6 candidates for such status among the native damselflies in the genus *Megalagrion*. The *Drosophila* species live in mesic to wet native forests at higher altitudes and the *Megalagrion* species frequent aquatic habitats or wet forests. None of these habitats occur within the project corridor and none of these species or their kin were seen.

DISCUSSION AND RECOMMENDATIONS

Six non-native mammals and twelve non-native birds were recorded along the 4.4 mile project corridor during the survey. No native mammals, birds, insects or snails were seen. Thus there were no Endangered or Threatened wildlife present and no candidates for such status.

No Endangered Hawaiian hoary bats were detected at two evening survey locations. It is possible, however, that these highly mobile bats could be present for short periods at the outset of the wet season when insect populations spike. There is nothing associated with this project that would pose a significant threat to these nocturnal flying mammals.

As a protective measure for protected seabirds that are often attracted to bright lights during the evening and early morning hours where they can crash and be injured or killed, it is recommended that any outdoor flood lights around the Operations and Maintenance Building be hooded to direct the light downwards to mitigate this threat.

With the above recommended measure in place, there is nothing about this project that is expected to have a significant negative impact on the wildlife resources in this part of O'ahu.

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			
Horse	*Equus caballus*	non-native	uncommon
Dog	*Canis familiaris*	non-native	uncommon
Cat	*Felis catus*	non-native	rare
Cattle	*Bos taurus*	non-native	rare
Pig	*Sus scrofa*	non-native	rare
Mongoose	*Herpestes auropunctatus*	non-native	rare
BIRDS			
Red-vented bulbul	*Pycnonotus cafer*	non-native	abundant
House finch	*Carpodacus mexicanus*	non-native	common
Zebra dove	*Geopelia striatus*	non-native	common
Spotted dove	*Streptopelia chinensis*	non-native	uncommon
Common myna	*Acridotheres tristis*	non-native	uncommon
Northern cardinal	*Cardinalis cardinalis*	non-native	uncommon
Nutmeg mannikin	*Lonchura punctulata*	non-native	uncommon
Japanese white-eye	*Zosterops japonicus*	non-native	rare
House sparrow	*Passer domesticus*	non-native	rare
Gray francolin	*Francolinus pondicerianus*	non-native	rare
White-rumped shama	*Copsychus malabaricus*	non-native	rare
Red-crested cardinal	*Paroaria coronata*	non-native	rare

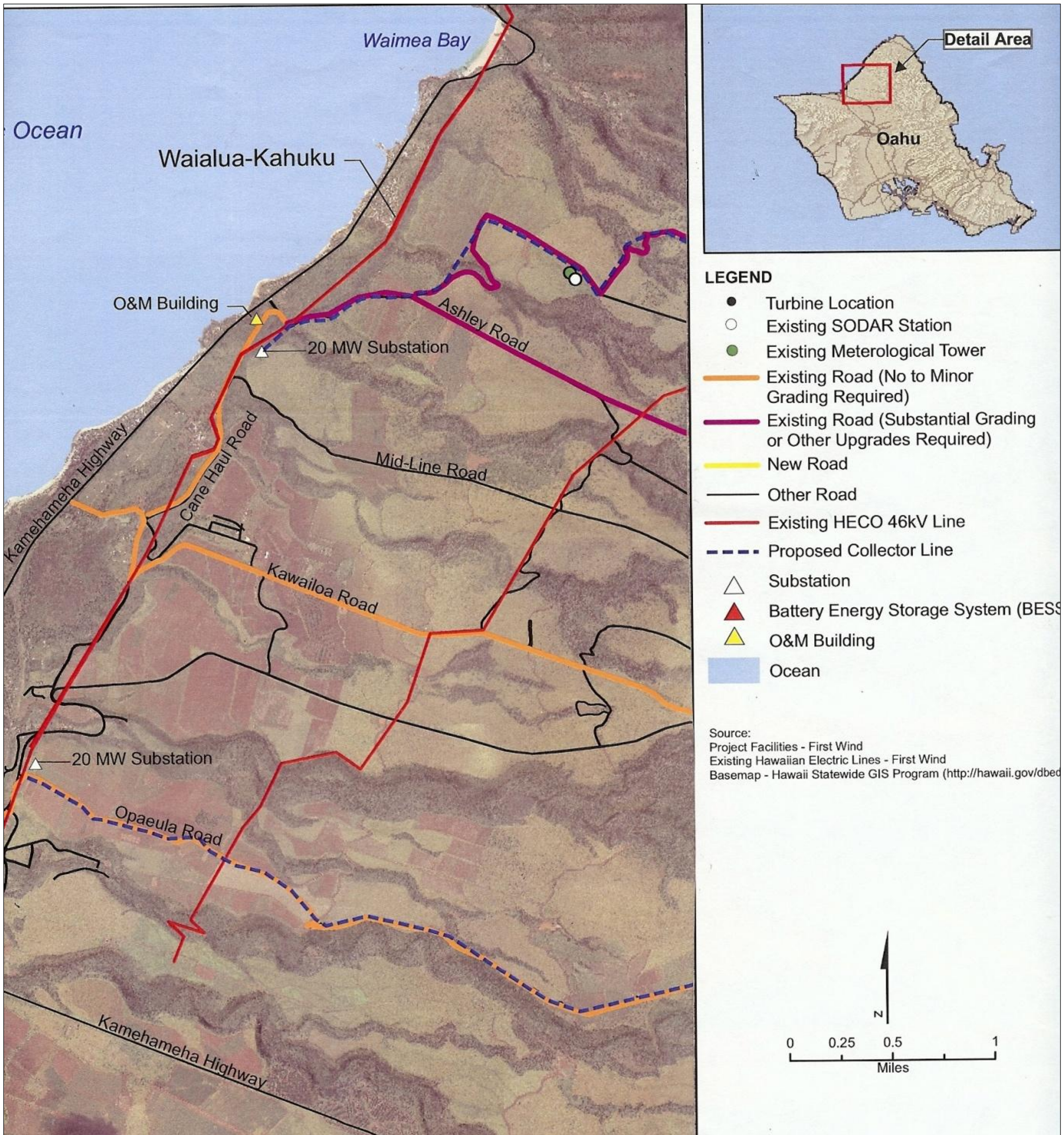


FIGURE 1
Project Location
Kawailoa First Wind Project
Oahu, Hawaii

Literature Cited

American Ornithologists' Union 2010. 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.

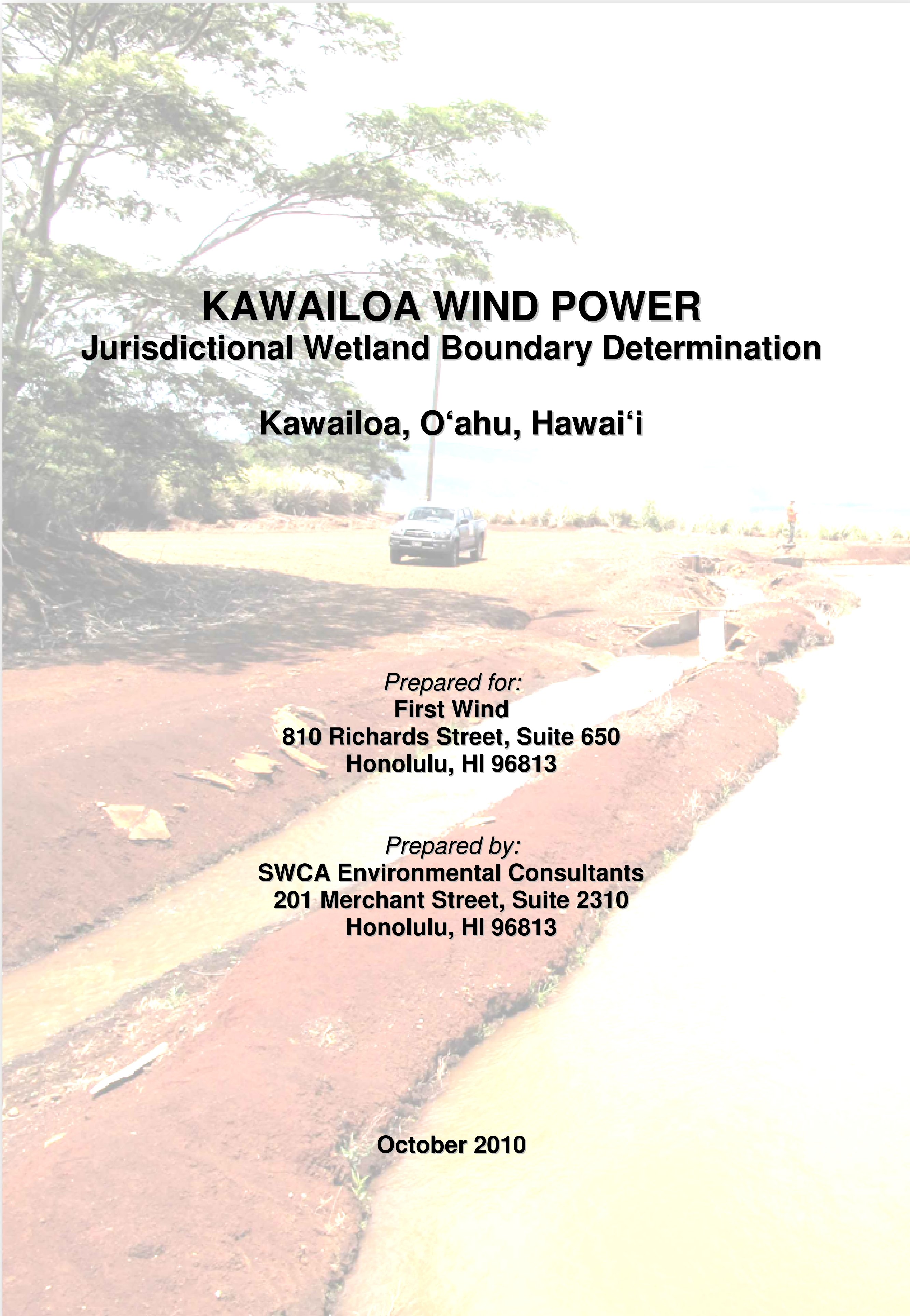
Palmer, D.D. 2003. Hawai'is Ferns and Fern Allies. University of Hawaii Press, Honolulu.

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.

U.S. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and Plants. 50 CFR 17.11 & 17.12 (update of 1999 lists).

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 2



KAWAILOA WIND POWER
Jurisdictional Wetland Boundary Determination

Kawailoa, O‘ahu, Hawai‘i

Prepared for:
First Wind
810 Richards Street, Suite 650
Honolulu, HI 96813

Prepared by:
SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, HI 96813

October 2010

TABLE OF CONTENTS

WETLAND DELINEATION SUMMARY 1
1.0 INTRODUCTION TO WETLANDS AND WETLAND DELINEATION 2
- 1.1 Vegetation Indicators 2
- 1.2 Soil Indicators 3
- 1.3 Hydrologic Indicators 3

2.0 Regional Background 4
- 2.1 Location and Vicinity 4
- 2.2 Geology and Soils 4
- 2.3 Hydrology and Drainage 7
- 2.4 Flora and Fauna 7
- 2.5 Land Use 9

3.0 METHODOLOGY 9
- 3.1 Vegetation 10
- 3.2 Soils 10
- 3.3 Hydrology 10

4.0 FINDINGS 10
- 4.1 Vegetation 10
- 4.2 Soils 10
- 4.3 Hydrology 10
- 4.4 Sampling Points 11
  - *4.4.1 ʻOpaeʻula Road* 11
  - *4.4.2 Kawailoa Road* 12
  - *4.4.3 Cane Haul Road* 13
  - *4.4.4 Midline Road* 13
  - *4.4.5 Ashley Road* 14
  - *4.4.6 Bull's Boulevard* 15

5.0 UPLANDS 15
6.0 CONCLUSION 15
7.0 LIMITATIONS 16
8.0 REFERENCES 18

LIST OF TABLES AND FIGURES

Table 1. Wetland plant indicators. 3
Table 2. Soil types identified by Foote et al. (1972) at the various sampling points. 11

Figure 1. Hydrology and sampling points in the Kawailoa Wind Power project area. 5
Figure 2. Soil types identified by Foote et al. (1972) throughout the Kawailoa Wind Power project area. 6
Figure 3. Probable jurisdictional wetlands at the Kawailoa Wind Power project area. 17

ACRONYMS AND ABBREVIATIONS

ac	acre
C	Celsius
cm	centimeter
CWA	Clean Water Act
FAC	facultative species
FACU	facultative upland species
FACW	facultative wetland species
F	Fahrenheit
ft	feet
ha	hectare
in	inches
km	kilometer
m	meter
mi	mile
MW	megawatt
NI	no indicator status
NRCS	National Resources Conservation Service
NWI	National Wetlands Inventory
OBL	obligate wetland species
RPW	Relatively Permanent Waters
TNW	Traditional Navigable Waters
UPL	upland species
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WTG	wind turbine generator

WETLAND DELINEATION SUMMARY

SITE NAME: Kawailoa Wind Power
TMKs 6-1-005:001, 6-1-006:001, 6-1-007:001, 6-2-009:001, 6-2-010:001, 6-2-011:001

SITE LOCATION: The site is located east of Haleʻiwa Town and south of Waimea Valley in the District of Waialua on the Island of Oʻahu, Hawaiʻi

OWNER/LEASEE: Bishop Estate (owner), First Wind (lessee)

DATE OF SITE VISITS: July 1, 8, 9, 2010; September 23, 2010

PROJECT STAFF: John Ford, Pacific Office Director / Senior Biologist, SWCA
Tiffany Thair, Environmental Specialist II, SWCA
Ryan Taira, GIS Analyst, SWCA

SUMMARY

SWCA Environmental Consultants (SWCA) was tasked by First Wind to conduct a Preliminary Determination of Jurisdiction of waters governed by the Clean Water Act (CWA) within the proposed Kawailoa Wind Power project area. Wetland identification and delineation fieldwork was conducted by SWCA biologists on July 1, 8, and 9, and September 23, 2010. Investigations were performed in accordance with the 1987 *U.S. Army Corps of Engineers Wetland Delineation Manual* and the 2007 joint U.S. Environmental Protection Agency (USEPA) – U.S. Army Corps of Engineers (USACE) guidance on wetland jurisdictional determinations, which was prepared following *Rapanos* v. *United States* and *Carabell* v. *United States* (hereinafter referred to as *Rapanos*). The *Draft Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Hawaii and Pacific Island Region* (draft for peer review and field testing dated June 20, 2009) was also consulted, along with additional references and standards for Hawaiʻi soils and wetland vegetation.

The six project parcels are situated in the Kawailoa region on the Island of Oʻahu and encompasses approximately 10,550.04 ac (4,269.60 ha). The construction and operation of the proposed facility; however, is anticipated to disturb roughly 550 - 650 ac (222.6 – 263.1 ha), or approximately 6% of the area encompasses by the project parcels. The wind energy facility is expected to have a generating capacity of up to 70 megawatts (MW). Kawailoa Wind Power will consist of up to 43 wind turbine generators, an operations and maintenance building, underground and overhead electrical connector lines carrying electrical power from the individual wind generators to two electrical substations, a Battery Energy Storage System, underground and overhead connection lines between, the communication facilities, wind monitoring equipment, and service roadways to connect the new facilities to the existing main access roads (CH2MHill 2010).

Twenty-four sampling points were evaluated by SWCA over the four survey dates. Due to the large size of the project area, only areas expected to be impacted by construction and operation of the wind facility were surveyed for jurisdictional waters. No wetlands meeting the three established criteria of hydrophilic vegetation, soils, and water regime were found to occur within the project area through application of the methods identified in USACE (1987) during the survey by SWCA. ʻUkoʻa Pond, located outside the project area, is a wetland subject to USACE jurisdiction under Section 404 of the CWA. Historically, ʻUkoʻa Pond drained into the Pacific Ocean near Haleʻiwa Harbor; however, the former channel is heavily overgrown with dense vegetation today. SWCA has determined that three intermittent gulches within the project area are not Relatively Permanent Waters (RPW): Loko ea (above ʻUkoʻa Pond), Laniakea, and Kawailoa. However, these three gulches would likely be subject to Department of the Army discretionary jurisdiction following *Rapanos* due to their significant nexus with the Traditional Navigable Waters (TNW) of the Pacific Ocean. The unnamed, southern-most tributary of the Waimea River appears to be a naturally interrupted stream without perennial flow and may be considered a RPW. Therefore, it would also be subject to Department of the Army discretionary jurisdiction following *Rapanos* due to its significant nexus with Waimea Estuary and the TNW of Waimea Bay.

1.0 INTRODUCTION TO WETLANDS AND WETLAND DELINEATION

The U.S. Army Corps of Engineers (USACE) derives its regulatory authority over wetlands and waters of the United States from two Federal laws: Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA), 33 U.S.C. §1251 et seq (1972). Section 404 of the CWA created a legislative mandate to regulate the discharge of dredged or fill material into the waters of the United States. This program is overseen jointly by the USACE and the U.S. Environmental Protection Agency (USEPA). According to 40 CFR 230.3, waters of the United States subject to agency jurisdiction under Section 404 include navigable waters and their tributaries, interstate waters and their tributaries, wetlands adjacent to these waters, and impoundments of these waters.

The U.S. Supreme Court's recent decision in the consolidated cases *Rapanos* v. *United States* and *Carabell* v. *United States* (126 S. Ct. 2208) provided further information regarding whether a wetland or tributary is a water of the United States. In 2007, the USEPA AND USACE issued joint guidance on determining agency jurisdiction over a wetland or tributary based on the *Rapanos* and *Carabell* decisions. The guidance states that the agencies will assert jurisdiction over the following waters:

- 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; and
- Wetlands that directly abut such tributaries (USACE and USEPA 2007).

The guidance states that 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 (USACE and USEPA 2007). Wetlands have been defined by the USACE (33 CFR 230.3) and USEPA (40 CFR 230.3) 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"* (40 CFR 232.3). Wetlands are considered an especially critical ecosystem due to their role in flood prevention and pollution control, and their ability to act as essential habitat for breeding and feeding species of fish and wildlife.

The 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987), as amended, outlines the technical guidelines and methods for identifying and delineating wetlands potentially subject to Section 404 of the CWA. Wetland jurisdictional boundary determinations involve an assessment of the relationship between three parameters - vegetation, soil, and hydrology. Positive wetland indicators of all three parameters (i.e., hydrophytic vegetation, hydric soils, and wetland hydrology) are normally present in wetlands. Wetland indicators for each parameter are summarized below.

1.1 Vegetation Indicators

Hydrophytic vegetation is defined by the USACE as "macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present" (USACE 2009). Plants occurring almost exclusively in wetland areas are categorized as Obligate (OBL). Plant species that are not wetland obligate, but are found in wetland areas to varying degrees are classified as Facultative Wetland (FACW), Facultative (FAC), and Facultative Upland (FACU). An Upland species (UPL) is not considered an indicator of a wetland area (Table 1). Plants are considered hydrophytes if they are classified as OBL, FACW+, FACW, FACW-, FAC+, and FAC.* 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,

* (+) = wetter than FAC; (-) = drier than FAC

morphological adaptations, technical literature such as taxonomic references and botanical journals, and physiological and reproductive adaptations (Environmental Laboratory 1987).

Table 1. Wetland plant indicators.

Plant Indicator	Code	Description
Obligate Wetland Species	OBL	> 99% found in wetlands
Facultative Wetland Species	FACW	67-99% found in wetlands
Facultative Species	FAC	33-66% found in wetlands
Facultative Upland Species	FACU	1-33% found in wetlands
Upland Species	UPL	<1% found in wetlands
No Indicator Status	NI	Ignored in count

Source: (Environmental Laboratory 1987).

The U.S. Fish and Wildlife Service's *National List of Vascular Plant Species That Occur in Wetlands* (1996) designates wetland indicator statuses for plants in the Hawaiian Islands and estimates the probability of a species occurring in wetlands versus non-wetlands.

1.2 Soil Indicators

A hydric soil is formed under conditions of saturation and is sufficiently wet during the growing season to develop anaerobic conditions (NRCS 2010). Hydric soils are either drained or un-drained and are classified as either organic or mineral soils. Soil characteristics are determined in the field by digging 18 in (45 cm) holes near potential wetland areas and documenting the texture, smell, color, and water level (Erickson and Puttock 2006). For non-sandy soils, the following features indicate the presence of hydric soils: organic soils, histic epipedons, sulfidic material, aquic (reducing) or peraquic moisture regime, reducing soil conditions, soil colors, soil appearing on hydric soils list, and iron and manganese concretions. 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, and the presence of organic pans (Environmental Laboratory 1987).

The National Resources Conservation Service's (NRCS) National List of Hydric Soils (February 2007) for O'ahu Island includes 13 hydric soils for the island. Soils within the Kawailoa project area are mapped by the NRCS (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm). None of the soil types that were mapped within the project area by the NRCS are listed as hydric soils. Considering that some soils that meet the hydric soil definition may not exhibit hydric soil indicators, attention was given the assessment of problematic hydric soils (USACE 2009). The irrigation reservoirs found within the project parcels could be construed as recently developed wetlands with seasonally ponded, red soils in which obvious hydric soil indicators have not yet developed. However, none of these soils show stratified layers or other indicators when evaluated against applicable criteria USACE (2009).

Not all areas having hydric soils will qualify as jurisdictional wetlands. Only when a hydric soil supports hydrophytic vegetation *and* the area has indicators of wetland hydrology, as defined in the 1987 *Corps of Engineers Wetlands Delineation Manual*, may the soil be referred to as a "wetland" soil (Environmental Laboratory 1987).

1.3 Hydrologic Indicators

The 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) notes that "hydrology is often the least exact of the parameters, and indicators of wetland hydrology are sometimes difficult to find in the field." Visual observation of inundation, soil saturation, watermarks, drift lines, sediment deposition, and surface drainage patterns are all indicators of wetland hydrology. Frequency, timing, and duration of inundation or soil saturation can be used as a basis for classification. The 1987 *Corps of Engineers Wetlands Delineation Manual* 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" (Environmental Laboratory 1987).

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). Secondary hydrologic indicators include presence of oxidized rhizospheres associated with living plant roots in the upper 12 in (31 cm) of the soil, presence of water stained leaves, local soil survey hydrology data for identified soils, and the FAC-neutral test of the vegetation. Any two secondary indicators must be present to conclude that wetland hydrology is present (Environmental Laboratory 1987).

2.0 REGIONAL BACKGROUND

2.1 Location and Vicinity

The Kawailoa region is situated east of Haleʻiwa Town and south of Waimea Valley in the District of Waialua, Oʻahu. The site is accessed by Kawailoa Road or Ashley Road via Kamehameha Highway. The entire study area encompasses 10,550.04 ac (4,269.60 ha) and ranges from 200 ft (61 m) elevation at the western makai portion of the project area to approximately 1,280 ft (390 m) elevation at the eastern mauka side of the project area (CH2MHill 2010). However, the project components will occupy between 550 and 650 ac (222.6 – 263.1 ha). The remainder of the project area consists of agricultural fields, fallow former cane and pineapple fields, and vacant lands. The western portion along Kamehameha Highway also abuts a low to medium density residential area. Undeveloped military training lands which are part of the U.S. Army Kawailoa Training Area are present to the north and east (Figure 1).

Average monthly temperatures in the area range from 67.3°F (19.6°C) in January to 76.6°F (24.8°C) in August (Western Regional Climate Center 2005b). Annual mean precipitation in the area ranges from 22.5 inches (57 cm) near the makai (seaward) portion of the project area to slightly over 56 inches (142 cm) near the mauka (inland) portion of the project area (Western Regional Climate Center 2005a).

2.2 Geology and Soils

Oʻahu, 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). 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 and Waiʻanae Volcanoes were formed about 2.2 to 2.5 million years ago and 2.7 to 3.4 million years ago, respectively (Juvik and Juvik 1998, Lau and Mink 2006).

The project area is located on the Schofield Plateau, an alluvial fan of erosional unconformity that formed between the Koʻolau Volcano and the eroded slopes of the Waiʻanae Volcano (Macdonald et al. 1983). 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 is present in the southern portion of the project area. No unique or unusual geologic resources or conditions are known to occur on-site.

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 characterized for crop suitability by the Land Survey Bureau of the University of Hawaiʻi (Sahara et al. 1972), and classified by the U.S. Department of Agriculture (USDA) Soil Conservation Service and NRCS (Foote et al. 1972).

The three primary soil types underlying the project area are Helemano silty clay, 30-90% slopes; Wahiawa silty clay, 3-8% slopes; and Leilehua silty clay, 2-6% slopes. All soils within the area are deep, moderately fine to fine, dark reddish brown, well-drained, without ponding frequency class, and have a depth-to-water-table of over 200 ft (NRCS 2007). The stream gulches are dominated by rocky, well-drained soils of the Rough Broken Lands and Rock Lands association with slopes of 36-80% (Sahara et al. 1972, Foote et al. 1972, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm). Soils types identified by Foote et al. (1972) throughout the project area are shown in Figure 2. According to the NRCS National Hydric Soils List none of these soils are considered hydric.

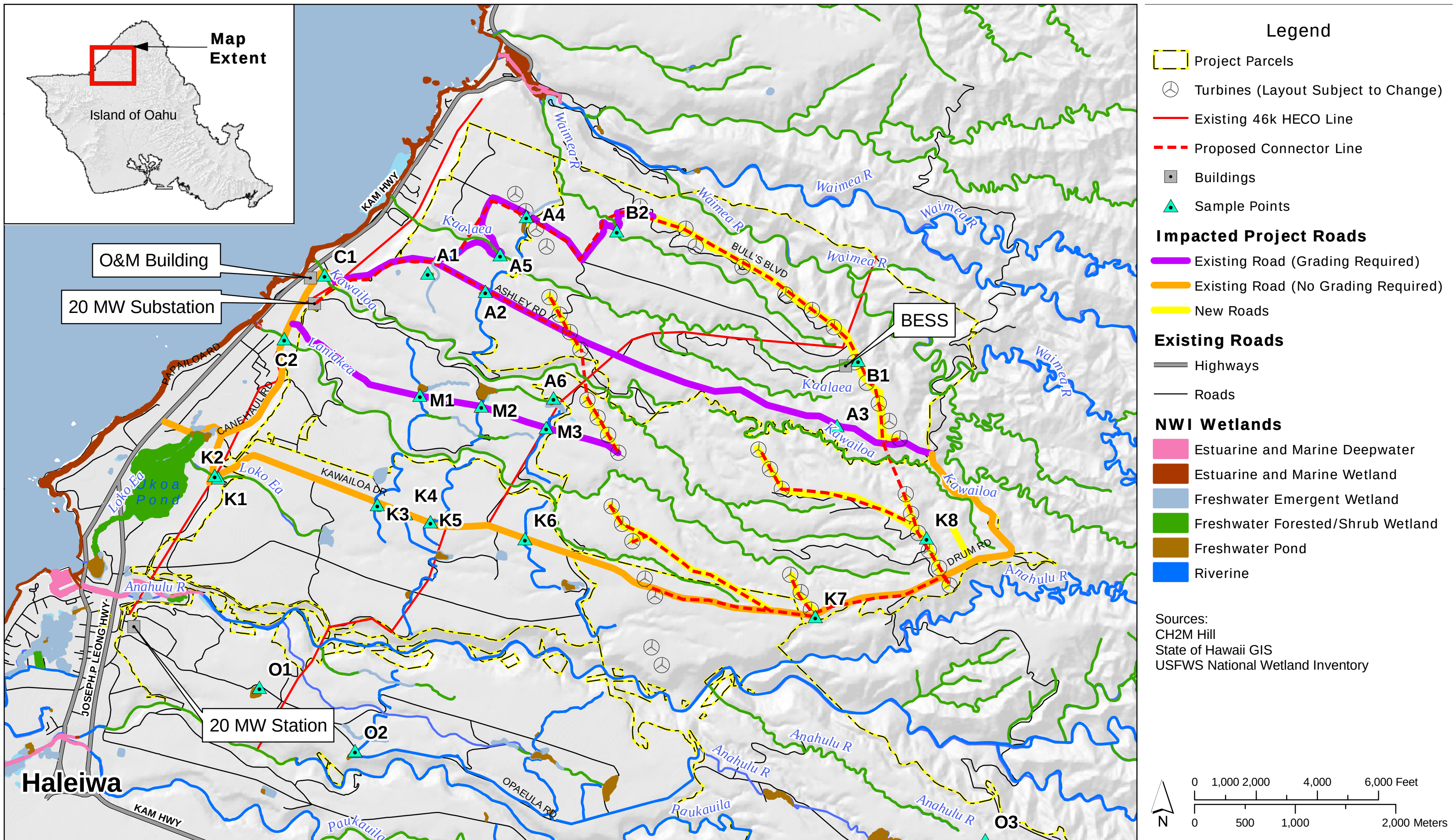
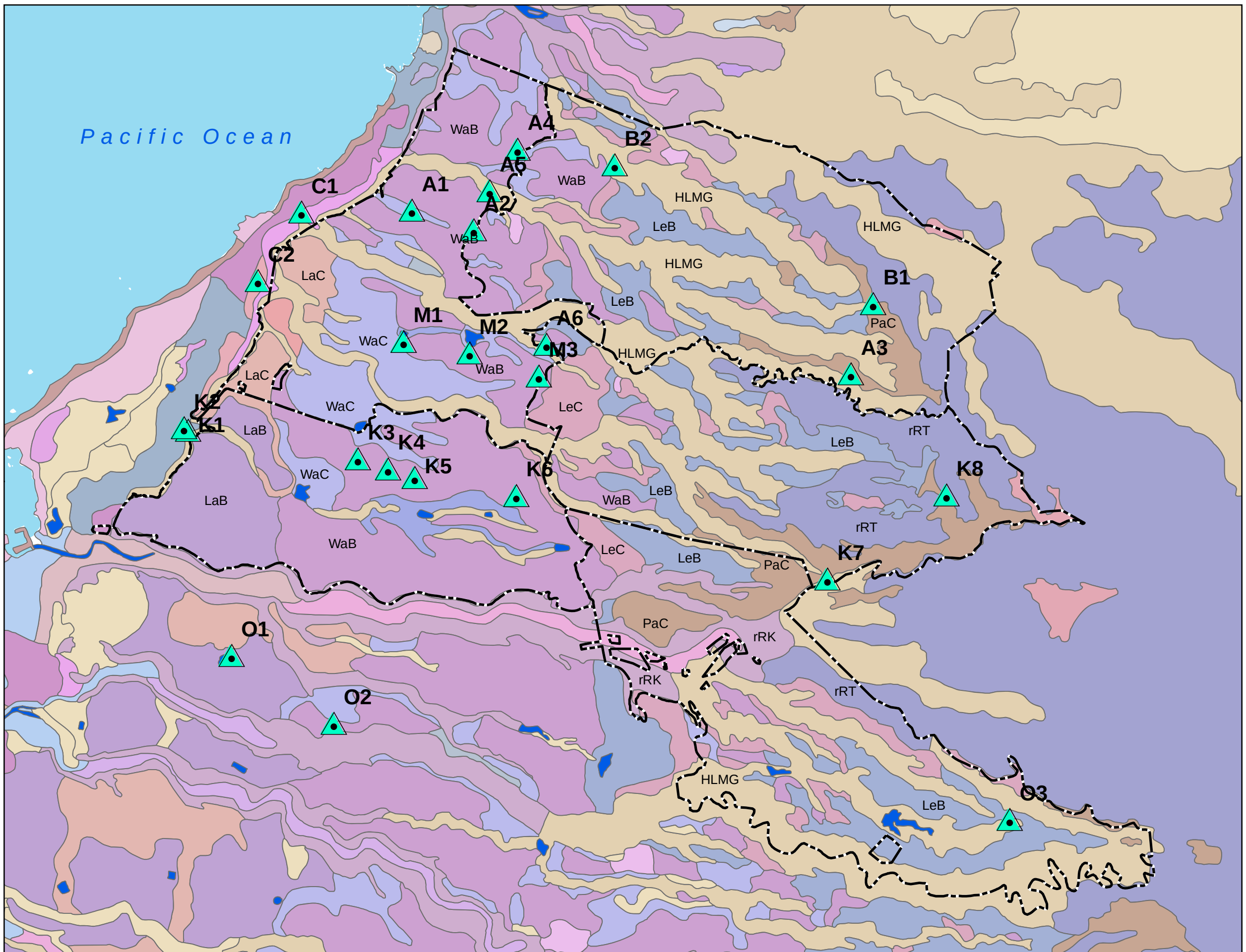


Figure 1.
Kawailoa Wind Power Hydrologic Features and Sampling Points



Legend

Project Parcels

Sampling Points

Soil Type

- EwC, Ewa stony silty clay, 6 to 12 percent slopes
- HLMG, Helemano silty clay, 30 to 90 percent slopes
- KlB, Kawaihapai clay loam, 2 to 6 percent slopes
- KlaB, Kawaihapai stony clay loam, 2 to 6 percent slopes
- LaB, Lahaina silty clay, 3 to 7 percent slopes
- LaC, Lahaina silty clay, 7 to 15 percent slopes
- LaC3, Lahaina silty clay, 7 to 15 percent slopes, severely e
- LeB, Leilehua silty clay, 2 to 6 percent slopes
- LeC, Leilehua silty clay, 6 to 12 percent
- MoB, Manana silty clay loam, 2 to 6 percent slopes
- PaC, Paaloa silty clay, 3 to 12 percent slopes
- PbC, Paaloa clay, 2 to 12 percent
- W, Water > 40 acres
- WaA, Wahiawa silty clay, 0 to 3 percent slopes
- WaB, Wahiawa silty clay, 3 to 8 percent slopes
- WaC, Wahiawa silty clay, 8 to 15 percent slopes
- WaD2, Wahiawa silty clay, 15 to 25 percent slopes, eroded
- WkA, Waialua silty clay, 0 to 3 percent slopes
- WkB, Waialua silty clay, 3 to 8 percent slopes
- WlB, Waialua stony silty clay, 3 to 8 percent slopes
- rRK, Rock land
- rRT, Rough mountainous land

0 0.5 1 2 Miles

0 0.5 1 2 3 Kilometers

N

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

Figure 2.
Kawailoa Wind Power
Map of Soil Types
and Soil Sample Locations

2.3 Hydrology and Drainage

Hydrologic processes in Hawai‘i are highly dependent on the climatic and geological features, and stream flow is influenced by rainfall and wind patterns. Permeable underlying rock may cause some streams on O‘ahu to have lengthy dry reaches under natural conditions. The majority of the perennial streams on O‘ahu are located in the windward Ko‘olau Mountains which produce a larger amount of orographic precipitation compared to the leeward side (Polhemus 2007).

The Kawailoa watershed is cut by several intermittent streams, which flow across portions of the study area. The Waimea River and its four tributaries – ‘Elehaha, Kaiwiko‘ele, Kamananui, and an unnamed tributary - flow near the northern boundary of the project area and discharge into Waimea Bay (U.S. Army Environmental Command 2008). Only the unnamed tributary of the Waimea River and the Waimea River mainstream occur within the project parcels.

The Anahulu River runs near the southern portion of the project area and discharges into Waialua Bay. The total tributary length of the Anahulu River is approximately 66.8 mi (107.5 km). Portions of the Anahulu River are dry during low flow conditions (SWCA 2008). The Anahulu River has two perennial tributaries, Kawainui and Kawaiiki Streams, which join the main stem immediately mauka of the eastern boundary of the project area at roughly 400 ft (120 m) elevation. Each of these tributaries is diverted once, supplying water to the Kaiwainui Ditch System (DAR 2008, SWCA 2008). There are several reservoirs associated with the ditch system. Two are located on Anahulu River at 967.6 ft (295 m) and 780.64 ft (238 m) (SWCA 2008).

‘Opae‘ula Stream flows adjacent to the southeastern boundary of the project area. This is joined by Helemano Stream before flowing into Kaiaka Bay. ‘Opae‘ula Stream is diverted once near an elevation of 1,200 ft (366 m) just mauka of the project area. Water from this diversion feeds into the ditch from the Kawaiiki Diversion on the Anahulu River (SWCA 2008). Downstream of the diversion dam the military access road crosses ‘Opae‘ula Stream with a bridge at an elevation of 805 ft (245.4 m).

Other streams or gulches that occur within the property include Ka‘alaea, Kawailoa, Laniakea, and Loko ea. These are primarily dry throughout most of the year and are ***not*** considered relatively permanent waters (RPW). A former Hawaiian fishpond, ‘Uko‘a Pond, occurs seaward and outside of the project parcels near the intersection of Kawailoa Drive and Kamehameha Highway. The extent of this basal, spring-fed pond was reduced due to dumping and filing within the old Kawailoa Landfill (Elliott and Hall 1977, Miller et al. 1989). Loko ea is both the name of the waterway that historically drained ‘Uko‘a Pond to the sea at Haleiwa Harbor (Miller et al. 1989) and of the influent intermittent gulch above the pond.

In the late 1970s, the U.S. Fish and Wildlife Service (USFWS) Division of Ecological Services biologists used orthophoto quadrangle maps and ground truth studies to map wetlands in Hawai‘i as a part of the National Wetlands Inventory (NWI) Program (Cowardin et al. 1979). Several wetland types identified by the NWI are located within the project area including: Freshwater Pond (PUBH, PUBHh, PUBHx), Riverine (R4SBCx), Freshwater Emergent Wetland (PEM1Cx), and Freshwater Forested/Shrub Wetland (PFO3C).

Flood Insurance Rate Maps (FIRM) prepared by the Federal Emergency Management Agency (FEMA) National Flood Insurance Program classified flood hazard areas through the state. The project area is almost entirely within Flood Zone D where analysis of flood hazards has not been conducted and flood hazards are undetermined. Near the mouths of several streams (Kawailoa, Laniakea, Loko ea, and Anahulu) the land is identified as Flood Zone X, an area defined as having less than 0.2% annual risk of flood inundation.

2.4 Flora and Fauna

Botanical surveys of the project area were conducted by Robert Hobdy in February and August 2010. Hobdy recorded approximately 183 plant species within the project area in February (Hobdy 2010a) and an additional 40 species during the survey in August (Hobdy 2010b). 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. No portion of the project area has been designated as critical habitat for any listed plant species.

The vegetation in the project area is a mixture of aggressive weedy species that have taken over since the abandonment of sugar cane agriculture. Guinea grass (*Urochloa maxima*) is the most abundant species on the property, forming deep growth on all the ridge tops and in many of the gulches (Hobdy 2010a and 2010b). Other common species include: common ironwood (*Casuarina equisetifolia*), albizia (*Falcataria moluccana*), Formosan koa (*Acacia confusa*), koa haole (*Leucaena leucocephala*), Padang cassia (*Cinnamomum burmanni*), Java plum (*Syzygium cumini*), strawberry guava (*Psidium cattleianum*), cork bark passion flower (*Passiflora suberosa*) and swamp mahogany (*Eucalyptus robusta*). All of these species are non-native to the Hawaiian Islands (Hobdy 2010a and 2010b).

Wildlife occurring in the area has been investigated through a combination of pedestrian surveys (Hobdy 2010a and 2010bb), avian point counts (SWCA, in prep), nocturnal radar surveys (Cooper et al. 2009), and acoustic monitoring using bat detectors (SWCA, in prep). Species observed during driving transects and incidental sightings of wildlife were also documented by SWCA (SWCA, in prep). Seventeen bird species were seen by Hobdy during five days and two evenings. The most common birds seen during the February survey were the Zebra dove (*Geopelia striata*) and the Common waxbill (*Estrilda astrild*). Red-vented bulbul (*Carpodacus mexicanus*) was most abundant species during the August survey. Only one native migrant bird, Kōlea or Pacific golden-plover (*Pluvialis fulva*), was observed by Hobdy.

Additionally, twenty-four bird species were observed by SWCA biologists at a 29 avian point count stations between October 2009 and September 2010. Like Hobdy's observations, SWCA counts of birds in flight were dominated by introduced bird species. Common waxbills, red-vented bulbuls, finches (*Carpodacus mexicanus* and unidentified species), and Japanese white-eyes (*Zosterops japonicus*) accounted nearly 70% of the bird activity observed at Kawailoa Wind Power by SWCA over the study period. Native bird species observed during the study period included: Black crowned night heron (*Nycticorax nycticorax hoactli*), Hawaiian duck-mallard hybrid (*Anas* sp.), and the Hawaiian coot (*Fulica alai*). Only a single Hawaiian coot, which is listed as federally and state endangered, was seen in September 2010 in an irrigation pond. Incidental observations of a single winter migrant species, Kōlea or Pacific golden plover, were also made occasionally throughout the project parcels (SWCA, in prep).

Cooper et al. (2009) conducted surveillance radar and audiovisual sampling at the Kawailoa Wind Power project area in summer and fall 2009. These surveys found a relatively low number of targets exhibiting flight speeds and flight patterns that fit the shearwater-like category. Over five nights of sampling in June 2009, Cooper et al. (2009) recorded one landward-flying and 20 seaward-flying radar targets that fit the criteria for shearwater-like targets. One landward-flying and 52 seaward-flying radar targets that fit the criteria for shearwater-like targets were recorded in October 2009. The mean movement rate across all nights and both sites was 0.60 ± 0.07 shearwater-like targets/h in summer 2009 and 1.41 ± 0.15 shearwater-like targets/h in fall 2009 (Cooper et al. 2009). No visual identification of these birds was possible; however, Cooper et al. (2009) suggested that the individuals were likely to be Newell's shearwaters (*Puffinus auricularis newelli*). Though originally known from all the main islands, Hawaiian petrels (*Pterodroma sandwichensis*) have not be reported from O'ahu in decades.

Two to seven Anabat detectors (Titley Electronics, NSW, Australia) were deployed by SWCA biologists at various locations within the project parcels from October 2009 to September 2010 to monitor Hawaiian hoary bat (*Lasiurus cinereus semotus*) activity. As of October 1, 2010, 16 sites were acoustically sampled for a total of 935 detector nights. During this time period, a total of 99 bat calls resulting in 75 bat passes were recorded. Anabat detectors on the site estimate an average hoary bat activity rate of 0.08 bat passes/detector/night for the entire year but occurs at 0.12 bat passes/detector/night from April to September and 0.003 bat passes/detector/night from October thought March (SWCA, in prep).

Feral pigs (*Sus scrofa*) are common throughout the project area. Other mammals observed include domestic dogs (*Canis familiaris*), rats (*Rattus* spp.), cattle (*Bos taurus*), small Indian mongoose

(*Herpestes auropunctatus*), horses (*Equus caballus*), feral cats (*Felis catus*). Although not seen, it is likely that mice (*Mus domesticus*) occur on the property (Hobdy 2010a and 2010b).

2.5 Land Use

The proposed facility is situated in the Waialua District on the north central portion of O‘ahu. The project area encompasses portions of six parcels (TMKs 6-1-005:001, 6-1-006:001, 6-1-007:001, 6-2-009:001, 6-2-010:001, 6-2-011:001). All parcels are owned by Bishop Estate/ Kamehameha Schools. Portions of the parcels are leased for diversified agricultural operations with roughly 2,200 acres in cultivation (Kamehameha Schools 2005). Nearby urban areas include the residential communities of Kawailoa, Hale‘iwa (to the south), and Pūpūkea (beyond Waimea Bay to the north). Other land uses currently within the vicinity include:

- Kawailoa Training Area: The largest U.S. Military training area on Oahu, covering 23,348 acres (9,449 ha) (U.S. Army Environmental Command 2008).
- Kawailoa Refuse Transfer Station: Site for the temporary collection and storage of waste.
- Waimea Valley: Roughly 1,875 acre (759 ha) valley owned by the Office of Hawaiian Affairs and managed by Hi‘ipaka, a non-profit organization which operates Hawaiian based recreational and educational activities (http://waimeavalley.net/default.aspx).
- Drum Road: A military access road running along the west slope of the Ko‘olau Mountain Range and across the Schofield Plateau (SWCA 2009).

Sugar cultivation within the Waialua area of O‘ahu’s north shore extends back to 1865; however, it did not prosper until taken over by the Waialua Sugar Company in the early 1900s. This plantation was distinguished by its efficient water storage and irrigation system (Wilcox 1997), which consisted of interconnected concrete flumes designed in portable sections that could be placed in fields in a herringbone configuration (Wilcox 1997). Water was released to the fields through small tin gates in the flumes. The plantation built four surface-water collection systems, and remnants of two are still found within the project area today: the ‘Opae‘ula and Kamananui ditches, which delivered 350 million gallons a year (mg/y) and 90 mg/y, respectively, to the cane fields. Together with the interconnected Helemano and Wahiawa ditches which delivered 700 mg/y and 12 billion mg/y, the Waialua Sugar Company boasted the largest water storage capacity of all plantations in Hawai‘i. In 1931, the Waialua Sugar Company ranked fourth in the islands in terms of sugar production (Wilcox 1997). Additional lands in the upper Kawailoa watershed area were also cultivated in pineapple by Castle & Cooke. In 1995, when Castle & Cooke announced its closure, the Waialua Sugar Company was the last remaining sugar plantation on O‘ahu. Today, much of the irrigation system lay in disrepair; however, some flumes and reservoirs have been restored to supply irrigation water to agricultural lessees on Kamehameha Schools’ lands within the project area.

3.0 METHODOLOGY

SWCA biologists 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. Fieldwork was conducted by SWCA biologists and staff on July 1, 8, and 9, 2010, and on September 23, 2010. Wetland determination data sheets prepared on these dates appear in Appendix A.

All the sites where the USFWS National Wetland Inventory (NWI) had identified wetlands that intersected areas planned to be developed within the Kawailoa Wind Power project area were sampled by SWCA biologists using the methods defined in USACE (1987). Additional points were sampled in areas with distinct vegetation communities not previously studied. Number and letter identifications were assigned to each sampling point (Figure 1).

SWCA biologists collected the geographic coordinates of sampling points and NWI boundaries in the field with Trimble® GeoExplorer® 2008 Series Global Positioning System (GPS) receivers running ESRI ArcPad software and with a Garmin GISMAP 76Cx GPS receiver. SWCA subsequently compiled maps of the wetlands identified in this report with USGS 7.5 minute quadrangle maps and GPS data points collected in the field.

3.1 Vegetation

At each sampling point, the absolute areal cover was estimated for each species within each vegetation strata (i.e. tree, shrub, herb, woody vine). Species that individually or collectively exceeded 50% of the total cover and those with 20% of the total percent cover were considered dominant (USACE 2009). These species were then compared with the regional indicator designated for the State of Hawai‘i. Plant taxonomy and synonymy follows Wagner et al. (1999), with revisions from Wagner and Herbst (2003).

3.2 Soils

Soil samples were collected at eight sampling points throughout the project area. Samples were obtained by digging test pits and by taking sediment cores to approximately 12 inches (30.5 cm) below ground level, although hardpans and rocks limited the depth of pits and cores at some 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. All test pits were refilled following examination.

3.3 Hydrology

Both primary and secondary hydrology indicators were evaluated at each sampling site. SWCA biologists evaluated the areas for surface water, high water table, saturation, and evidence of water marks, sediment deposits, drift lines, algal crusts, iron deposits, soil cracks, hydrogen sulfide odor, aquatic fauna, and drainage patterns.

4.0 FINDINGS

4.1 Vegetation

A list of vegetation observed at Kawailoa by Hobdy (2010a and 2010b) and SWCA is included in Appendix B. Hobdy recorded 223 plant species throughout the project area and three additional species were identified by SWCA in July 2010. Based on the National List of Plant Species that Occur in Wetlands - Hawai‘i (Reed 1988), only two plant species recorded by Hobdy in the project area are considered Obligate Wetland species. Seventeen additional non-obligate hydrophytes were identified by Hobdy (FACW+ – 1 sp.; FACW – 3 spp., FAC+ – 2 spp., FAC – 11 spp.) and seven species are tentatively assigned as Facultative due to lack of information (FAC*). Twelve species are classified as Obligate Upland (UPL); 34 species are classified as Facultative Upland (FACU); six species are Facultative Upland, but with tentative assignment due to lack of information (FACU*); seven species are Facultative Upland with lower frequency of occurrence in wetlands in Hawai‘i (FACU-); two species are Facultative with lower frequency of occurrence in wetlands in Hawai‘i (FAC-); and 17 species with no information to determine indicator status (NI). The remaining species are not listed on the National List of Plant Species that Occur in Wetlands - Hawai‘i (Reed 1988).

4.2 Soils

NRCS (Foote et al. 1972) does not list any hydric soils within the Kawailoa Wind Power project area. SWCA biologists found no evidence of hydric soil conditions anywhere within the Kawailoa project area during their studies. Soil types identified by Foote et al. (1972) at the various sampling points are shown in Table 2. All the irrigation ditches and reservoirs sampled during this study were constructed in upland areas that lack hydric soils. Even soils sampled on the floors of empty reservoirs did not reveal any hydric soil indicators.

4.3 Hydrology

Eight man-made reservoirs and associated ditch systems originally constructed for irrigation of commercial sugar cane fields were sampled by SWCA biologists. These water features were all located immediately adjacent to proposed roads that may be used for the transport of wind turbine blades and towers. Only one of the eight reservoirs did not contain surface water. Many of the areas defined as Riverine by the NWI are actually irrigation ditches. Many irrigation ditches were constructed of concrete forms that lay upon the surface of the ground. Larger ditches were excavated into the soil, some of which were lined with concrete forms. Only one naturally occurring wetted area was found by SWCA near the easternmost portion of the project area at Sampling Point K8 (Figure 1). On July 8, 2010, SWCA biologists found less than 96 ft^2 (9 m^2) area inundated with approximately 1 inch (2.5 cm) of water, perhaps due to recent heavy rainfall that occurred during the previous evening.

Table 2. Soil types identified by Foote et al. (1972) at the various sampling points.

Sampling Point	Soil Type
A1	Wahiawa silty clay, 8 to 15 percent slopes
A2	Wahiawa silty clay, 3 to 8 percent slopes
A3	Paaloa silty clay, 3 to 12 percent slopes
A4	Wahiawa silty clay, 3 to 8 percent slopes
A5	Helemano silty clay, 30 to 90 percent slopes
A6	Helemano silty clay, 30 to 90 percent slopes
B1	Paaloa silty clay, 3 to 12 percent slopes
B2	Helemano silty clay, 30 to 90 percent slopes
C1	Waialua silty clay, 0 to 3 percent slopes
C2	Waialua silty clay, 3 to 8 percent slopes
K1	Waialua stony silty clay, 3 to 8 percent slopes
K2	Waialua stony silty clay, 3 to 8 percent slopes
K3	Wahiawa silty clay, 3 to 8 percent slopes
K4	Wahiawa silty clay, 3 to 8 percent slopes
K5	Wahiawa silty clay, 3 to 8 percent slopes
K6	Wahiawa silty clay, 3 to 8 percent slopes
K7	Paaloa silty clay, 3 to 12 percent slopes
K8	Rough mountainous land
M1	Wahiawa silty clay, 8 to 15 percent slopes
M2	Wahiawa silty clay, 3 to 8 percent slopes
M3	Wahiawa silty clay, 3 to 8 percent slopes
O1	Lahaina silty clay, 3 to 7 percent slopes
O2	Wahiawa silty clay, 3 to 8 percent slopes
O3	Leilehua silty clay, 2 to 6 percent slopes

4.4 Sampling Points

Twenty-four sampling points were selected and evaluated by SWCA biologists over the four survey dates (Figure 1). SWCA assigned an ID 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. Indicators of hydric soil were not investigated at the reservoirs and ditches. Photographic plates of each sampling point are included in Appendix C.

4.4.1 ʻOpaeʻula Road

Sampling Point O1. A reservoir occurs immediately adjacent to ‘Opae‘ula Road and is roughly 21,528 ft^2 (2,000 m^2) in size. The USFWS NWI identifies this site as a “Freshwater Pond.” The reservoir is inundated with surface water to an unknown depth and supports aquatic fauna (e.g. tilapia). The reservoir is fed by an irrigation ditch flowing from the east. The vegetation along the edges of the reservoir is mostly dead or dying; however, the dominant living vegetation at the time of the survey included *Chloris barbata* (FACU), *Emilia fosbergii* (N/A), and *Boerhavia* sp. (N/A). No soil pit or core was taken at this sampling point.

Sampling Point O2. The NWI system classifies this point as “Freshwater Pond”, with “Riverine” flowing north across ‘Opae‘ula Road and east along the road. During the survey, the reservoir contained surface water to an unknown depth with water entering the reservoir from a pipe under the road (Figures 3 and 4). Aquatic fauna observed during the survey included *Corbicula fluminea*, *Bufo marinus*, and *Pantala flavescens*. Yellow-striped mud daubers (*Sceliphron haematogastrum)* were frequently scene along the water’s edge at irrigation reservoirs and ditches here and throughout the project parcels. *Coccinia grandis* (N/A), *Paspalum conjugatum* (FAC+), *Emilia fosbergii* (N/A), and *Leucaena leucocephala* (UPL) are the dominant plant species, found scattered along the water’s edge. No test pits were dug at the sampling point as the area failed to meet the initial test for dominance of obligate or hydrophytic vegetation.

Sampling Point O3. ‘Opae‘ula Sampling Point 3 is located in the vicinity of a proposed turbine string. This point is found in the southeastern corner of the project area. *Leucaena leucocephala* (UPL), *Urochloa maxima* (FACU), *Psidium guajava* (FACU), *Falcataria moluccana* (N/A), and *Schinus terebinthifolius* (FACU-) are the dominant plant species at this site. No hydrology indicators or hydric soils were observed in this location, and therefore no test pits were dug at this sampling point.

4.4.2 Kawailoa Road

Sampling Point K1. Sampling Point K1 is located in the lower reaches of Loko ea Gulch near the project area’s makai boundary. The USFWS NWI defines this area as “Freshwater Forested/Shrub Wetland.” No water and no hydrology indicators (e.g. high water marks, drift lines) were observed during the survey, suggesting that there has not been a recent flow in the gulch. There is a culvert that passes under the road, although it appears to be easily clogged by debris. The dominant plants in this area include: *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Ficus microcarpa* (N/A), and *Neonotonia wightii* (N/A). Due to its potential connection to ‘Uko‘a Pond, a soil pit was dug at this point. Soils at 10 inches (25 cm) below the surface were generally found to be 2.5YR, with a value of 3 and chroma of 4 (2.5YR 3/4). Soils at the point are identified as Waialua stony silty clay, 3-8% slopes (Foote et al. 1972).

Sampling Point K2. Sampling Point K2 is makai of Sampling Point K1 on the seaward side of Kawailoa Road. *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Ficus microcarpa* (N/A), *Syzygium cumini* (FACU), and *Neonotonia wightii* (N/A) are the dominant plant species. According to Foote et al. (1972), the soils at this location are considered Waialua stony silty clay, 3-8% slopes. Pit digging to a depth of 8 in (20 cm), revealed a yellow-red hue of 2.5, with both a value and chroma of 4 (2.5YR 4/4). Similar to Sampling Point K1, the USFWS NWI defines this area as “Freshwater Forested/Shrub Wetland,” although no water is likely to have recently flowed through the gulch due to the presence of mature vegetation in the stream bed.

Sampling Point K3. This reservoir is located immediately mauka of the banana and Plumeria plantations along Kawailoa Road. According to the USFWS NWI system, this site is classified as “Freshwater Pond” and “Riverine.” The reservoir contains surface water to an unknown depth and a ditch/channel containing water continues along the road, as well as northeast toward Laniakea Gulch where water is siphoned across the gulch. Dominant vegetation at K3 includes *Chloris barbata* (FACU), *Amaranthus viridis* (FAC*), *Paspalum conjugatum* (FAC+), *Eclipta prostrata* (FACW), *Ipomoea obscura* (N/A). No test pit was dug here.

Sampling Point K4. Sampling Point K4 is defined as “Riverine” in the USFWS NWI system. During the survey, there was no water in the ditch. *Urochloa maxima* (FACU) and *Chloris barbata* (FACU) were the dominant plants observed during the survey. No test pit was dug here.

Sampling Point K5. Sampling Point K5 is located at a reservoir along Kawailoa Road which is connected to an irrigation ditch. Similar to K3, this point is classified as "Freshwater Pond" and "Riverine" by NWI. The berm surrounding this location appears to have been constructed recently and there is little vegetative growth here. The few plants seen during the survey included *Emilia fosbergii* (N/A), *Sacciolepis indica* (FAC+), *Ludwigia octovalvis* (OBL), and *Chloris barbata* (FACU). No soil core or pit was dug here.

Sampling Point K6. This sampling point is located near a locked gate along Kawailoa Road. The old irrigation ditch that crosses under the road at Sampling Point K6 is identified as "Riverine" by USFWS NWI. No water was present in the ditch during the survey. *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Bidens alba* (N/A) are the dominant plant species inside and surrounding the ditch. No core or soil pit was dug here.

Sampling Point K7. Sampling Point K7 is located along Kawailoa Road above Laniakea Gulch. *Urochloa maxima* (FACU), *Polygala paniculata* (FACU*), *Setaria parviflora* (N/A), *Axonopus fissifolius* (FAC), *Plantago lanceolata* (FACU), and *Mimosa pudica* (FACU) are the dominant plant species. This area is not classified in the USFWS NWI; however, algal crust and water stained leaves were observed during the survey. Due to the presence of hydrologic indicators, a soil pit was dug at the sampling point. Shallow rock allowed pit digging to a maximum depth of 7 in (18 cm), yielding a soil of 10R 3/4. According to Foote et al. (1972), this site is underlain with Paaloa silty clay, 3-12% slopes.

Sampling Point K8. This sampling point is located near the second string of turbines between Kawailoa Road and Ashley Road. The dominant plants in this area include the following: *Urochloa maxima* (FACU), *Mimosa pudica* (FACU), *Hyparrhenia rufa* (N/A), *Axonopus fissifolius* (FAC), *Acacia koa* (N/A), and *Cyperus difformis* (OBL). Moss, algal mats, and inundation were observed during the survey. The wetted area was approximately 9 x 9 ft (3 x 3 m) in area and 1 in (2.5 cm) deep. This could have been due to recent heavy rainfall that occurred during the previous evening. This area is not classified in the USFWS NWI. A test pit dug to a depth of 12 in (31 cm) revealed fine soil, with a 2.5 YR hue and a value and chroma of 3 (2.5YR 3/3). Foote et al. (1972), classify the soils at K8 as Rough Mountainous Land.

4.4.3 Cane Haul Road

Sampling Point C1. Sampling Point C1 is located within the lower reaches of Kawailoa Gulch near the Cane Haul Road crossing. The dominant vegetation at the site is *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Neonotonia wightii* (N/A), and *Schinus terebinthifolius* (FACU-). NWI identifies this area as "Freshwater Forested/Shrub Wetland." Erosion marks and rocks suggest this area is may be the bed of a small, highly intermittent stream. No test pits were dug here.

Sampling Point C2. Sampling Point C2 is located at the intersection of Cane Haul Road and Laniakea Gulch. Similar to Kawailoa Gulch, the USFWS NWI identifies this drainage area as "Freshwater Forested/Shrub Wetland." No culvert is visible at the road crossing and the channel is poorly defined; grass is knocked down in some areas, but most of the area is heavily overgrown with non-native vegetation. No water was seen during the survey and no water is likely to have recently flowed through the gulch due to the presence of mature woody vegetation in the stream bed. *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Syzygium cumini* (FACU), *Clusia rosea* (NI), and *Neonotonia wightii* (N/A) are the dominant plant species. No pit was dug here.

4.4.4 Midline Road

Sampling Point M1. Sampling Point M1 is located at a reservoir along the proposed Midline Road which is connected to an irrigation ditch flowing from the south. This point is classified as "Freshwater Pond" and "Riverine" by the USFWS NWI. Dominant plants seen during the survey include *Eleusine indica* (FACU), *Sporobolus africanus* (N/A), *Ipomoea obscura* (N/A), and *Eclipta prostrata* (FACW). No core or soil pit was dug at the point.

Sampling Point M2. This sampling point is located at a reservoir with a wetted irrigation ditch flowing under the road. *Corbicula fluminea* and tilapia were observed in the ditch system. The USFWS NWI system classifies this area as "Freshwater Pond," "Riverine," and "Freshwater Emergent Wetland."

Chloris barbata (FACU) and *Eleusine indica* (FACU-) are the dominant plant species along the reservoir. No core or soil pit was dug at the point. A larger reservoir is located to the north and outside the area that would be affected by road construction and stabilization for the wind power project; therefore, it was not sampled during this study.

Sampling Point M3. This sampling point is classified as "Riverine" by the USFWS NWI; however, there is only a degraded irrigation ditch system with a culvert that passes under the dirt road here. The culvert was dry and filled with silt during the survey. Dominant plant species observed include: *Eleusine indica* (FACU-), *Ipomoea obscura* (N/A), *Ciclospermum leptophyllum* (NI), and *Urochloa maxima* (FACU). No soil pit or core was dug here.

4.4.5 Ashley Road

Sampling Point A1. Sampling Point A1 is located along the lower portion of Ashley Road roughly 394 ft (120 m) from the road. The dominant vegetation at the site is *Urochloa maxima* (FACU), *Clusia rosea* (NI), and *Ficus microcarpa* (N/A). The area is identified as "Freshwater Forested/Shrub Wetland" by the USFWS NWI. The area appears to be a depression that was filled with large boulders and debris. Although the rocks have moss on them, there is no indication of recent inundation. A test pit was dug in a clear area around the edge of the depression. Soils at 12 in (31 cm) below the surface had a hue of 10R, with a value of 3 and a chroma of 4 (10R 3/4). NRCS classifies soils at the point as Wahiawa silty clay, 8-15% slopes. Large trees suggest there has not been ponded water at this location in decades.

Sampling Point A2. Sampling Point A2 is a reservoir and associated ditch system along Ashley Road. It is identified as "Freshwater Pond" and "Riverine" by USFWS NWI. The reservoir contains water; however, the ditch on both sides of the road is filled with soil. *Ipomoea triloba* (N/A), *Chloris barbata* (FACU) and *Chamaesyce hirta* (FACU) are the dominant plants along the reservoir's edge. No pit or core was taken.

Sampling Point A3. This sampling point is located along upper Ashley Road near the intersection of Bull's Boulevard. *Leucaena leucocephala* (UPL), *Pennisetum purpureum* (FACU), *Falcataria moluccana* (N/A), and *Schinus terebinthifolius* (FACU-) are the dominate plant species at this site. No hydrology indicators or hydric soils were observed in this location. NRCS identifies soils at A3 as Paaloa silty clay, 3-12% slopes. A test pit dug to a depth of 12 in (31 cm) revealed a hue of 10R and a value and chroma of 3 (10R 3/3).

Sampling Point A4. This sampling point, located between the unnamed Waimea tributary and Ka'alaea Gulch, is defined as "Freshwater Pond and "Riverine," with "Freshwater Emergent Wetland" occurring slightly to the north according to the USFWS NWI. The reservoir did not contain water at the time of the survey, but was overgrown with *Urochloa maxima* (FACU) and *Syzygium cumini* (FACU) scattered along the edges of the berm. The ditches that formerly existed at the site were filled in with soil or overgrown with *U. maxima*. No pit was dug here.

Sampling Point A5. Sampling Point A5 occurs where an unnamed road crosses Ka'alaea Gulch. This gulch has a large culvert with signs of recent water flow. It is identified as "Freshwater Forested/Shrub Wetland" by the USFWS NWI. *Urochloa maxima* (FACU), *Syzygium cumini* (FACU), *Schinus terebinthifolius* (FACU-), and *Aleurites moluccana* (NI) are the dominant plants at the sampling point. No pit was dug here.

Sampling Point A6. Sampling Point A6 is located in a large depression that was formerly an irrigation reservoir. It is adjacent to a pump house with pipes and waterlines that lead into the depression. The sampling point is dominated by two plant species – a thick mat of *Urochloa mutica* (FACW) and scattered *Falcataria moluccana* (N/A) trees. The USFWS NWI primarily classifies the area as "Freshwater Emergent Wetland" with a smaller portion identified as "Freshwater Pond." Soils under the mat of *U. mutica* are characteristic of dry, deeply cracked soils in abandoned reservoirs. Soil samples retrieved from a crack by hand from the surface to a depth of approximately 18 inches (46 cm) revealed consistently hard, dry, dark reddish brown clay (2.5YR 3/4) with no evidence of anoxic conditions. According to NRCS (Foote et al. 1972), soils at the site are Helemano silty clay, 30-90% slopes. Water levels in this depression were formerly maintained by the adjacent pump station. Google Earth imagery shows the reservoir full of water in May 2000, but subsequent images in

November 2002 and August 2004 revealed a progressively shrinking shoreline area as the reservoir emptied. By July 2006, the former reservoir was empty and covered with a solid mat of *U. mutica,* appearing virtually identical to conditions today.

4.4.6 Bull's Boulevard

Sampling Point B1. Sampling Point B1 is located within the proposed turbine string along Bull's Boulevard. *Urochloa maxima* (FACU) and *Falcataria moluccana* (N/A) are the dominant plant species. Pit digging to a depth of 12 in (31 cm), revealed a hue of 10R, with a value of 3 and chroma of 4 (10R 3/4). No hydrology indicators or hydric soils were observed in this location.

Sampling Point B2. Sampling point B2 is located near a dirt road that crosses an unnamed tributary of Waimea River. The dominant vegetation at the site is *Urochloa maxima* (FACU), *Schinus terebinthifolius* (FACU-), *Psidium cattleianum* (FACU), *Aleurites moluccana* (NI), and *Syzygium cumini* (FACU). Although the stream channel is not clearly defined, the drainage area is devoid of vegetation in some areas makai of the road due to disturbance by pigs and hunter trails. Water stained leaves were apparent at the point. A thick mat of *Urochloa mutica* (FACW) occurs on the makai side of the dirt road. No water was present in the stream bed and the presence of mature grasses suggests there has not been a recent flow at this location. The USFWS NWI defines the area as "Freshwater Forested/Shrub Wetland." The test pit, dug to a depth of 13 in (33 cm), showed Helemano silty clay with a 2.5 YR hue and a value and chroma of 3 (2.5YR 3/3).

5.0 UPLANDS

None of the areas to be directly impacted by the proposed construction and operation of the wind power facility at Kawailoa meet the three criteria for hydrophilic vegetation, hydric soils, and wetland hydrology; therefore, all these areas are considered upland.

6.0 CONCLUSION

Wetlands and waters (streams) of the U.S. are regulated by the U.S. Army Corps of Engineers 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.

Following *Rapanos,* 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 areas to be affected by construction and operation of the proposed wind power facility.

The USACE provides limited guidance regarding the jurisdictional status of irrigation ditches and other man-made surface water conveyances. The decision about jurisdiction of these features is typically determined by individual districts (GAO 2004). Irrigation ditches in uplands are generally not considered waters of the United States; however, the courts have found at least one case in which an irrigation ditch connected to an intermittent tributary of a TNW is jurisdictional (Headwaters v. Talent Irrigation Dist., 243 F.3d 526,533 (9th Cir. 2001)). Of primary concern is whether excavated ditches lower adjacent water tables. At Kawailoa, depth to water table is in excess of 200 ft (61 m) for all soil types (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm). All of the ditches and reservoirs surveyed were constructed in upland areas, and do not represent impoundments of natural streams.

None of the irrigation ditches that contained open water were observed to connect directly to another natural surface water body or to TNW.

‘Uko‘a Pond, located outside the project area, is a wetland subject to Department of the Army jurisdiction under Section 404 of the CWA. Historically, ‘Uko‘a Pond drained into the Pacific Ocean near Hale‘iwa Harbor; however, the former channel is heavily overgrown with dense vegetation today. SWCA has determined that three intermittent gulches within the project area are not Relatively Permanent Waters (RPW): Loko ea (above ‘Uko‘a Pond), Laniakea, and Kawailoa. However, these three gulches would likely be subject to Department of the Army discretionary jurisdiction following *Rapanos* due to their significant nexus with the TNW of the Pacific Ocean. The unnamed, southern-most tributary of the Waimea River appears to be a naturally interrupted stream without perennial flow and may be considered a RPW. Therefore, it would also be subject to Department of the Army discretionary jurisdiction following *Rapanos* due to its significant nexus with Waimea Estuary and the TNW of Waimea Bay. Any work involving the discharge of dredged or fill material into a interrupted or intermittent streams within the project parcels will require a priori submittal of a permit application and a wetland mitigation plan to the Honolulu District, USACE.

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.

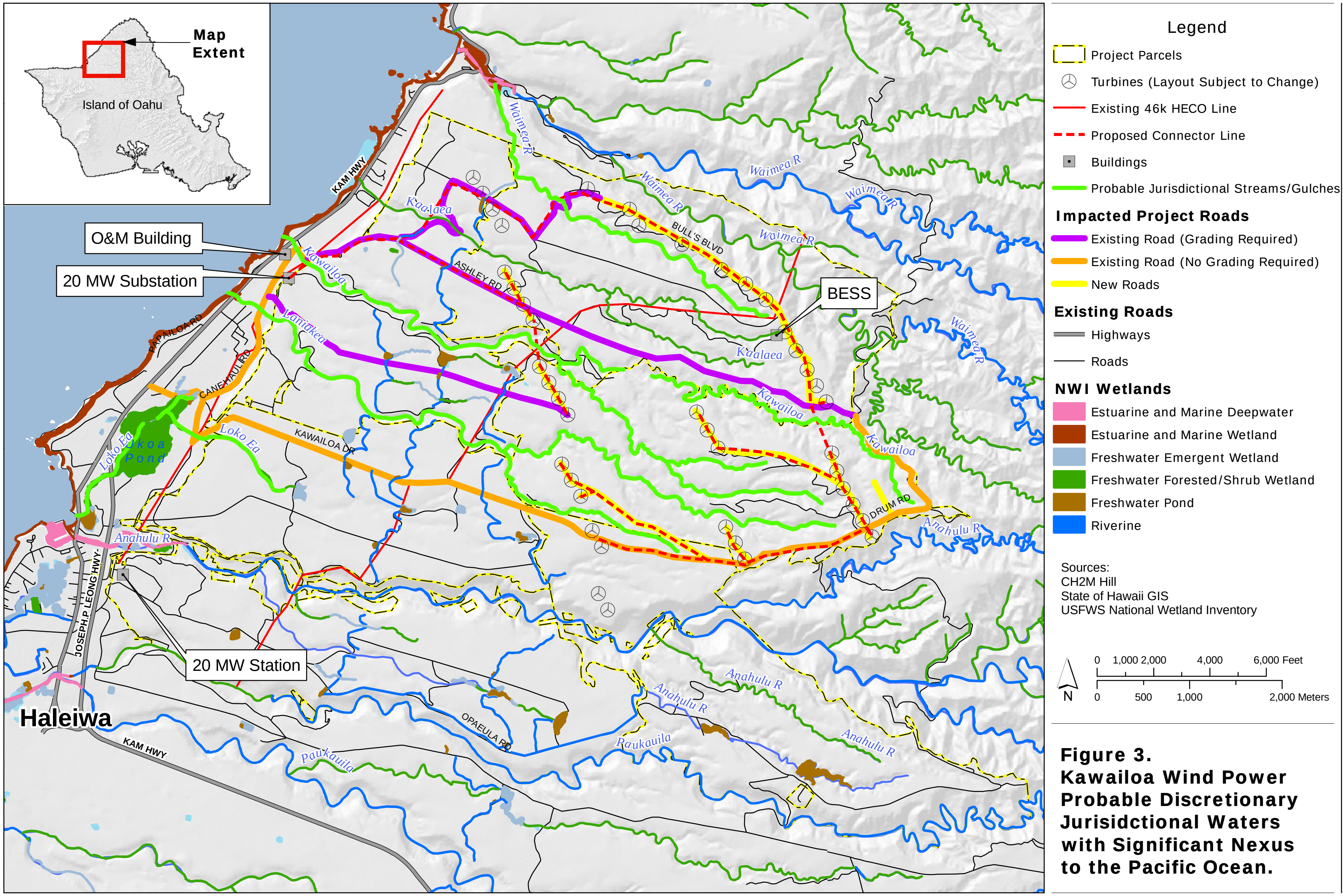


Figure 3.
Kawailoa Wind Power Probable Discretionary Jurisidctional Waters with Significant Nexus to the Pacific Ocean.

8.0 REFERENCES

CH2MHill. 2010. Environmental Impact Statement Preparation Notice, Kawailoa Wind Farm Project, Oahu, Hawaii. Prepared for First Wind, LLC.

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).

DBEDT (Department of Business, Economic Development, and Tourism). 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. 294p.

Fitzgerald, E.A. 2003. Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers: Isolated Waters, Migratory Birds, Statutory and Constitutional Interpretation.
Natural Resources Journal 43:11-76.

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.

General Accounting Office. 2004. Waters and Wetlands: Corps of Engineers Needs to Evaluate Its District Office Practices in Determining Jurisdiction. Report to the Chairman, Subcommittee on Energy Policy, Natural Resources and Regulatory Affairs, Committee on Government Reform, House of Representatives. GAO-04-297.

HDOA (Hawai'i Department of Agriculture). 1977. Agricultural Lands of Importance to the Islands of Hawai'i - Island of O'ahu. Available online at: http://hawaii.gov/dbedt/gis/alish.htm.

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.

Hobdy, R.W. 2010a. Biological Resources Survey for the Kawailoa Wind Farm, Kawailoa, Oahu, Hawaii. February 2010. Prepared for CH2M Hill.

Hobdy, R.W. 2010b. Biological Resources Survey for the Kawailoa Wind Farm, Cane Haul Road, Collection Line Route and O&M Building Site, Kawailoa, Oahu, Hawaii. August 2010. Prepared for CH2M Hill.

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

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.

Miller, J.N., Armann, SS., Chan-Hui, S.S.C. & Chiang, J. 1989. Ecologically sensitive wetlands on Oahu: groundwater protection strategy for Hawai'i. Environmental Center Water Resources Research Center, University of Hawaii at Manoa. Honolulu, Hawaii. 369p.

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 (National Oceanic and Atmospheric Administration). 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. 21p.

PIER (Pacific Island Ecosystems at Risk). 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).

Sahara, T., E.T. Murabayashi, A.Y. Ching, G.D. DeVight, Jr., F.N. Fujimura, E.L. Awai, L.S. Nishimoto, Jr., and H.L. Baker. 1972. Detailed Land Classification – Island of Oahu. Land Study Bureau, University of Hawaii, Honolulu. 314p.

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. 116p.

SWCA. 2008. Baseline Biological Survey of the Anahulu River and ʻOpaeʻula Stream, Oʻahu, Hawaiʻi. Prepared for The Kamehameha Schools Land Assets Division, Endowment Group.

SWCA, in prep. Kawailoa Wind Power Wildlife Monitoring Report and Fatality Estimates for Waterbirds and Bats (October 2009 – September 2010). CONFIDENTIAL DRAFT REPORT. Prepared for First Wind.

USACE (United States Army Corps of Engineers). 2009. DRAFT Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Hawaii and Pacific Islands Region.

USDA (U.S. Department of Agricultural) 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/site/ExtSL.aspx.

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.xls. .

USFWS (U.S. Fish and Wildlife Service). 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://library.fws.gov/Pubs9/wetlands_plantlist96.pdf.

USGS (U.S. Geological Service). 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. 1999. Manual of the flowering plants of Hawai‘i, Volumes I & II. Revised edition. University of Hawai‘i Press: Honolulu, HI.

Wagner, W.L. and D.R. Herbst. 2003. Supplement to the Manual of the Flowering Plants of Hawai‘i. Smithsonian Institute: Flora of the Hawaiian Islands. Available: http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/ManualSupplement3.pdf. Accessed July 2010.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: Thair / Ford / Taira	Date: 7-1-2010 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 : Opae Transect ID: Plot ID: 01

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Chloris barbata	H	FACU	9.		
2. ~~[illegible]~~			10.		
3. Emilia fosbergii	H	N/A	11.		
4. Boerhavia	H	N/A	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/3 = 0%.

Remarks: veg mostly dead or dying
non-dominant: Syzygium cumini, paspalum, Psidium cattleianum

HYDROLOGY

___ Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
____ Aerial Photographs
_X_ Other NWI
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: ________(in.)

Depth to Free Water in Pit: ________(in.)

Depth to Saturated Soil: ________(in.)

Wetland hydrology Indicators:
Primary Indicators:
_X_ 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"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks: NWI identified as "Freshwater pond" ~40×50m
This is a res. for adjacent ag. land

Pantalla flavescence, mud daubers, termites, tilapia (young + adults)
intake into res. from ditch along road

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: No pit or core

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FirstWind Investigator: TT/JF/RT	Date: 7-1-2010 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: Opae Transect ID: Plot ID: 02

Answers circled: Yes; No; No.

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. ~~[illegible]~~			9.		
2. Coccinia grandis	H	N/A	10.		
3. Paspalum conj.	H	FAC+	11.		
4. Emilia fosbergii	H	N/A	12.		
5. Leucaena leu	S	UPL	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 1/4 = 25%.

Remarks: non-dominant: Scaevola taccada

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: ________(in.)

Depth to Saturated Soil: ________(in.)

Wetland hydrology Indicators:
Primary Indicators:
X 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"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks: NWI - Freshwater Pond + Riverine. Actually reservoir + ditch
Corbicula fluminea, Bufo marinus, pantalla flavescense

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:
No pit or core

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: Kawailoa Applicant/Owner: First Wind Investigator: Thair / Ford / Taira	Date: 7-1-10 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: opae Transect ID: Plot ID: 03

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. leucaena leu	T	UPL	9.		
2. Urochloa max	H	FACU	10.		
3. Psidium gua	T	FACU	11.		
4. Falcat molu	T	N/A	12.		
5. Schinus tere	T	FACU-	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/5 = 0%

Remarks: Non-dominant = pluchea, Desmodium

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: ________(in.) Depth to Saturated Soil: ________(in.)	Wetland hydrology Indicators: Primary Indicators: ____ Inundated ____ Saturated in Upper 12 Inches Ø ____ Water Marks ____ Drift Lines ____ Sediment Deposits ____ Drainage Patterns in Wetlands Secondary Indicators (2 or more required): ____ Oxidized Root Channels in Upper 12" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)

Remarks: No wetland hydro indicators
Adjacent to Anahulu gulch

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: First Wind Investigator: TT / JF / RT	Date: 7-1-2010 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: Kawai Transect ID: Plot ID: K1

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max (90)	H	FACU	9.		
2. Leucaena leu (50)	T	UPL	10.		
3. Ficus micro (25)	T	N/A	11.		
4. Neonotonia wightii (15)	H	N/A	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/4 = 0%

Remarks: Others - Leonotis nepetifolia

HYDROLOGY

___ Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
X Other NWI
___ 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"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks: NWI - Freshwater Forested/Shrub Wetland
No water, no high water marks, rocks in bed
Culverts under roadway (easily blocked by ~~[illegible]~~ debris)

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/Contrast	Texture, Concretions, Structure, etc.
10	~~[illegible]~~	2.5YR3/4		~~0~~	Fine/medium

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

No stratification

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:

Dry Streambed

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FirstWind Investigator: TT / JF / RT	Date: 7-1-2010 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 : Ka Transect ID: Plot ID: K2

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max-90	H	FACU	9.		
2. Leucaena leu-30	T	UPL	10.		
3. Ficus micro-10	T	N/A	11.		
4. Syzygium cu-5	T	FACU	12.		
5. Neon wight-5	H	N/A	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/5 = 0%.

Remarks:

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs _X_ Other NWI ___ No Recorded Data Available	Wetland hydrology Indicators: Primary Indicators: ____ Inundated ____ Saturated in Upper 12 Inches ____ Water Marks ____ Drift Lines ____ Sediment Deposits _X_ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: 0 (in.) Depth to Free Water in Pit: ____(in.) Depth to Saturated Soil: ____(in.)	Secondary Indicators (2 or more required): ____ Oxidized Root Channels in Upper 12" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)

Remarks: NWI- Freshwater Forested Shrub/wetland
stream bed dry, culvert blocked by debris

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/Contrast	Texture, Concretions, Structure, etc.
8		2.5YR4/4	Sand	15%	Fine + Course

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:
Sandy + rocks
intermit. stream bed

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:
Dry streambed

Approved by HQUSACE 3/92

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: T. Thair / K. Talla	Date: 7-28-10 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 : KA Transect ID: Plot ID: K3

Circled answers: Yes; No; No.

VEGETATION

just makka of Banana & plumeria plantations

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. [illegible]			9.		
2. Chloris barbata	H	FACU	10.		
3. Amaranthus viridis	H	FAC*	11.		
4. Paspalum conj	H	FAC+	12.		
5. [illegible]			13.		
6. Eclipta prostrata	H	FACW	14.		
7. ipomoea obscura	H	N/A	15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 3/5 = 60%

Remarks: non-dominant – Chamaesyce hirta, Lagenaria siceraria, Emilia Fosbergii

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs _x_ Other NWI ___ No Recorded Data Available	Wetland hydrology Indicators: Primary Indicators: _x_ 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" ___ Water-Stained Leaves ___ Local Soil Survey Data ___ FAC-Neutral Test ___ Other (Explain in Remarks)
Field Observations: Depth of Surface Water: ________(in.) Depth to Free Water in Pit: ________(in.) Depth to Saturated Soil: ________(in.)	

Remarks: NWI – "Freshwater pond" + "Riverine"
Pantalla flavescense

Ditch / channel continues northeast toward Laniakea gulch and siphon (pipe) across gulch. water stagnant in channel

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: No pit or core

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: First Wind Investigator: T. Thair / R. Taira	Date: 7-8-10 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 : KA Transect ID: Plot ID: ~~K5~~ K4

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max	H	FACU	9.		
2. Chloris barb.	H	FACU	10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/2 = 0%

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"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks: NWI - Riverine
No surface H_2O

SOILS

Map Unit Name
(Series and Phase): ______________________

Drainage Class: ______________

Taxonomy (Subgroup): ______________________

Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks: No pit

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: Kawailoa Applicant/Owner: FW Investigator: Thair / Taira	Date: 7-8-10 County: Honolulu State: HI
Do Normal Circumstances Exist on the site? Yes No (Yes circled) Is the site significantly disturbed (Atypical Situation)? Yes No (No circled) Is the area a potential Problem Area? Yes No (No circled) (If needed, explain on reverse.)	Community ID: KA Transect ID: Plot ID: K5

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Emilia fosbergii	H	N/A	9.		
2. Sacciolepis indica	H	FAC+	10.		
3. Ludwigia octo.	H	OBL	11.		
4. Chloris barb.	H	FACU	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 2/4 = 50%

Remarks: Not much veg; berm looks newly formed

HYDROLOGY

___ Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
____ Aerial Photographs
X Other NWI
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: ________(in.)

Depth to Free Water in Pit: ________(in.)

Depth to Saturated Soil: ________(in.)

Wetland hydrology Indicators:
Primary Indicators:
X 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"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks: NWI - Riverine + Freshwater pond

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

No pit or core

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: First Wind Investigator: T. Thair/ R. Taira	Date: 7-8-2010 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: KA Transect ID: Plot ID: K6

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max	H	FACU	9.		
2. Leucaena leu	T	UPL	10.		
3. Bidens alba	H	N/A	11.		
4.			12.		
5.			13.		
6.			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	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" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)
Field Observations: Depth of Surface Water: Ø (in.) Depth to Free Water in Pit: ____ (in.) Depth to Saturated Soil: ____ (in.)	

Remarks: NWI - Riverine
No surface water

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

No pit

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: Tiff Thair / Ryan Taira	Date: 7-8-10 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: KA Transect ID: ___ Plot ID: K7

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max	H	FACU	9.		
2. Polygala panicu	H	FACU*	10.		
3. Setaria parviflora	H	N/A	11.		
4. Axonopus fissif.	H	FAC	12.		
5.			13.		
6. Plantago lance	H	FACU	14.		
7. Mimosa pudica	H	FACU	15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 1/6 = 16%

Remarks: Non-Dominant: Desmodium, Chamaecrista, Centella asiatica, Bidens alba

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: ________(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"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks: algal crust, H_2O stained leaves

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/Contrast	Texture, Concretions, Structure, etc.
7		10R 3/4	2.5YR 3/2	10%	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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:
Gray Rock @ bottom; very difficult to core & dig

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: Kawailoa	Date: 7-8-10
Applicant/Owner: FW	County: Honolulu
Investigator: Thair / Taira	State: HI
Do Normal Circumstances Exist on the site? **Yes** No	Community ID: KA
Is the site significantly disturbed (Atypical Situation)? Yes **No**	Transect ID:
Is the area a potential Problem Area? Yes **No**	Plot ID: K8
(If needed, explain on reverse.)	

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max 15	H	FACU	9.		
2. ~~[illegible]~~ Mimosa pudica 5	H	FACU	10.		
3. Acacia koa 2	T	N/A	11.		
4. Cyperus diff 2	H	OBL	12.		
5. Hyparr. rufa 20	H	N/A	13.		
6. Axonopus fiss 50	H	FAC	14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 2 / 6 = 33%

Remarks: Non-Dominant: guava, Paygala

HYDROLOGY

___ Recorded Data (Describe in Remarks):
- ____ Stream, Lake, or Tide Gauge
- ____ Aerial Photographs
- ____ Other

___ No Recorded Data Available

Field Observations:

Depth of Surface Water: 1 (in.)

Depth to Free Water in Pit: ____ (in.)

Depth to Saturated Soil: ____ (in.)

Wetland hydrology Indicators:

Primary Indicators:
- X 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"
- ____ Water-Stained Leaves
- ____ Local Soil Survey Data
- ____ FAC-Neutral Test
- ____ Other (Explain in Remarks)

Remarks: only wet in 3x3m area - rained throughout night & morning
algal mat

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/Contrast	Texture, Concretions, Structure, etc.
12		2.5YR 3/3	Ø		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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: TT / JF / RT	Date: 7-1-2010 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 : Cane Transect ID: Plot ID: C1

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Leucaena leu (50)	T	UPL	9.		
2. Neon wightii (25)	H	N/A	10.		
3. Urochloa max (50)	H	FACU	11.		
4. Schinus ter (20)	T	FACU-	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/4 = 0%

Remarks:

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs ____ Other ___ No Recorded Data Available	Wetland hydrology Indicators: Primary Indicators: ____ Inundated ____ Saturated in Upper 12 Inches ____ Water Marks X Drift Lines ____ Sediment Deposits X Drainage Patterns in Wetlands Secondary Indicators (2 or more required): ____ Oxidized Root Channels in Upper 12" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)
Field Observations: Depth of Surface Water: ~~6~~ (in.) Depth to Free Water in Pit: ____ (in.) Depth to Saturated Soil: ____ (in.)	

Remarks: NWI - Freshwater Forested / Shrub wetland
Erosion marks, rocks in bed
USGS Quad identifies as Kawailoa St. / gulch

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:
No pit or cove

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:
Dry Stream Bed

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: TT/ JF/ RT	Date: 7-1-2010 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 : Cane Transect ID: Plot ID: C2

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Leucaena leu	T	UPL	9.		
2. Urochloa max	H	FACU	10.		
3. Syzygium cu	T	FACU	11.		
4. Clusia rosea	T	NI	12.		
5. Neonot wightii	H	N/A	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/5 = 0%

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
X Drainage Patterns in Wetlands
Secondary Indicators (2 or more required):
____ Oxidized Root Channels in Upper 12"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks: No culvert visible at rd crossing; poorly defined channel/ urochloa max knocked ↓ but everything heavily overgrown

NWI - Freshwater Forest/Shrub wetland
USGS quad identified as Laniakea stream/gulch

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: No pit or core

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: T. Thair / J. Ford	Date: 9-23-2010 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: midline Transect ID: Plot ID: M1

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Ipomoea obscura	H	N/A	9.		
2. Sporobolus africanus	H	N/A	10.		
3. Eleusine indica	H	FACU-	11.		
4. Eclipta prostrata	H	FACW	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 1/4 = 25%

Remarks: Non-dom: Emilia fosbergii, Papaya, Chamaesyce hyper, Chamaesyce prost, Cyperus difformis, Portulaca, Amaranthus spinosus, Ciclosperum leptophyllum

HYDROLOGY

___ Recorded Data (Describe in Remarks):
- ___ Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- X Other NWI

___ No Recorded Data Available

Field Observations:

Depth of Surface Water: ______(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"
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ___ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks: Reservoir w/ water. Ditch under road flowing from Kawailoa Road (south) to reservoir.

NWI - Freshwater pond & riverine

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

No pit or cone

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: Kawailoa Applicant/Owner: FW Investigator: T. Thair / J. Ford	Date: 9-23-2010 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 : midline Transect ID: ____ Plot ID: M2

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Chloris barbata	H	FACU	9.		
2. Eleusine indica	H	FACU	10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0%

Remarks: moss along water's edge
Non-dominant = Boerhavia, dead Asteraceae

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs _X_ Other NWI ___ No Recorded Data Available	Wetland hydrology Indicators: Primary Indicators: ____ Inundated ____ Saturated in Upper 12 Inches ____ Water Marks ____ Drift Lines ____ Sediment Deposits ____ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: unknown (in.) Depth to Free Water in Pit: ____ (in.) Depth to Saturated Soil: ____ (in.)	Secondary Indicators (2 or more required): ____ Oxidized Root Channels in Upper 12" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)

Remarks: Adjacent to 2 reservoirs. One large to north & smaller to south. Ditch system along road leading into reservoir filled w/ water. NWI - Freshwater pond, Freshwater emergent wetland, Riverine

Corbicula & Tilapia in ditch system

SOILS

Map Unit Name
(Series and Phase): ______________________ Drainage Class: ____________
Field Observations
Taxonomy (Subgroup): ______________________ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

No pit or core was taken.

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: Kawailoa Applicant/Owner: FW Investigator: T. Thair / J. Ford	Date: 9-23-2010 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 : midline Transect ID: Plot ID: m3

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Ipomoea obscura	H	N/A	9.		
2. Cicلospermum lepto.	H	NI	10.		
3. ~~[illegible]~~			11.		
4. Eleusine indica	H	FACU-	12.		
5. Urochloa max.	H	FACU	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0%.

Remarks: Non-dom: albizia seedlings, clusia seedlings

HYDROLOGY

___ Recorded Data (Describe in Remarks): ___ Stream, Lake, or Tide Gauge ___ Aerial Photographs X Other NWI - Riverine ___ No Recorded Data Available	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" ___ Water-Stained Leaves ___ Local Soil Survey Data ___ FAC-Neutral Test ___ Other (Explain in Remarks)
Field Observations: Depth of Surface Water: Ø (in.) Depth to Free Water in Pit: ___ (in.) Depth to Saturated Soil: ___ (in.)	

Remarks: Ditch under road - no water; culvert full of silt
corbicula present

m2 & m1 do not connect - Guinea grass overgrown

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:
No pit or core

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: Thair / Taira	Date: 7-9-10 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 : ASH Transect ID: Plot ID: A1

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Clusia rosea	T	NI	9.		
2. Ficus micro	T	N/A	10.		
3. Urochloa max	H	FACU	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/3 = 0%

Remarks:

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs _X_ Other NWI ___ 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" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)

Remarks: Rocks have moss, but no indication of recent water. Depression. Potentially filled in many years ago.

NWI identified as "Freshwater Forested / shrub wetland"

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/Contrast	Texture, Concretions, Structure, etc.
12		10 R 3/4	Ø		

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

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: Kawailoa Applicant/Owner: First Wind Investigator: Thair / Taira	Date: 7-9-2010 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: ASH Transect ID: Plot ID: A2

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Ipomoea triloba	H	N/A	9.		
2. Chloris barbata	H	FACU	10.		
3. Chamaesy. hirta	H	FACU	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/3 = 0%.

Remarks: No much vegetation

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs ____ Other ___ No Recorded Data Available	Wetland hydrology Indicators: Primary Indicators: ____ Inundated ____ Saturated in Upper 12 Inches ____ Water Marks ____ Drift Lines ____ Sediment Deposits ____ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: ________(in.) Depth to Free Water in Pit: ________(in.) Depth to Saturated Soil: ________(in.)	Secondary Indicators (2 or more required): ____ Oxidized Root Channels in Upper 12" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)

Remarks: NWI identify as "Freshwater Pond" & "Riverine". This is actually a reserVoir w/ dry ditch.

No H_2O on other side of road; channel filled in
Both sides of road already filled

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/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:
No core or pit

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: Thair / Taira	Date: 7-9-10 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 : ASH Transect ID: Plot ID: A3

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Pennisetum purp	H	FACU	9.		
2. Falca molu	T	N/A	10.		
3. Schinus tere	T	FACU-	11.		
4. Leuc leuc	T	UPL	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/4 = 0%

Remarks: Non-dominant = Clidemia hirta, ficus sp., Pluchea

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"
 ____ Water-Stained Leaves
 ____ Local Soil Survey Data
 ____ FAC-Neutral Test
 ____ Other (Explain in Remarks)

Remarks:

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/Contrast	Texture, Concretions, Structure, etc.
12		10R3/3	~~0~~		

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Wind Power Applicant/Owner: First Wind Investigator: Thair / Taira	Date: 9-23-2010 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 : AGH Transect ID: Plot ID: A4

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max	H	FACU	9.		
2. Syzygium cum	T	FACU	10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/2 = 0%.

Remarks: mostly Uro max in old res.

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs ____ Other ___ No Recorded Data Available	Wetland hydrology Indicators: Primary Indicators: ____ Inundated ____ Saturated in Upper 12 Inches ____ Water Marks ____ Drift Lines ____ Sediment Deposits ____ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: Ø (in.) Depth to Free Water in Pit: ____(in.) Depth to Saturated Soil: ____(in.)	Secondary Indicators (2 or more required): ____ Oxidized Root Channels in Upper 12" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)

Remarks: NWI identified "Freshwater Pond", "Riverine," & "Freshwater Emergent wetland". No water in reservoir & completely choked w/grass. Channel filled in toward south & culvert on northern side of road completely overgrown w/ grass.

SOILS

Map Unit Name
(Series and Phase): ____________________ Drainage Class: ____________
Field Observations
Taxonomy (Subgroup): ____________________ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks: No soil pit or core

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: Kawailoa Applicant/Owner: First Wind Investigator: Thair / Taira	Date: 9-23-2010 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 : ASH Transect ID: Plot ID: A5

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. urochloa max	H	FACU	9.		
2. schinus ter	T	FACU-	10.		
3. Syzygium cum	T	FACU	11.		
4. Aleurites molu	T	NI	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/4 = 0%.

Remarks:

HYDROLOGY

___ Recorded Data (Describe in Remarks): ____ Stream, Lake, or Tide Gauge ____ Aerial Photographs ____ Other ___ No Recorded Data Available	Wetland hydrology Indicators: Primary Indicators: ____ Inundated ____ Saturated in Upper 12 Inches ____ Water Marks ____ Drift Lines ____ Sediment Deposits ____ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: ________(in.) Depth to Free Water in Pit: ________(in.) Depth to Saturated Soil: ________(in.)	Secondary Indicators (2 or more required): ____ Oxidized Root Channels in Upper 12" ____ Water-Stained Leaves ____ Local Soil Survey Data ____ FAC-Neutral Test ____ Other (Explain in Remarks)

Remarks: crosses USGS identified Kaala-ea gulch.
NWI identified as "Freshwater Forested/Shrub wetland"
Large culvert under road

SOILS

Map Unit Name
(Series and Phase): ______________________________

Drainage Class: ______________

Taxonomy (Subgroup): ______________________________

Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.

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 Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks: No pit or core

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:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Kawailoa Applicant/Owner: FW Investigator: Thair / Ford	Date: 9-23-2010 County: Honolulu State: HI
Do Normal Circumstances Exist on the site? Yes (circled) No Is the site significantly disturbed (Atypical Situation)? Yes No (circled) Is the area a potential Problem Area? Yes No (circled) (If needed, explain on reverse.)	Community ID : Ashley Transect ID: Plot ID: A10

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa mutica	H	FACW	9.		
2. Falcat molu	T	N/A	10.		
3. ~~[illegible]~~	~~[illegible]~~		11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 50%

Remarks: Non-dominant = Buddleia, melaleuca, Schinus terebinthifolius, Urochloa maxima

HYDROLOGY

___ Recorded Data (Describe in Remarks):
- ____ Stream, Lake, or Tide Gauge
- ____ Aerial Photographs
- X Other NWI

___ No Recorded Data Available

Field Observations:

Depth of Surface Water: Ø (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"
- ____ Water-Stained Leaves
- ____ Local Soil Survey Data
- ____ FAC-Neutral Test
- ____ Other (Explain in Remarks)

Remarks: previous reservoir. Adjacent to pumphouse for irrigation. Pipes and waterline leading into depression

NWI - Freshwater emergent wetland & Freshwater pond.

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/Contrast	Texture, Concretions, Structure, etc.
18 in.		2.5 YR 3/4			

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: Sample retrieved by hand under thick mat of California grass.
dry & deeply cracked

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: Kawailoa Applicant/Owner: FW Investigator: Thair / Taira	Date: 7-9-10 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: Bull Transect ID: Plot ID: B1

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Falc molu	T	N/A	9.		
2. Urochloa max	H	FACU	10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/2 = 0%

Remarks: Non-dominant:
Clidemia hirta

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"
____ Water-Stained Leaves
____ Local Soil Survey Data
____ FAC-Neutral Test
____ Other (Explain in Remarks)

Remarks:

Peacock

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/Contrast	Texture, Concretions, Structure, etc.
12		10R 3/4	Ø		

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 Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

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: Kawailoa Applicant/Owner: FW Investigator: Thair / Taira	Date: 7-9-2010 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 : BWII Transect ID: Plot ID: B2

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Urochloa max.	H	FACU	9.		
2. Schinus tere.	T	FACU-	10.		
3. Psidium cattle.	T	FACU	11.		
4. Aleurites molu.	T	NI	12.		
5. Syzygium cum.	T	FACU	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 0/5 = 0%.

Remarks: Urochloa mutica (OBL) immediately adjacent to road but completely overgrown so no signs of recent flow.

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: ________(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"
 ____ Water-Stained Leaves
 ____ Local Soil Survey Data
 ____ FAC-Neutral Test
 ____ Other (Explain in Remarks)

Remarks: Areas devoid of vegetation due to pig disturbance & trails; not really defined stream channel; water stained leaves.

NWI - Freshwater Forested/Shrub Wetland

SOILS

Map Unit Name
(Series and Phase): ______________________ Drainage Class: ______________

Field Observations

Taxonomy (Subgroup): ______________________ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
13		2.5YR3/3			

Hydric Soil Indicators:

___ Histosol
___ Histic Epipedon
___ Sulfidic Odor
___ Aquic Moisture Regime
___ Reducing Conditions
___ Gleyed or Low-Chroma Colors
___ Concretions
___ High Organic Content in Surfa ce Layer Sandy Soils
___ Organic Streaking in Sandy Soils
___ Listed on Local Hydric Soils List
___ Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks: Rock & Kukui shells in sides of pit.

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: may be a problem if need to improve road.
Likely jurisdictional due to sig. nex. to Waimea

Approved by HQUSACE 3/92

APPENDIX B: LIST OF VEGETATION FOUND WITHIN THE KAWAILOA WIND POWER PROJECT PARCELS

The following checklist is an inventory of all the plant species observed by Robert Hobdy (2010a and 2010b) and SWCA biologists at the proposed Kawailoa Wind Power project area, O‘ahu, Hawai‘i. The plant names are arranged alphabetically by family and then by species into four groups: Ferns and Fern Allies, Gymnosperms, Monocots, and Dicots. The taxonomy and nomenclature of the flowering plants are in accordance with Wagner et al. (1999), Wagner and Herbst (2003), and Staples and Herbst (2005). Recent name changes are those recorded in the Hawaii Biological Survey series (Evenhuis and Eldredge, eds., 1999-2002). Fern taxonomy and nomenclature follows Palmer (2003). Species not recorded by Hobdy, but observed by SWCA between July and September 2010, are identified with two asterisks (**).

Wetland Indicator:

OBL =	Obligate Wetland Species
FACW =	Facultative Wetland Species
FAC =	Facultative Species
FACU =	Facultative Upland Species
UPL =	Upland Species
NI =	No Indicator Status
N/A =	Not Listed

Status:

E = endemic	= Native only to the Hawaiian Islands.
I = indigenous	= Native to the Hawaiian Islands and elsewhere.
P = Polynesian	= Introduced by Polynesians.
X =introduced/ alien/non-native	= All those plants brought to the Hawaiian Islands by humans, intentionally or accidentally, after Western contact (Cook’s arrival in the islands in 1778).

Taxa	Hawaiian, Common name(s)	Wetland Indicator	Status
FERNS AND FERN ALLIES			
BLECHNACEAE (Chain Fern Family)			
Blechnum appendiculatum Willd.	palm fern	N/A	X
DENNSTAEDTIACEAE (Bracken Fern Family)			
Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) R.M.Tryon	kilau, bracken fern	N/A	E

Taxa	**Hawaiian, Common name(s)**	**Wetland Indicator**	**Status**
DICKSONIACEAE (Dicksonia Family)			
Cibotium chamissoi Kaulf.	hapu'u	N/A	E
GLEICHENIACEAE (False Staghorn Fern Family)			
Dicranopteris linearis (Burm.f.) Underw.	uluhe	N/A	I
LINDSAEACEAE (Lindsaea Fern Family)			
Sphenomeris chinensis (L.) Maxon	pala'a	N/A	I
NEPHROLEPIDACEAE (Sword Fern Family)			
Nephrolepis brownii (Desv.) Hovencamp & Miyam.	Asian sword fern	N/A	X
Nephrolepis exaltata (L.) Schott	ni'ani'au	N/A	I
POLYPODIACEAE (Polypody Fern Family)			
Lepisorus thunbergianus (Kaulf.) Ching	pākahakaha	N/A	I
Phlebodium aureum (L.) J. Sm.	rabbit's foot fern	N/A	X
Phymatosorus grossus (Langsdon&Fisch.) Brownlie	laua'e	N/A	X
PSILOTACEAE (Whisk Fern Family)			
Adiantum hispidulum Sw.	rough maidenhair fern	N/A	X
Psilotum nudum (L.) P. Beauv.	moa	N/A	I
PTERIDACEAE (Brake Fern Family)			
Pityrogramma calomelanos (L.) Link	silver fern	N/A	X
THELYPTERIDACEAE (Marsh Fern Family)			
Christella dentata (Forssk.) Brownsey & Jermy		N/A	X
Christella parasitica (L.) H. Lev.		N/A	X
GYMNOSPERMS			
ARAUCARIACEAE (Araucaria Family)			
Agathis robusta (F.Mueller) F.M. Bailey	Queensland kauri	N/A	X
Araucaria columnaris (G. Forster) J.D. Hooker	Cook pine	N/A	X
MONOCOTS			
AMARYLLIDACEAE (Amaryllis Family)			
Hippeastrum striatum (Lam.) H.E. Moore	amaryllis	N/A	X
ARECACEAE (Palm Family)			
Cocos nucifera L.	niu	FACU	P

Taxa	**Hawaiian, Common name(s)**	**Wetland Indicator**	**Status**
Phoenix x *dactylifera*	phoenix hybrid	N/A	X
Washingtonia robusta H. Wendl.	hybrid date palm	N/A	X
ASPARAGACEAE (Asparagus Family)			
Cordyline fruticosa (L.) A. Chev.	kī, ti leaf	N/A	P
Pleomele halapepe St. John	halapepe	N/A	E
Sanseviera trifasciata Prain	sanseviera	N/A	X
COMMELINACEAE (Spiderwort Family)			
Commelina diffusa N.L. Burm.	honohono	FACW	X
CYPERACEAE (Sedge Family)			
Carex meyenii Nees		N/A	I
Carex wahuensis C.A. Meyen		N/A	E
Cyperus difformis L.		OBL	X
Cyperus polystachyos Rottb.		FAC*	I
Cyperus rotundus L.	nut sedge	FACU	X
Kyllingia brevifolia Rottb.	kili'o'opu	FAC	X
ORCHIDACEAE (Orchid Family)			
Phaius tankarvilleae (Banks ex L'Her) Blume	nun's orchid	FACU	X
Spathoglottis plicata Blume	Phillipine ground orchid	FACU	X
PANDANACEAE (Screwpine Family)			
Freycinetia arborea Gaud.	'ie'ie	FACU	I
POACEAE (Grass Family)			
Andropogon virginicus L.	broomsedge	FACU	X
Axonopus compressus (S.W.) P. Beauv.	broad-leaved carpetgrass	N/A	X
Axonopus fissifolius (Raddi) Kuhlm.	narrow-leaved carpetgrass	FAC	X
Chloris barbata (L.) Sw.	swollen fingergrass	FACU	X
Chloris radiata (L.) Sw.	plush grass	FACU	X
Chrysopogon aciculatus (Retz.) Trin.	pili pili ula	N/A	X
Cynodon dactylon (L.) Pers.	Bermuda grass	FACU	X
Digitaria insularis (L.) Mez ex Ekman	sourgrass	FAC	X
Eleusine indica (L.) Gaertn.	wiregrass	FACU-	X

Taxa	**Hawaiian, Common name(s)**	**Wetland Indicator**	**Status**
Eragrostis sp. **			X
Hyparrhenia rufa (Nees) Stapf	thatching grass	N/A	X
Melinis minutiflora P. Beauv.	molasses grass	NI	X
Oplismenus hirtellus (L.) P.Beauv.	basketgrass	FACU	X
Panicum sp.			X
Paspalum conjugatum Bergius	Hilo grass	FAC+	X
Paspalum dilatatum Poir.	Dallis grass	FACU	X
Paspalum fimbriatum Kunth	Panama grass	FAC	X
Paspalum scrobiculatum L.	ricegrass	FAC*	X
Paspalum urvillei Steud.	Vasey grass	FAC	X
Pennisetum polystachion (L.) Schult.	feathery pennisetum	N/A	X
Pennisetum purpureum Schumach.	Napier grass	FACU	X
Saccharum officinarum L.	sugar cane	FACU	P
Sacciolepis indica (L.) Chase	Glenwood grass	FAC+	X
Setaria palmifolia (J. Konig) Stapf	palmgrass	FACU	X
Setaria parviflora (Poir.) Kerguelen	yellow foxtail	N/A	X
Sporobolus africanus (Poir.) Robyns & Tournay	smutgrass	N/A	X
Urochloa maxima (Jacq.) R. Webster	Guinea grass	FACU	X
Urochloa mutica (Forssk.) T.Q. Nguyen	California grass	FACW	X
<u>ZINGIBERACEAE (Ginger Family)</u>			
Alpinia zerumbet (Pers.) B.L. Burtt & R.M. Smith	shell ginger	N/A	X
DICOTS			
<u>ACANTHACEAE (Acanthus Family)</u>			
Asystasia gangetica (L.) T.Anderson	Chinese violet	N/A	X
Barleria lupulina Lindl.	hophead	N/A	X
Justicia betonica L.	white shrimp plant	N/A	X
<u>AMARANTHACEAE (Amaranth Family)</u>			
Alternanthera pungens Kunth	Khaki weed	N/A	X
Amaranthus spinosus L.	spiny amaranth	FACU-	X

Taxa	**Hawaiian, Common name(s)**	**Wetland Indicator**	**Status**
Amaranthus viridis L.	slender amaranth	FAC*	X
ANACARDIACEAE (Mango Family)			
Mangifera indica L.	mango	FACU	X
Schinus terebinthifolius Raddi	Christmas berry	FACU-	X
APIACEAE (Parsley Family)			
Centella asiatica (L.) Urb.	Asiatic pennywort	FAC	X
Ciclospermum leptophyllum (Pers.)	Sprague fir-leaved celery	NI	X
APOCYNACEAE (Dogbane Family)			
Alstonia sp.		N/A	X
ARALIACEAE (Ginseng Family)			
Shefflera actinophylla (Endl.) Harms	octopus tree	UPL	X
ASTERACEAE (Sunflower Family)			
Acanthospermum australe (Loefl.) Kuntze	spiny bur	N/A	X
Ageratum conyzoides L.	maile hohono	FAC*	X
Bidens alba (L.) DC	Spanish needle	N/A	X
Bidens sandvicensis Less	ko'oko'olau	N/A	E
Conyza bonariensis (L.) Cronq.	hairy horseweed	N/A	X
Crassocephalum crepidioides (Benth.)S.Moore	redflower ragleaf	FAC	X
Cyanthillium cinereum (L.) H. Rob.	little ironweed	N/A	X
Eclipta prostrata (L.) L.	false daisy	FACW	X
Emilia fosbergii Nicolson	red pualele	N/A	X
Emilia sonchifolia (L.) DC.	violet pualele	N/A	X
Gamochaeta purpurea (L.) Cabrera	purple cudweed	UPL	X
Pluchea carolinensis (Jacq.) G.Don	sourbush	FAC*	X
Sonchus oleraceus L.	pualele	FACU	X
Verbesina encelioides (Cav.) Benth. & Hook.	golden crown-beard	FACU-	X
BASELLACEAE (Basella Family)			
Anredera cordifolia (Ten.) Steenis	Madeira vine	N/A	X
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P. Beauv.	African tulip tree	NI	X

Taxa	**Hawaiian, Common name(s)**	**Wetland Indicator**	**Status**
BORAGINACEAE (Borage Family)			
Heliotropium procumbens Mill.	fourspike heliotrope	NI	X
BRASSICACEAE (Mustard Family)			
Lepidium virginicum L.	pepperwort	UPL	X
Rorippa sarmentosa (J. Forst. ex DC.) J.F. Macbr	pa'ihi	FACW+	P
CACTACEAE (Cactus Family)			
Hylocereus undatus (Haw.) Britton & Rose	night-blooming cereus	N/A	X
CANNABACEAE (Hemp Family)			
Trema orientalis (L.) Blume	gunpowder tree	N/A	X
CARICACEAE (Papaya Family)			
Carica papaya L.	papaya	N/A	X
CASUARINACEAE (She-oak Family)			
Casuarina glauca Sieber ex Spreng.	longleaf ironwood	NI	X
Casuarina equisetifolia L.	common ironwood	FACU	X
CLUSICACEAE (Mangosteen Family)			
Clusia rosea Jacq.	autograph tree	NI	X
CONVOLVULACEAE (Morning Glory Family)			
Ipomoea obscura (L.) Ker-Gawl.		N/A	X
Ipomoea triloba L.	little bell	N/A	X
Merremia tuberosa (L.) Rendle	wood rose	N/A	X
CUCURBITACEAE (Gourd Family)			
Coccinia grandis (L.) Voigt	ivy gourd	N/A	X
Cucumis dipsaceus Ehrenb. ex Spach	hedgehog gourd	N/A	X
Lagenaria siceraria (Molina) Standley	long squash	N/A	X
Momordica charantia L.	balsam pear	FAC*	X
EBENACEAE (Ebony Family)			
Diospyros sandwicensis (A.DC.) Fosb.	lama	N/A	E
ERICACEAE (Heath Family)			
Leptecophylla tameiameiae (Cham.&Schlect.) C.M. Weiller	pukiawe	FACU*	I
EUPHORBIACEAE (Spurge Family)			

Taxa	**Hawaiian, Common name(s)**	**Wetland Indicator**	**Status**
Aleurites moluccana (L.) Willd.	kukui	NI	P
Chamaesyce hirta (L.) Millsp.	hairy spurge	FACU	X
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	FACU	X
Chamaesyce prostrata (Aiton) Small	prostrate spurge	NI	X
Codiaeum variegatum (L.) Blume	croton	N/A	X
Phyllanthus debilis Klein ex Willd.	niruri	N/A	X
Ricinus communis L.	castor bean	FACU-	X
FABACEAE (Pea Family)			
Acacia confusa Merr.	Formosa koa	N/A	X
Acacia farnisiana (L.) Willd.	klu	N/A	X
Acacia koa A. Gray	koa	N/A	E
Arachis glabrata Bentham	rhizoma peanut	N/A	X
Bauhinia variegata L.	orchid tree	N/A	X
Calliandra surinamensis Benthan	powderpuff	N/A	X
Canavalia cathartica Thouars	maunaloa	FACU	X
Chamaecrista nictitans (L.) Moench	partridge pea	NI	X
Crotalaria incana L.	fuzzy rattlepod	UPL	X
Crotalaria pallida Aiton	smooth rattlepod	N/A	X
Desmanthus pernambucanus (L.) Thellung	slender mimosa	FACU*	X
Desmodium incanum DC.	Spanish clover	NI	X
*Desmodium sandwicens*e E. Mey.	Spanish or chili clover	FACU*	X
Desmodium triflorum (L.) DC.	three-flowered beggarweed	FACU*	X
Falcataria moluccana (Miq.) Barneby & Grimes	albizia	N/A	X
Indigofera hendcaphylla Jacq.	creeping indigo	N/A	X
Indigofera suffruticosa Mill.	inikö	UPL	X
Leucaena leucocephala (Lam.) de Wit	koa haole	UPL	X
Macroptilium lathyroides (L.) Urb.	wild bean	UPL	X
*Medicago lupulin*a L.	black medic	UPL	X
Medicago polymorpha L.	bur clover	NI	X
Mimosa pudica L.	sensitive plant	FACU	X

Taxa	Hawaiian, Common name(s)	Wetland Indicator	Status
Neonotonia wightii (Wight & Arnott) Lackey	glycine n	N/A	X
Parkia timoriana (A.P. de Candolle) Merrill	drumstick tree	N/A	X
Peltophorum pterocarpum (A.P. de Candolle) K. Heyne	yellow poinciana	N/A	X
Pithecellobium dulce (Roxb.) Benth.	opiuma	N/A	X
Prosopis pallida (Humb. & Bonpl. ex Willd) Kunth	kiawe	FACU-	X
Samanea saman (Jacq.) Merr.	monkeypod	N/A	X
Senna surattensis (N.L.Burm.) H.Irwin & Barneby	kolomona	UPL	X
Stylosanthes fruticosa (Retz.) Alston	shrubby pencilflower	N/A	X
Vigna marina (J. Burm.) Merr.	nanea	FACU	I
GOODENIACEAE (Goodenia Family)			
Scaevola taccada (Gaertn.) Thieret & B. Lipscomb **	beach naupaka	N/A	I
Scaevola gaudichaudiana Cham.	naupaka kuahiwi	N/A	E
GROSSULARIACEAE (Gooseberry Family)			
Brexia madagascariensis (Lamarck) Ker Gawler	brexia	N/A	X
LAMIACEAE (Mint Family)			
Hyptis pectinata (L.) Poit.	comb hyptis	NI	X
Leonotis nepetifolia (L.) R. Br.	lion's ear	NI	X
Salvia officinalis L.	garden sage		X
LAURACEAE (Laurel Family)			
Cassytha filiformis L.	kauna'oa pehu	FACU	I
Cinnamomum burmanni (Nees) Blume	Padang cassia	N/A	X
Persea americana Mill.	avocado	N/A	X
LYTHRACEAE (Loosestrife Family)			
Cuphea carthagenensis (Jacq.) Macbr.	tarweed	FAC	X
MALVACEAE (Mallow Family)			
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	N/A	X
Malva parviflora L.	cheese weed	N/A	X
Malvastrum coromandelianum (L.) Garckey	false mallow	FACU	X
Melochia umbellata (Houtt.) Stapf	hierba del soldado	N/A	X
Sida ciliaris L.	red 'ilima	N/A	X

Taxa	Hawaiian, Common name(s)	Wetland Indicator	Status
Sida cordifolia L.	heart-leaves sida	N/A	X
Sida rhombifolia L.	Cuban jute	FACU	X
Sida spinosa L.	prickly sida	NI	X
Triumfetta semitriloba Jacq.	Sacramento bur	UPL	X
Waltheria indica L.	ʽuhaloa	N/A	I
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D.Don	Koster's curse	FACU	X
Pterolepis glomerata (Rottb.) Miq.	false meadow beauty	FAC	X
MELIACEAE (Mahogany Family)			
Melia azedarach L.	pride-of-India	N/A	X
Toona ciliata M. Roem	Australian red-cedar	N/A	X
MENISPERMACEAE (Moonseed Family)			
Cocculus orbiculatus (L.) DC.	huehue	N/A	I
MORACEAE (Fig Family)			
Broussonetia luzonica (Blanco) Bureau	alokon, Phillipine spinach	N/A	X
Ficus microcarpa L.	Chinese banyan	N/A	X
Ficus platypoda (A.Cunn.ex Miq.)A.Cunn.ex Miq.	rock fig	N/A	X
Ficus religiosa L.	Bo tree	N/A	X
Ficus sp.			X
MYRTACEAE (Myrtle Family)			
Corymbia citriodora (Hook.) K.D. Hill & L.A.S.Johnson	lemon gum	N/A	X
Eucalyptus robusta Sm.	swamp mahogany	FACU	X
Eucalyptus rudis Endl.	desert gum	FACU*	X
Melaleuca quinquenervia (Cav.) S.T.Blake	paperbark	FACU	X
Metrosideros polymorpha Gaud. var. *polymorpha*	ʽōhiʽa	FAC-	E
Psidium cattleianum Sabine	strawberry guava	FACU	X
Psidium guajava L.	common guava	FACU	X
Syzygium cumini (L.) Skeels	Java plum	FACU	X
Syzygium jambos (L.) Alston	rose apple	FAC	X
NYCTAGINACEAE (Four-o'clock Family)			

Taxa	Hawaiian, Common name(s)	Wetland Indicator	Status
Boerhavia coccinea Mill.	scarlet spiderling	N/A	X
Bougainvillea spectabilis Willd.	bougainvillea	N/A	X
OLEACEAE (Olive Family)			
Nestegis sandwicensis (A. Gray) Degener, I.Degener & L. Johnson	olopua	N/A	E
ONAGRACEAE (Evening Primrose Family)			
Ludwigia octovalvis (Jacq.) Raven	primrose willow	OBL	X
OXALIDACEAE (Wood Sorrel Family)			
Oxalis corniculata L.	yellow wood sorrel	FACU	P
PASSIFLORACEAE (Passion Flower Family)			
Passiflora edulis Sims	passion fruit	UPL	X
Passiflora suberosa L.	cork-bark passion flower	N/A	X
Passiflora subpeltata Ort.	white passion flower	N/A	X
PHYTOLACCACEAE (Pokeweed Family)			
Rivina humilis L.	coral berry	NI	X
PLANTAGINACEAE (Plantain Family)			
Plantago lanceolata L.	narrow-leaved plantain	FACU	X
POLYGALACEAE (Milkwort Family)			
Polygala paniculata L.	polygala	FACU*	X
PORTULACACEAE (Purslane Family)			
Portulaca pilosa L.		FACU-	X
PRIMULACEAE (Primrose Family)			
Angallis arvensis L.	scarlet pimpernel	N/A	X
PROTEACEAE (Protea Family)			
Grevillea robusta A.Cunn.ex R.Br.	silk oak	N/A	X
ROSACEAE (Rose Family)			
Osteomeles anthyllidifolia (Sm.) Lindl.	‘ūlei	N/A	I
Rubus rosifolius Sm.	thimbleberry	FAC-	X
RUBIACEAE (Coffee Family)			
Coffea arabica L.	Arabian coffee	N/A	X
Morinda citrifolia L.	noni	NI	P

Taxa	Hawaiian, Common name(s)	Wetland Indicator	Status
Posoqueria latifolia (Rudge) J. Roemer & J.A. Schultes	tree jasmine	N/A	X
Psychotria mariniana (Cham.& Schlectend) Fosb.	kōpiko	N/A	E
Psydrax odorata (G. Forst.) A.C.Smith & S.P.Darwin	alahe'e	N/A	I
Spermacoce assurgens Ruiz & Pav.	buttonweed	N/A	X
RUTACEAE (Rue Family)			
Citrus aurantiifolia (Cristmann) Swingle	lime	N/A	X
SANTALACEAE (Sandalwood Family)			
Santalum album L.	white sandalwood	N/A	X
Santalum freycinetianum Gaud. *var. freycinetianum*	iliahi	N/A	E
SAPINDACEAE (Soapberry Family)			
Dodonaea viscosa Jacq.	a'ali'i	NI	I
SAPOTACEAE (Sapodilla Family)			
Chrysophyllum mexicanus T. Brandegee	satin leaf	N/A	X
SCROPHULARIACEAE (Snapdragon Family)			
Buddleia asiatica Lour.	dog tail	N/A	X
SOLANACEAE (Nightshade Family)			
Nicandra physalodes (L.) Gaertn.	apple of Peru	N/A	X
Solanum seaforthianum Andr.	Brazilian nightshade	N/A	X
THYMELAEACEAE ('Akia Family)			
Wikstroemia oahuensis (A. Gray) Rock	ʻakia	FAC	E
URTICACEAE (Nettle Family)			
Cecropia obtusifolia Bertol.	cecropia	N/A	X
VERBENACEAE (Verbena Family)			
Citharexylum caudatum L.	fiddlewood	NI	X
Lantana camara L.	lantana	UPL	X
Stachytarpheta australis Modenke	ōwī	N/A	X
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain	FAC*	X
Stachytarpheta jamaicensis (L.) Vahl ōwī	ōwī	FACU*	X
Verbena littoralis kunth	ōwī	N/A	X
ZYGOPHYLLACEAE (Creosote Bush Family)			

Taxa	Hawaiian, Common name(s)	Wetland Indicator	Status
Tribulus terrestris L.	puncture vine	N/A	X

APPENDIX C: PHOTOGRAPHIC PLATES OF THE SAMPLING POINTS WITHIN THE KAWAILOA WIND POWER PROJECT PARCELS

Plate 1. The dominant vegetation along the water's edge at Sampling Point O1 is *Chloris barbata* (FACU), *Emilia fosbergii* (N/A), and *Boerhavia* sp. (N/A).

Plate 2. Sampling Point O2 lays adjacent to 'Opae'ula Road. Its banks are dominated by *Chloris barbata* (FACU), *Emilia fosbergii* (N/A), and *Boerhavia* sp. (N/A).

Plate 3. An irrigation ditch runs under ‘Opae‘ula Road through a concrete box culvert adjacent to the irrigation reservoir at Sampling Point O2.

Plate 4. Dominant plants at Sampling Point O3 are *Leucaena leucocephala* (UPL), *Urochloa maxima* (FACU), *Psidium guajava* (FACU), *Falcataria moluccana* (N/A), and *Schinus terebinthifolius* (FACU-).

Plate 5. Loko ea is an intermittent gulch where it passes under Kawailoa Road at this culvert upstream from ʻUkoʻa Pond at Sampling Point K1.

Plate 6. The Waialua stony silty clays found at Sampling Point K1 are not hydric soils.

Plate 7. Dominant plants at Sampling Point K2 are *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Ficus microcarpa* (N/A), *Syzygium cumini* (FACU), and *Neonotonia wightii* (N/A).

Plate 8. Dominant plants along the water's edge at the Sampling Point K3 reservoir are *Chloris barbata* (FACU), *Amaranthus viridis* (FAC*), *Paspalum conjugatum* (FAC+), *Eclipta prostrata* (FACW), *Ipomoea obscura* (N/A).

Plate 9. An irrigation ditch parallels the road near Sampling Point K3.

Plate 10. Sampling Point K4, mapped by the NWI, was dry during our survey. Dominant plants here are *Urochloa maxima* (FACU) and *Chloris barbata* (FACU).

Plate 11. Dominant plants at the irrigation reservoir at Sampling Point K5 are *Emilia fosbergii* (N/A), *Sacciolepis indica* (FAC+), *Ludwigia octovalvis* (OBL), and *Chloris barbata* (FACU).

Plate 12. Sampling Point K6, mapped by the NWI, was dry during our survey. Dominant plants are *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), and *Bidens alba* (N/A).

Plate 13. Moss and algal mats are present at Sampling Point K7 where the dominant plants are *Urochloa maxima* (FACU), *Mimosa pudica* (FACU), *Hyparrhenia rufa* (N/A), *Axonopus fissifolius* (FAC), *Acacia koa* (N/A), and *Cyperus difformis* (OBL).

Plate 14. Recent heavy rains may have accounted for the shallow standing water adjacent to Sampling Point K8.

Plate 15. Test pit at Sampling Point K8, an area mapped as Rough Mountainous Land, did not reveal hydric soils.

Plate 16. Sampling Point C1 is a dry intermittent stream bed. Dominant plants here are *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Neonotonia wightii* (N/A), and *Schinus terebinthifolius* (FACU-).

Plate 17. Sampling Point C2 is a poorly defined intermittent drainage channel. *Urochloa maxima* (FACU), *Leucaena leucocephala* (UPL), *Syzygium cumini* (FACU), *Clusia rosea* (NI), and *Neonotonia wightii* (N/A) are the dominant plants here.

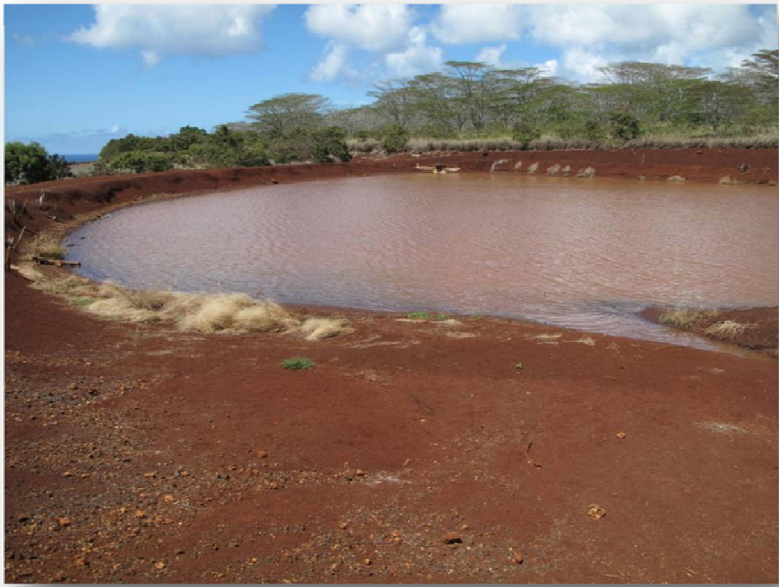


Plate 18. Similar to the other irrigation reservoirs excavated in uplands across the project parcels, the dominant plants at Sampling Point M1 are *Eleusine indica* (FACU), *Sporobolus africanus* (N/A), *Ipomoea obscura* (N/A), and *Eclipta prostrata* (FACW).

Plate 19. *Chloris barbata* (FACU) and *Eleusine indica* (FACU-) are the dominant plants at Sampling Point M2 adjacent to proposed Midline Road.

Plate 20. Mapped by the NWI, Sampling Point M3 consisted of irrigation ditch systems in disrepair. Dominant plants here are *Eleusine indica* (FACU-), *Ipomoea obscura* (N/A), *Ciclospermum leptophyllum* (NI), and *Urochloa maxima* (FACU).

Plate 21. Sampling Point A1 adjacent to Lower Ashley Road is a dry depression. Dominant plants here are *Urochloa maxima* (FACU), *Clusia rosea* (NI), and *Ficus microcarpa* (N/A).

Plate 22. Test pit dug at Sampling Point A1 did not reveal hydric soils.

Plate 23. *Ipomoea triloba* (N/A), *Chloris barbata* (FACU) and *Chamaesyce hirta* (FACU) are the dominant plants at Sampling Point A2.

Plate 24. Though damp at the time of excavation, the soil pit at Sampling Point A3 revealed Paaloa silt clay that did not show hydric characteristics.

Plate 25. Sampling Point A5 is located at where an old cane road crosses Ka'alaea Gulch. Dominant plants are *Urochloa maxima* (FACU), *Syzygium cumini* (FACU), *Schinus terebinthifolius* (FACU-), and *Aleurites moluccana* (NI).

Plate 26. Sampling Point A6 is an irrigation reservoir not inundated since2006. Dominant plants are *Urochloa mutica* (FACW) and scattered *Falcataria moluccana* (N/A) trees; however, no hydric soils were found at this site.

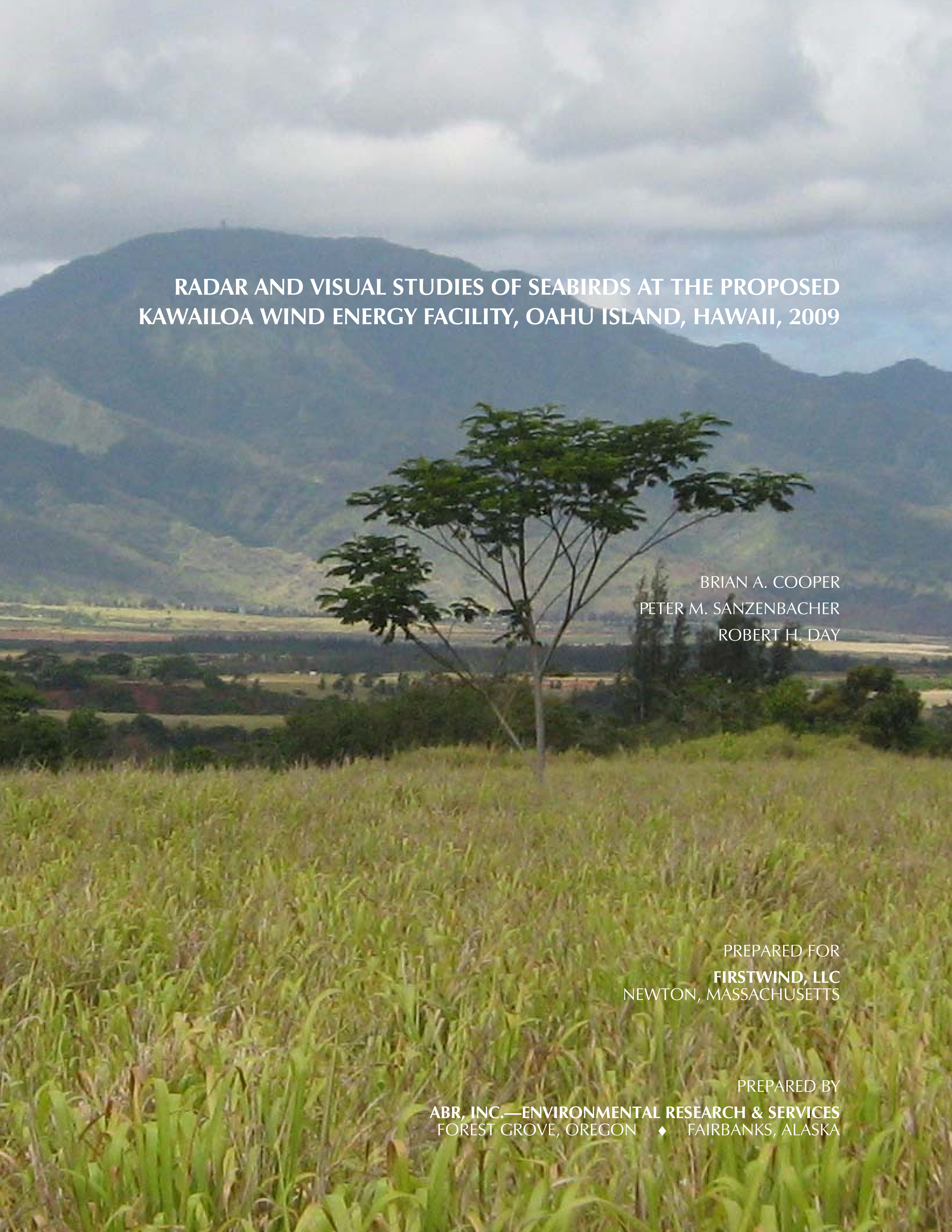
Plate 27. As expected, the soil surface at Sample Point A6 is deeply cracked. Samples are consistently hard, dry, dark reddish brown Helemano silty clay (2.5YR 3/4) with no evidence of hydric properties.

Plate 28. Dominant plants at Sampling Point B1 are *Urochloa maxima* (FACU) and *Falcataria moluccana* (N/A). Test pits found no evidence of hydric soils at this site.

Plate 29. Dominant plants at Sampling Point B2 are *Urochloa maxima* (FACU), *Schinus terebinthifolius* (FACU-), *Psidium cattleianum* (FACU), *Aleurites moluccana* (NI), and *Syzygium cumini* (FACU).

Plate 30. Although a thick mat of *Urochloa mutica (FACW) is found on the seaward side of the dirt road at Sampling Point B2, no evidence of hydric soils were found here*.

Appendix 3a



RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KAWAILOA WIND ENERGY FACILITY, OAHU ISLAND, HAWAII, 2009

BRIAN A. COOPER
PETER M. SANZENBACHER
ROBERT H. DAY

PREPARED FOR

FIRSTWIND, LLC
NEWTON, MASSACHUSETTS

PREPARED BY

ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES
FOREST GROVE, OREGON ♦ FAIRBANKS, ALASKA

RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KAWAILOA WIND ENERGY FACILITY, OAHU ISLAND, HAWAII, 2009

FINAL REPORT

Prepared for

FIRSTWIND, LLC
85 Wells Avenue, Suite 305
Newton, MA 02459–3210

Prepared by

Brian A. Cooper and Peter M. Sanzenbacher
ABR, Inc.—Environmental Research & Services
P.O. Box 249
Forest Grove, OR 97116–0249

and

Robert H. Day
ABR, Inc.—Environmental Research & Services
P.O. Box 80410
Fairbanks, AK 99708–0410

January 2011

EXECUTIVE SUMMARY

- FirstWind, LLC, is interested in developing the Kawailoa Wind Energy Facility on northern Oahu Island, Hawaii. This report summarizes the results of a radar and audiovisual study of seabirds and a visual study of bats conducted there in summer and fall 2009. 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 Kawailoa and Ashley study sites for 5 nights at each site in June 2009 and in October 2009, following standard ornithological radar and audiovisual techniques used in previous studies.
- We visually recorded no Hawaiian Petrels, no Newell's Shearwaters, and no unidentified shearwaters/petrels during our 20 nights of audiovisual sampling in summer and fall 2009.
- We visually recorded 2 Hoary Bats during the summer, but no bats in fall. Those observations translated to an estimated summer occurrence rate of 2 bats in 84 25-min observation sessions (i.e., 0.057 bats/h). Both bats were flying at an altitude of ≤5 m agl.
- Our radar data collected during this study on the timing of movements and the available literature indicating that Newell's Shearwaters but not Hawaiian Petrels occur on Oahu both suggest that the radar targets we observed were more likely to be Newell's Shearwaters than Hawaiian Petrels. In addition, our audiovisual observations of nine flocks of Pacific Golden-Plovers during fall sampling when wintering plovers have arrived from the summer breeding grounds, the difficulty of separating plover targets from shearwater targets on radar, and the higher movement rates we observed in fall when lower numbers of shearwaters are expected to occur, indicate that our fall radar data were highly likely to include a substantial proportion of plovers. Because of this likely contamination issue and because summer passage rates of shearwaters should be higher than fall rates at this site if there was no contamination, we excluded the fall passage rate data from our fatality models and instead only used summer data.
- We recorded 1 landward-flying and 20 seaward-flying radar targets that fit our criteria for shearwater-like targets in summer 2009 and recorded 1 landward-flying and 52 seaward-flying radar targets that fit our criteria for shearwater-like targets in fall 2009.
- The mean movement rate across all nights and both sites was 0.60 ± 0.07 shearwater-like targets/h in summer 2009 and 1.41 ± 0.15 shearwater-like targets/h in fall 2009.
- We recorded higher numbers of seaward-flying targets than landward-flying targets at both sampling sites. Overall, ~97% of all shearwater-like targets were flying seaward (i.e., away from the direction of the potential seabird colonies in the Koolau Mountains) and ~3% were flying landward (i.e., toward the potential nesting habitat).
- To determine the risk of collision-caused mortality, we used passage rates of shearwater-like targets observed on radar in summer 2009, Newell's Shearwater flight altitudes from previous studies, and dimensions and characteristics of the proposed wind turbines and met towers to generate an estimate of exposure risk. We then applied estimates of the fatality probability (i.e., the probability of collision with a portion of the wind turbine or met tower and dying while in the airspace occupied by the structure) and a range of estimated avoidance probabilities (i.e., the probability that a bird will detect and avoid entering the airspace containing the structure) to this estimate of exposure to calculate annual fatality rates that could be expected at the Kawailoa wind turbines and met towers.
- We estimate that ~1–11 Newell's Shearwater fly within the space occupied by each wind turbine in an average year, that ~4 Newell's

Shearwaters fly within the space occupied by each guyed, 60-m-tall met tower in an average year, and that ~1 Newell's Shearwaters fly within the space occupied by each free-standing, 100-m-tall met tower in an average year.

- We estimated annual fatality rates at wind turbines and met towers by assuming that 90%, 95%, or 99% of all shearwaters flying near a structure will see and avoid it. Based on these scenarios, we estimated a collision-caused fatality rate of 0.011–0.154 Newell's Shearwaters/turbine/year for each turbine, 0.035–0.347 Newell's Shearwaters/tower/year for each 60-m met tower, and 0.004–0.043 Newell's Shearwaters/tower/year for each 100-m met tower at the proposed Kawailoa Wind Energy Facility. Although the range of assumed avoidance rates at wind turbines and met towers (90–99%) is not fully supported by empirical data at this time we speculate that avoidance rates of petrels and shearwaters at wind farm structures potentially are ≥95%, based upon fatality rates at existing windfarms and avoidance behavior of petrels and shearwaters observed at other structures (e.g., powerlines and communication towers); thus, we believe that fatality rates will be within the lower half of the range of estimates.

TABLE OF CONTENTS

EXECUTIVE SUMMARY iii
LIST OF FIGURES v
LIST OF TABLES vi
ACKNOWLEDGMENTS vi
INTRODUCTION 1
  BACKGROUND 1
    SEABIRDS 1
    HAWAIIAN HOARY BATS 3
STUDY AREA 3
METHODS 5
  DATA ANALYSIS 8
    RADAR AND VISUAL DATA SUMMARY 8
    EXPOSURE AND FATALITY RATES 9
RESULTS 12
  SURVEILLANCE-RADAR OBSERVATIONS 12
  AUDIOVISUAL OBSERVATIONS 13
  EXPOSURE RATES 13
  FATALITY MODELING 18
DISCUSSION 18
  SPECIES COMPOSITION 18
  MOVEMENT RATES AND FLIGHT DIRECTIONS 23
  EXPOSURE RATES AND FATALITY ESTIMATES 23
  HAWAIIAN HOARY BATS 26
CONCLUSIONS 26
LITERATURE CITED 27

LIST OF FIGURES

Figure 1. Oahu Island, Hawaii, with approximate location of the proposed Kawailoa Wind Energy Facility 2
Figure 2. Location of 2009 radar sampling stations and meteorological towers and tentative locations of proposed wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii 4
Figure 3. Approximate shearwater-/petrel-sampling airspace for the Furuno FR–1510 marine radar at the 1.5-km range setting, as determined by field trials with Rock Pigeons. 8
Figure 4. Major variables used in estimating possible fatalities of Newell’s Shearwaters at wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii 10
Figure 5. Location of flight paths of shearwater-like radar targets observed during summer 2009 at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii 14
Figure 6. Location of flight paths of shearwater-like radar targets observed during fall 2009 at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii 15

LIST OF TABLES

Table 1. Sampling dates and number of landward, seaward, and other radar targets; and number of audio-visual observations of species of interest at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer 2009 6

Table 2. Sampling dates and number of landward, seaward, and other shearwater-like radar targets; and number of audio-visual observations of bird and bat species of interest at the proposed Kawailoa Wind Energy Site, Oahu Island, Hawaii, fall 2009 7

Table 3. Mean movement rates of shearwater-like radar targets observed at the Kawailoa and Ashley sampling stations and both stations combined at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer and fall 2009 12

Table 4. Evening and morning timing of movement of bird targets on ornithological radar, with total number of targets and percentages of nightly movements observed by half-hour period at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer and fall 2009 16

Table 5. Estimated average exposure rates and fatality rates of Newell's Shearwaters at proposed wind turbines at the Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer and fall 2009 17

Table 6. Estimated average exposure rates and fatality rates of Newell's Shearwaters at guyed 60-m monopole meteorological towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer and fall 2009 19

Table 7. Estimated average exposure rates and fatality rates of Newell's Shearwaters for free-standing 100-m-tall lattice meteorological towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer 2009 21

Table 8. Summary of exposure rates, fatality rates, and cumulative fatality rates for Newell's Shearwaters at one type of wind turbine and at two types of meteorological (met) towers in the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer 2009 22

ACKNOWLEDGMENTS

We thank FirstWind for funding this study and for providing the ornithological radar used for sampling. We thank Greg Spencer, Wren Wescoatt, and Dave Cowan (FirstWind) for help with logistics and thank Greg Spencer and Bob Roy (FirstWind) for assistance with the visual sampling. At ABR, Rich Blaha produced study figures and Pam Odom and Alice Stickney assisted with report production.

INTRODUCTION

FirstWind, LLC, is interested in developing the Kawailoa Wind Energy Facility on northern Oahu Island, Hawaii (Figure 1). 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 and bats 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 June (summer) and October (fall) 2009. The objectives of this study were to: (1) conduct radar and visual 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 wind turbines and meteorological towers (met towers) at the proposed windfarm.

BACKGROUND

SEABIRDS

Two seabird species that are protected under the Endangered Species Act (ESA) historically have occurred on Oahu and thus may have occurred in the Kawailoa project area: the endangered Hawaiian Petrel ('Ua'u) and the threatened Newell's (Townsend's) Shearwater ('A'o). The Hawaiian Petrel and the Newell's Shearwater are forms of tropical Pacific species that nest only on the Hawaiian Islands (American Ornithologists' Union 1998). Both species 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 one exception is Kauai Island, where colonies still are widespread and populations are substantial in size. Of note, Kauai (along with Lanai) also has no introduced Indian Mongooses (*Herpestes auropunctatus*) which prey on these seabirds.

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), Lanai (Shallenberger 1974; Hirai 1978a, 1978b; Conant 1980; J. Penniman, State of Hawaii, DOFAW, pers. comm.), 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. We can find no records of Hawaiian Petrels occurring on Oahu in the past 50–100 years.

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*).

There is interest in studying these two species because of concerns regarding collisions with structures such as met towers and wind turbines. To date, there is documented mortality of only one Hawaiian Petrel at a wind turbine and zero Newell's Shearwaters at wind-energy facilities (wind turbines or met towers) within the Hawaiian Islands (G. Spencer, FirstWind, pers. comm.). Note, however, that fatality studies have been conducted only for four years at one wind-energy facility located in the Hawaiian Islands (i.e., at KWP I, Maui) and for three months at six met towers at the same site prior to operation. Hence, there have not been enough studies of adequate

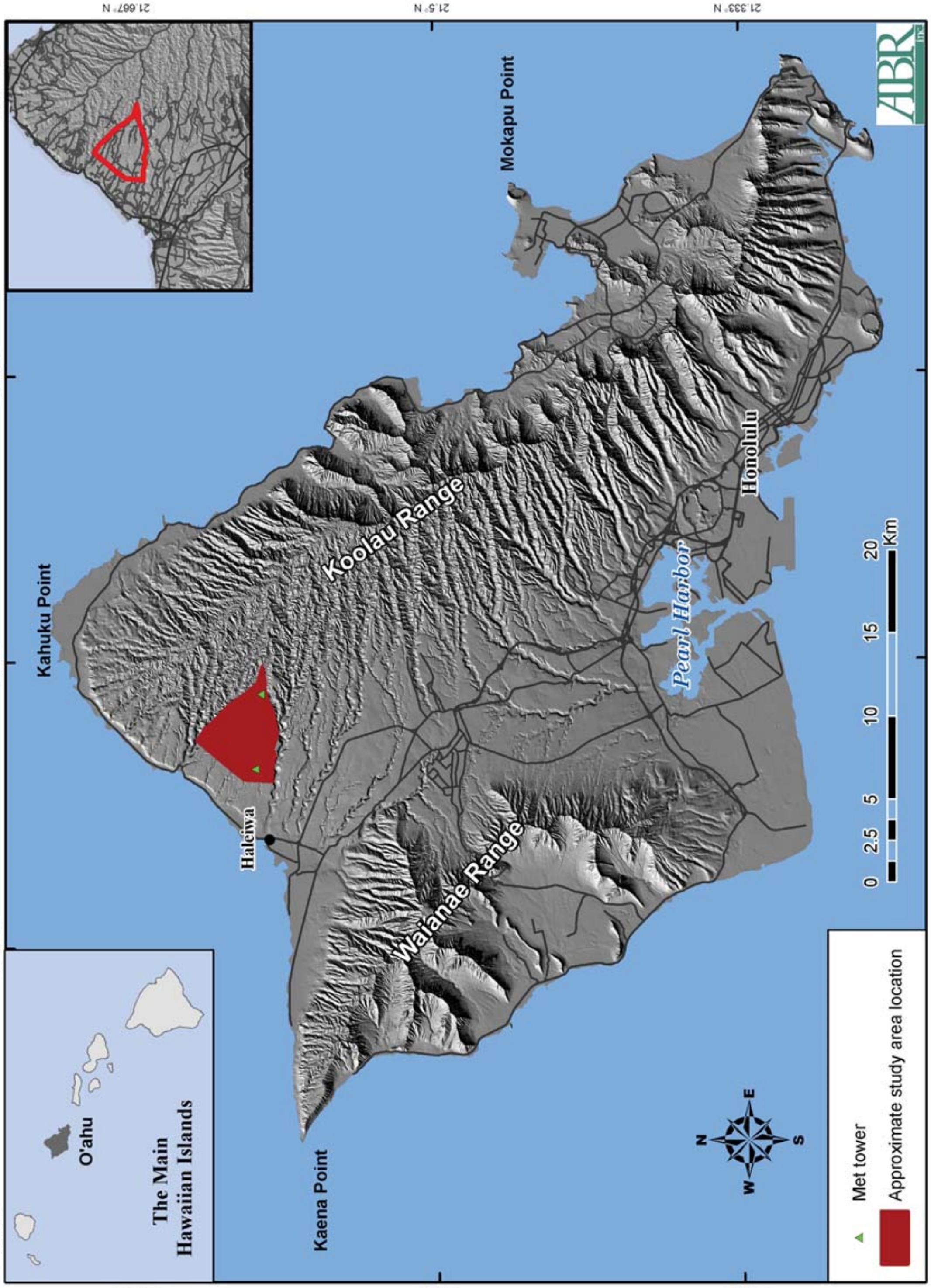


Figure 1. Oahu Island, Hawaii, with approximate location of the proposed Kawailoa Wind Energy Facility.

duration or geographic scope to answer the question definitively of how prone these species are to collisions with met towers and wind turbines. There has, however, been well-documented petrel and shearwater mortality resulting from collisions with other human-made structures (e.g., transmission lines, communication towers) on Kauai (Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998) and Maui (Hodges 1992), and there have been collision-caused fatalities of other seabirds at other Hawaiian Islands (Fisher 1966).

HAWAIIAN HOARY BATS

The Hawaiian Hoary Bat (*Lasiurus cinereus semotus*; 'Ope'ape'a) is the only terrestrial mammal native to Hawaii. It apparently was classified as endangered primarily because so little was 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 above sea level [asl] (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 bat use at sites proposed for wind-energy development (Reynolds 2006, Kunz et al. 2007a). Most of the bat fatalities documented at windfarms 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 fatalities at wind turbines (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) also 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 above the town of Haleiwa, which is located near the northern tip of Oahu Island (Figure 1). Between our summer and fall surveys, two 60-m-high NRG monopole 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 to these two met towers, three 100-m-tall, free-standing lattice met towers are proposed to be built at the site. In regards to wind turbines, the development plan for this site has not been finalized, but for the purposes of this report we proceed with the assumption that the plan is to install ~30 Siemens SWT-2.3-101 wind turbines. Each turbine would have a nominal generating capacity of ~2.3 MW, for a total installed capacity of ~69 MW for the windfarm as a whole. The currently proposed monopole towers would be ~100 m in height, and each turbine would have 3 rotor blades with a rotor diameter of 101 m; hence, the total maximal height of a turbine would be ~150.5 m with a blade in the top-vertical position.

The proposed windfarm will be located on a gently-sloping bench on agricultural lands situated on the lower slopes in the northwestern Koolau Range (Figures 1 and 2). The study site has an elevation varying from ~150 m to ~400 m above sea level and is extremely disturbed, being covered

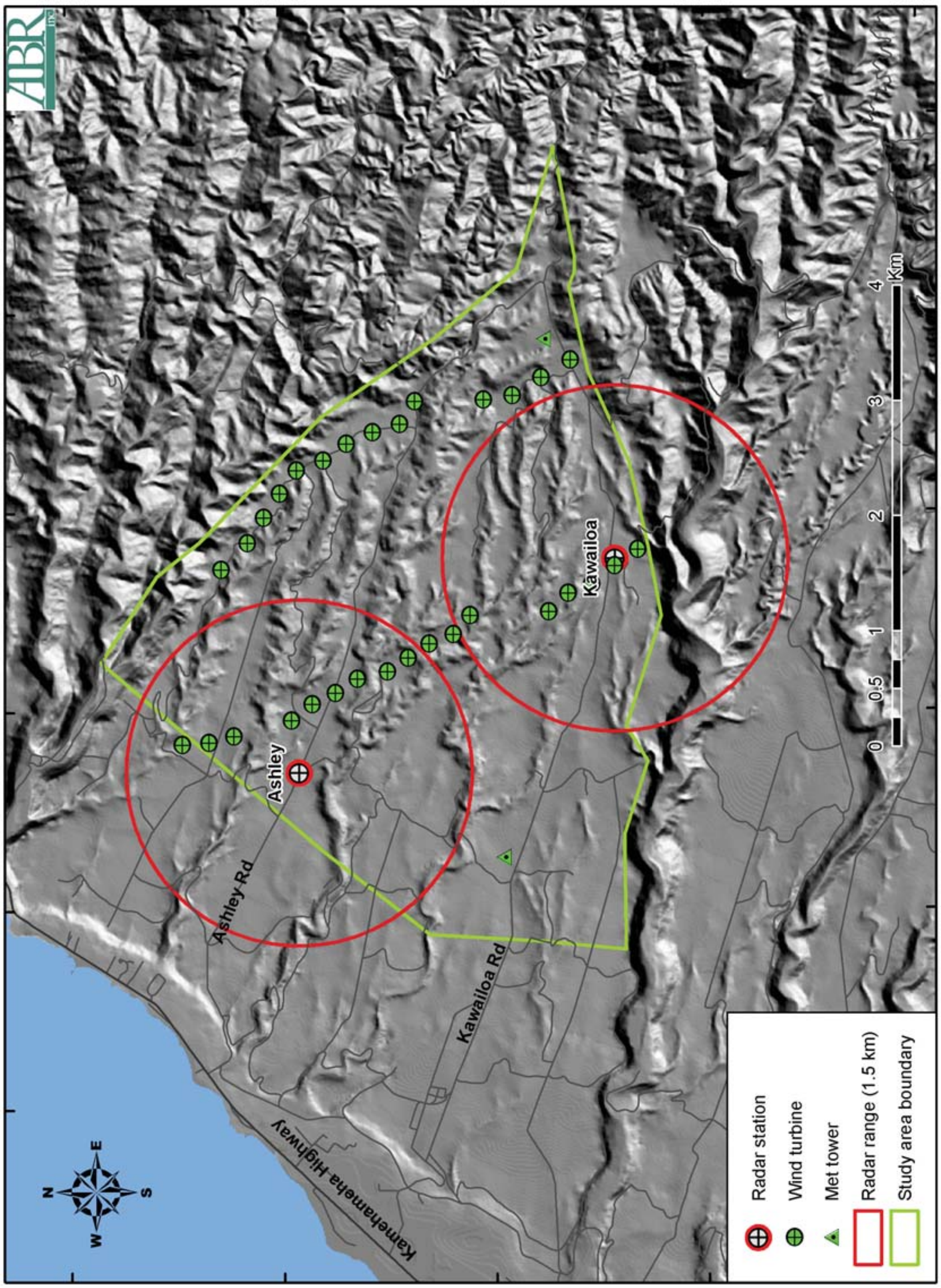


Figure 2. Location of 2009 radar sampling stations and meteorological (met) towers and tentative locations of proposed wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii.

with old pasturelands and introduced species such as haole koa (*Leucaena leucocephala*), kiawe (*Prosopis pallida*), *Eucalyptus*, *Albesia*, and christmasberry (*Schinus terebinthefolius*). Some native habitat containing ohia lehua trees and uluhe 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.

We conducted standard radar and audiovisual sampling at two sampling stations within the proposed windfarm (Figure 2). The Kawailoa sampling station was located in a cane field on a small side road ~50 m south of milepost 4.0 on the Kawailoa Road (21° 35.425"N, 158° 02.238"W; WGS84 datum) at an elevation of 306 m asl. The Ashley sampling station was located at a large intersection and pullout area at milepost 1.7 on the Ashley Road (21° 36.916"N, 158° 03.310"W; WGS84 datum) at an elevation of 187 m asl. Both sites provided good radar coverage of the surrounding area and were good sites for audiovisual sampling.

METHODS

We used marine radar and visual equipment to collect data on the movements, flight behaviors, and flight altitudes of petrels and shearwaters for five nights at each of two sampling stations (Ashley and Kawailoa stations) during summer (16–25 June) and fall (13–22 October) 2009 (Tables 1 and 2). The daily sampling effort consisted of 3 h each evening (1900–2200 h in summer and 1800–2100 h in fall) and 1.5 h each morning (0400–0530 h in summer and 0430–0600 h in fall). We also sampled an additional half-hour (i.e., until 0600 on some mornings in summer and until 0630 on all mornings in fall), but we determined that contamination from non-target bird species (e.g., doves, plovers, and other fast-flying species) during that period was too high to collect accurate data on petrels and shearwaters. Our sampling periods were selected to correspond to the evening and morning peaks of movement of petrels and shearwaters, as described near breeding colonies on Kauai (Day and Cooper 1995). During sampling, we collected radar and audiovisual data concurrently so the radar operator could help the audiovisual observer locate birds for species identification and data collection. In return, the audiovisual observer provided information to the radar operator on the identity and flight altitude of individual targets (whenever possible). For the purpose of recording data, a calendar day began at 0700 and ended at 0659 the following morning; that way, an evening and the following morning were classified as occurring on the same sampling day.

The ornithological radar used in this study was a Furuno (Model FCR-1510) X-band radar transmitting at 9.410 GHz through a slotted wave guide with a peak power output of 12 kW; a similar radar unit is described in Cooper et al. (1991) and Mabee et al. (2006). The antenna face was tilted upward by ~10°, and we operated the radar at a range setting of 1.5 km and a pulse-length of 0.07 μsec. 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*).

Issues associated with radar sampling include ground clutter and shadow zones. Whenever energy is reflected from the ground, surrounding vegetation and other objects around the radar unit, a ground-clutter echo that can obscure targets of interest (i.e., birds) appears on the radar's display screen. Shadow zones are areas of the screen where birds can fly at an altitude that potentially would put them behind a hill or row of vegetation where they could not be detected because the radar operates on line-of-sight. We attempted to minimize ground clutter and shadow zones during the selection of radar sampling stations; various landscape features visible on radar indicated that our sampling stations provided good coverage of the study area.

We sampled for six 25-min sessions during each evening and for three 25-min sessions each morning. Each 25-min sampling session was separated by a 5-min break for collecting weather data. To help eliminate non-target species, we collected data only for those targets that met a suite of selection criteria, following methods developed by Day and Cooper (1995), that included appropriate target signature, flight characteristics and flight speeds (≥30 mi/h [≥50 km/h]). We also removed radar targets identified by visual observers as being of other bird species.

Table 1. Sampling dates and number of landward, seaward, and other radar targets; and number of audio-visual observations of species of interest at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer (June) 2009 (HOBA = Hoary Bat; BAOW = Barn Owl; OWSP = unidentified owl).

			Number of Radar Targets			
Date	Site	Period	Landward (75–195°)	Seaward (255–15°)	"Other"[1] Directions	Audio-Visual
16 June	Kawailoa	Eve	0	2	1	0
		Morn	0	0	0	0
17 June	Ashley	Eve	0	2	1	1 HOBA
		Morn	0	0	0	1 HOBA
18 June	Kawailoa	Eve	No Data[2]	No Data[2]	No Data[2]	No Data[2]
		Morn	0	1	0	0
19 June	Ashley	Eve	0	0	0	0
		Morn	0	1	1	0
20 June	Kawailoa	Eve	1	2	4	0
		Morn	0	0	0	0
21 June	Ashley	Eve	0	0	1	0
		Morn	0	2	1	0
22 June	Kawailoa	Eve	0	0	1	1 OWSP
		Morn	0	1	0	0
23 June	Ashley	Eve	0	2	0	0
		Morn	0	0	0	0
24 June	Kawailoa	Eve	0	1	1	0
		Morn	0	2	0	0
25 June	Ashley	Eve	0	2	0	1 OWSP
		Morn	0	2	1	1 BAOW
TOTAL			1	20	12	

[1] "Other" directions include all other directions that were not landward or seaward.
[2] Sampling cancelled by rain.

We 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 10X binoculars during crepuscular periods and Generation 3 night-vision goggles (Model ATN-PVS7; American Technologies Network Corporation, San Francisco, CA) during nocturnal periods. The magnification of the night-vision goggles was 1X, 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 birds. Audiovisual observations were conducted within 25 m of the radar to facilitate coordination between observers, and we also listened for petrel and shearwater (and other) vocalizations.

Before each 25-min sampling session, we also collected environmental and weather data, including:

- wind speed (to the nearest 1 mi/h [1.6 km/h]);
- wind direction (to the nearest 1°);
- percent cloud cover (to the nearest 5%);

Table 2. Sampling dates and number of landward, seaward, and other shearwater-like radar targets; and number of audio-visual observations (i.e., flocks) of bird and bat species of interest at the proposed Kawailoa Wind Energy Site, Oahu Island, Hawaii, fall (October) 2009 (PGPL = Golden Plover; DOVE = unidentified dove).

			Number of Radar Targets			
Date	Site	Period	Landward (75–195°)	Seaward (255–15°)	"Other"[1] Directions	Audio-Visual[2]
13 October	Ashley	Eve	0	1	1	1 PGPL
		Morn	0	3	0	0
14 October	Kawailoa	Eve	0	3	0	0
		Morn	1	0	0	0
15 October	Ashley	Eve	0	2	0	1 PGPL
		Morn	0	7	0	0
16 October	Kawailoa	Eve	0	3	1	1 PGPL
		Morn	0	1	2	0
17 October	Ashley	Eve	0	3	0	0
		Morn	0	0	0	0
18 October	Kawailoa	Eve	0	4	1	1 PGPL
		Morn	0	2	1	0
19 October	Ashley	Eve	0	3	1	1 PGPL
		Morn	0	3	0	0
20 October	Kawailoa	Eve	0	3	2	1 PGPL
		Morn	0	1	0	0
21 October	Ashley	Eve	0	6	1	2 PGPL
		Morn	0	1	0	0
22 October	Kawailoa	Eve	0	5	1	1 DOVE
		Morn	0	1	0	1 PGPL
Totals[3]			1	52	11	9 PGPL; 1 DOVE

[1] "Other" directions include all other directions that were not inbound or outbound.

- cloud ceiling height, in meters 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).

For each appropriate radar target, we recorded the following data:

- species (if identified by visual observer);
- number of birds (if identified by visual observer);
- time;
- direction of flight (to the nearest 1°);
- cardinal transect crossed (000°, 090°, 180°, or 270°);
- tangential range (the minimal perpendicular distance to the target when it passed closest to the radar; used in reconstructing actual flight paths, if necessary);
- flight behavior (straight, erratic, circling);

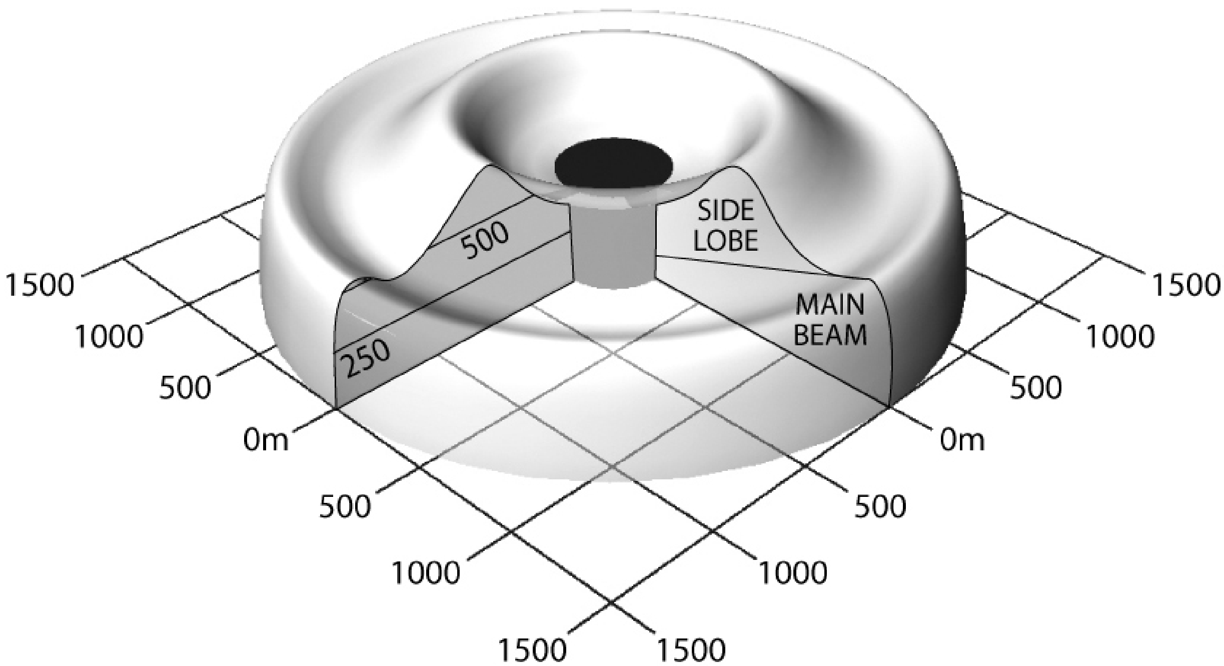


Figure 3. Approximate shearwater-/petrel-sampling airspace for the Furuno FR–1510 marine radar at the 1.5-km range setting, as determined by field trials with Rock Pigeons. Note that the shape of the radar beam within 250 m of the origin (i.e., the darkened area) was not determined.

- velocity (to the nearest 5 mi/h [8 km/h]); and
- flight altitude (meters agl, if identified by visual observer).

For each bird (or bat) recorded during audiovisual sampling, we recorded:

- time;
- species (to the lowest practical taxonomic unit [e.g., Hawaiian Petrel, unidentified petrel/shearwater]);
- number of individuals composing each target;
- ordinal flight direction (000°, 045°, 090°, 135°, 180°, 225°, 270°, 315°); and
- flight altitude (meters agl).

For any species of interest heard but not seen, we recorded species, number of calls, direction of calls, and approximate distance.

DATA ANALYSIS

RADAR AND VISUAL DATA SUMMARY

We entered all radar and visual data into Microsoft Excel spreadsheets. We checked data files visually for errors after each night of sampling and then checked files electronically for irregularities at the end of the field season, prior to data analyses. In addition, radar data were filtered to remove non-target species, and only known petrel/shearwater targets or unknown targets with appropriate characteristics (i.e., target size, flight directions, and airspeeds ≥30 mi/h) were included in data analyses. Airspeeds were calculated by correcting observed target flight speeds (groundspeeds) for speed and relative direction of wind, as measured each half-hour at the radar station (Mabee et al. 2006). Because we can find no records of Hawaiian Petrels on Oahu in the past 50–100 yr but did find records of Newell's Shearwaters on Oahu and because our radar detections occurred mainly during the fully-nocturnal hours when targets are most likely to be Newell's Shearwaters, we assumed that all petrel-/shearwater-like targets observed in this study were Newell's Shearwaters for the purposes of our exposure and fatality models (See Results and Discussion).

We categorized general flight directions of each radar target as landward, seaward, or "other" and summarized these directional categories by station and by night. Based on the shoreline orientation, we defined a landward flight direction as 75–195°, a seaward flight direction as 255–015°, and an "other" flight direction as 016–074° or 196–254°.

We tabulated counts of numbers of shearwater-like radar targets recorded during each sampling session, then converted those counts to estimates of movement rates of birds (radar targets/h), based on the number of minutes sampled. The only sampling sessions totally cancelled due to weather or other factors occurred on the evening of 18 June when rain prevented sampling; in all other cases, we standardized movement rates by actual minutes of sampling effort each half hour. We used all of the estimated movement rates across sampling sessions at a station to calculate the mean ± 1 standard error (SE) nightly movement rate of shearwaters by station and pooled data across nights to derive an overall hourly movement rate for the study. Only known shearwater targets (i.e., audio or visual confirmation) or unknown targets that met the criteria for shearwaters (i.e., appropriate target size, flight direction [i.e., landward and seaward flight only], and groundspeeds [i.e., ≥30 mi/h]) were included in data analyses of movement rates and flight behavior. We excluded all targets with "other" flight directions from movement-rate analyses because they were not flying toward or away from breeding habitat, as would be expected for shearwaters or petrels flying over land during those morning and evening periods of peak movement. Finally, we plotted all track lines of landward and seaward targets 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 stations and project 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 or wind turbines to estimate horizontal-interaction probabilities, uses flight-altitude data and information on the height of the met towers/wind turbines to estimate vertical-interaction probabilities, and combines these interaction probabilities with the movement rates to generate annual exposure rates (Figure 4). These exposure rates represent the estimated numbers of shearwaters that pass within the airspace occupied by a wind turbine or met tower and its associated guy wires 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 wind turbines and 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 wind turbines/met 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 by 5 h to estimate the number of targets moving over the radar site during those peak nightly movement periods (note that the 5 h extrapolation encompasses and accounts for the 0530–0600 h and 0600–0630 h periods that we were not able to sample in summer and fall, respectively); (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 wind turbines/met towers during an average night; and (4) multiplying those numbers by the number of days that these birds were exposed to risk in each

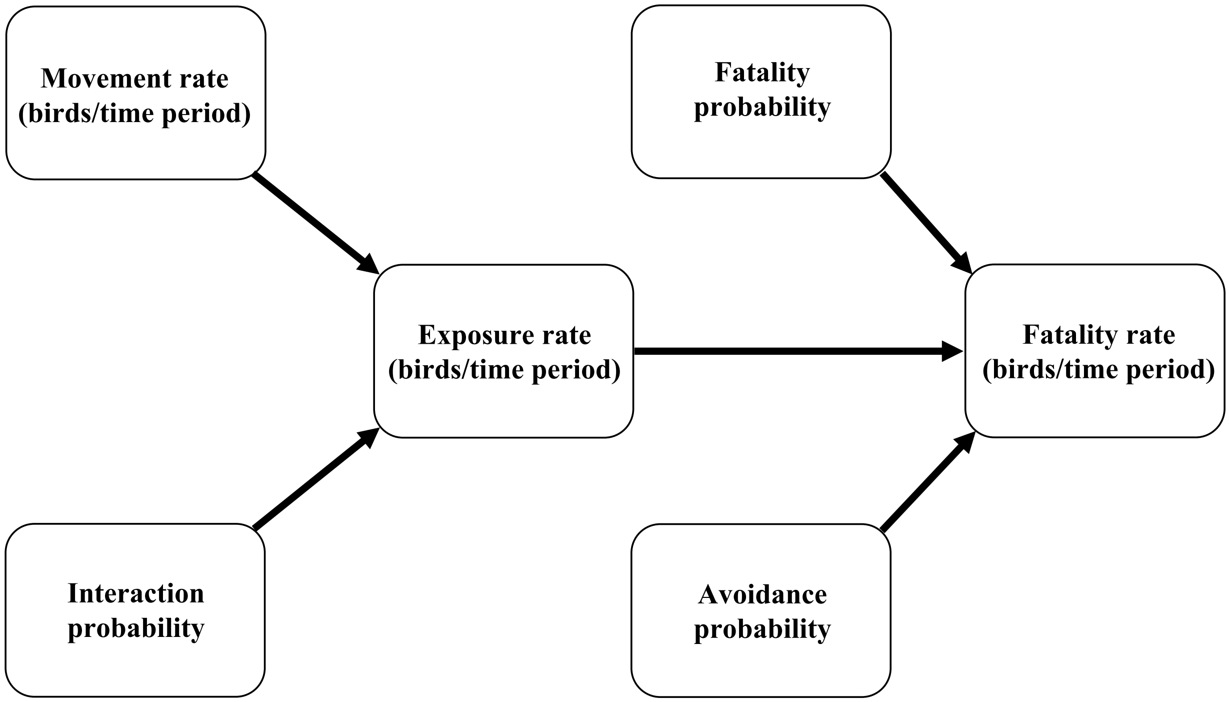


Figure 4. Major variables used in estimating possible fatalities of Newell's Shearwaters at wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii.

season (150 days in the spring/summer and 60 days in the fall; Ainley et al. 1997b).

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 wind turbine or met tower 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 wind turbine/met tower located somewhere on the radar screen. This probability is calculated from information on the two-dimensional area (side view) of the wind turbine/ met tower and the two-dimensional area sampled by the radar screen. The proposed wind turbine system will have a maximal height of 150.5 m, a rotor radius of 50.5 m, and minimal (side-view) and maximal (front-view) areas of 903 m^2 and 8,309 m^2. The existing, guyed, met towers each have a central tower with four sets of guy wires attached at six heights; hence, from a side view, the met tower/guy wire systems appear 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 proposed, free-standing, lattice-type met towers have a cross-sectional area of 313 m^2. The ensuing ratio of the cross-sectional area of the wind turbine or met tower 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.

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 wind turbine or met tower located somewhere on the radar screen. This probability is calculated from data on flight altitudes and from information on the height of the structures. We calculated the percentage of shearwaters with flight altitudes of ≤150.5 m agl (maximal height of the rotor-swept area of the proposed turbine) and the percentage of shearwaters with flight altitudes ≤60 m agl ≤100 m agl (maximal height of the two met tower types). 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 wind turbines (i.e., 75.2% ≤150.5 m agl) or met towers (i.e., 28.5% ≤60 m and 56.4% ≤60 m). 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 estimated fatality rate is calculated as the product of: (1) the exposure rate (i.e., the number of birds that might fly within the airspace occupied by a wind turbine or met tower); (2) the fatality probability (i.e., the probability of collision with a portion of the wind turbine/ met tower and dying while in the airspace occupied by the structure); and (3) the avoidance probability (i.e., the probability that a bird will detect and avoid entering the airspace containing the wind turbine/met tower). The annual fatality rate is generated as an estimate of the number of birds killed/yr as a result of collisions with the wind turbine or met tower, based on a 210-d breeding season for Newell's Shearwaters (Ainley et al. 1997b).

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 met 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, whereas the latter is an estimate of the probability of collision-caused fatality. Because any collision with a met tower or wind turbine falls under the ESA definition of "take," we used an estimate of 100% for this fatality-probability parameter; however, note that the actual probability of fatality resulting from a collision is less than 100% because a bird can hit a met tower frame or guy wires and not die (e.g., a bird could brush a wingtip but avoid injury/death).

The probability 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 monopole 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 (16 revolutions/min for the SWT-2.3-101 turbines); also see Tucker (1996). These calculations indicated that up to 15.2% 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).

The final parameter in estimating the fatality rate is the avoidance rate, which is the probability that a bird will see the wind turbine or met tower and change flight direction, flight altitude, or both, so that it completely avoids flying through the space occupied by the wind turbine or met tower. Because avoidance rates are largely unknown, we present fatality estimates for a range of probabilities of collision avoidance by these birds by assuming that 90%, 95%, or 99% of all shearwaters flying near a turbine or met tower structure will detect and avoid it. See discussion for explanation of avoidance rates used.

RESULTS

SURVEILLANCE-RADAR OBSERVATIONS

During our ten survey nights in summer 2009, we recorded 1 landward-flying and 20 seaward-flying radar targets that fit our criteria for shearwater-like targets (Table 1). We also recorded 12 targets headed in “other” directions. In our ten nights of sampling in fall 2009, we recorded 1 landward-flying and 52 seaward-flying radar targets that fit our criteria for shearwater-like targets (Table 2). In addition, we recorded 11 targets heading in “other” directions during fall 2009.

Mean movement rates of shearwater-like targets (i.e., landward and seaward rates combined) during the summer were 0.62 ± 0.10 targets/h at the Kawailoa Site, 0.57 ± 0.12 targets/h at the Ashley Site, and 0.60 ± 0.07 targets/h at both sites combined (Table 3). During fall, mean movement rates of shearwater-like targets were slightly higher: 1.28 ± 0.13 targets/h at the Kawailoa Site,

Table 3. Mean movement rates (targets/h ± SE) of shearwater-like radar targets observed at the Kawailoa and Ashley sampling stations and both stations combined at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer (June) and fall (October) 2009. *n* = number of sampling days.

Season/station	Time period (*n*)	Landward	Seaward	Total
SUMMER				
Kawailoa	Eve (4)[1]	0.10 ± 0.10	0.50 ± 0.19	0.60 ± 0.26
	Morn (5)	0.00 ± 0.00	0.59 ± 0.26	0.59 ± 0.26
	Total (5)			0.62 ± 0.10
Ashley	Eve (5)	0.00 ± 0.00	0.50 ± 0.21	0.50 ± 0.21
	Morn (5)	0.00 ± 0.00	0.72 ± 0.31	0.72 ± 0.31
	Total (5)			0.57 ± 0.12
Both sites combined	Eve (9)[1]	0.04 ± 0.04	0.50 ± 0.13	0.55 ± 0.15
	Morn (10)	0.00 ± 0.00	0.65 ± 0.19	0.65 ± 0.19
	Total (10)			0.60 ± 0.07
FALL				
Kawailoa	Eve (5)	0.00 ± 0.00	1.44 ± 0.16	1.44 ± 0.16
	Morn (5)	0.16 ± 0.16	0.80 ± 0.25	0.96 ± 0.16
	Total (5)			1.28 ± 0.13
Ashley	Eve (5)	0.00 ± 0.00	1.30 ± 0.41	1.30 ± 0.41
	Morn (5)	0.00 ± 0.00	2.24 ± 0.96	2.24 ± 0.96
	Total (5)			1.55 ± 0.28
Both sites combined	Eve (10)	0.00 ± 0.00	1.38 ± 0.19	1.38 ± 0.19
	Morn (10)	0.08 ± 0.08	1.52 ± 0.53	1.60 ± 0.51
	Total (10)			1.41 ± 0.15

[1] One entire evening of sampling at Kawailoa cancelled due to rain.

1.55 ± 0.28 targets/h at the Ashley Site, and 1.41 ± 0.15 targets/h at both sites combined. There were no consistent differences between evening and morning in mean movement rates (Table 3).

We recorded much higher numbers of seaward-flying targets than landward-flying targets at both sampling sites in both seasons (Tables 1 and 2). Overall, 97.3% of all targets were flying seaward (i.e., away from the direction of the potential seabird colonies in the Koolau Mountains) and 2.7% were flying landward (i.e., toward the potential nesting habitat). A qualitative assessment of landward and seaward (i.e., probable shearwater target) flight paths and trajectories suggested that there were northwesterly flights across most of the study area in both seasons (Figures 5 and 6). There was no evidence of a distinct flight corridor or concentration point over any particular portion of the study area in either season.

Fewer than 10% of all targets in both seasons were recorded during the first sampling session, which is a time when only Hawaiian Petrels are active, and 0–15% of all targets were recorded during the second evening session, which is when Hawaiian Petrel numbers on Kauai are thought to begin tapering off and Newell's Shearwater numbers are known to increase (Day and Cooper 1995, Cooper and Day 2003; however, note that some Hawaiian Petrels on Lanai also are active after the second session; Cooper and Day, unpubl. data; Table 4). The remaining 78–92% of evening targets were flying after the point of complete darkness. Similarly, almost all of our targets in the morning were recorded prior to the half-hour before sunrise (i.e., before the period when Hawaiian Petrels are known to be active). Hence, the timing of observations suggests that our radar targets were more likely to have been Newell's Shearwaters than Hawaiian Petrels.

Only two of the shearwater-like targets we observed were flying in an erratic or circling manner. Straight-line flights composed 97% of all flights.

AUDIOVISUAL OBSERVATIONS

We did not observe any Hawaiian Petrels, Newell's Shearwaters, or unidentified shearwaters/ petrels during our 20 nights of audiovisual sampling in summer and fall 2009 (Tables 1 and 2). We did visually record two Hoary Bats during summer 2009, however. The Hoary Bats both occurred at the Ashley site on 17 June 2009, at 2048 hr and 0446 hr. Those observations translated to an estimated occurrence rate of 2 bats in 84 25-min summer observation sessions (i.e., 0.057 bats/h). Both bats were flying at an altitude of ≤5 m agl. No bats were observed in fall 2009.

Other species of interest that we observed during audiovisual sampling in summer included a Barn Owl (*Tyto alba*) and two unidentified owls (Table 1). No Pacific Golden-Plovers (*Pluvialis fulva*) were observed in summer, but during fall they were very common in the area and we observed nine flocks of Pacific Golden-Plovers (Table 2). We also observed one flock of unidentified doves in fall. Note that after sampling hours (i.e., during 0530–0600 hr in summer and 0600–0630 h in fall) we observed a large number of non-target species in the area, including fast-flying dove species (e.g., Rock Doves and Spotted Doves [*Streptopelia chinensis*]) and Pacific Golden-Plovers (fall only) that would have led to unacceptably high levels of contamination in our radar data set, had we included radar data collected during these later sampling periods.

EXPOSURE RATES

The exposure rate is calculated as the product of three variables: annual movement rate, horizontal-interaction probability, and vertical-interaction probability (Figure 4). As such, it is an estimate of the number of birds flying in the vicinity of the wind turbine/met tower (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 turbine or tower. Because our fall radar data included such obvious contamination from non-target species (i.e., from Pacific Golden-plovers that are indistinguishable from shearwaters on radar and were present in high numbers in fall; See Results and Discussion) we decided that it was most appropriate to use the summer-only passage rates for the modeling exercise. Further, the use of summer-only data should be conservative because the number of shearwaters visiting breeding colonies generally tends to decline from summer to fall because

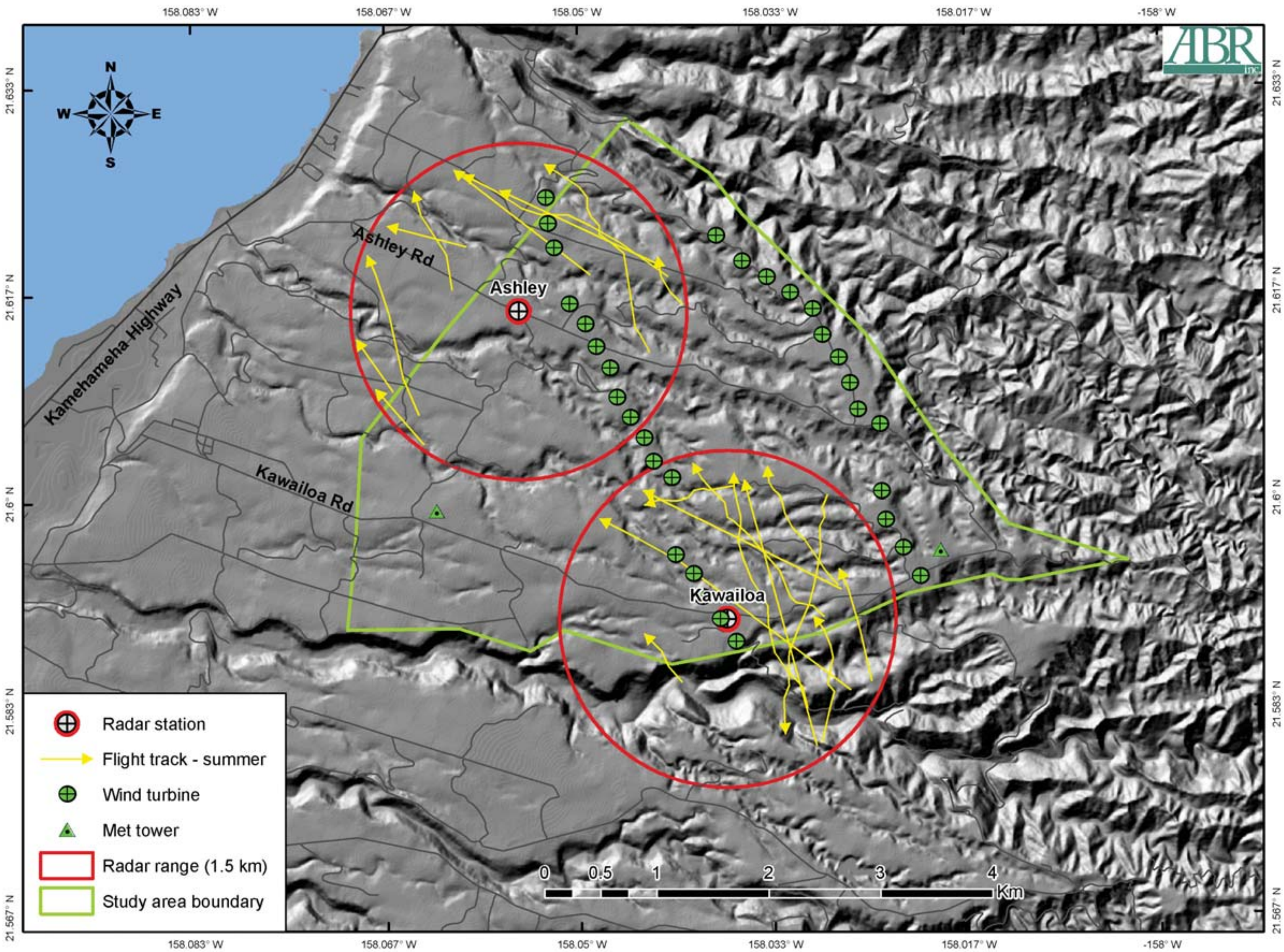


Figure 5. Location of flight paths of shearwater-like (i.e., landward and seaward) radar targets observed during summer 2009 at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii.

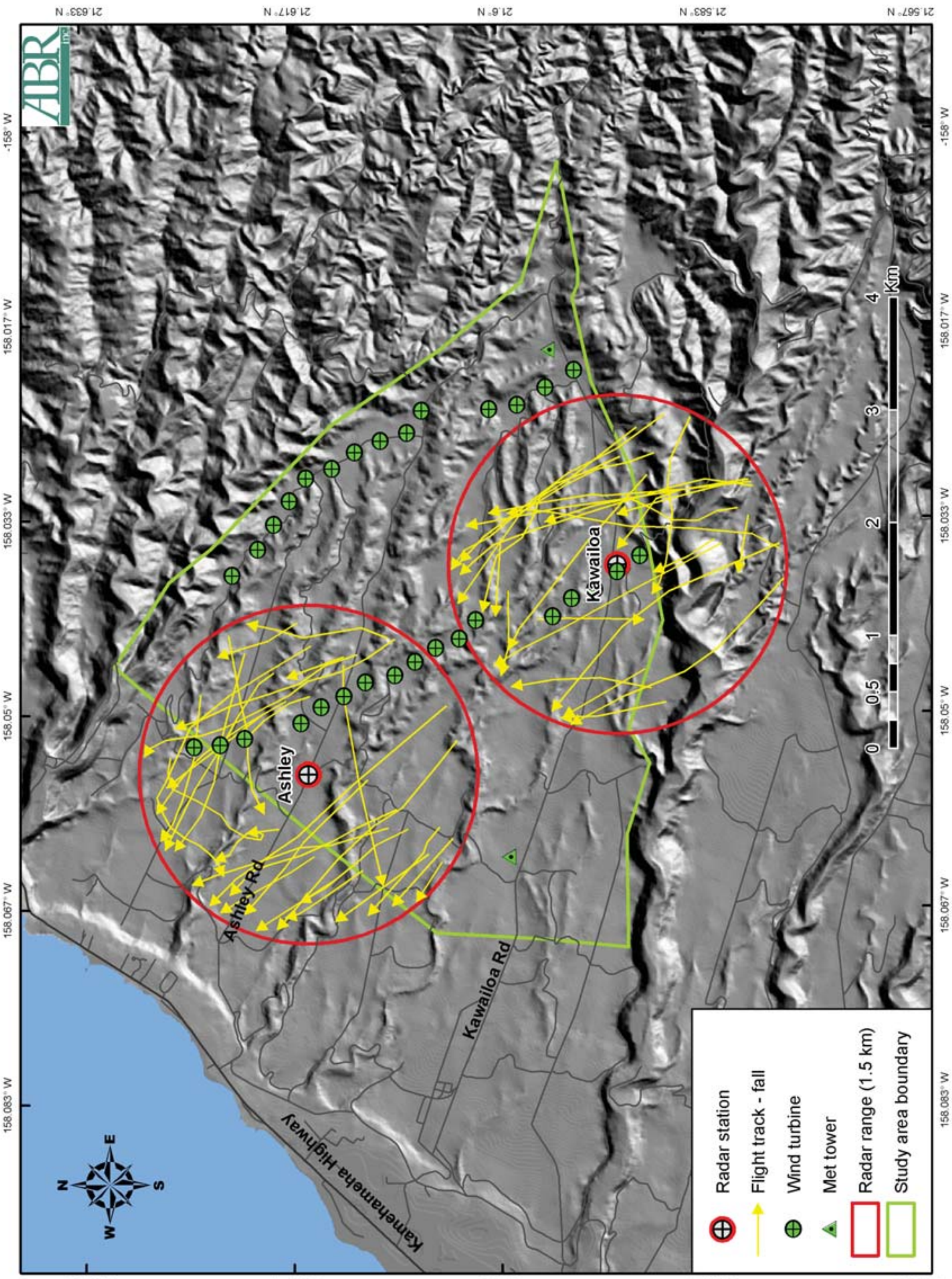


Figure 6. Location of flight paths of shearwater-like (i.e., landward and seaward) radar targets observed during fall 2009 at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii.

Table 4. Evening and morning timing of movement of bird targets on ornithological radar, with total number of targets and percentages of nightly movements observed by half-hour period at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer (June) and fall (October) 2009.

Season/Time period/Time	Light Condition	Number of targets	Percent
SUMMER			
EVENING	Crepuscular		
1900–1929	Crepuscular/Nocturnal	1	8.3
1930–1959	Nocturnal	0	0.0
2000–2029	Nocturnal	1	8.3
2030–2059	Nocturnal	3	25.0
2100–2129	Nocturnal	4	33.3
2130–2159	Nocturnal/Crepuscular	3	25.0
MORNING			
0400–0429	Nocturnal	1	11.1
0430–0459	Nocturnal	2	22.2
0500–0529	Nocturnal	6	66.7
FALL			
EVENING	Crepuscular		
1800–1829	Crepuscular/Nocturnal	3	7.3
1830–1859	Nocturnal	6	14.6
1900–1929	Nocturnal	6	14.6
1930–1959	Nocturnal	12	29.3
2000–2029	Nocturnal	10	24.4
2030–2059	Nocturnal	4	9.8
MORNING			
0430–0459	Nocturnal	1	4.3
0500–0529	Nocturnal	5	21.7
0530–0559	Nocturnal/Crepuscular	17	73.9

attendance at colonies by nonbreeders and failed breeders declines as chick-rearing progresses (Serventy et al. 1971, Warham 1990, Ainley et al. 1997b, Simons and Hodges 1998). Lastly, there also are no known, large shearwater colonies nearby, or lights near the site, that might explain higher fall counts (e.g., because of high passage rates of juveniles) than summer counts at the site. Thus, we think that it is justifiable in this particular case to use only the summer data to calculate fatality estimates.

Based on our summer 2009 movement rate data, we estimate that ~731 Newell's Shearwaters pass over the 1.5-km-radius radar sampling area at both stations combined in an average year (including birds at all altitudes; Tables 5–7). To generate annual exposure rates of birds exposed to each turbine or met tower (e.g., bird passes/structure/yr), we then multiplied the annual movement rate by the horizontal-interaction probability and the vertical-interaction probability. By applying those proportions to our data (and rounding up to the nearest whole number), we estimate that ~1–11 Newell's Shearwaters fly within the space occupied by each wind turbine in an average year (Table 5), that ~4 Newell's Shearwaters fly within the space occupied by each guyed, 60-m-tall met tower in an average year (Table 6), and that ~1 Newell's Shearwaters fly within the space occupied by each free-standing, 100-m-tall met tower in an average year (Table 7). Note that all these calculations are exposure rates

Table 5. Estimated average exposure rates and fatality rates of Newell's Shearwaters for Siemens SWT-2.3-101 wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) and fall (October) 2009. Values of particular importance are in boxes.

Variable/parameter for Siemens SWT-2.3-101 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 June 2009 data (targets/h)	0.6	0.6
A2) Mean rate during nightly peak movement periods in fall based on June 2009 data (targets/h)	0.6	0.6
B) Number of hours of evening and morning peak period of movement	5	5
C) Mean number of targets during evening and morning peak movement periods		
C1) Spring/summer (A1 * B)	3.000	3.000
C2) Fall (A2 * B)	3.000	3.000
D) Mean proportion of birds moving during off-peak h of night	0.126	0.126
E) Seasonal movement rate (targets/night) = ((C * D)+ C)		
E1) Spring/summer	3.38	3.38
E2) Fall	3.38	3.38
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 (bird passes/day =E * F * G)		
H1) Spring/summer	3.48	3.48
H2) Fall	3.48	3.48
I) Fatality domain (days/year)		
I1) Spring/summer	150	150
I2) Fall	60	60
J) Annual movement rate (bird passes/year; = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	731	731
HORIZONTAL INTERACTION PROBABILITY (HIP)		
K) Turbine height (m)	150.5	150.5
L) Blade radius (m)	50.5	50.5
M) Height below blade (m)	49.5	49.5
N) Front to back width (m)	6	6
O) Min side profile area (m²) = (K * N)	903	
P) Max front profile area (m²) = (M * N) + (π * L²)		8309
Q) Cross-sectional sampling area of radar at or below 150.5 m turbine height (= 3000 m * 150.5 m = 451,500 m²)	451500	451500
R) Minimal horizontal interaction probability (= O/Q)	0.00200000	
S) Maximal horizontal interaction probability (= P/Q)		0.01840280
VERTICAL INTERACTION PROBABILITY (VIP)		
T) Proportion of shearwaters flying £ turbine height in Hawaiian Islands (n = 688)	0.752	0.752
EXPOSURE INDEX (ER = MVR*HIP*VIP)		
U) Daily exposure index (bird passes/turbine/day = H * (R or S) * T, rounded to 8 decimal places)		
O1) Spring/summer	0.00523293	0.04815026
O2) Fall	0.00523293	0.04815026
V) Annual exposure index (bird passes/turbine/year = J * (R or S) * T, rounded to 8 decimal places	1.09942400	10.11624145

Table 5. Continued.

Variable/parameter for Siemens SWT-2.3-101 turbine	Minimum	Maximum
FATALITY PROBABILITY (FP)		
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	0.152	0.152
Y) Probability of fatality if striking turbine[1]	1.00	1.00
Z1) Probability of fatality if an interaction on side approach (= W * Y)	1.00000	
Z2) Probability of fatality if an interaction on frontal approach (= X * Y)		0.15200
FATALITY INDEX (= ER*FP)		
Annual fatality rate with 90% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.10)	0.10994	0.15377
Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.05)	0.05497	0.07688
Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.01)	0.01099	0.01538

[1] Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision <100% (see methods).

and, thus, include an unknown proportion of birds that would detect and avoid the turbines and met towers. Hence, exposure rates estimate how many times/year a shearwater would be exposed to wind turbines or met towers and not necessarily the number that actually would collide with those structures.

FATALITY MODELING

The individual steps and estimates involved in calculating fatality rates are shown in Table 5 (for wind turbines) and Tables 6 and 7 (for met towers). We speculate that the proportions of birds that detect and avoid wind turbines and met towers is substantial (see Discussion), but limited shearwater-specific data are available to use for estimates of avoidance rates for these structures. Because it is necessary to estimate the fatality of shearwaters at the proposed project, however, we assumed that 90%, 95%, or 99% of all birds will be able to detect and avoid the met towers and wind turbines. If we also assume that 100% of the birds colliding with a wind turbine/met tower die (although see above), the annual fatality rates are 0.011–0.154 Newell's Shearwaters/turbine/year (Table 5). For each 60-m met tower, we estimate a fatality rate of 0.035–0.347 Newell's Shearwaters/tower/year (Table 6) and for each 100-m met tower, we estimate a fatality rate of 0.004–0.043 Newell's Shearwaters/tower/year (Table 7). The cumulative annual fatalities would be 0.330–4.613 Newell's Shearwaters/yr for all 30 of the proposed wind turbines combined (Table 8). The cumulative annual fatalities at the two 60-m guyed met towers would be 0.069–0.694 Newell's Shearwaters/yr and the cumulative fatality for the three 100-m free-standing met towers would be 0.013–0.129 Newell's Shearwaters/yr.

DISCUSSION

SPECIES COMPOSITION

Similar to what Day and Cooper (2008) found, the timing of our radar observations suggested that the radar targets we recorded in summer 2009 were more likely to be Newell's Shearwaters than Hawaiian Petrels. In other words, the majority of shearwater-/petrel-like targets we observed occurred during the period when only Newell's Shearwater are known to be active on Kauai (Day and Cooper 1995, Cooper and Day 2003, Reynolds et al. 1997, Day et al. 2003a; however, note that an unknown proportion of Hawaiian Petrels on Lanai also are active during nocturnal hours after the second evening sampling session; Cooper and Day, unpubl. data).

More important than the timing evidence from Kauai suggesting that only Newell's Shearwaters

Table 6. Estimated average exposure rates and fatality rates of Newell's Shearwaters for guyed 60-m monopole meteorological (met) towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) 2009. Values of particular importance are in boxes.

Variable/parameter for: 60-m guyed monopole met tower	Newell's Shearwater
MOVEMENT RATE (MVR)	
A) Mean movement rate (targets/h)	
A1) Mean rate during nightly peak movement periods in spring/summer based on June 2009 data (targets/h)	0.6
A2) Mean rate during nightly peak movement periods in fall based on June 2009 data (targets/h)	0.6
B) Number of hours of evening and morning peak period sampling	5
C) Mean number of targets during evening and morning peak movement periods	
C1) Spring/summer (A1 * B)	3.000
C2) Fall (A2 * B)	3.000
D) Mean proportion of birds moving during off-peak h of night	0.126
E) Seasonal movement rate (targets/night) = ((C * D) + C)	
E1) Spring/summer	3.38
E2) Fall	3.38
F) Mean number of birds/target	1.03
G) Estimated proportion that is Newell's Shearwater (vs. Hawaiian Petrel)	1.00
H) Daily movement rate (bird passes/day = E * F * G)	
H1) Spring/summer	3.48
H2) Fall	3.48
I) Fatality domain (days/year)	
I1) Spring/summer	150
I2) Fall	60
J) Annual movement rate (bird passes/year; = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	731
HORIZONTAL INTERACTION PROBABILITY (HIP)	
K) Maximal cross-sectional area of tower and guys (side view = ((50 m * 60 m)/2) * 2 = 3000 m²	3000
L) Cross-sectional sampling area of radar at or below 60 m tower height (= 3000 m * 60 m = 180,000 m²)	180000
M) Average probability of radar target intersecting the met tower (= K/L, rounded to 8 decimal places)	0.01666667
VERTICAL INTERACTION PROBABILITY (VIP)	
N) Proportion of shearwaters flying ≤ tower height in Hawaiian Islands (n = 688)	0.285
EXPOSURE INDEX (ER = MVR*HIP*VIP)	
O) Daily exposure index (bird passes/tower/day = H * M * N, rounded to 8 decimal places)	
O1) Spring/summer	0.01652012
O2) Fall	0.01652012
P) Annual exposure index (bird passes/tower/year = J * M * N, rounded to 8 decimal places)	3.47083333
FATALITY PROBABILITY (FP)	
Q) Probability of striking tower or guys if in airspace	1.00
R) Probability of fatality if striking tower or guys[1]	1.00
S) Probability of fatality if an interaction (= Q * R)	1.00000

Table 6. Continued.

Variable/parameter for: 60-m guyed monopole met tower	Newell's Shearwater
FATALITY INDEX (= ER*FP)	
T) Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year = P * S * 0.10)	0.34708
U) Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year = P * S * 0.05)	0.17354
V) Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year = P * S * 0.01)	0.03471

[1] Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision <100% (see methods).

were present during our sampling, we can find no records of Hawaiian Petrels on Oahu in the past 50–100 yr. In contrast, 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).

Importantly, there also 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 that Newell's Shearwaters nest somewhere in the Koolau Range.

An additional piece of information suggesting nesting by seabirds, presumably Newell's Shearwaters in the Koolau Range, comes from the radar data collected by Day and Cooper (2008) at the nearby Kahuku wind site on the northern tip of Oahu. All of their radar targets except one were heading into or out of the northeastern side of the Koolau Range. In this area, the mountains are steep (providing some protection from ground-based predators), and there were 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. They believed that the consistent orientation of movements toward this area and the presence of both safe habitat (steep hillsides) and appropriate nesting habitat (uluhe ferns) suggested that at least one small Newell's Shearwater colony exists in that area.

While the recent records of Newell's Shearwaters on Oahu and the timing of our radar data suggest that our radar targets were more likely to be Newell's Shearwaters rather than Hawaiian Petrels, it is highly likely that some non-target species also were included as shearwater-like targets in our radar data, especially during the fall season. For example, Pacific Golden-Plovers (which can look similar to shearwaters on radar) were common fall residents and we recorded audiovisual detections of this species on nine occasions during our fall 2009 sampling. In contrast, we did not detect any Newell's Shearwaters during audiovisual sampling in fall (or summer), nor did we observe on radar the typical Newell's Shearwater pattern of landward movements during the evening followed by seaward movements during the morning. Lastly, the fact that our movement rates were higher in fall

Table 7. Estimated average exposure rates and fatality rates of Newell's Shearwaters for free-standing 100-m-tall lattice meteorological (met) towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) 2009. Values of particular importance are in boxes.

Variable/parameter for: 100-m-tall free-standing lattice tower	Newell's Shearwater
MOVEMENT RATE (MVR)	
A) Mean movement rate (targets/h)	
A1) Mean rate during nightly peak movement periods in spring/summer based on June 2009 data (targets/h)	0.6
A2) Mean rate during nightly peak movement periods in fall based on June 2009 data (targets/h)	0.6
B) Number of hours of evening and morning peak period sampling	5
C) Mean number of targets during evening and morning peak movement periods	
C1) Spring/summer (A1 * B)	3.000
C2) Fall (A2 * B)	3.000
D) Mean proportion of birds moving during off-peak h of night	0.126
E) Seasonal movement rate (targets/night) = ((C * D) + C)	
E1) Spring/summer	3.38
E2) Fall	3.38
F) Mean number of birds/target	1.03
G) Estimated proportion that is Newell's Shearwaters	1.00
H) Daily movement rate (bird passes/day =E * F * G)	
H1) Spring/summer	3.48
H2) Fall	3.48
I) Fatality domain (days/year)	
I1) Spring/summer	150
I2) Fall	60
J) Annual movement rate (bird passes/year; = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	731
HORIZONTAL INTERACTION PROBABILITY (HIP)	
K) Maximal cross-sectional area of tower (side view = 313 m²)	313
L) Cross-sectional sampling area of radar at or below 100 m tower height (= 3000 m * 100 m = 300,000 m²)	300000
M) Average probability of radar target intersecting the met tower (= K/L, rounded to 8 decimal places)	0.00104333
VERTICAL INTERACTION PROBABILITY (VIP)	
N) Proportion of shearwaters flying ≤ tower height in Hawaiian Islands (n = 688)	0.564
EXPOSURE INDEX (ER = MVR*HIP*VIP)	
O) Daily exposure index (bird passes/tower/day = H * M * N, rounded to 8 decimal places)	
O1) Spring/summer	$\boxed{0.00204738}$
O2) Fall	$\boxed{0.00204738}$
P) Annual exposure index (bird passes/tower/year = J * M * N, rounded to 8 decimal places)	$\boxed{0.43014964}$
FATALITY PROBABILITY (FP)	
Q) Probability of striking tower or guys if in airspace	1.00
R) Probability of fatality if striking tower[1]	1.00
S) Probability of fatality if an interaction (= Q * R)	1.00000

Table 7. Continued.

Variable/parameter for: 100-m-tall free-standing lattice tower	Newell's Shearwater
FATALITY INDEX (= ER*FP)	
T) Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year = P * S * 0.10)	0.04301
U) Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year = P * S * 0.05)	0.02151
V) Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year = P * S * 0.01)	0.00430

[1] Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision <100% (see methods).

Table 8. Summary of exposure rates, fatality rates, and cumulative fatality rates for Newell's Shearwaters (NESH) at one type of wind turbine and at two types of meteorological (met) towers in the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) 2009.

		Fatality Index per structure		Cumulative Fatality Index
Structure	Avoidance Rate	Birds/structure/year	No. Structures	Birds/year
Siemens SWT-101 turbine	0.90 (min)	0.110	30	3.298
	0.90 (max)	0.154	30	4.613
	0.95 (min)	0.055	30	1.649
	0.95 (max)	0.077	30	2.306
	0.99 (min)	0.011	30	0.330
	0.99 (max)	0.015	30	0.461
60-m guyed met tower	0.90	0.347	2	0.694
	0.95	0.174	2	0.347
	0.99	0.035	2	0.069
100-m lattice met tower	0.90	0.043	3	0.129
	0.95	0.022	3	0.065
	0.99	0.004	3	0.013

than summer was very indicative of inclusion of non-shearwater targets in fall because the number of shearwaters visiting breeding colonies generally tends to decline from summer to fall. That drop occurs because attendance at colonies by nonbreeders and failed breeders declines as chick-rearing progresses (Serventy et al. 1971, Warham 1990, Ainley et al. 1997b, Simons and Hodges 1998). Thus, while the identity of the majority of radar targets we observed in the current study is unknown, our audiovisual data suggest that it is highly likely that some Pacific Golden-Plover targets were included in fall (i.e., after migrant birds returned to Hawaii from summer breeding grounds in the arctic); however, it cannot completely be ruled out that some or all of the targets that we observed were Newell's Shearwaters. What can be said at this time is that movement rates of Newell's Shearwater-like targets through the study area were very low during the known peak daily activity periods for Newell's Shearwater and that our data set errs on the conservative side because it is highly likely to include some non-shearwater targets, especially in the fall.

MOVEMENT RATES AND FLIGHT DIRECTIONS

The overall mean evening movement rate of shearwater-like targets at the proposed windfarm site was 0.60 ± 0.07 targets/h during summer 2009 and 1.41 ± 0.15 targets/h during fall 2009. These data suggest that low numbers of shearwaters may be flying over the Kawailoa site: movement rates from almost all sampling sites on all other Hawaiian Islands (Day and Cooper 1995, Cooper and Day 2003, Day et al. 2003b) are higher, and often much higher, than the 2009 movement rates observed at the proposed Kawailoa windfarm. For example, the mean summer movement rate on Kauai was 118 targets/h (range = 8–569 targets/h, n = 13 sites; Day et al. 2003b). The only comparable radar data available for Oahu was collected by Day and Cooper (2008), who observed a mean summer movement rate of 0.2 ± 0.1 targets/h and a mean fall movement rate of 0.3 ± 0.2 targets/h at the nearby Kahuku site, located ~10 km NE of the Kawailoa site. The only other radar data set from Oahu is Denis and Verschuyl (2007), but those data are not comparable to ours because they were collected in May (a period when Newell's Shearwaters make an egg-laying exodus from the colonies [Ainley et al. 1997b]) and because they used a different minimal-cutoff flight speed (i.e., an airspeed of 40 mi/h [64 km/h}) for their speed cut-off for petrel-/shearwater-like radar targets.

Most (~97%) of all targets we observed were flying seaward (i.e., heading northwest, away from the direction of the potential seabird colonies in the Koolau Mountains). Similar flight directions of radar targets were observed at the nearby Kahuku site by Day and Cooper (2008).

EXPOSURE RATES AND FATALITY ESTIMATES

We estimated that ~1–11 Newell's Shearwater fly within the space occupied by each proposed wind turbine in an average year (Table 5), that ~4 Newell's Shearwater fly within the space occupied by each guyed, 60-m-high met tower in an average year (Table 6), and that ~1 Newell's Shearwater fly within the space occupied by each free-standing, 100-m-high met tower in an average year (Table 7). We used these estimated exposure rates as a starting point for developing a complete avian risk assessment; however, we emphasize that it currently is unknown whether bird use (i.e., exposure) and fatality at windfarm structures 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, indicating that other factors had a much greater effect on causing fatality than movement rates did. Other factors such as poor weather could be more highly correlated with fatality rates than is bird abundance. As an example, collisions of Laysan Albatross with a large array of communication-tower antenna wires and guy wires adjacent to large, high-density albatross breeding colonies on Midway Atoll occurred at a far higher rate during periods of high winds, rain, and poor visibility than during periods of better weather: 838 (>25%) of the 2,901 birds killed during the study were killed during two storms (Fisher 1966). To determine which factors are most relevant, future studies that collect concurrent data on movement rates, weather, and fatality rates would be useful to evaluate how well movement rates and/or weather conditions can be used to predict the likelihood of shearwater fatalities at wind turbines, met towers and other structures at wind-energy facilities.

In addition, few data are available on the proportion of petrels and shearwaters that do not collide with wind turbines or met towers because of collision-avoidance behavior (i.e., birds that completely alter their flight paths horizontally and/or vertically to avoid flying through the space occupied by a structure). Some collision-avoidance information near transmission lines is available on petrels and shearwaters from earlier work that we conducted on Kauai, however (Cooper and Day 1998; Day et al., *In prep*). In summary, those data suggest that the behavioral-avoidance rate of Hawaiian Petrels and Newell's Shearwaters near transmission lines is high. For example, across all 207 Hawaiian Petrels observed flying within 150 m of transmission lines on Kauai, 40 exhibited behavioral responses; of those 40 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. Thus, the collision-avoidance rate for Hawaiian Petrels was 100% (i.e., 40 of 40 interactions resulted in collision avoidance). Across all 392 Newell's Shearwaters observed flying within 150 m of transmission lines, 29 exhibited behavioral responses; of those 29 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. However, one Newell's Shearwater that did not exhibit a collision-avoidance response hit a transmission line. Thus, the collision-avoidance rate for Newell's Shearwaters was 97% (i.e., 29 of 30 interactions resulted in successful collision avoidance).

There also is some information available on collision-avoidance of Hawaiian Petrels on Lanai, where the behavior of petrels was studied as they approached large communication towers near the breeding colony (TetraTech 2008; Day et al., *In prep*). In that study, all 20 (100%) of the Hawaiian Petrels that were on a collision-course toward communication towers exhibited avoidance behavior and avoided collision.

Additional data that provides some insight on collision-avoidance behavior of petrels and shearwaters at windfarm structures (e.g., wind turbines and met towers) are available from other studies associated with the operational KWP I wind facility on Maui. There was 1 Hawaiian Petrel fatality and 0 Newell's Shearwater fatalities observed at the 20-turbines and three met towers in the first four years of operation (G. Spencer, FirstWind, pers. comm.). Calculations using data for scavenging bias and searcher efficiency collected at the KWP I wind facility indicate that the one observed fatality equates to a corrected direct take of 0.5 Hawaiian Petrels/yr and 0 Newell's Shearwaters/yr (Kaheawa Wind Power LLC 2009, *in prep*). Cooper and Day (2004b) modeled seabird fatality for the KWP I wind turbines, based on movement rates from radar studies at the site (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 turbines 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 that used a 99% avoidance value was a closer fit with the measured fatality rates than was the fatality models that used a 50% or 95% avoidance rate.

In summary, currently available data from Kauai, Lanai, and Maui suggest that the avoidance rate of petrels and shearwaters at transmission lines and communications towers is high and approaches 100% (Day et al., *In prep*). Data from the fatality searches at turbines and met towers on Maui are more difficult to interpret because they suggest high avoidance but are not a direct measure of avoidance; however those data also suggest that avoidance of those structures must be occurring because only one Hawaiian Petrel has been found during regular fatality searches of those structures over a four-year period. Thus, the overall body of evidence, while incomplete, is consistent with the hypothesis that the average avoidance rate of wind turbines and met towers is substantial and potentially is ≥95%. 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 low-light conditions.

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 structures (e.g., wind turbines, met towers) 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 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), Common Terns (*Sterna hirundo*) and Sandwich Terns (*Sterna sandvicensis*) during the daytime (>99%, Everaert and Stienen 2007), 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).

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 fatality data at KWP I wind turbines and met towers on Maui while incomplete, is consistent with the notion that a substantial proportion of shearwaters and 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 structures at windfarms, we continue to provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance), along with a discussion of the body of evidence that, while incomplete at this time, is consistent with the notion that the average avoidance-rate value is substantial and potentially is ≥95%. With an assumption of a 95% avoidance rate, the estimated average annual take at the proposed Kawailoa facility would be 0.055–0.077 Newell's Shearwaters/wind turbine/yr, 0.174 Newell's Shearwaters/met tower/yr at each guyed, 60-m-tall met towers and, 0.022 Newell's Shearwaters/met tower/yr at each free-standing, 100-m-tall met towers.

Other factors could affect our estimates of fatality in either a positive or a negative direction. One factor that would have created a positive bias was the inclusion of targets that were not petrels or shearwaters (see above). The elimination of shearwater-like radar targets that were confirmed by concurrent visual observations to be non-target species and the exclusion of fall radar data helped to minimize the inclusion of non-target species, but it still is possible that some of our radar targets could have been other fast-flying species that were active during the sampling period (e.g., Sooty Terns [*Sterna fuscata*]) and thus inflated our movement rate calculations. A second positive bias in our fatality model is our simplistic assumption that movement rates of seabirds do not fall as individual fatalities occurred (i.e., we assumed sampling with replacement for fatalities). Given the 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. A third positive bias is the assumption that turbines are operating at maximal rotor speed; this assumption clearly is incorrect because of variability in winds, but using it results in maximal estimates of collision rates for birds flying through the turbine rotors.

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 stations provided good coverage of the surrounding area, we believe that the proportion of targets that was missed because they passed through the entire area of coverage of the study area within a radar shadow was minimal.

A factor that could affect the predictive value of our fatality estimates in either direction is interannual variation in the number of birds visiting nesting colonies. There are examples of sites with high interannual variation in counts, such as the three sites on Kauai where counts were ~100–300 birds/hr lower (~four times lower) in fall 1992 than in fall 1993; the lower counts in 1992 were attributed to the effects of Hurricane Iniki (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). There was a moderate El Niño–Southern Oscillation event that began in April 2009 and was still developing when our summer study occurred in June 2009 (NOAA 2009). We speculate that it is unlikely that El Niño-related oceanographic effects were large enough by June 2009 to have significantly affected seabird movement rates during our summer study period, but it is possible that fall rates could have been affected (however, note that this is unlikely, given that fall 2009 rates were higher than summer 2009 rates). Another factor that could cause interannual variation in counts in either direction is overall population increases or declines. For example, there was a ~60% decline in radar counts on Kauai between 1993 and 1999–2001 that was attributed to population declines of Newell's Shearwaters (Day et al. 2003b).

HAWAIIAN HOARY BATS

Recent data from Appalachian ridge tops in the eastern US 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), transmission lines (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 visual data on Hawaiian Hoary Bats during this study, using binoculars and night-vision equipment, even though the Hawaiian subspecies is non-migratory. Our data indicate that Hawaiian Hoary Bats are present in the Kawailoa study area in low numbers in summer: only 2 bats were recorded during the 10 nights of this study (i.e., 2 bats in 84 25-min observation sessions, or 0.057 bats/h). We did not observe any bats in fall. Similarly, Day and Cooper (2008) also recorded low numbers of bats at the nearby Kahuku wind site summer (i.e., they observed 1 bat in 97 25-min sampling sessions) but not fall. Hawaiian Hoary 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 on our visual data at the Kawailoa site and previous data from the nearby Kahuku site (Day and Cooper 2008) it appears that they are present in low numbers 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 Kawailoa Wind Energy Facility in summer and fall 2009. The key results of our study were: (1) movement rates of shearwater-like targets were low (0.6 targets/h in summer and 1.4 targets/h in fall) relative to other locations in the Hawaiian Islands; (2) the timing of movements and absence of recent records of Hawaiian Petrels on Oahu suggested that the petrel-/sheawater-like radar targets that we observed were most likely Newell's Shearwaters rather than Hawaiian Petrels; (3) our observations of nine flocks of Pacific Golden-Plovers during fall sampling, the difficulty of separating plover targets from shearwater targets on radar, and the higher movement rates we observed in fall when lower numbers of shearwaters are expected to occur all indicate that our fall radar data were highly likely to include an substantial proportion of plovers (thus inflating our movement rates used in the shearwater fatality models, had we not excluded those fall data from the models); (4) Hawaiian Hoary Bats were detected during visual observations in the vicinity of the proposed windfarm in summer only, but summer movement rates were low (~0.057 bats/h); (5) an estimated ~1–11 Newell's Shearwater fly within the space occupied by each proposed wind turbine in an average year, ~4 Newell's Shearwater fly within the space occupied by each guyed, 60-m-high met tower in an average year, and that ~1 Newell's Shearwater fly within the space occupied by each free-standing, 100-m-high met tower in an average year; and (6) by using a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance), we estimated a collision-caused fatality rate of 0.011–0.154 Newell's Shearwaters/turbine/year for each wind turbine, 0.035–0.347 Newell's Shearwaters/ tower/year for each 60-m met tower, and 0.004–0.043 Newell's Shearwaters/tower/year for each 100-m met tower. In conclusion, we believe that the proportion of seabirds that would see and avoid wind turbines and met towers at the proposed Kawailoa Wind Energy Facility will be high, but until further studies are conducted to quantify avoidance behavior at these structures, we provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance rates) along with a discussion of the body of evidence that is consistent with the hypothesis that the average avoidance-rate value is substantial and potentially ≥95%.

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's 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., and B. A. Cooper. 2008. Results of endangered seabird and Hawaiian Hoary Bat surveys on northern Oahu Island, October 2007 and July 2008. Unpublished report prepared for FirstWind, Newton, MA, by ABR, Inc.—Environmental Research & Services, Fairbanks, AK, and Forest Grove, OR. 27 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, T. J. Mabee, J. H. Plissner, P. M. Sanzenbacher, and A. Oller. *In prep*. Collision-avoidance behavior of Hawaiian Petrels and Newell's Shearwaters in the Hawaiian Islands.

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.

Everaert, M. and E. W. M. Stienen. 2007. Impact of wind turbines on birds in Zeebrugge (Belgium). Biodivers. Conserv. 16: 3345–2259.

Fisher, H. I. 1966. Midway's deadly antennas. Audubon Magazine, July–August 1966. Pp. 220–223.

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.

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.

Kaheawa Wind Power, LLC. 2009 (*In prep*). Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 3 Annual Report. First Wind Energy, LLC, Environmental Affairs, Newton, MA.

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. Szewczak. 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.

NOAA 2009. National Climatic Data Center El Niño and La Niña website. [http://www.ncdc.noaa.gov/oa/climate/elnino/elnino.html]

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.

TetraTech EC. 2008. Draft Habitat Conservation Plan for the construction and operation of Lanai met towers, Lanai, Hawaii (Revised February 8, 2008, TTEC-PTLD-2008-080). Unpublished report prepared by Tetratech EC, Honolulu, HI, for Castle and Cooke LLC, Lanai City, HI. 52 pp. + appendices. [http://www.state.hi.us/dlnr/dofaw/pubs/Lana'i_Met_Towers_HCP.pdf]

Tucker, V. A. 1996. A mathematical model of bird collisions with wind turbine rotors. ASME Journal of Solar Energy Engineering 118: 253–262.

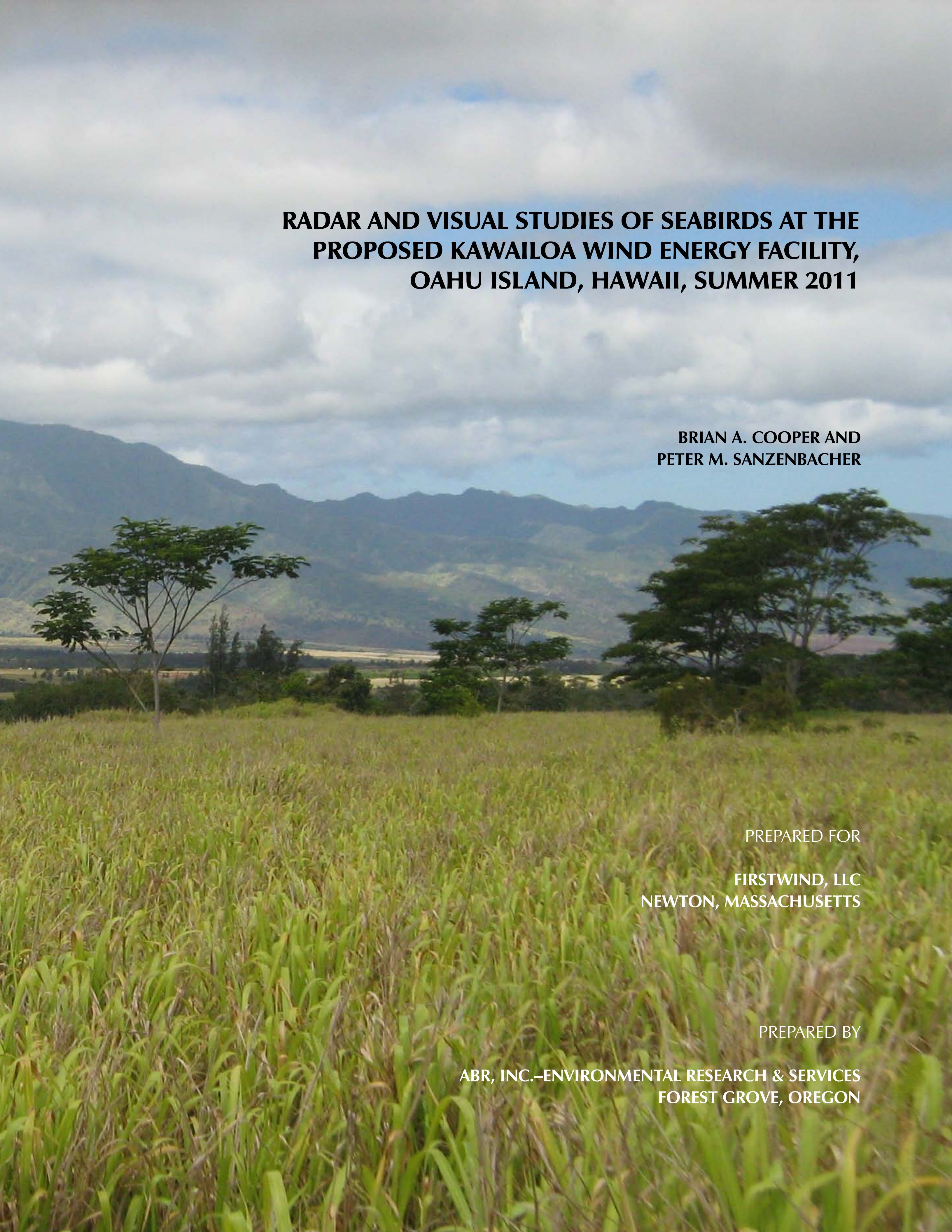
van Riper, S. G., and C. van Riper II. 1982. A field guide to the mammals in Hawaii. Oriental Publishing Co., Honolulu, HI. 68 pp.

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. [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 3b



RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KAWAILOA WIND ENERGY FACILITY, OAHU ISLAND, HAWAII, SUMMER 2011

BRIAN A. COOPER AND
PETER M. SANZENBACHER

PREPARED FOR

FIRSTWIND, LLC
NEWTON, MASSACHUSETTS

PREPARED BY

ABR, INC.–ENVIRONMENTAL RESEARCH & SERVICES
FOREST GROVE, OREGON

RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KAWAILOA WIND ENERGY FACILITY, OAHU ISLAND, HAWAII, SUMMER 2011

FINAL REPORT

Prepared for

FIRSTWIND, LLC
85 Wells Avenue, Suite 305
Newton, MA 02459–3210

Prepared by

Brian A. Cooper and Peter M. Sanzenbacher
ABR, Inc.—Environmental Research & Services
P.O. Box 249
Forest Grove, OR 97116–0249

October 2011

EXECUTIVE SUMMARY

- FirstWind, LLC, is interested in developing the Kawailoa Wind Energy Facility (i.e., the Project) on northern Oahu Island, Hawaii. This report summarizes the results of a radar and audiovisual study of seabirds and a visual study of bats conducted at the Project in summer 2011 and builds upon studies conducted there during 2009 by Cooper et al. (2011). 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 Project area by these species; and (3) assess possible fatality rates of these species at the Project.
- Two-to-four observers monitored movements of seabirds and bats at four study sites for a total of 16 nights during June 2011, following standard ornithological radar and audiovisual techniques used in previous studies.
- We visually recorded no Hawaiian Petrels, no Newell's Shearwaters, and no unidentified shearwaters/petrels during our 16 nights of audiovisual sampling in summer 2011.
- We visually recorded 1 Hoary Bat during summer 2011. This observation translated to an estimated summer occurrence rate of 1 bat in 249 25-min summer observation sessions (i.e., 0.010 bats/h). The bat was flying at an altitude of ~40 m agl.
- Our radar data collected during this study on the timing of movements and the available literature indicating that Newell's Shearwaters but not Hawaiian Petrels occur on Oahu both suggest that the radar targets we observed were more likely to be Newell's Shearwaters than Hawaiian Petrels.
- During our 16 survey nights in summer 2011, we recorded 5 landward-flying and 32 seaward-flying radar targets that fit our criteria for shearwater-like targets.
- The mean movement rates of shearwater-like targets (i.e., landward and seaward rates combined) during the summer 2011 were 0.29 ± 0.29 targets/h at the Lower Kawailoa Station, 0.92 ± 0.08 targets/h at the Ashley Station, 0.81 ± 0.25 targets/h at the Upper Kawailoa Station, 0.76 ± 0.19 targets/h at the North Site Station, and 0.72 ± 0.12 targets/h at all stations combined. For comparison, during summer 2009 there were 0.62 ± 0.10 targets/h at the Lower Kawailoa Station, 0.57 ± 0.12 targets/h at the Ashley Station, and 0.60 ± 0.07 targets/h at all stations combined. There was overlap in the 95% confidence intervals for passage rates of all stations and years, suggesting that there were no differences in passage rates among stations or between years.
- We recorded higher numbers of seaward-flying targets than landward-flying targets at all sampling stations. Overall, ~87% of all shearwater-like targets were flying seaward (i.e., away from the direction of the potential seabird colonies in the Koolau Mountains) and ~14% were flying landward (i.e., toward the potential nesting habitat).
- To determine the risk of collision-caused mortality, we used the mean passage rates of shearwater-like targets observed on radar in summer 2009 and 2011, Newell's Shearwater flight altitudes from previous studies, and dimensions and characteristics of the proposed wind turbines and met towers to generate an estimate of exposure risk. We then applied estimates of the fatality probability (i.e., the probability of collision with a portion of the wind turbine or met tower and dying while in the airspace occupied by the structure) and a range of estimated avoidance probabilities (i.e., the probability that a bird will detect and avoid entering the airspace containing the structure) to this estimate of exposure to calculate annual fatality rates that could be expected at the Project's proposed wind turbines and met towers.
- We estimate that an average of ~2–12 Newell's Shearwater/yr fly within the space occupied by each wind turbine, that ~4 Newell's Shearwaters/yr fly within the space occupied by each guyed, 60-m-tall met tower , and that ~1 Newell's Shearwater/yr flies within the space occupied by each free-standing, 100-m-tall met tower.

- We estimated annual fatality rates at wind turbines and met towers by assuming that 90%, 95%, or 99% of all shearwaters flying near a structure will see and avoid it. Based on these scenarios, we estimated a collision-caused fatality rate of 0.012–0.169 Newell's Shearwaters/turbine/year for each wind turbine, 0.038–0.382 Newell's Shearwaters/tower/year for each 60-m met tower, and 0.005–0.047 Newell's Shearwaters/tower/year for each 100-m met tower. Although the range of assumed avoidance rates at wind turbines and met towers (90–99%) is not fully supported by empirical data at this time we speculate that avoidance rates of petrels and shearwaters at wind farm structures potentially are ≥95%, based upon fatality rates at existing windfarms and avoidance behavior of petrels and shearwaters observed at other structures (e.g., powerlines and communication towers); thus, we believe that fatality rates will be within the lower half of the range of estimates.

TABLE OF CONTENTS

EXECUTIVE SUMMARY iii
LIST OF FIGURES v
LIST OF TABLES vi
ACKNOWLEDGMENTS vi
INTRODUCTION 1
BACKGROUND 1
SEABIRDS 1
HAWAIIAN HOARY BATS 3
STUDY AREA 3
METHODS 5
DATA ANALYSIS 8
RADAR AND VISUAL DATA SUMMARY 8
EXPOSURE AND FATALITY RATES 9
RESULTS 12
RADAR OBSERVATIONS 12
AUDIOVISUAL OBSERVATIONS 14
EXPOSURE RATES 16
FATALITY MODELING 18
DISCUSSION 18
SPECIES COMPOSITION 18
PASSAGE RATES AND FLIGHT DIRECTIONS 22
EXPOSURE RATES AND FATALITY ESTIMATES 22
COLLISION AVOIDANCE RATES 23
POTENTIAL BIASES 24
HAWAIIAN HOARY BATS 25
SUMMARY 26
LITERATURE CITED 26

LIST OF FIGURES

Figure 1. Oahu Island, Hawaii, with approximate location of the proposed Kawailoa Wind Energy Facility 2
Figure 2. Location of 2009 and 2011 radar sampling stations and meteorological towers and tentative locations of proposed wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii 4
Figure 3. Approximate shearwater-/petrel-sampling airspace for the Furuno FR–1510 marine radar at the 1.5-km range setting, as determined by field trials with Rock Pigeons 7
Figure 4. Major variables used in estimating possible fatalities of Newell’s Shearwaters at wind turbines and met towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii. 10
Figure 5. Location of flight paths of shearwater-like radar targets observed during summer 2011 at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii 15

LIST OF TABLES

Table 1. Radar and audiovisual sampling location coordinates and elevations at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer 2011 5

Table 2. Sampling dates at each radar and audiovisual sampling location at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer 2011 6

Table 3. Sampling dates and number of landward, seaward, and other radar targets; and number of audiovisual observations of species of interest at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer 2011 13

Table 4. Mean passage rates of shearwater-like radar targets observed at sampling stations at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer 2009 and 2011.. 14

Table 5. Evening and morning timing of movement of bird targets on ornithological radar, with total number of targets and percentages of nightly movements observed by half-hour period at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer 2009 and 2011.. 16

Table 6. Estimated average exposure rates and fatality rates of Newell's Shearwaters for Siemens SWT-2.3-101 wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer 2009 and 2011 17

Table 7. Estimated average exposure rates and fatality rates of Newell's Shearwaters for guyed 60 m monopole meteorological towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer 2009 and 2011...... 19

Table 8. Estimated average exposure rates and fatality rates of Newell's Shearwaters for free-standing 100 m lattice meteorological towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer 2009 and 2011.. 20

Table 9. Summary of exposure rates, fatality rates, and cumulative fatality rates for Newell's Shearwaters at one type of wind turbine and at two types of meteorological towers in the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer 2009 and 2011 21

ACKNOWLEDGMENTS

We thank FirstWind, LLC (FirstWind) for funding this study and for providing the ornithological radar used for sampling. We thank Greg Spencer, Wren Wescoatt, and Dave Cowan (FirstWind) and Ling Ong (SWCA) for help with logistics. We thank Todd Mabee (ABR) for help with radar sampling and thank Ling Ong, Jaap Elizenja (SWCA), and Phil Taylor (SWCA) for assistance with the visual sampling. At ABR, Rich Blaha produced study figures and Pam Odom assisted with report production.

INTRODUCTION

FirstWind, LLC (FirstWind), is interested in developing the Kawailoa Wind Energy Facility (hereafter Project) on northern Oahu Island, Hawaii (Figure 1). As part of the siting process, FirstWind wanted to obtain information on endangered seabirds and bats in the vicinity of the Project. Ornithological radar and night-vision techniques have been shown to be successful in studying these species groups 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). This report summarizes the results of a radar and visual study of seabirds and bats conducted by ABR, Inc. (ABR) at the Project in June (summer) 2011 and builds upon previous studies conducted there by Cooper et al. (2011) in 2009. The objectives of this study were to: (1) conduct radar and visual surveys of endangered seabirds and bats in the vicinity of the Project; (2) summarize available information to help assess use of the Project by these species; and (3) assess possible fatality rates of these species at wind turbines and meteorological towers (met towers) at the Project.

BACKGROUND

SEABIRDS

Two seabird species that are protected under the Endangered Species Act (ESA) historically have occurred on Oahu and thus may have occurred at the Project: the endangered Hawaiian Petrel ('Ua'u) and the threatened Newell's (Townsend's) Shearwater ('A'o). The Hawaiian Petrel and the Newell's Shearwater are forms of tropical Pacific species that nest only on the Hawaiian Islands (American Ornithologists' Union 1998). Both species 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 one exception is Kauai Island, where colonies still are widespread and populations are substantial in size. Of note, Kauai (along with Lanai) also has no introduced Indian Mongoose (*Herpestes auropunctatus*) which preys on these seabirds.

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), Lanai (Shallenberger 1974; Hirai 1978a, 1978b; Conant 1980; J. Penniman, State of Hawaii, DOFAW, pers. comm.), 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). The most recent information from Molokai (Simons and Hodges 1998, Day and Cooper 2002) also suggests breeding. We can find no records of Hawaiian Petrels occurring on Oahu in the past 50–100 years.

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*).

There is interest in studying these two species because of concerns regarding collisions with human-made structures such as met towers and wind turbines. To date, there is documented mortality of two Hawaiian Petrels at a wind turbine and zero Newell's Shearwaters at wind-energy facilities (wind turbines or met towers) within the Hawaiian Islands (Kaheawa Wind Power LLC 2009; G. Spencer, FirstWind, pers. comm.; A. Oller, TetraTech EC, pers. comm.). While there only are fatality data available for two wind energy projects, there has been well-documented petrel and shearwater mortality resulting from collisions with other human-made structures (e.g.,

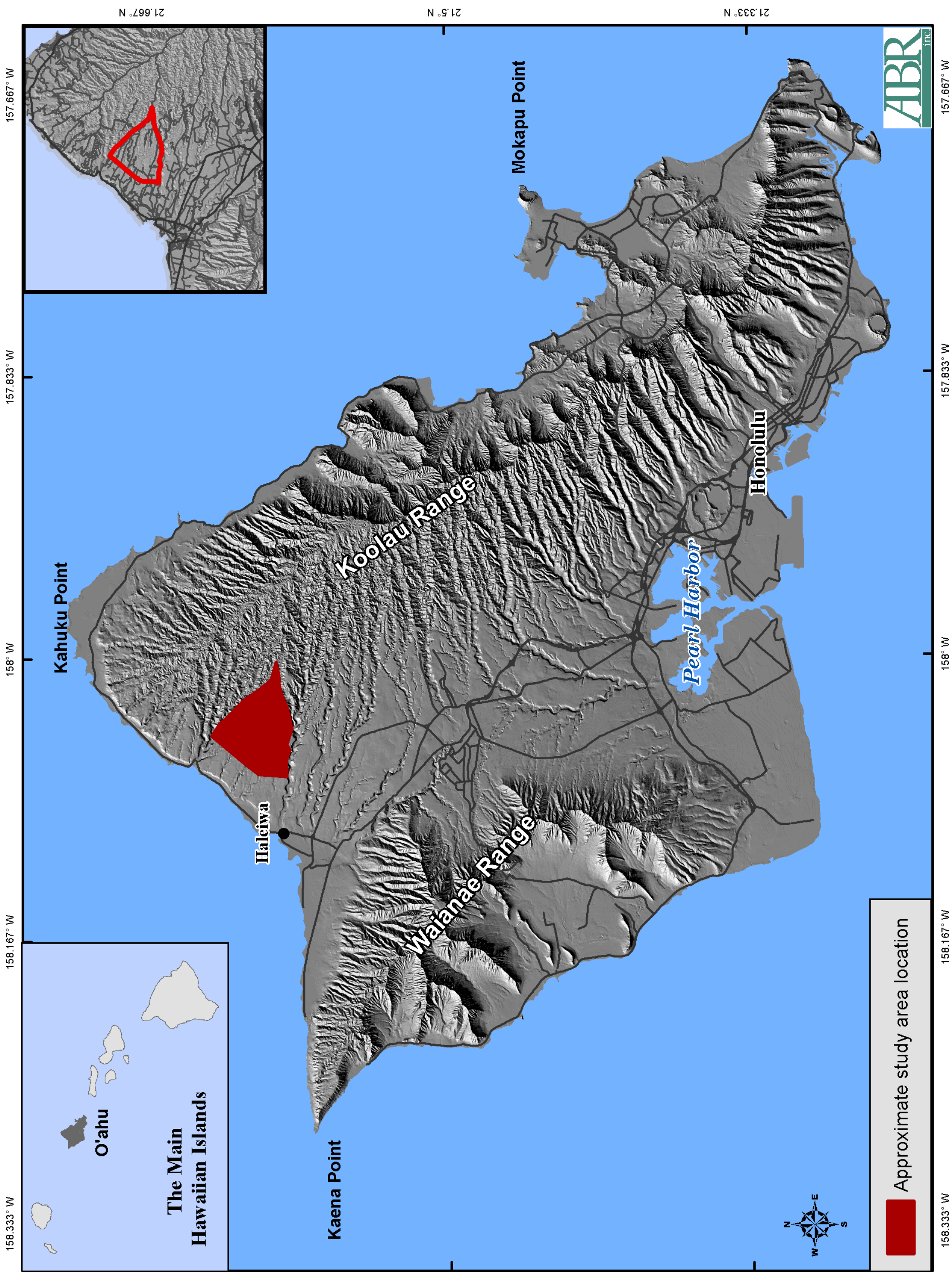


Figure 1. Oahu Island, Hawaii, with approximate location of the proposed Kawailoa Wind Energy Facility.

transmission lines, communication towers) 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 was classified as endangered primarily because so little was 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 above sea level [asl] (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 2008).

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 (*Lasiurus cinereus*), 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 bat use at sites proposed for wind energy development (Reynolds 2006, Kunz et al. 2007a). Most of the bat fatalities documented at windfarms have been of migratory tree-roosting species, including Hoary, 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 fatalities at wind turbines (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 passage rates or foraging activity near windfarms; however, recent research by Baerwald et al. (2008) indicates that barotrauma (high-pressure damage to mammalian lungs) also is a major cause of the fatalities. Because of these fatalities of migratory Hoary Bats at windfarms on the US mainland as well as documentation of two Hawaiian Hoary Bat fatalities at wind turbines on Maui (Kaheawa Wind Power LLC 2009, G. Spencer, First Wind, pers. comm.), there was interest in having ABR collect visual data on Hawaiian Hoary Bats during this study.

STUDY AREA

The proposed Project is located above the town of Haleiwa, which is located near the northern tip of Oahu Island (Figure 1). In 2009, two 60-m-high NRG monopole met towers that are anchored by six guy wires in each of four directions were installed at the proposed windfarm. All guy wires were 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 to these two met towers, three 100-m-tall, free-standing lattice met towers are proposed to be built at the Project site (Figure 1). In regards to wind turbines, the development plan for the Project has not been finalized, but for the purposes of this report we proceed with the assumption that the plan is to install ~30 Siemens SWT-2.3-101 wind turbines (SWCA 2011a). Each turbine would have a nominal generating capacity of ~2.3 MW, for a total installed capacity of ~69 MW for the windfarm as a whole. The currently proposed monopole towers would be ~100 m in height, and each turbine would have 3 rotor blades with a rotor diameter of 101 m; hence, the total maximal height of a turbine would be ~150.5 m with a blade in the top-vertical position.

The proposed windfarm will be located on a gently-sloping bench on agricultural lands situated on the lower slopes in the northwestern Koolau Range (Figures 1 and 2). The Project has an elevation varying from ~150–400 m above sea level and is extremely disturbed, being covered with old pasturelands and introduced species such as guinea grass (*Urochloa maxima*), common ironwood (*Casuarina equisetifolia*), albizia (*Falcataria moluccana*), Formosa koa (*Acacia confusa*), koa haole (*Leucaena leucocephala*), padang cassia (*Cinnamomum burmanni*), Java plum (*Syzygium cumini*), strawberry guava (*Psidium cattleianum*), cork bark passion flower (*Passiflora suberosa*) and swamp mahogany (*Eucalyptus robusta*). Some native habitat

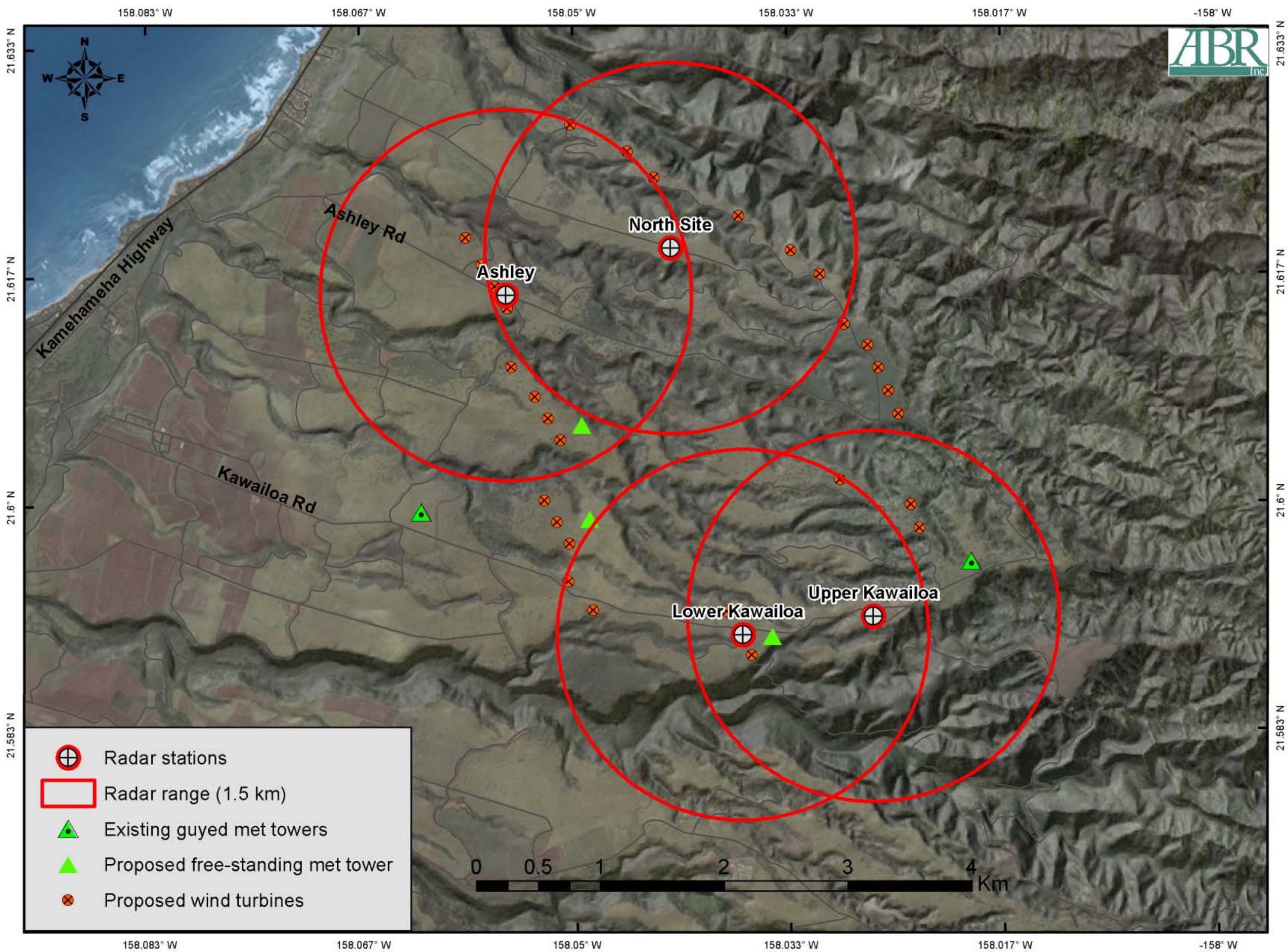


Figure 2. Location of 2009 and 2011 radar sampling stations and meteorological (met) towers and tentative locations of proposed wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii.

containing ohia lehua trees and uluhe 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 Koolau Range.

During June 2011, we conducted standard radar and audiovisual surveys at four primary sampling stations within the proposed windfarm (Figure 2; Table 1). The Lower Kawailoa and Ashley stations also were sampled in 2009 (Cooper et al. 2011); the two new stations (i.e., Upper Kawailoa and North Site) were added in 2011 to provide better coverage of the most current turbine string locations. All four stations provided good radar and audiovisual coverage of the surrounding area. In addition to these four primary stations where both radar and audiovisual data were collected, we added two supplementary audiovisual-only sampling stations at each station, one on the eastern side of each primary station and one on the western side of each primary station (Table 1).

METHODS

We used marine radar and visual equipment to collect data on the movements, flight behaviors, and flight altitudes of petrels and shearwaters for five nights at each of two new primary sampling stations (Upper Kawailoa and North Site) and for three nights at each of the historic primary sampling locations (Ashley and Lower Kawailoa stations) during June 2011 (Table 2). In addition, supplementary visual observations generally occurred at one or both audiovisual-only sampling stations each night, whenever additional observers were available (Table 2).

The daily sampling effort consisted of a 3 h period each evening (1900–2200 h) and 1.5 h period each morning (0400–0530 h) at each primary site. Our sampling periods were selected to correspond to the evening and morning peaks of movement of petrels and shearwaters, as described near breeding colonies on Kauai (Day and Cooper 1995). During sampling, we collected radar and audiovisual data concurrently so the radar operator could provide locations and flight directions of incoming targets to help the audiovisual observer locate birds for species identification and additional data collection. In return, the audiovisual observer provided information to the radar operator on the identity and flight altitude of any targets observed. For the purpose of recording data, a calendar day began at 0700 h and ended at 0659 h the following morning; that way, an evening and the following morning were classified as occurring on the same sampling day.

Table 1. Radar and audiovisual (AV) sampling location coordinates (WGS84 decimal degrees) and elevations at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer (June) 2011.

Site	Sampling Type	Location Coordinates		Elevation (m asl)
Lower Kawailoa	Radar & AV	21.59038°	-158.03700°	300
Lower Kawailoa East[1]	AV only	21.59169°	-158.02682°	336
Lower Kawailoa West	AV only	21.59150°	-158.04192°	279
Upper Kawailoa	Radar & AV	21.59169°	-158.02682°	336
Upper Kawailoa East	AV only	21.59335°	-158.02227°	367
Upper Kawailoa West	AV only	21.59089°	-158.03656	301
Ashley	Radar & AV	21.61529°	-158.05534°	190
Ashley East	AV only	21.61391°	-158.05148°	206
Ashley West	AV only	21.61869°	-158.06192°	155
North Site	Radar & AV	21.61866°	-158.04247°	233
North Site East	AV only	21.61777°	-158.03915°	249
North Site West	AV only	21.62007°	-158.04698°	211

[1] Same location as the Upper Kawailoa radar and audiovisual site.

Table 2. Sampling dates at each radar and audiovisual (AV) sampling location at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer (June) 2011 (N = not sampled, Y = sampled).

Date	Radar/AV Station	Period	AV-only Site East	AV-only Site West
14 June	North	Eve	Y	Y
		Morn	N	N
15 June	North	Eve	Y	Y
		Morn	N	N
16 June	Upper Kawailoa	Eve	N	Y
		Morn	N	Y
17 June	Lower Kawailoa	Eve	Y	Y
		Morn	N	N
18 June	Upper Kawailoa	Eve	N	Y
		Morn	N	N
19 June	Upper Kawailoa	Eve	N	Y
		Morn	N	N
20 June	Ashley	Eve	N	N
		Morn	N	N
21 June	Lower Kawailoa	Eve	N	Y
		Morn	N	N
22 June	North	Eve	N	Y
		Morn	N	N
23 June	Upper Kawailoa	Eve	Y	N
		Morn	N	N
24 June	Lower Kawailoa	Eve	Y	N
		Morn	N	N
25 June	Ashley	Eve	Y	N
		Morn	N	N
26 June	North	Eve	Y	N
		Morn	N	N
27 June	Ashley	Eve	N	N
		Morn	N	N
28 June	North	Eve	N	Y
		Morn	N	N
29 June	Upper Kawailoa	Eve	Y	N
		Morn	N	N

The ornithological radar used in this study was a Furuno (Model FCR-1510) X-band radar transmitting at 9.410 GHz through a slotted wave guide with a peak power output of 12 kW; a similar radar unit is described in Cooper et al. (1991) and Mabee et al. (2006). The antenna face was tilted upward by ~10°, and we operated the radar at a range setting of 1.5 km and a pulse-length of 0.07 µsec. 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*). Based on these trials and our prior radar studies of seabirds, we assumed that differences in detectability of petrels and shearwaters were not sufficient at the 1.5 km range to necessitate a correction factor.

Issues associated with radar sampling include ground clutter and shadow zones. Whenever energy is reflected from the ground, surrounding vegetation and other objects around the radar unit, a ground-clutter echo that can obscure targets of interest (i.e., birds) appears on the radar's display screen. Shadow zones are areas of the screen where birds can fly at an altitude that potentially would put them behind a hill or row of vegetation where they could not be detected because the radar operates on line-of-sight. We attempted to minimize ground clutter and shadow zones during the selection of radar sampling stations; various landscape features visible on radar indicated that our sampling stations provided good coverage of the Project area.

We sampled for six 25 min sessions during each evening and for three 25 min sessions each morning. Each 25 min sampling session was separated by a 5 min break for collecting weather data. To help eliminate non-target species, we collected data only for those targets that met a suite of selection criteria, following methods developed by Day and Cooper (1995), that included appropriate target signature, flight characteristics, and flight speeds (≥50 km/h [≥30 mi/h]). We also removed radar targets identified by visual observers as being of other bird species.

We 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

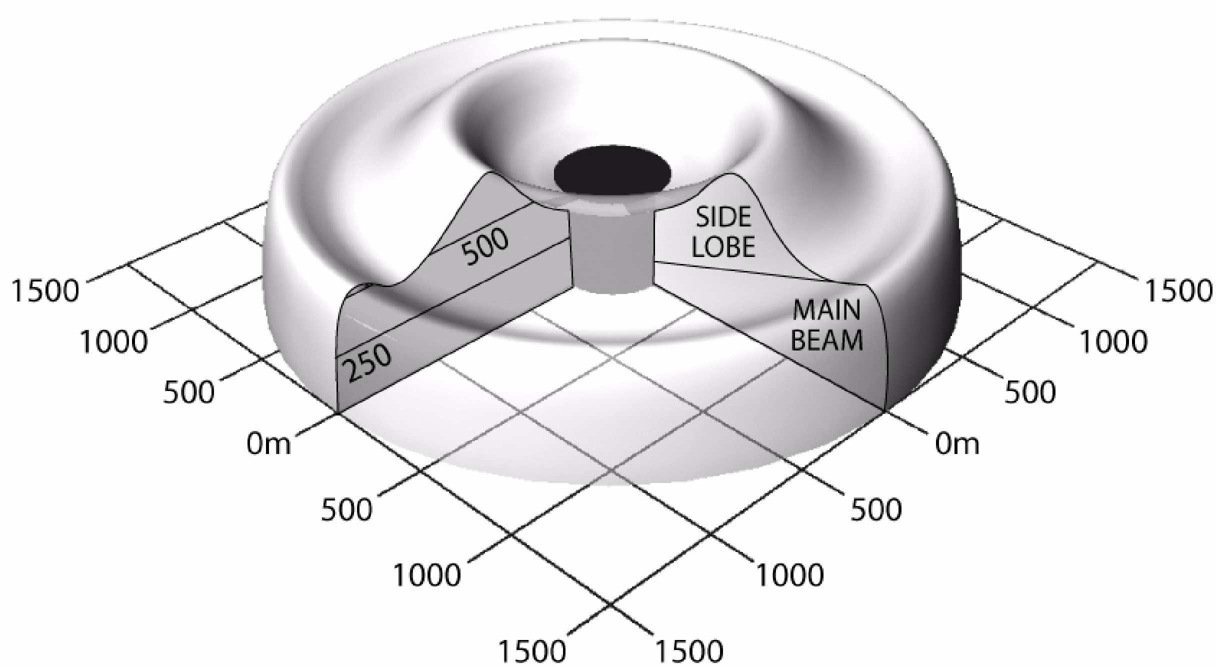


Figure 3. Approximate shearwater-/petrel-sampling airspace for the Furuno FR–1510 marine radar at the 1.5-km range setting, as determined by field trials with Rock Pigeons. Note that the shape of the radar beam within 250 m of the origin (i.e., the darkened area) was not determined.

sampling, we used 10X binoculars during crepuscular periods and Generation 3 night-vision goggles (Model ATN-PVS7; American Technologies Network Corporation, San Francisco, CA) during nocturnal periods. The magnification of the night-vision goggles was 1X, and their performance was enhanced with the use of a 3-million-Cp floodlight that was fitted with an infrared filter to avoid blinding and/or attracting birds. Audiovisual observations at the primary sampling stations were conducted within 25 m of the radar to facilitate communication between observers, but communication between the radar observer and visual observers at supplementary stations was done by handheld radio. All audiovisual observers also listened for petrel and shearwater (and other) vocalizations while sampling.

Before each 25-min sampling session, we also collected environmental and weather data, including:

- wind speed (to the nearest 1.6 km/h [1.0 mi/h]);
- wind direction (to the nearest 1°);
- percent cloud cover (to the nearest 5%);
- cloud ceiling height, in meters 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 (none, mist, drizzle, etc.); and
- moon phase/position (lunar phase and whether the moon was above or below the horizon in the night sky).

For each appropriate radar target, we recorded the following data:

- species (if identified by visual observer);
- number of birds (if identified by visual observer);
- time;
- direction of flight (to the nearest 1°);
- cardinal transect crossed (000°, 090°, 180°, or 270°);
- tangential range (the minimal perpendicular distance to the target when it passed closest to the radar; used in reconstructing actual flight paths, if necessary);
- flight behavior (straight, erratic, circling);
- velocity (to the nearest 8 km/h [5 mi/h]); and
- flight altitude (meters agl, if identified by visual observer).

For each bird (or bat) recorded during audiovisual sampling, we recorded:

- time;
- species (to the lowest practical taxonomic unit [e.g., Hawaiian Petrel, unidentified petrel/shearwater]);
- number of individuals composing each target;
- ordinal flight direction (000°, 045°, 090°, 135°, 180°, 225°, 270°, 315°); and
- flight altitude (meters agl).

For any species of interest heard but not seen, we recorded species, number of calls, direction of calls, and approximate distance from the observer.

DATA ANALYSIS

RADAR AND VISUAL DATA SUMMARY

We entered all radar and visual data into Microsoft Excel spreadsheets. We checked data files visually for errors after each night of sampling and then checked files for errors and outliers at the end of the field season, prior to data analyses. In addition, radar data were filtered to remove non-target species so only known petrel/shearwater radar targets and unknown targets with appropriate petrel/shearwater characteristics (based on target size, flight directions, and airspeeds ≥50 km/h) were included in data analyses. Airspeeds were calculated by correcting observed target flight speeds (groundspeeds) for speed and relative direction of wind, as measured each half-hour at the radar station (Mabee et al. 2006). Because we can find no records of Hawaiian Petrels on Oahu in the past 50–100 yr but did find records of Newell's Shearwaters on Oahu and because our radar detections occurred mainly during the fully-nocturnal hours when targets are most likely to be Newell's Shearwaters (Day and Cooper 1995, Cooper and Day 2003), we assumed that all petrel-/shearwater-like targets observed in this study were Newell's Shearwaters for the purposes of our exposure and fatality models (See Results and Discussion).

We categorized general flight directions of each radar target as landward, seaward, or "other" and summarized these directional categories by station and by night. Based on the shoreline orientation, we defined a landward flight direction as 75–195°, a seaward flight direction as 255–015°, and an "other" flight direction as 016–074° or 196–254°.

We tabulated counts of numbers of shearwater-like radar targets recorded during each sampling session, then converted those counts to estimates of passage rates of birds (radar targets/h), based on the number of minutes sampled per session. The only sampling sessions totally cancelled due to weather occurred on the morning of 18 June and the evening of 23 June when rain prevented sampling. We used all of the estimated passage rates across sampling sessions at a station to calculate the mean ± 1 standard error (SE) nightly passage rate of shearwaters by station and pooled data across nights to derive an overall hourly passage rate for the study. Only known shearwater targets (i.e., audio or visual confirmation) or unknown targets that met the criteria for shearwaters (i.e., appropriate target size, flight direction [i.e., landward and seaward flight only], and groundspeeds [i.e., ≥50 km/h]) were included in data analyses of passage rates and flight behavior. We excluded all targets with "other" flight directions from passage-rate analyses because they were not flying toward or away from breeding habitat, as would be expected for shearwaters or petrels flying over land during those morning and evening periods of peak movement (Day and Cooper 1995). Finally, we plotted all track lines of landward and seaward targets on a map of the Project.

EXPOSURE AND FATALITY RATES

The risk-assessment technique that we have developed uses the radar data on seasonal passage rates to estimate numbers of birds flying over the area of interest (sampling stations and Project) 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 or wind turbines to estimate horizontal-interaction probabilities, uses flight-altitude data and information on the height of the met towers/ wind turbines to estimate vertical-interaction probabilities, and combines these interaction probabilities with the passage rates to generate annual exposure rates (Figure 4). These exposure rates represent the estimated numbers of shearwaters that pass within the airspace occupied by a wind turbine or met tower and its associated guy wires 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 annual fatality rates at each of the wind turbines and met towers.

Exposure Rates

The exposure rate is calculated as the product of three variables: annual passage rate, horizontal-interaction probability, and vertical-interaction probability (Figure 4). As such, it is an estimate of the number of birds flying in the vicinity of the wind turbine/met tower (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 turbine or tower. Normally we would use data from both summer and fall sampling periods to model annual fatalities; however, data collected at the Project in fall 2009 indicated that there was obvious contamination from non-target species (Cooper et al. 2011). In particular, Pacific Golden-plovers (*Pluvialis fulva*) are seasonal migrants that overwinter in the region and can be difficult to distinguish from shearwaters on radar. Audiovisual sampling conducted during the 2009 studies indicated that these plovers were present in high numbers in the Project area during fall (Cooper et al. 2011). Therefore, we followed the precedent of Cooper et al. (2011) and decided that it was most appropriate to use summer-only

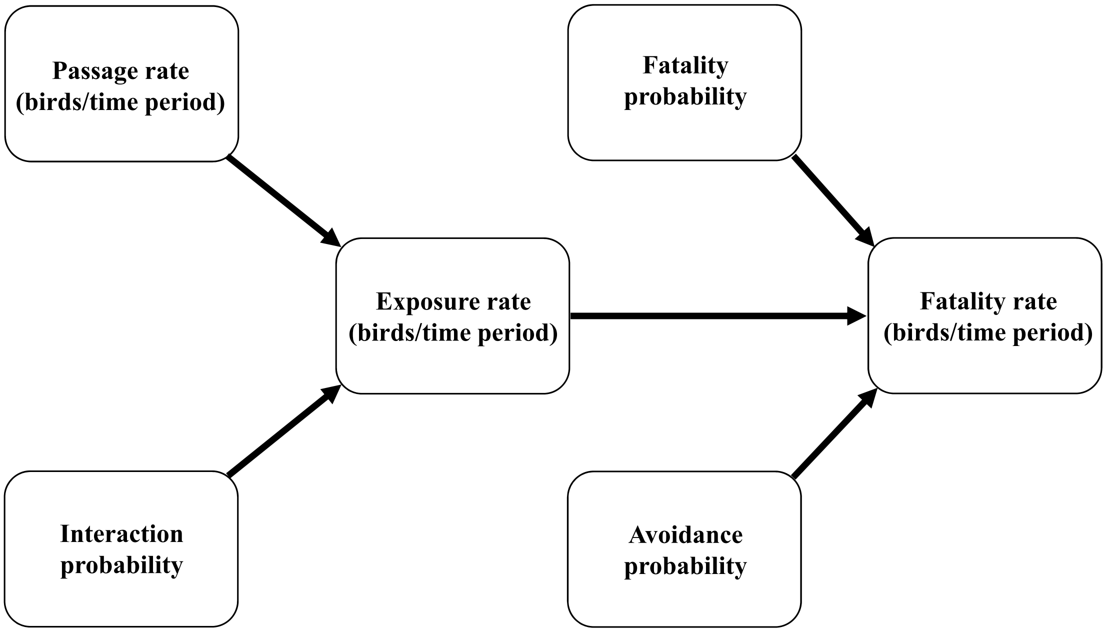


Figure 4. Major variables used in estimating possible fatalities of Newell's Shearwaters at wind turbines and met towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii.

passage rates for the fatality modeling exercise. This meant assuming that fall passage rates were the same as summer passage rates, a conservative approach because the number of shearwaters visiting breeding colonies generally tends to decline from summer to fall because attendance at colonies by nonbreeders and failed breeders declines as chick-rearing progresses (Serventy et al. 1971, Warham 1990, Ainley et al. 1997b, Simons and Hodges 1998). In addition, there also are no known, large shearwater colonies nearby, or lights near the site, that might explain higher fall counts (e.g., because of high passage rates of juveniles) than summer counts at the site. Thus, because we think that it is justifiable at this site to use only the summer data to calculate fatality estimates, we used the average of the summer 2009 and summer 2011 passage rates (i.e., the average of 0.60 and 0.72 targets/h = 0.66 targets/h) as the basis for our fatality modeling effort.

We generated annual passage rates from the radar data by: (1) multiplying the average passage rates by 5 h to estimate the number of targets moving over the radar station during those peak nightly movement periods (note that the 5 h extrapolation encompasses and accounts for the 0530–0600 h periods that we did not sample due to concerns about inclusion of diurnal, non-shearwater species); (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 wind turbines/met towers during an average night; and (4) multiplying those numbers by the number of nights that these birds were exposed to risk in each season (150 nights in the spring/summer and 60 nights in the fall; Ainley et al. 1997b).

Interaction probabilities consist of both horizontal and vertical components. 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 wind turbine or met tower 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 or front) occupied by a wind turbine/met tower located somewhere on the radar screen. This probability is calculated from information on the two-dimensional area of the wind turbine/met tower and the two-dimensional area sampled by the radar screen. The proposed wind turbine system will have a maximal height of 150.5 m, a rotor radius of 50.5 m, and minimal (side view) and maximal (frontal view) areas of 903 m^2 and 8,309 m^2. The existing, guyed, met towers each have a central tower with four sets of guy wires attached at six heights; hence, from a side view, the met tower/guy wire systems appear 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 proposed, free-standing, lattice-type met towers have a cross-sectional area of 313 m^2. The ensuing ratio of the cross-sectional area of the wind turbine or met tower 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.

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 wind turbine or met tower located somewhere on the radar screen. This probability is calculated from data on flight altitudes and from information on the height of the structures. We calculated the percentage of shearwaters with flight altitudes of ≤150.5 m agl (maximal height of the rotor-swept area of the proposed turbine) and the percentage of shearwaters with flight altitudes ≤60 m agl and ≤100 m agl (maximal height of the two met tower types). 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 wind turbines (i.e., 75.2% ≤150.5 m agl) or met towers (i.e., 28.5% ≤60 m and 56.4% ≤100 m). We would have preferred to use site-specific flight altitude data for this calculation but there were no available data for the Project area or elsewhere on Oahu.

Fatality Rates

As previously stated the annual estimated fatality rate is calculated as the product of: (1) the exposure rate; (2) the fatality probability; and (3) the avoidance probability. The annual fatality rate is generated as an estimate of the number of birds killed/yr as a result of collisions with the wind turbine or met tower, based on a 210-d breeding season for Newell's Shearwaters (Ainley et al. 1997b).

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 met 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, whereas the latter is an estimate of the probability of collision-caused fatality after a bird collided with a structure. Because any collision with a met tower or wind turbine falls under the ESA definition of "take," we used an estimate of 100% for this fatality-probability parameter; however, note that the actual probability of fatality resulting from a collision is less than 100% because a bird can hit a met tower frame or guy wires and not die (e.g., a bird could brush a wingtip but avoid injury/death).

The probability of striking a structure needs to be calculated differently for met towers and wind turbines. In the met tower design, the tower frame is either an unguyed lattice pole, or a solid monopole tower with four sets of guy wires at six different heights each occupying a substantial proportion of the total cone of airspace enclosed by the tower and guy wires, resulting in 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 assumed that the probability of hitting a met tower or guy wires if the bird enters the airspace was 100%. Similarly, a bird approaching a wind turbine from the side has essentially a 100% probability of hitting the monopole 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. Therefore we calculated the probability of collision for this "frontal" bird approach based upon the length of a Newell's 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 (16 revolutions/min for the SWT-2.3-101 turbines); also see Tucker (1996). These calculations indicated that up to 15.2% 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).

The final parameter in estimating the fatality rate is the avoidance rate, which is the probability that a bird will see a structure (i.e., wind turbine or met tower) and change flight direction, flight altitude, or both, so that it completely avoids flying through the space occupied by the structure. Because avoidance rates are largely unknown, we present fatality estimates for a range of probabilities of collision avoidance by these birds by assuming that 90%, 95%, or 99% of all shearwaters flying near a turbine or met tower structure will detect and avoid it. See Discussion for explanation of avoidance rates used.

RESULTS

RADAR OBSERVATIONS

During our 16 survey nights in summer 2011, we recorded 5 landward-flying and 32 seaward-flying radar targets that fit our criteria for shearwater-like targets (Table 3). We also recorded 13 targets headed in "other" directions and therefore not classified as shearwater-like targets. Mean passage rates of shearwater-like targets (i.e., landward and seaward rates combined) during the summer 2011 were 0.29 ± 0.29 targets/h at the Lower Kawailoa Station, 0.92 ± 0.08 targets/h at the Ashley Station, 0.81 ± 0.25 targets/h at the Upper Kawailoa Station, 0.76 ± 0.19 targets/h at the North Site station, and 0.72 ± 0.12 targets/h at all stations combined (Table 4). For comparison, during summer 2009 there were 0.62 ± 0.10 targets/h at the Lower Kawailoa Station, 0.57 ± 0.12 targets/h at the Ashley Station, and 0.60 ± 0.07 targets/h at all stations combined (Table 4). There were no consistent differences between evening and morning in mean passage rates in either year (Table 4). Further, there was overlap in the 95% confidence intervals for passage rates of all stations and years, suggesting that there were no differences in passage rates among stations or between years.

We recorded much higher numbers of seaward-flying targets than landward-flying targets at all sampling stations in both years (Tables 3 and 4). In summer 2011, 86.5% of all shearwater-like targets were flying seaward (i.e., away from the direction of the potential seabird colonies in the Koolau Mountains) and 13.5% were flying landward (i.e., toward the potential nesting habitat). A qualitative assessment of landward and seaward (i.e., probable shearwater target) flight paths and trajectories suggested that there were northwesterly flights across most of the Project in 2011 (Figure 5). There was no evidence of a distinct flight corridor or concentration point over any particular portion of the Project.

Fewer than 10% of all targets in either summer 2009 or 2011 were recorded during the first sampling session (Table 5), which is a time when on Kauai Island, only Hawaiian Petrels are thought to be active (Day and Cooper 1995, Cooper and Day 2003). Further, 0–4% of all targets were recorded during the second evening session, which is when Hawaiian Petrel numbers on Kauai are thought to begin tapering off and Newell's Shearwater numbers are known to increase (Day and Cooper 1995, Cooper and Day 2003; however, note that some Hawaiian Petrels on Lanai also are active after the second session; Cooper and Day, unpubl. data). The remaining 92–96% of evening targets were flying after the point of complete darkness. Similarly, almost all of our targets in the morning were recorded prior to the half-hour before sunrise (i.e., before the period when

Table 3. Sampling dates and number of landward, seaward, and other radar targets; and number of audiovisual observations of species of interest at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, summer (June) 2011 (HOBA = Hoary Bat; BAOW = Barn Owl; CAEG = Cattle Egret; OWSP = unidentified owl).

			Number of Radar Targets			
Date	Site	Period	Landward (75–195°)	Seaward (255–15°)	"Other"[1] Directions	Audiovisual
14 June	North	Eve	0	4	1	1 BAOW
		Morn	0	1	0	0
15 June	North	Eve	0	1	0	0
		Morn	0	0	1	0
16 June	Upper Kawailoa	Eve	0	0	0	0
		Morn	0	0	0	0
17 June	Lower Kawailoa	Eve	0	0	0	0
		Morn	0	0	0	0
18 June	Upper Kawailoa	Eve	0	2	1	0
		Morn	Rained Out	Rained Out	Rained Out	0
19 June	Upper Kawailoa	Eve	0	2	0	0
		Morn	0	1	0	0
20 June	Ashley	Eve	2	0	1	0
		Morn	1	0	0	0
21 June	Lower Kawailoa	Eve	0	3	1	0
		Morn	0	0	0	0
22 June	North	Eve	0	1	0	0
		Morn	0	1	2	0
23 June	Upper Kawailoa	Eve	Rained Out	Rained Out	Rained Out	0
		Morn	0	2	0	0
24 June	Lower Kawailoa	Eve	0	0	0	0
		Morn	0	0	0	0
25 June	Ashley	Eve	0	2	3	OWSP
		Morn	0	2	1	0
26 June	North	Eve	0	1	0	0
		Morn	0	1	0	0
27 June	Ashley	Eve	1	0	0	0
		Morn	0	2	0	0
28 June	North	Eve	0	2	0	HOBA
		Morn	0	2	0	0
29 June	Upper Kawailoa	Eve	1	1	2	BAOW, CAEG
		Morn	0	1	0	0
TOTAL			5	32	13	5

[1] "Other" directions include all other directions that were not landward or seaward.
[2] Sampling cancelled by rain.

Table 4. Mean passage rates (targets/h ± SE) of shearwater-like radar targets observed at sampling stations at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer (June) 2009 and 2011. n = number of sampling days.

Season/station	Time period (n)	Landward	Seaward	Total
SUMMER 2009[1]				
Lower Kawailoa	Eve (4)[2]	0.10 ± 0.10	0.50 ± 0.19	0.60 ± 0.26
	Morn (5)	0.00 ± 0.00	0.59 ± 0.26	0.59 ± 0.26
	Total (5)			0.62 ± 0.10
Ashley	Eve (5)	0.00 ± 0.00	0.50 ± 0.21	0.50 ± 0.21
	Morn (5)	0.00 ± 0.00	0.72 ± 0.31	0.72 ± 0.31
	Total (5)			0.57 ± 0.12
All sites combined	Eve (9)[2]	0.04 ± 0.04	0.50 ± 0.13	0.55 ± 0.15
	Morn (10)	0.00 ± 0.00	0.65 ± 0.19	0.65 ± 0.19
	Total (10)			0.60 ± 0.07
SUMMER 2011				
Lower Kawailoa	Eve (3)	0.00 ± 0.00	0.43 ± 0.43	0.43 ± 0.43
	Morn (3)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	Total (3)			0.29 ± 0.29
Ashley	Eve (3)	0.40 ± 0.23	0.27 ± 0.27	0.67 ± 0.13
	Morn (3)	0.27 ± 0.27	1.17 ± 0.59	1.44 ± 0.33
	Total (3)			0.92 ± 0.08
Upper Kawailoa	Eve (4)[3]	0.10 ± 0.10	0.51 ± 0.20	0.61 ± 0.20
	Morn (4)[3]	0.00 ± 0.00	0.80 ± 0.33	0.80 ± 0.33
	Total (5)			0.81 ± 0.25
North Site	Eve (5)	0.00 ± 0.00	0.74 ± 0.23	0.74 ± 0.23
	Morn (5)	0.00 ± 0.00	0.80 ± 0.25	0.80 ± 0.25
	Total (5)			0.76 ± 0.19
All sites combined	Eve (15)	0.11 ± 0.06	0.52 ± 0.13	0.63 ± 0.12
	Morn (15)	0.05 ± 0.05	0.71 ± 0.18	0.77 ± 0.17
	Total (16)			0.72 ± 0.12

[1] Data from Cooper et al. (2011).
[2] One entire evening of sampling at Lower Kawailoa cancelled due to rain.
[3] One entire evening and an entire morning (on a different day) of sampling at Upper Kawailoa cancelled due to rain.

Hawaiian Petrels are known to be active). Hence, if one assumes that these species would exhibit similar timing of their movement on Oahu as on Kauai, then the timing of observations suggests that our radar targets were more likely to have been Newell's Shearwaters than Hawaiian Petrels.

AUDIOVISUAL OBSERVATIONS

We did not observe any Hawaiian Petrels, Newell's Shearwaters, or unidentified shearwaters/petrels during our 16 nights of audiovisual sampling in summer 2011 (Table 3). We did visually record one Hoary Bat flying at an altitude of ~40 m agl at the North Site during the evening of 28 June 2011. That observation translated to an estimated occurrence rate of 1 bat in 249 25-min summer observation sessions (i.e., 0.010 bats/h).

Other species that we observed during audiovisual sampling in summer 2011 included two Barn Owls (*Tyto alba*) and one unidentified

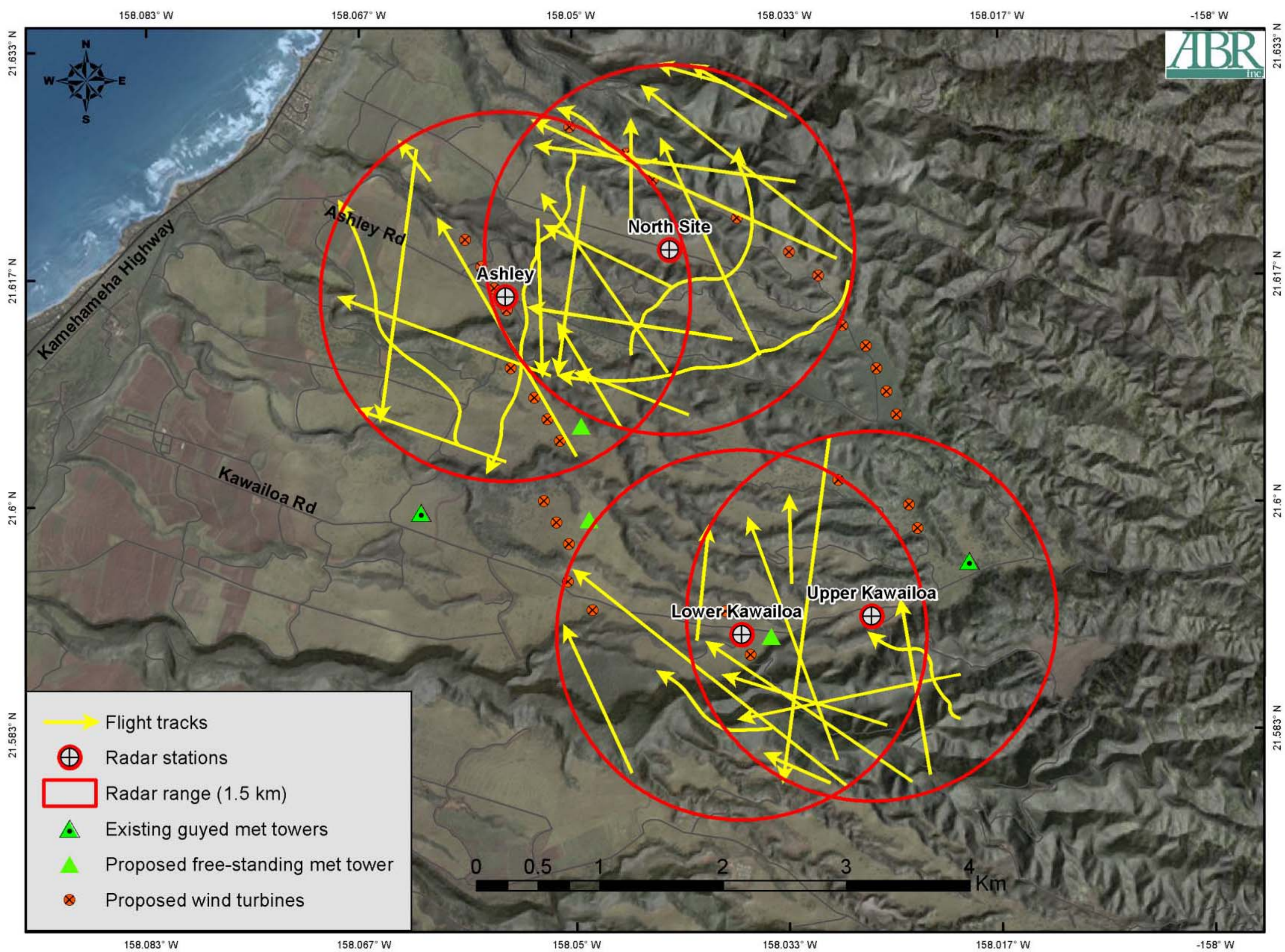


Figure 5. Location of flight paths of shearwater-like (i.e., landward and seaward) radar targets observed during summer 2011 at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii.

Table 5. Evening and morning timing of movement of bird targets on ornithological radar, with total number of targets and percentages of nightly movements observed by half-hour period at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, during summer (June) 2009 and 2011.

Season/Time period/Time	Light condition	Number of targets	Percent
SUMMER 2009[1]			
EVENING			
1900–1929	Crepuscular/Nocturnal	1	8.3
1930–1959	Nocturnal	0	0.0
2000–2029	Nocturnal	1	8.3
2030–2059	Nocturnal	3	25.0
2100–2129	Nocturnal	4	33.4
2130–2159	Nocturnal	3	25.0
MORNING			
0400–0429	Nocturnal	1	11.1
0430–0459	Nocturnal	2	22.2
0500–0529	Nocturnal/Crepuscular	6	66.7
SUMMER 2011			
EVENING			
1900–1929	Crepuscular/Nocturnal	0	0.0
1930–1959	Nocturnal	1	4.4
2000–2029	Nocturnal	3	13.1
2030–2059	Nocturnal	9	39.1
2100–2129	Nocturnal	5	21.7
2130–2159	Nocturnal	5	21.7
MORNING			
0400–0429	Nocturnal	3	21.4
0430–0459	Nocturnal	4	28.6
0500–0529	Nocturnal/Crepuscular	7	50.0

[1] 2009 data from Cooper et al. (2011).

owl (Table 3). No Pacific Golden-plovers were observed in summer 2011. Note that after the morning sampling hours (i.e., during 0530–0600 h) we observed a large number of non-target species in the Project, including fast-flying dove species (e.g., Rock Doves and Spotted Doves [*Streptopelia chinensis*]) that would have led to high levels of contamination in our radar data set, had we included radar data collected during these later sampling periods.

EXPOSURE RATES

Based on the average of the combined summer 2009 (Cooper et al. 2011) and summer 2011 passage rates (i.e., 0.66 targets/h), we estimate that ~804 Newell's Shearwaters pass over the 1.5-km-radius radar sampling area at all stations combined in an year (including birds at all altitudes; Tables 6–8). To generate annual exposure rates of birds at each wind turbine or met tower (e.g., bird passes/structure/yr), we then multiplied the annual passage rate by the horizontal-interaction probability and the vertical-interaction probability. By applying those proportions to our data (and rounding up to the nearest whole number), we estimate that an average of ~2–12 Newell's Shearwaters/yr fly within the space occupied by each wind turbine (Table 6), that ~4

Table 6. Estimated average exposure rates and fatality rates of Newell's Shearwaters for Siemens SWT-2.3-101 wind turbines at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) 2009 and 2011. Values of particular importance are in boxes.

Variable/parameter for Siemens SWT-2.3-101 turbine	Side Approach	Frontal Approach
PASSAGE RATE (PR)		
A) Mean passage rate (targets/h)		
A1) Mean rate during nightly peak movement periods in spring/summer based on June 2009/2011 data (targets/h)	0.66	0.66
A2) Mean rate during nightly peak movement periods in fall based on June 2009/2011 data (targets/h)	0.66	0.66
B) Number of hours of evening and morning peak period of movement	5	5
C) Mean number of targets during evening and morning peak movement periods		
C1) Spring/summer (A1 * B)	3.300	3.300
C2) Fall (A2 * B)	3.300	3.300
D) Mean proportion of birds moving during off-peak h of night	0.126	0.126
E) Seasonal passage rate (targets/night) = ((C * D)+ C)		
E1) Spring/summer	3.72	3.72
E2) Fall	3.72	3.72
F) Mean number of birds/target	1.03	1.03
G) Estimated proportion that is Newell's Shearwaters	1.00	1.00
H) Daily passage rate (bird passes/day =E * F * G)		
H1) Spring/summer	3.83	3.83
H2) Fall	3.83	3.83
I) Fatality domain (days/year)		
I1) Spring/summer	150	150
I2) Fall	60	60
J) Annual passage rate (bird passes/year) = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	804	804
HORIZONTAL INTERACTION PROBABILITY (HIP)		
K) Turbine height (m)	150.5	150.5
L) Blade radius (m)	50.5	50.5
M) Height below blade (m)	49.5	49.5
N) Front to back width (m)	6	6
O) Minimum side profile area (m²) = (K * N)	903	
P) Maximum front profile area (m²) = (M * N) + (π * L²)		8,309
Q) Cross-sectional sampling area of radar at or below 150.5 m turbine height (= 3000 m * 150.5 m = 451,500 m²)	451,500	451,500
R) Minimal horizontal interaction probability (= O/Q)	0.00200000	
S) Maximal horizontal interaction probability (= P/Q)		0.01840280
VERTICAL INTERACTION PROBABILITY (VIP)		
T) Proportion of shearwaters flying ≤ turbine height in Hawaiian Islands (n = 688)	0.752	0.752
EXPOSURE RATE (ER = PR*HIP*VIP)		
U) Daily exposure rate (bird passes/turbine/day = H * (R or S) * T, rounded to 8 decimal places)		
O1) Spring/summer	0.00575622	0.05296529
O2) Fall	0.00575622	0.05296529
V) Annual exposure rate (bird passes/turbine/year = J * (R or S) * T, rounded to 8 decimal places	1.20921600	11.12648171

Table 6. Continued.

Variable/parameter for Siemens SWT-2.3-101 turbine	Side Approach	Frontal Approach
FATALITY PROBABILITY (FP)		
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	0.152	0.152
Y) Probability of fatality if striking turbine	1.00	1.00
Z1) Probability of fatality if an interaction on side approach (= W * Y)	1.00	
Z2) Probability of fatality if an interaction on frontal approach (= X * Y)		0.15200
FATALITY RATE (= ER*FP)		
Annual fatality rate with 90% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.10)	0.12092	0.16912
Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.05)	0.06046	0.08456
Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/year = V * Z * 0.01)	0.01209	0.01691

[1] Used 100% fatality probability due to ESA definition of “take”; however, actual probability of fatality with collision <100% (see methods).

Newell’s Shearwaters/yr fly within the space occupied by each guyed, 60-m-tall met tower (Table 7), and that ~1 Newell’s Shearwater/yr flies within the space occupied by each free-standing, 100-m-tall met tower (Table 8). Note that all these calculations are exposure rates and, thus, include an unknown proportion of birds that would detect and avoid the wind turbines and met towers. Hence, exposure rates estimate how many times/year a shearwater would be exposed to each wind turbine or met tower and not the number that actually would collide with those structures.

FATALITY MODELING

The individual steps and estimates involved in calculating fatality rates are shown in Table 6 (for wind turbines) and Tables 7 and 8 (for met towers). We speculate that the proportions of birds that detect and avoid wind turbines and met towers is substantial (see Discussion), but limited shearwater-specific data are available to use for estimates of avoidance rates for these structures. Because it is necessary to estimate the fatality of shearwaters at the proposed project, however, we assumed that 90%, 95%, or 99% of all birds will be able to detect and avoid the met towers and wind turbines. With the assumption that 100% of the birds colliding with a wind turbine/met tower die, the annual fatality rates are 0.012–0.169 Newell’s Shearwaters/turbine/year (Table 6). For each 60-m met tower, we estimate a fatality rate of 0.038–0.382 Newell’s Shearwaters/tower/year (Table 7) and for each 100-m met tower, we estimate a fatality rate of 0.005–0.047 Newell’s Shearwaters/tower/year (Table 8). The cumulative annual fatalities would be 0.363–5.040 Newell’s Shearwaters/yr for all 30 of the proposed wind turbines combined (Table 9). The cumulative annual fatalities at the two 60-m guyed met towers combined would be 0.076–0.763 Newell’s Shearwaters/yr and the cumulative fatality for the three 100-m free-standing met towers combined would be 0.014–0.142 Newell’s Shearwaters/yr.

DISCUSSION

SPECIES COMPOSITION

Similar to findings from other radar studies on Oahu (Day and Cooper 2008), the timing of radar targets we recorded in summer 2009 and 2011 suggested that these targets were more likely to be Newell's Shearwaters than Hawaiian Petrels. In other words, the majority of shearwater-/petrel-like targets we observed at the Project occurred during the period when only Newell’s Shearwater are known to be active on Kauai (Day and Cooper 1995, Reynolds et al. 1997, Cooper and Day 2003, Day et al. 2003a; however, note that an unknown

Table 7. Estimated average exposure rates and fatality rates of Newell’s Shearwaters for guyed 60 m monopole meteorological (met) towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) 2009 and 2011. Values of particular importance are in boxes.

Variable/parameter for: 60-m guyed monopole met tower	Newell's Shearwater
PASSAGE RATE (PR)	
A) Mean passage rate (targets/h)	
A1) Mean rate during nightly peak movement periods in spring/summer based on June 2009/2011 data (targets/h)	0.66
A2) Mean rate during nightly peak movement periods in fall based on June 2009/2011 data (targets/h)	0.66
B) Number of hours of evening and morning peak period sampling	5
C) Mean number of targets during evening and morning peak movement periods	
C1) Spring/summer (A1 * B)	3.300
C2) Fall (A2 * B)	3.300
D) Mean proportion of birds moving during off-peak h of night	0.126
E) Seasonal passage rate (targets/night) = ((C * D) + C)	
E1) Spring/summer	3.72
E2) Fall	3.72
F) Mean number of birds/target	1.03
G) Estimated proportion that is Newell's Shearwaters	1.00
H) Daily passage rate (bird passes/day = E * F * G)	
H1) Spring/summer	3.83
H2) Fall	3.83
I) Fatality domain (days/year)	
I1) Spring/summer	150
I2) Fall	60
J) Annual passage rate (bird passes/year) = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	804
HORIZONTAL INTERACTION PROBABILITY (HIP)	
K) Maximal cross-sectional area of tower and guys (side view = ((50 m * 60 m)/2) * 2 = 3,000 m²	3,000
L) Cross-sectional sampling area of radar at or below 60 m tower height (= 3000 m * 60 m = 180,000 m²)	180,000
M) Average probability of radar target intersecting the met tower (= K/L, rounded to 8 decimal places)	0.01666667
VERTICAL INTERACTION PROBABILITY (VIP)	
N) Proportion of shearwaters flying ≤ tower height in Hawaiian Islands (n = 688)	0.285
EXPOSURE RATE (ER = PR*HIP*VIP)	
O) Daily exposure rate (bird passes/tower/day = H * M * N, rounded to 8 decimal places)	
O1) Spring/summer	0.01817213
O2) Fall	0.01817213
P) Annual exposure rate (bird passes/tower/year = J * M * N, rounded to 8 decimal places)	3.81744186
FATALITY PROBABILITY (FP)	
Q) Probability of striking tower or guys if in airspace	1.00
R) Probability of fatality if striking tower or guys	1.00
S) Probability of fatality if an interaction (= Q * R)	1.00
FATALITY RATE (= ER*FP)	
T) Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year = P * S * 0.10)	0.38174
U) Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year = P * S * 0.05)	0.19087
V) Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year = P * S * 0.01)	0.03817

[1] Used 100% fatality probability due to ESA definition of “take”; however, actual probability of fatality with collision <100% (see methods).

Table 8. Estimated average exposure rates and fatality rates of Newell's Shearwaters for free-standing 100 m lattice meteorological (met) towers at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) 2009 and 2011. Values of particular importance are in boxes.

Variable/parameter for: 100-m-tall free-standing lattice tower	Newell's Shearwater
PASSAGE RATE (PR)	
A) Mean passage rate (targets/h)	
A1) Mean rate during nightly peak movement periods in spring/summer based on June 2009/2011 data (targets/h)	0.66
A2) Mean rate during nightly peak movement periods in fall based on June 2009/2011 data (targets/h)	0.66
B) Number of hours of evening and morning peak period sampling	5
C) Mean number of targets during evening and morning peak movement periods	
C1) Spring/summer (A1 * B)	3.300
C2) Fall (A2 * B)	3.300
D) Mean proportion of birds moving during off-peak h of night	0.126
E) Seasonal passage rate (targets/night) = ((C * D) + C)	
E1) Spring/summer	3.72
E2) Fall	3.72
F) Mean number of birds/target	1.03
G) Estimated proportion that is Newell's Shearwaters	1.00
H) Daily passage rate (bird passes/day = E * F * G)	
H1) Spring/summer	3.83
H2) Fall	3.83
I) Fatality domain (days/year)	
I1) Spring/summer	150
I2) Fall	60
J) Annual passage rate (bird passes/year) = ((H1 * I1) + (H2 * I2)), rounded to next whole number)	804
HORIZONTAL INTERACTION PROBABILITY (HIP)	
K) Maximal cross-sectional area of tower (side view = 313 m²)	313
L) Cross-sectional sampling area of radar at or below 100 m tower height (= 3,000 m * 100 m = 300,000 m²)	300,000
M) Average probability of radar target intersecting the met tower (= K/L, rounded to 8 decimal places)	0.00104333
VERTICAL INTERACTION PROBABILITY (VIP)	
N) Proportion of shearwaters flying ≤ tower height in Hawaiian Islands (n = 688)	0.564
EXPOSURE RATE (ER = PR*HIP*VIP)	
O) Daily exposure rate (bird passes/tower/day = H * M * N, rounded to 8 decimal places)	
O1) Spring/summer	0.00225212
O2) Fall	0.00225212
P) Annual exposure rate (bird passes/tower/year = J * M * N, rounded to 8 decimal places)	0.47310576
FATALITY PROBABILITY (FP)	
Q) Probability of striking tower or guys if in airspace	1.00
R) Probability of fatality if striking tower	1.00
S) Probability of fatality if an interaction (= Q * R)	1.00
FATALITY RATE (= ER*FP)	
T) Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year = P * S * 0.10)	0.04731
U) Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year = P * S * 0.05)	0.02366
V) Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year = P * S * 0.01)	0.00473

[1] Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision <100% (see methods).

Table 9. Summary of exposure rates, fatality rates, and cumulative fatality rates for Newell's Shearwaters (NESH) at one type of wind turbine and at two types of meteorological (met) towers in the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, based on radar data collected in summer (June) 2009 and 2011.

		Fatality Rate per structure		Cumulative Fatality Rate
Structure	Avoidance Rate (Approach)	Birds/structure/year	No. Structures	Birds/year
Siemens SWT-101 turbine	0.90 (side)	0.121	30	3.628
	0.90 (frontal)	0.169	30	5.040
	0.95 (side)	0.060	30	1.814
	0.95 (frontal)	0.084	30	2.520
	0.99 (side)	0.012	30	0.363
	0.99 (frontal)	0.017	30	0.504
60 m guyed met tower	0.90	0.382	2	0.763
	0.95	0.191	2	0.382
	0.99	0.038	2	0.076
100 m lattice met tower	0.90	0.047	3	0.142
	0.95	0.024	3	0.071
	0.99	0.005	3	0.014

proportion of Hawaiian Petrels on Lanai also are active during nocturnal hours; Cooper and Day, unpubl. data).

More important than the timing evidence from Kauai suggesting that only Newell's Shearwaters were present during our sampling, we can find no records of Hawaiian Petrels on Oahu in the past 50–100 yr. In contrast, Newell's Shearwaters have been recorded on Oahu in the past 50–100 yr, with a high probability of nesting in the Koolau Range. For instance, there are multiple records of Newell's Shearwaters on Oahu including: the Aiea area on 27 May, 1954 (Richardson 1955) and 26 May and 2 and 5 June, 1990 (Pyle 1990); and 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).

Importantly, there also 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 that Newell's Shearwaters nest somewhere in the Koolau Range.

While the recent records of Newell's Shearwaters on Oahu and the timing of our radar data suggest that our radar targets were more likely to be Newell's Shearwaters rather than Hawaiian Petrels, it also is likely that some non-target species also were included as shearwater-like targets in the radar data for the Project. For example, diurnal point count studies in the Project area documented Mallard-Hawaiian Duck (*Anas spp.*) hybrids (i.e., a species that would look similar to shearwaters on radar and that could be active during crepuscular/nocturnal hours) in all months except January (SWCA 2011b). In addition, we did not observe on radar the typical Newell's Shearwater pattern of landward movements during the evening followed by seaward movements during the morning in the Project area during either 2009 or 2011. That said, it cannot be ruled out that some or all of the targets that we observed were Newell's Shearwaters. What can be said at this time is that passage rates of Newell's Shearwater-like targets through the Project were very low during the known peak daily activity periods for Newell's Shearwater and that our data set errs on the conservative side because it is likely to include some non-shearwater targets.

PASSAGE RATES AND FLIGHT DIRECTIONS

The overall mean evening passage rate of shearwater-like targets at the proposed windfarm site was similar between summer 2009 (i.e., 0.60 ± 0.07 targets/h) and summer 2011 (0.72 ± 0.12 targets/h). In addition, there was overlap in the 95% confidence intervals for passage rates of all stations and years. These data suggest that there were no differences in passage rates among stations or between the two years of study and that the shearwaters that do fly over the Project do so along a broad front without any zones of concentration.

Passage rates from almost all studies on other Hawaiian Islands (Day and Cooper 1995, Cooper and Day 2003, Day et al. 2003b) are higher, and often much higher, than the 2009 and 2011 passage rates observed at the proposed Project. For example, the mean summer passage rate from a study on Kauai was 118 targets/h (range = 8–569 targets/h, n = 13 sites; Day et al. 2003b). The only comparable radar data available for Oahu was collected by Day and Cooper (2008), who observed a mean summer passage rate of 0.2 ± 0.1 targets/h and a mean fall passage rate of 0.3 ± 0.2 targets/h at the nearby Kahuku site, located ~10 km northeast of the Project. The radar data from Denis and Verschuyl (2007) on Oahu are not comparable to ours because they were collected in May (a period when Newell's Shearwaters make an egg-laying exodus from the colonies [Ainley et al. 1997b]) and because they used a different minimal-cutoff flight speed (i.e., an airspeed of 40 mi/h [64 km/h]) for determining petrel-/shearwater-like radar targets.

Most (~87%) of all targets we observed were flying seaward (i.e., heading northwest, away from the direction of the potential seabird colonies in the Koolau Mountains) in 2011. Similar flight directions of radar targets were observed at the Project in 2009 (Cooper et al. 2011) and at the nearby Kahuku site by Day and Cooper (2008).

EXPOSURE RATES AND FATALITY ESTIMATES

We estimated that an average of ~2–12 Newell's Shearwaters/yr fly within the space occupied by each wind turbine (Table 6), that ~4 Newell's Shearwaters/yr fly within the space occupied by each guyed, 60-m-tall met tower (Table 7), and that ~1 Newell's Shearwater/yr flies within the space occupied by each free-standing, 100-m-tall met tower (Table 8). We used these estimated exposure rates as a starting point for developing a complete avian risk assessment; however, we emphasize that it currently is unknown whether bird use (i.e., exposure) and fatality at windfarm structures are strongly correlated. For example, Cooper and Day (1998) found no relationship between passage rates and fatality rates of Hawaiian Petrels and Newell's Shearwaters at powerlines on Kauai, indicating that other factors had a much greater effect on causing fatality than passage rates did. Other factors such as poor weather could be more highly correlated with fatality rates than is bird abundance. As an example, collisions of Laysan Albatross (*Phoebastria immutabilis*) with a large array of communication-tower antenna wires and guy wires adjacent to large, high-density albatross breeding colonies on Midway Atoll occurred at a far higher rate during periods of high winds, rain, and poor visibility than during periods of less severe weather: 838 (>25%) of the 2,901 birds killed during the study were killed during two storms (Fisher 1966). To determine which factors are most relevant, future studies that collect concurrent data on passage rates, weather, and fatality rates would be useful to evaluate how well passage rates and/or weather conditions can be used to predict the likelihood of shearwater fatalities at wind turbines, met towers and other structures at wind-energy facilities.

COLLISION AVOIDANCE RATES

Few data are available on the proportion of petrels and shearwaters that do not collide with wind turbines or met towers because of collision-avoidance behavior (i.e., birds that completely alter their flight paths horizontally and/or vertically to avoid flying through the space occupied by a structure). Some collision-avoidance information near transmission lines is available on petrels and shearwaters from earlier work that we conducted on Kauai, however (Cooper and Day 1998; Day et al., *In prep*). In summary, those data suggest that the behavioral-avoidance rate of Hawaiian Petrels and Newell's Shearwaters near transmission lines is high. For example, across all 207 Hawaiian Petrels observed flying within 150 m of transmission lines on Kauai, 40 exhibited behavioral responses; of those 40 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. Thus, the collision-avoidance rate for Hawaiian Petrels was 100% (i.e., 40 of 40 interactions resulted in collision avoidance). Across all 392 Newell's Shearwaters observed flying within 150 m of transmission lines, 29 exhibited behavioral responses; of those 29 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. Thus, the collision-avoidance rate for Newell's Shearwaters was 100% (i.e., 29 of 29 interactions resulted in successful collision avoidance).

There also is some information available on collision-avoidance of Hawaiian Petrels on Lanai, where the behavior of petrels was studied as they approached large communication towers near a petrel breeding colony (TetraTech 2008). In that study, all 20 (100%) of the Hawaiian Petrels that were on a collision-course toward communication towers exhibited avoidance behavior and avoided collision.

Additional data that provide some insights on collision-avoidance behavior of petrels and shearwaters at windfarm structures (e.g., wind turbines and met towers) are available from other studies associated with the operational KWP I wind facility on Maui and the six meteorological towers on Lanai. On Maui, there have been 2 Hawaiian Petrel fatalities and 0 Newell's Shearwater fatalities observed at the 20-turbines and three met towers during the first five years of operation (Kaheawa Wind Power LLC 2009; G. Spencer, FirstWind, pers. comm.). Cooper and Day (2004b) used similar methods as the current study to model seabird fatality for the KWP I wind turbines, based on passage rates from radar studies at the site (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 turbines 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. Their fatality model that used a 99% avoidance value was a closer fit with the measured fatality rates (uncorrected for scavenging bias and searcher efficiency) than were the fatality estimates based on a 50% or 95% avoidance rates. Similarly, 0 Hawaiian Petrels were found in four years of fatality searches at six met towers on Lanai (A. Oller, TetraTech EC, pers. comm.), which fit the preconstruction fatality estimates based upon radar data and a >99% avoidance factor (i.e., <0.07–0.77 petrels/met tower/year with an assumption of 99% avoidance; Cooper et al. 2007). Thus, the two wind energy projects in Hawaii with preconstruction fatality estimates and post-construction fatality data both suggest that fatality models based on an assumption that 99% of petrels avoided met towers produced more realistic estimates of fatality than did models using lower avoidance values.

In summary, currently available data suggest that the avoidance rate of petrels and shearwaters at transmission lines and communications towers is high and approaches 100%. Data from the fatality searches at turbines and met towers on Maui and Lanai are more difficult to interpret because they are not a direct measure of avoidance, but they also suggest high avoidance rates. Thus, the overall body of evidence, while incomplete, is consistent with the hypothesis that the average avoidance rate of petrels and shearwaters at wind turbines and met towers is substantial and potentially is ≥95%. The ability of Hawaiian Petrels and Newell's Shearwater to detect and avoid objects under low-light conditions makes sense from a life-history standpoint, since they are known to forage extensively at night and to fly through forests near their nests during low-light conditions.

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 structures (e.g., wind turbines, met towers) 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 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), Common Terns (*Sterna hirundo*) and Sandwich Terns (*Sterna sandvicensis*) during the daytime (>99%, Everaert and Stienen 2007), gulls (*Larus* spp.) in the daytime (>99%; Painter et al. 1999, cited in Chamberlain et al. 2006), and passerines during both the day and night (>99%; Winkelman 1992, cited in Chamberlain et al. 2006).

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 fatality data at wind turbines and met towers on Maui and Lanai, while incomplete, is consistent with the notion that a substantial proportion of shearwaters and 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 structures at windfarms, we continue to provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance), along with a discussion of the growing body of evidence that, while incomplete at this time, is consistent with the notion that the average avoidance-rate value is substantial and potentially is ≥95%. With an assumption of a 95% avoidance rate, the estimated average annual take at the proposed Kawailoa facility would be 0.060–0.084 Newell's Shearwaters/turbine/year, 0.191 Newell's Shearwaters/60-m-tall, guyed met tower/year, and 0.024 Newell's Shearwaters/100-m-tall unguyed met tower/year.

POTENTIAL BIASES

In addition to avoidance rates, there are other factors that could bias our exposure model and collision estimates in a positive or a negative direction. One factor that would have created a positive bias was the inclusion of targets that were not petrels or shearwaters (see above). The elimination of shearwater-like radar targets that were confirmed by concurrent visual observations to be non-target species and the exclusion of fall radar data helped to minimize the inclusion of non-target species, but it still is possible that some of our radar targets were other fast-flying species that were active during the sampling period (e.g., Mallard-Hawaiian Duck hybrids or Sooty Terns [*Sterna fuscata*]) and thus inflated our passage rate calculations. A second positive bias in our fatality model is our simplistic assumption that passage rates of seabirds do not decrease as individual fatalities occur (i.e., we assumed sampling with replacement for fatalities). Given the low passage rates observed in this study, it is likely that the fatality of just a single bird would substantially reduce the average nightly passage rates. A third positive bias is the assumption that turbines are operating at maximal rotor speed; this assumption clearly is incorrect because of variability in winds, but using it results in maximal estimates of collision rates for birds flying through the turbine rotors.

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 stations provided good coverage of the surrounding area, we believe that the proportion of targets that was missed because they passed through the entire area of coverage of the Project within a radar shadow was minimal.

A factor that could affect our fatality estimates in either direction is interannual variation in the number of birds visiting nesting colonies. There are examples of sites with high interannual variation in petrel and shearwater radar counts, such as the three sites on Kauai where counts were ~100–300 birds/hr lower (~four times lower) in fall 1992 than in fall 1993; the lower counts in 1992 were attributed to the effects of Hurricane Iniki (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). There was a moderate El Niño–Southern Oscillation event that began in April 2009 and was still developing when our summer study occurred in June 2009 and there were ENSO-neutral conditions in June 2011 (NOAA 2011). Thus, we speculate that it is unlikely that El Niño-related oceanographic effects were large enough to have significantly affected seabird passage rates during our summer 2009 or 2011 sampling periods. Another factor that could cause interannual variation in counts in either direction is overall population increases or declines. For example, there was a ~60% decline in radar counts on Kauai between 1993 and 1999–2001 that was attributed to population declines of Newell's Shearwaters (Day et al. 2003b).

HAWAIIAN HOARY BATS

Recent data from Appalachian ridge tops in the eastern US 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), transmission lines (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 fatalities of migratory Hoary Bats at wind turbines on the US mainland (Kunz et al. 2007a) and of Hawaiian Hoary Bats on Maui, there was interest in having us collect visual data on Hawaiian Hoary Bats during this study, using binoculars and night-vision equipment. Our data indicate that Hawaiian Hoary Bats are present in the Project area in low numbers in summer: 2 bats were recorded during the 10 nights of study in summer 2009 (0.057 bats/h; Cooper et al. 2011) and one bat was recorded during this study in 2011 (0.010 bats/h). Similarly, Day and Cooper (2008) also recorded low numbers of bats at the nearby Kahuku wind site summer (i.e., <0.001 bats/h). In addition, acoustic monitoring studies in the Project area reported an average of 0.12 bat passes/detector/night (SWCA 2011b). Hawaiian Hoary Bats have been recorded elsewhere 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 was speculation that the species had disappeared from Oahu and Molokai (State of Hawaii 2005), although our studies and others clearly indicates persistence on this island and the work of Day and Cooper (2002) does the same for Molokai. In summary, our visual data and the bat acoustic data (SWCA 2011b) at the Kawailoa site indicate that bats are present in low numbers in the vicinity of the Project.

SUMMARY

This study focused on the movement patterns and flight behavior of Hawaiian Petrels and Newell's Shearwaters near the proposed Kawailoa Wind Energy Facility in summer 2011 and built upon similar studies conducted there by Cooper et al. (2011) in 2009. The key results of the study were: (1) passage rates of shearwater-like targets at the Project during 2009 and 2011 were low (an average rate of 0.66 targets/h) relative to other locations in the Hawaiian Islands; (2) passage rates at the Project were similar among sampling stations and similar between years; (3) the timing of movements on radar and absence of recent records of Hawaiian suggested that the petrel-/ sheawater-like radar targets that we observed were most likely Newell's Shearwaters rather than Hawaiian Petrels; (4) low numbers of Hawaiian Hoary Bats were detected during visual observations in the vicinity of the Project in summer (~0.01 bats/h in 2011); (5) an average of ~2–12 Newell's Shearwaters/yr fly within the space occupied by each wind turbine, ~4 Newell's Shearwaters/yr fly within the space occupied by each guyed, 60-m-tall met tower, and ~1 Newell's Shearwater/yr flies within the space occupied by each free-standing, 100-m-tall met tower; and (6) by using a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance), we estimated a collision-caused fatality rate of 0.012–0.169 Newell's Shearwaters/turbine/year for each wind turbine, 0.038–0.382 Newell's Shearwaters/tower/year for each 60-m met tower, and 0.005–0.047 Newell's Shearwaters/tower/year for each 100-m met tower. In conclusion, we speculate that the proportion of seabirds that would detect and avoid wind turbines and met towers at the proposed Project will be high, but until further studies are conducted to quantify avoidance behavior at these structures, we provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance rates) along with a discussion of the growing body of evidence that is consistent with the hypothesis that the average avoidance-rate value is substantial and potentially ≥95%.

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.

American Ornithologists' Union (AOU). 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's 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, and J. H. Plissner. 2007. Radar and audio-visual studies of Hawaiian Petrels near proposed meteorological towers and wind turbines on northwestern Lanai Island, May-July 2007. Unpublished report prepared for KC Environmental, Inc., Makawao, HI, and TetraTech EC, Portland, OR, by ABR, Inc.—Environmental Research & Services, Forest Grove, OR, and Fairbanks, AK. 44 pp. Appendix 3 *in* Draft Habitat Conservation Plan for the construction and operation of the Lanai metereological towers, Lanai, Hawaii. Prepared for Castle and Cooke, Lanai City, HI, by TetraTech EC, Honolulu, HI. 54 pp. + appendices. http://www.state.hi.us/dlnr/dofaw/pubs/Lana'i_Met_Towers_HCP.pdf. Accessed September 2011.

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.

Cooper, B. A., P. M. Sanzenbacher, and R. H. Day. 2011. Radar and visual studies of seabirds at the proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii, 2009. Unpublished report prepared for First Wind LLC, Newton, MA by ABR, Inc., Forest Grove, OR, and Fairbanks, AK. 32 pp. Appendix 3 *in* Kawailoa Wind Power Draft Habitat

Conservation Plan. Prepared by SWCA, Honolulu, HI, for Kawailoa Wind Power LLC, Honolulu, HI. 144 pp + appendices. http://www.fws.gov/pacificislands/Publications/Kawailoa_DraftHCP_with_App.pdf. Accessed September 2011.

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., and B. A. Cooper. 2008. Results of endangered seabird and Hawaiian Hoary Bat surveys on northern Oahu Island, October 2007 and July 2008. Unpublished report prepared for FirstWind, Newton, MA, by ABR, Inc.—Environmental Research & Services, Fairbanks, AK, and Forest Grove, OR. 27 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, T. J. Mabee, J. H. Plissner, P. M. Sanzenbacher, and A. Oller. *In prep*. Collision-avoidance behavior of Hawaiian Petrels and Newell's Shearwaters in the Hawaiian Islands.

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.

Everaert, M. and E. W. M. Stienen. 2007. Impact of wind turbines on birds in Zeebrugge (Belgium). Biodiversity and Conservation 16: 3345–2259.

Fisher, H. I. 1966. Midway's deadly antennas. Audubon Magazine, July–August 1966. Pp. 220–223.

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.

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.

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

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. Szewczak. 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.

National Oceanic and Atmospheric Administration (NOAA). 2011. National Climatic Data Center El Niño and La Niña website. http://www.ncdc.noaa.gov/oa/climate/elnino/elnino.html. Accessed September 2011.

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.

SWCA. 2011a. Kawailoa Wind Power Draft Habitat Conservation Plan. Prepared by SWCA, Honolulu, HI, for Kawailoa Wind Power LLC, Honolulu, HI. 144 pp + appendices. http://www.fws.gov/pacificislands/Publications/Kawailoa_DraftHCP_with_App.pdf. Accessed September 2011.

SWCA. 2011b. Kawailoa Wind Power wildlife monitoring report for waterbirds and bats, October 2009–April 2011. Prepared by SWCA, Honolulu, HI, for First Wind, Honolulu, HI. 26 pp. Appendix 4 *in* Kawailoa Wind Power Draft Habitat Conservation Plan. Prepared by SWCA, Honolulu, HI, for Kawailoa Wind Power LLC, Honolulu, HI. 144 pp + appendices. http://www.fws.gov/pacificislands/Publications/Kawailoa_DraftHCP_with_App.pdf. Accessed September 2011.

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.

TetraTech EC. 2008. Draft Habitat Conservation Plan for the construction and operation of Lanai met towers, Lanai, Hawaii (Revised February 8, 2008, TTEC-PTLD-2008-080). Unpublished report prepared by Tetratech EC, Honolulu, HI, for Castle and Cooke LLC, Lanai City, HI. 54 pp. + appendices. http://www.state.hi.us/dlnr/dofaw/pubs/Lana'i_Met_Towers_HCP.pdf. Accessed September 2011.

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.

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. https://www.nationalwind.org/assets/research_meetings/Research_Meeting_I_Proceedings.pdf. Accessed September 2011.

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 4

FINAL REPORT

Kawailoa Wind Power Wildlife Monitoring Report for Waterbirds and Bats (October 2009 – April 2011)

Submitted to
First Wind
810 Richards Street, Suite 650
Honolulu, HI 96813

Prepared By
SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, HI 96813

May 2011

Table of Contents

1.0 INTRODUCTION 1
2.0 METHODS 1
2.1 Quantifying Bird Activity 1
2.1.1 Point Count Stations 1
2.1.2 Playbacks 4
2.1.3 Driving Transects 4
2.1.4 Incidental Sightings 4
2.1.5 Data Analysis 4
2.2 Quantifying Bat Activity 4
2.2.1 Assumptions in the Anabat Study Design 7
2.3 Calculating Fatality Estimates for Hawaiian Duck-Mallard Hybrids 7
2.3.1 Passage Rates 8
2.3.2 Calculating Vertical Interaction Probabilities 8
2.3.3 Calculating Horizontal Interaction Probabilities 8
2.3.4 Fatality Probability Factors 11
2.3.5 Avoidance Rates 11
3.0 RESULTS 11
3.1 Diurnal Surveys 11
3.1.1 Native Non-Listed Species 12
3.1.2 Threatened and Endangered Species 14
3.1.3 Migratory Species 16
3.2 Bat Surveys 16
3.2.1 Acoustic Monitoring 16
3.3 Estimated Fatality Rates of Hawaiian Duck-Mallard 20
4.0 DISCUSSION AND CONCLUSION 24
5.0 REFERENCES 25

List of Tables

Table 1. Dominant Vegetation Cover at Point Count Stations 3
Table 2. Detector Nights per Anabat Location 5
Table 3. Turbine Specifications 9
Table 4. Bird Species Observed at the Project Site, Nearby Ponds and Vicinity 13
Table 5. Distribution of Bat Passes by Anabat Location 18
Table 6. Bat Activity By Anabat Location During Higher Activity Periods 19
Table 7. Calculation of Passage Rates of Hawaiian Duck-Mallard Hybrids Over the Project Site 20
Table 8. Probability of Hawaiian Duck-Mallard Hybrids Striking a Turbine Blade 20
Table 9. Estimated Fatality of Hawaiian Duck-Mallard Hybrids from Turbine Collision 21
Table 10. Estimated Fatality of Hawaiian Duck-Mallard Hybrids from Collision with the Free-Standing Permanent Met Tower 23

List of Figures

Figure 1. Site Layout, Point Count Station Locations and Airspace Envelope at Kawailoa Wind Power .. 2
Figure 2. Anabat Locations 6
Figure 3. Horizontal Interaction Probabilities 9
Figure 4. Schematic of Met Tower and Assumed Profile (red line). 10
Figure 5. Box Plot of Flight Altitude of Flocks Observed On-site Imposed on Rotor Swept Zones (RSZ) of Proposed Turbines. 12
Figure 6. Distribution of Waterbird Activity On-site and Off-Site 15
Figure 7. Distribution of Bat Passes Over Survey Period 17
Figure 8. Time Distribution of All Bat Call Sequences Detected 17

1.0 INTRODUCTION

First Wind proposes to develop a wind power facility of up to 70 megawatts (MW) near the town of Hale‘iwa on the island of O‘ahu, Hawai‘i. Kawailoa Wind Power is situated on 4,200 acres (1,700 ha) of former Kawailoa Plantation lands above Hale‘iwa on the North Shore of O‘ahu. The vegetation in the project area is a mixture of non-native weedy species that dominate the former cane fields. Guinea grass (*Urochloa maxima*) is the most abundant species on the property, dominating the ridge tops and many of the gulches (Hobdy 2010). Other common species include: common ironwood (*Casuarina equisetifolia*), albizia (*Falcataria moluccana*), Formosa koa (*Acacia confusa*), koa haole (*Leucaena leucocephala*), padang cassia (*Cinnamomum burmanni*), Java plum (*Syzygium cumini*), strawberry guava (*Psidium cattleianum*), cork bark passion flower (*Passiflora suberosa*) and swamp mahogany (*Eucalyptus robusta*). All of these species are non-native to the Hawaiian Islands (Hobdy 2010).

Prior to human contact the project area was most likely forested with a variety of native trees, shrubs, ferns and vines. Changes were first introduced by forest clearing and cultivation of crops along the stream channels, lowlands, and hills by Native Hawaiians between 1100 and 1650 AD (Cuddihy and Stone 1990). This change was followed by nearly 100 years of commercial sugar and pineapple cultivation (Wilcox 1998), purposeful introduction of non-native trees and shrubs, and unintentional invasion by non-native plant and animal species (Hobdy 2010). Remnant native vegetation may be found on the walls of gulches at higher elevations.

The proposed project is expected to consist of up to 30 turbines arranged in three turbine strings located in Zone 1, Zone 2 and Zone 3 (Figure 1). Up to five permanent meteorological (met) tower locations are being considered, although not all are expected to be needed and the actual number to be constructed will likely be less.

Bird and bat surveys were conducted to assess the risk of the proposed wind facility operations to federal- or state-listed threatened or endangered species that may be found on, or transit through, the site. The goals of these surveys were to:

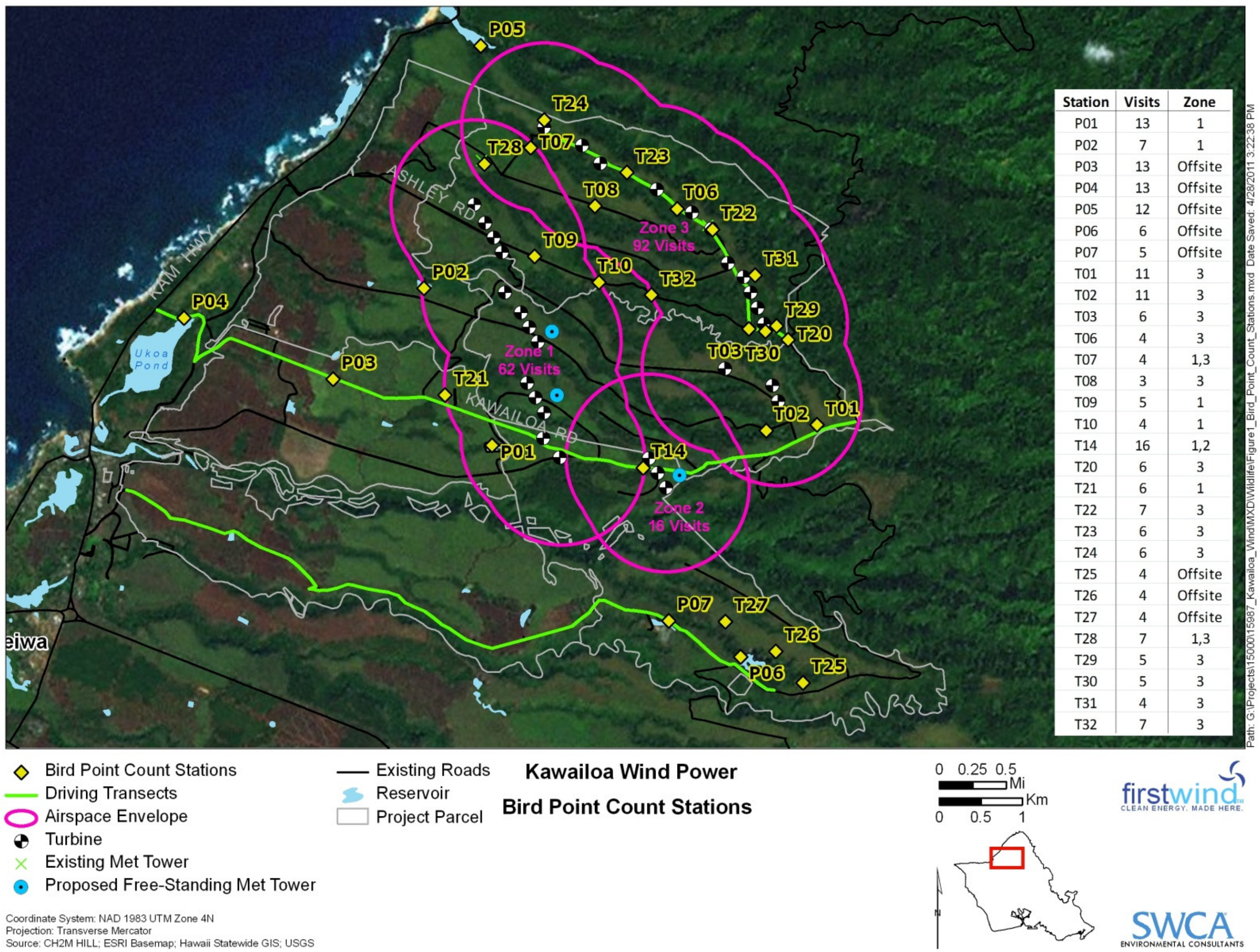
1) quantify the level of bird activity on site using visual surveys with emphasis on characterizing the flight patterns and activity of threatened and endangered species;
2) quantify the level of bat activity on site using Anabat detectors;
3) conduct waterbird surveys at nearby water bodies to characterize flight activity and diurnal or seasonal variations in abundance or activity; and,
4) estimate fatality rates of threatened and endangered bird species that might result from interaction with the operating turbines and met towers.

2.0 METHODS

2.1 Quantifying Bird Activity

2.1.1 Point Count Stations

SWCA biologists surveyed 29 bird point count stations (Figure 1) from October 2009 to February 2011. An "airspace envelope" was defined around each turbine string by placing a 1 kilometer (km) wide buffer around each preliminary turbine location as illustrated in Figure 1. All flight observations occurring at point count stations within the 1 km airspace envelope were considered to be within the possible area of turbine interaction and were deemed "on-site." Point count stations outside the airspace envelope were considered to be "off-site." The point count stations were chosen to be representative of vegetation types and elevations within the project area, close to potential turbine locations. Additional point counts were conducted at water bodies in the vicinity of the project area to document waterbird activity. The dominant vegetation type within a 200 meter (m) radius of each point count station is listed in Table 1.



Station	Visits	Zone
P01	13	1
P02	7	1
P03	13	Offsite
P04	13	Offsite
P05	12	Offsite
P06	6	Offsite
P07	5	Offsite
T01	11	3
T02	11	3
T03	6	3
T06	4	3
T07	4	1,3
T08	3	3
T09	5	1
T10	4	1
T14	16	1,2
T20	6	3
T21	6	1
T22	7	3
T23	6	3
T24	6	3
T25	4	Offsite
T26	4	Offsite
T27	4	Offsite
T28	7	1,3
T29	5	3
T30	5	3
T31	4	3
T32	7	3

Figure 1. Site Layout, Point Count Station Locations and Airspace Envelope at Kawailoa Wind Power

Table 1. Dominant Vegetation Cover at Point Count Stations

Point Count Station	Vegetation Cover
P01	Small irrigation pond
P02	Medium-sized irrigation pond
P03	Small irrigation pond
P04	Natural water body choked with invasive species: water hyacinth (*Eichornia* spp.) and California bulrush (*Schoenoplectus californicus*)
P05	Stream at Waimea Valley
P06	Large irrigation pond with heavily vegetated sides
P07	Large irrigation pond (drained and under repair)
T01	Met tower with grassland understory and koa trees (*Acacia koa*)
T02	Grassy ridge dominated by kukui (*Aleurites moluccana*) and strawberry guava (*Psidium littorale* var. cattleianum) with some native trees: koa and ‘ōhi‘a (*Metrosideros polymorpha*)
T03	Dense albizia forest with grass understory
T06	Grassy understory with mostly alien forest: Java plum (*Syzgium cumini*), silk oak (*Grevillea robusta*), albizia trees and some koa overlooking Waimea Valley
T07	Ironwood, albizia trees, silk oak, Java plum and Christmas berry (*Schinus terebinthifolius*) mixed forest with grass understory
T08	Grassland and sparsely scattered albizia, Java plum and silk oak, with an ironwood stand in the distance
T09	Grassland and albizia forest
T10	Grassland and albizia forest
T14	Grassland and *Eucalyptus* forest with scattered albizia
T20	*Eucalyptus* trees with *Ficus* spp., Java plum, strawberry guava and some koa; overlooking Waimea Valley
T21	Met tower with grassland understory and scattered albizia, Formosa koa (*Acacia confusa*), pride of India (*Melia azedarach*), Christmas berry and koa haole (*Leucaena leucocephala*)
T22	Met tower with albizia trees and grass understory, gulch edge growing with Java plum, koa, alahe‘e (*Psydras odorata*) and ‘ōhi‘a
T23	Grassy understory with Java plum, silk oak, koa haole, overlooking Waimea Valley
T24	Grassland with albizia, Java plum and Formosa koa
T25	Dominated by strawberry guava, with scattered silk oak, koa and ‘ōhi‘a
T26	Met tower with grass understory, with scattered silk oak, albizia and ironwoods
T27	Alien forest with albizia, silk oak, koa haole and grass understory
T28	Met tower – grassland with ironwood stand in the distance
T29	Albizia forest with grassy understory. Some *Ficus* sp.
T30	Ridge top with albizia forest and some paperbark tree (*Melaleuca quinquenervia*). Ō‘hi‘a, Java plum, silk oak, strawberry guava and Christmas berry (*Schinus terebinthifolius*) with uluhe (*Dicranopteris linearis*) understory
T31	Albizia forest with grassy understory, koa, alahe‘e and ‘ōhi‘a along the gulch edge overlooking Waimea Valley
T32	Koa haole, Java plum, ironwood trees and albizia with grassy understory

Some of the point count locations were added or discontinued over time as different turbine configurations were considered or eliminated by project engineers. However, overall, the surveys resulted in more-or-less even coverage of the proposed airspace of the project due to overlap and a greater than one-year survey period.

Four to eight point count stations were typically surveyed between 0600 and 1100 h, and 1400 and 1900 h during each visit to the project area. Each point count lasted 15 minutes per station. One to two observers using 10 x 50 binoculars with a 6.5 degree field of vision were present at each point count and all birds observed within a radius of approximately 200 m from the station were recorded. Time of day, species, size of flock, flight direction, flight altitude, and distance between bird(s) and observer were recorded. Negative values for flight altitudes were recorded when flight activity occurred at elevations below the observer. Weather conditions were also documented. Wind speed and wind direction were recorded with a Kestrel 4500 (Nielsen Kellerman, USA), and percent cloud cover and visibility were estimated visually. Precipitation was categorically documented.

2.1.2 Playbacks

Playbacks of Hawaiian moorhen (*Gallinula chloropus sandvicensis*) calls at the ponds (P01-P07) were also conducted from May to September 2010. Playbacks were two minutes in duration and consisted of the following sequence: chick distress calls (30 seconds), silence to listen for a response (30 seconds), moorhen territorial calls (30 seconds), and silence to listen for a response (30 seconds). The calls chosen were calls most likely to elicit a response from nearby moorhen (DesRochers et al. 2008). The calls we used were originally recorded from the James Campbell Wildlife Refuge (http://ase.tufts.edu/biology/labs/reed/res-pub-suppl.html) by U.S. Fish and Wildlife Service biologists. Playbacks have been shown to increase detection by 30% on O'ahu (DesRochers et al. 2008), and so were incorporated into the standard 15-minute point count (i.e., two minutes playback plus 13 minutes point count observations).

2.1.3 Driving Transects

Driving transects were conducted between April and August 2010 to document waterbird activity between ponds and were also conducted along sections of turbine strings accessible by road (Figure 1). A vehicle was driven at speeds between 8 km/h (5 mph) and 24 km/h (15 mph) while an observer recorded occurrences of all native birds (waterbirds and owls). Transect start location, end location, start time, end time, distance traveled, location of sighting, species, and the number of birds, were recorded.

2.1.4 Incidental Sightings

SWCA biologists also recorded incidental sightings of native birds while on site and in the vicinity of the project area. Incidental sightings were recorded from October 2009 to February 2011.

2.1.5 Data Analysis

All point count data were entered in Microsoft Office Access 2007 database. Descriptive bird activity data, including flight direction, altitude, and distribution of species on-site, were summarized for each point count station in the field. A list of species most likely to occur in the rotor swept zone (RSZ) was also included.

2.2 Quantifying Bat Activity

Anabat acoustic detectors (Titley Electronics, NSW, Australia) were employed to quantify Hawaiian hoary bat (*Lasiurus cinereus semotus*) activity at the Kawailoa Wind Power facility. Two to nine Anabat detectors were deployed at any one time at various locations on the site from October 2009 to April 2011 (Figure 2, Table 2). Anabat detectors record ultrasonic sounds, including those emitted by bats. The recorded sonograms are subsequently examined for the presence of bat ultrasonic echolocation calls.

Table 2. Detector Nights per Anabat Location

		Nights per Anabat																			
Year	**Month**	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**E1**	**F1**	**F2**	**F3**	**F4**	**G1**	**G2**	**H1**	**J1**	**J2**	**J3**	**Total Nights**
2009	Oct				23			26													**49**
2009	Nov				11			30			11										**52**
2009	Dec				23			31			17										**71**
2010	Jan				12	17		31			22										**82**
2010	Feb					10		19													**29**
2010	Mar					14		24				7									**45**
2010	Apr	8				24		23				16									**71**
2010	May	19				26		31				19	4		7		6	6			**118**
2010	Jun	9				3		1					2		14		5	2			**36**
2010	Jul	23	3			26		26					10			26	26	10	3		**153**
2010	Aug		31			31		30					28			31	31		31		**213**
2010	Sep		15			1	6	3					14	16		15	15		15		**100**
2010	Oct		31				31	27						31		31	31		31		**213**
2010	Nov		30				27	30						30		28	30		23		**198**
2010	Dec		28				31	31						31		29	31		31		**212**
2011	Jan		31				31	25		13				25		31	25		4	13	**198**
2011	Feb		28				25	27		28				27		19	18			25	**197**
2011	Mar		31				23	31		31				31		30	21			28	**226**
2011	Apr			18			23		19	23				30		30	30			30	**203**
																				Total Nights	**2466**

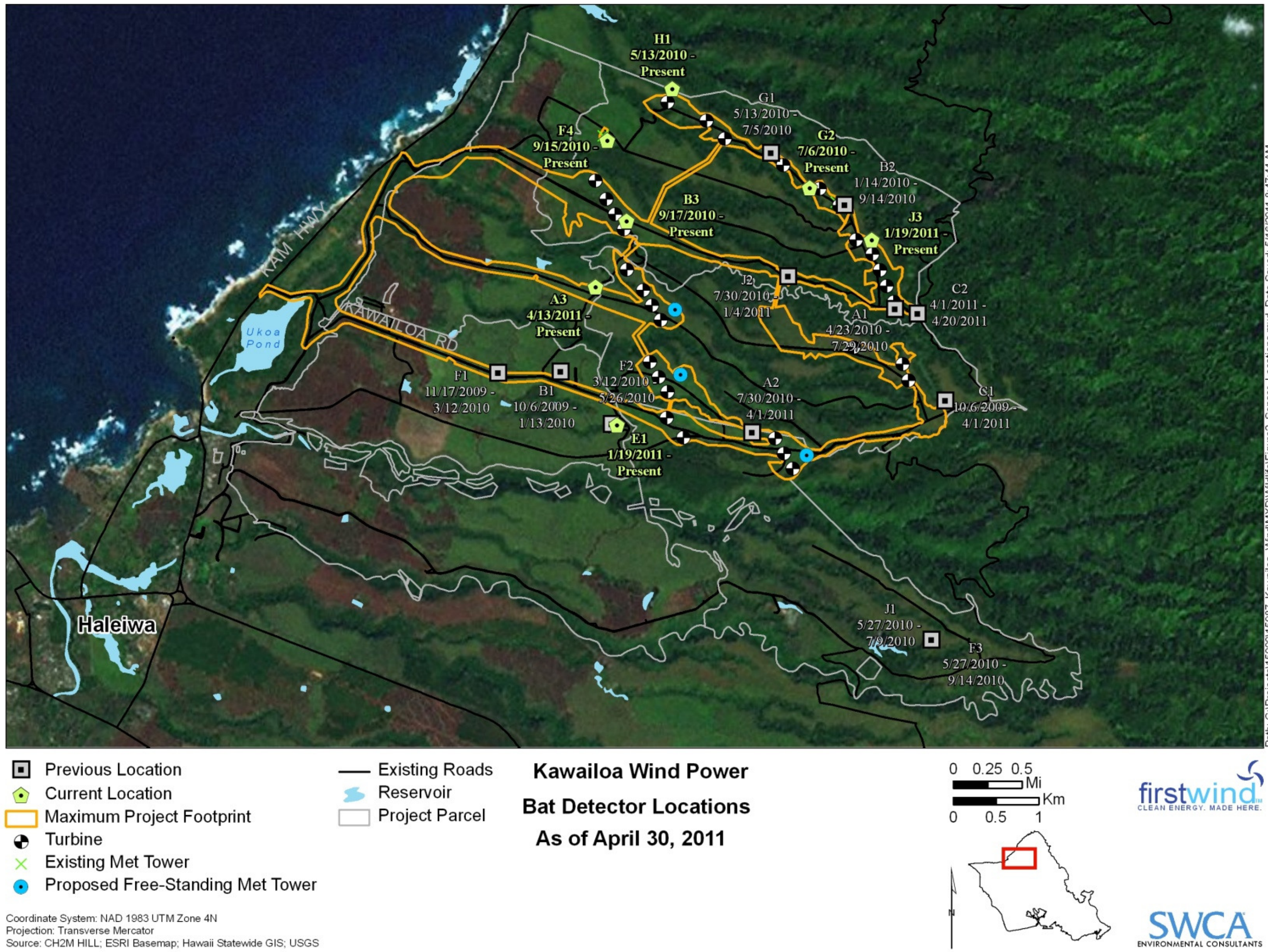


Figure 2. Anabat Locations

Anabats were placed between 1.5 to 3 m above ground level, except for F3 which was deployed two-thirds the way up the met tower at T28 at approximately 40 m height. The Anabats were placed in a variety of locations and vegetation types to ensure good representation of the site. At each chosen site, whenever possible, Anabats were situated in spots sheltered from wind, along roads or edges of vegetation to maximize the probability of detecting a bat.

Bat detections were classified as either bat call sequences or bat passes. A bat call is one frequency modulated sweep. A call sequence consists of a continuous recording of one or more bat calls. A bat pass is a call sequence consisting of two of more calls (Baerwald and Barclay 2009) and are, therefore, a subset of the total number of call sequences. Individual call sequences are separated by a time interval of more than one second between calls (Kunz et al. 2007).

Bat activity was quantified by the number of bat passes per detector night (Baerwald and Barclay 2009). A detector night consists of one Anabat detector recording data for one night. Bat activity per month was calculated by adding up the number of bat passes recorded for that month divided by the number of detector nights for that month. Total number of bat passes or detector nights were summed for months that were sampled over multiple years. Months that had detection rates equal to or over 0.1 passes/detector night were considered "higher activity" months, while months with activity rates below 0.1 passes/detector night were considered "lower activity" months.

2.2.1 Assumptions in the Anabat Study Design

Anabat detectors were moved among locations to improve coverage of the entire site. Typically this would not be done until at least 30 detector nights had been logged (although locations G1 and J1 were moved after 21 and 19 detector nights, respectively, see Table 2). A3 and C2 also have fewer than 30 detector nights, due to having been deployed in April 2011, at the end of the survey period.

The study results show that some seasonality in bat activity exists (see Section 3.2). However, since some Anabats were moved to different locations regardless of season, some locations were only sampled in fall/winter, while others were only sampled in summer/spring. As a result, the activity rates at different locations were often not directly comparable due to the seasonal changes in detection rates. To determine locations of higher bat activity, only Anabat locations that were sampled for more than 50 detector nights during months with relatively high bat activity (months with greater than or equal to 0.1 passes/detector nights) were examined. Each chosen month also had six or more bat detectors deployed at different locations for that month. As a result, only locations sampled during the months of May to September 2010 and March to April 2011 were chosen for analysis. February 2011 was excluded as a higher activity month as 95% of the call sequences were detected on February 28 (see Figure 7). Locations that had detection rates equal or greater than 0.1 passes/detector night were considered to be locations of higher bat activity.

2.3 Calculating Fatality Estimates for Hawaiian Duck-Mallard Hybrids

The Hawaiian duck-mallard hybrid (*Anas* sp.) is considered a native but not an endangered species. It is a hybrid of the endangered Hawaiian duck (*Anas wyvilliana*) and the mallard (*Anas platyrhynchos*). Browne et al. (1993) determined that the Hawaiian duck alleles have nearly disappeared on O'ahu as a result of hybridization with domestic mallards. One Hawaiian duck was documented, through genetic testing, at Honolulu airport in 2005 (Helber Hastert & Fee 2010), but Uyehara et al. (2007) found a predominance of hybrids on O'ahu. Ducks resembling Hawaiian ducks at the site are, therefore, assumed most likely to be hybrids.

Hawaiian duck-mallard hybrids were used as a proxy for the Hawaiian duck, as they are likely to exhibit similar behaviors.

Fatality estimates for duck-mallard hybrids were described in detail below. The fatality estimates SWCA employed in this study closely followed the model developed by Day and Cooper (2008, 2009), Sazenbacher and Cooper (2009) and Cooper et al. (2009), with modifications. The model included movement rates (average passage rates over the site), horizontal and vertical interaction probabilities (probability of a bird encountering a turbine), and fatality probability (i.e., the likelihood of being struck while passing through the RSZ and the likelihood of the strike causing fatality). 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; 1) fatality at height of the RSZ, 2) fatality from colliding with the tubular towers below the RSZ, and 3) fatality upon collision with the met tower.

2.3.1 Passage Rates

As the Hawaiian duck-mallard hybrids were only observed in the airspace envelope at the lowest elevations (Zone 1), the average passage rate (flocks/hr/ha) of the hybrid was determined from flight activity rates from all point count stations found within the Zone 1 airspace envelope (see Figure 1). A uniform passage rate was assumed over Zone 1. The passage rates in Zones 2 and 3 were assumed to be zero due to no Hawaiian duck-mallard hybrids having been documented in these Zones during any of the point count surveys.

2.3.2 Calculating Vertical Interaction Probabilities

The vertical interaction probability is the likelihood that a flock is flying at an altitude within the RSZ. This was calculated using the flight altitude of all Hawaiian duck-mallard hybrid flocks observed on-site and at adjacent water bodies. The flock, rather than individual birds, was used as the unit of measure because individual birds in a flock tended to fly at the same altitude and were, therefore, not considered to be independent observations. A flock can consist of one or more ducks.

2.3.3 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 the length of the turbine blades (Figure 3). The volume of space around the turbine was defined as a 1 hectare (ha) plot centered around the turbine multiplied by the relevant turbine height.

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 hectare plot from the minimum tip height to the maximum tip height of the turbine (Figure 3).

Interaction probability for RSZ = volume of RSZ / volume of 1 ha plot within RSZ

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 from ground level to the minimum tip height over the volume of 1 ha plot below the RSZ (Figure 3).

Interaction probability for tubular tower = tower volume from ground level to below RSZ / volume of 1 ha plot from ground level to below RSZ

The specifications for the proposed turbine are provided in Table 3.

Table 3. Turbine Specifications

	Turbine specifications
Tower height (m)	100
Rotor diameter (m)	101.0
Max tip height (m)	150.5
Min tip height (m)	49.5

The interaction probability for one met tower is as follows:

Interaction probability of met tower = volume of met tower / volume of 1 h plot from ground level to top of met tower

The met tower used in these calculations was modeled as a free-standing solid structure with a triangular base with sides 7.62 m in length tapering to a triangular peak with 0.46 m sides. The tower extended to a height of 100 m. The actual met tower will be a lattice structure, not a solid structure and the model also overestimates the volume of the met tower by assuming a straight taper from the bottom to the top, rather than a curve (Figure 4).

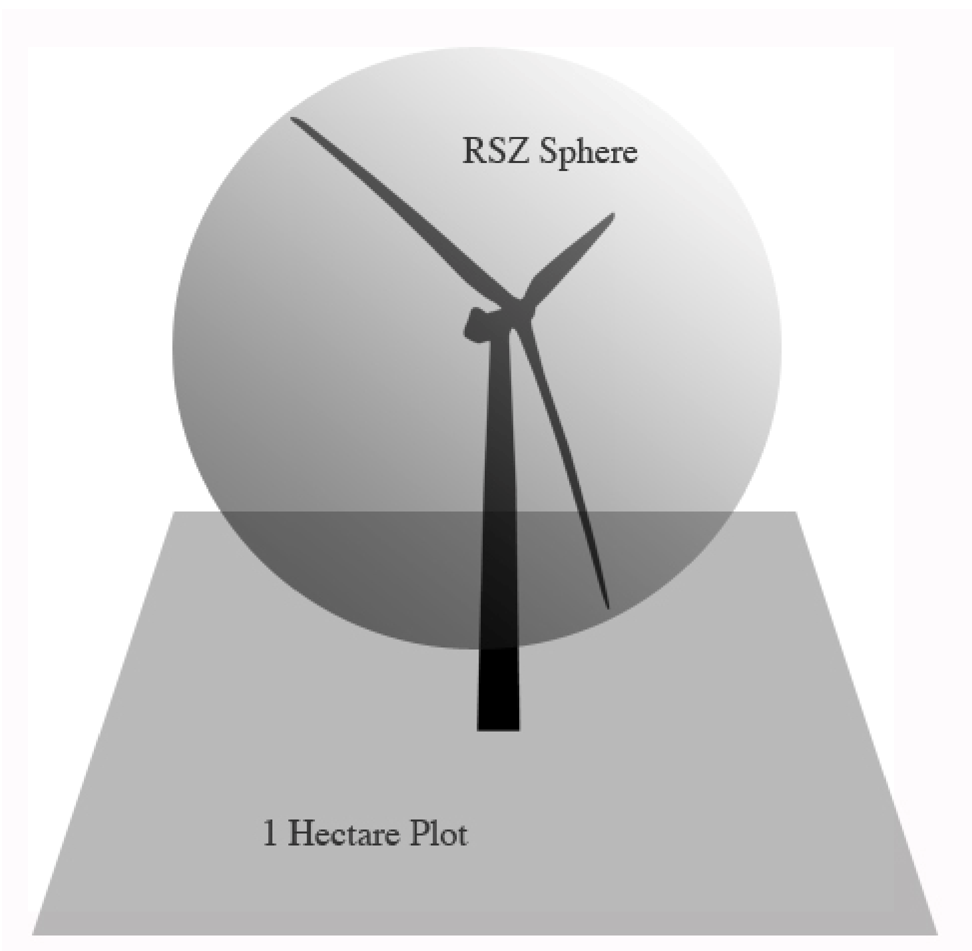


Figure 3. Horizontal Interaction Probabilities

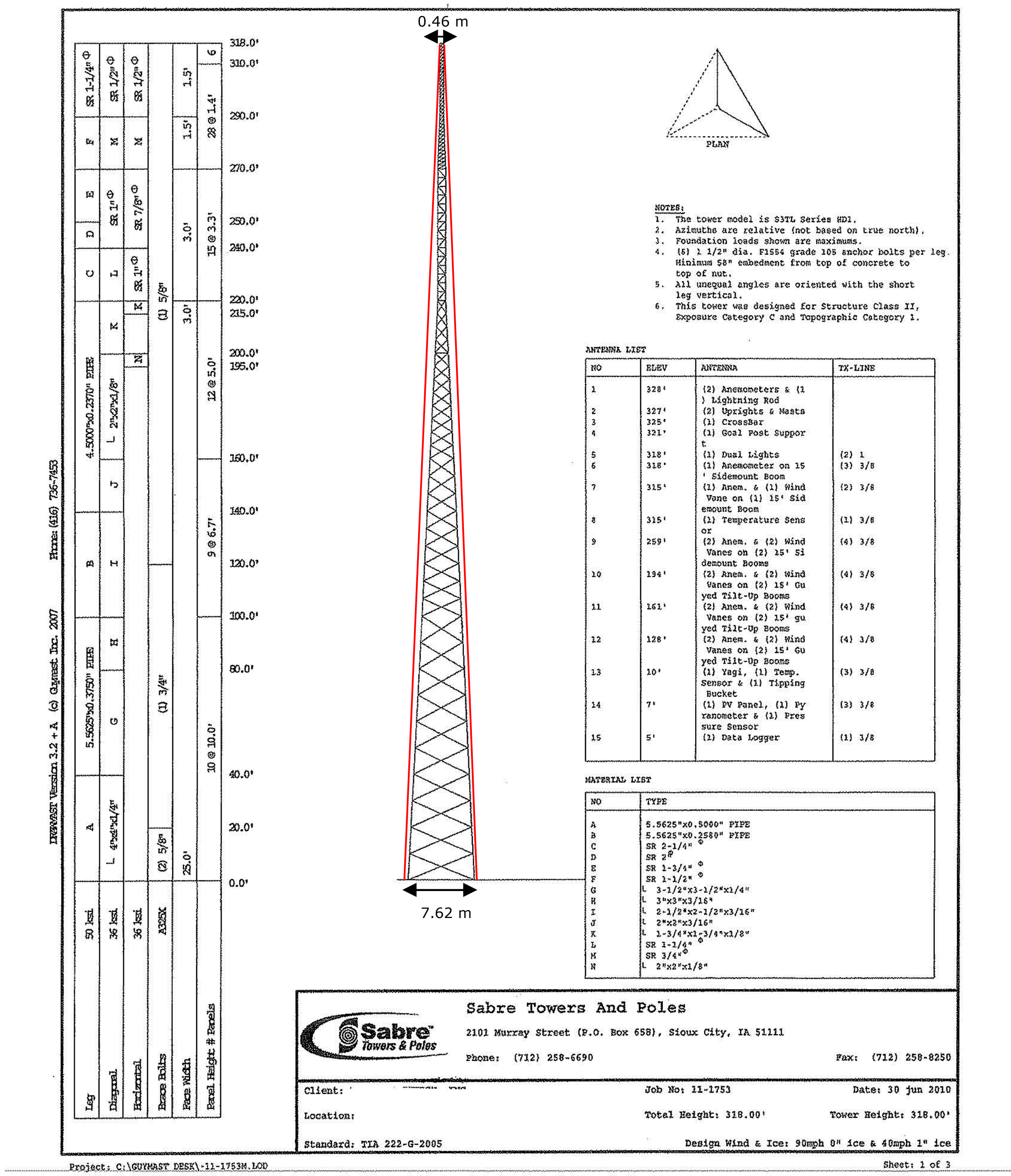


Figure 4. Schematic of Met Tower and Assumed Profile (red line).

2.3.4 Fatality Probability Factors

Fatality probability factors within the rotor swept zone consist of the probability of a duck striking a blade on frontal approach and the probability of fatality after striking a blade. When calculating the probability of striking a blade (interaction probability) when flying through the RSZ, the flight speed of the duck, the number of revolutions per minute (RPMs) of the turbine and the area of the RSZ are taken into account. Similarly, the fatality probability factors for the tubular towers of the turbines and met towers consist of the probability of a duck striking a tower if in the airspace and the probability of fatality after striking the tower. These are the same factors used in the models by Day and Cooper (2008, 2009), Sazenbacher and Cooper (2009) and Cooper et al. (2009).

2.3.5 Avoidance Rates

Low mortality of waterbirds has been documented at wind turbines in coastal areas 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 exhibit a wariness of turbines and birds tend to “learn” to avoid the turbines over time (Koford et al. 2004; Jain 2005; Carothers 2008). Similar to the models used by Day and Cooper (2009), Sazenbacher and Cooper (2009) and Cooper et al. (2009) (see Section 2.3 above), avoidance rates of 90, 95 and 99% were applied to this project to provide a range of reasonable and prudent fatality estimates.

3.0 RESULTS

3.1 Diurnal Surveys

SWCA biologists conducted bird point count surveys for 35.75 hours (143 individual point counts) within the airspace envelopes between October 2009 and February 2011. An additional 15.25 hours (61 individual point counts) were spent at point count stations off-site.

By February 2011, 62 point counts were completed in Zone 1, 16 in Zone 2 and 92 in Zone 3 (Figure 1). Some point counts are included in more than one zone.

SWCA biologists conducted driving transects from April to August 2010 from P04 to T01 (Kawailoa Upper met tower), from T29 to T24 and from the entrance of Opaeʻula Road to P07. Approximately 55.4 km were covered in 3 hours and 53 minutes of observation.

Twenty-four (24) bird species were observed on-site including two native species, the black-crowned night heron (*Nycticorax nycticorax*) and the Hawaiian duck-mallard hybrid (*Anas* sp.), and the winter migrant, the Pacific golden-plover (*Pluvialis fulva*). Nine additional species were observed at nearby ponds and in the vicinity of the project area. Native birds observed off-site include the endangered Hawaiian coot (*Fulica alai*), the endangered Hawaiian moorhen (*Gallinula chloropus sandvicensis*), and the great frigate bird (*Fregata minor*, Table 5).

Most recorded flight activity (n = 1,723 flocks) on the site was attributed to introduced passerine bird species. Common waxbills (*Estrilda astrild*), various finch species, red-vented bulbuls (*Pycnonotus cafer*) and Japanese white-eyes (*Zosterops japonicus*) accounted for almost 70% of the bird activity observed. Seventy-five percent of all flights observed (3^{rd} quartile) were at 6 m or less above ground level (Figure 5). For the proposed turbine model, 99.9% of all flocks observed were below the RSZ; only 0.1% (n = 2) of all flocks flew within the RSZ and none above the RSZ. The two flocks comprised observations of unidentified finches (one individual per observation). No ducks were seen higher than 40 m above ground level. No other native species were observed flying within the RSZ.

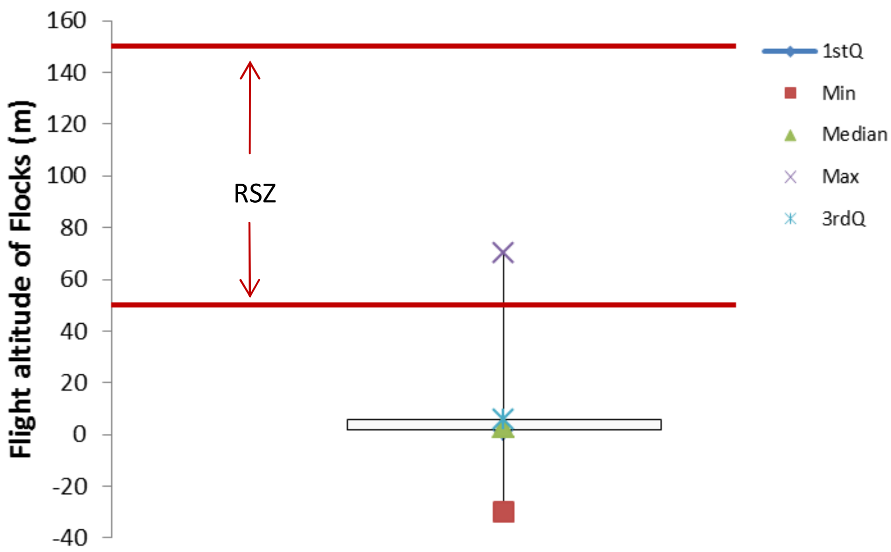


Figure 5. Box Plot of Flight Altitude of Flocks Observed On-site Imposed on Rotor Swept Zone (RSZ) of the Proposed Turbine.

3.1.1 Native Non-Listed Species

On Site

Six sightings of the black-crowned night heron were recorded on-site (two during point count surveys, three incidental sightings and one sighting during driving transects). All sightings were of single birds in flight. Birds were observed in flight at the ponds in the area (P01 and P02) or flying near the lower met tower on Kawailoa Road (T21) or in the area between the met tower and P01. No birds have been observed foraging at the irrigation ponds on-site. No birds were observed flying within the RSZ of the proposed turbine.

Off-Site

Thirteen observations of the black-crowned night heron were recorded (nine during point count surveys and four incidental sightings). Flock size ranged from one to two birds with an average of one bird. This species was observed in flight at ponds P03, P04 and P05. None were observed at P06 or P07. The black-crowned night heron was also frequently seen foraging at P04 and P05. Moorhen playback sessions usually elicited interest from foraging black-crowned night herons either with a display of increased vigilance or a vocal response.

The black-crowned night heron was present on-site or off-site for all months of the year except January and February. Based on observations, the black-crowned night heron is likely present on-site and in the vicinity year round.

Other Observations

The great frigate bird is resident year round in Hawai‘i and was observed once, flying over Waimea Valley (Table 4).

Table 4. Bird Species at the Project Site, Off-Site and Vicinity

Common Name	*Scientific Name*	Status[1]	MBTA	On Site	Off Site	Others
Great frigate bird	*Fregata minor*	I	X			Waimea Valley
Cattle egret	*Bubulcus ibis*	NN	X		X	
Black-crowned night heron	*Nycticorax nycticorax hoactli*	I	X	X	X	
Mallard	*Anas platyrhynchos*	NN	X		X	
Hawaiian duck-mallard hybrids	*Anas* sp.	I	X	X	X	
Muscovy	*Cairina moschata*	NN			X	
Domestic duck	*Anas platyrhynchos domestica*	NN			X	
Domestic geese	*Anser anser domesticus*	NN			X	
Gray francolin	*Francolinus pondicerianus*	NN		X		
Black francolin	*Francolinus francolinus*	NN		X		
Domestic chicken	*Gallus gallus*	NN		X	X	
Common peafowl	*Pavo cristatus*	NN		X		
Hawaiian coot	*Fulica alai*	E, En	X		X	
Hawaiian moorhen	*Gallinula chloropus sandvicensis*	E, En	X		X	
Pacific golden-plover	*Pluvialis fulva*	M	X	X	X	
Spotted dove	*Streptopelia chinensis*	NN		X	X	
Zebra dove	*Geopelia striata*	NN		X	X	
Barn owl	*Tyto alba*	NN	X	X	X	
Sky lark	*Alauda arvensis*	NN				Opaeʻula Road
Red-vented bulbul	*Pycnonotus cafer*	NN		X	X	
Red-whiskered bulbul	*Pycnonotus jocosus*	NN		X	X	
Japanese bush-warbler	*Cettia diphone*	NN		X		
White-rumped shama	*Copsychus malabaricus*	NN		X	X	
Red billed leothrix	*Leiothrix lutea*	NN		X		
Japanese white-eye	*Zosterops japonicus*	NN		X	X	
Common myna	*Acridotheres tristis*	NN		X	X	
Red-crested cardinal	*Paroaria coronata*	NN		X	X	
Northern cardinal	*Cardinalis cardinalis*	NN	X	X	X	
House finch	*Carpodacus mexicanus*	NN	X	X	X	
Common waxbill	*Estrilda astrild*	NN		X	X	
Red avadavat	*Amandava amandava*	NN		X	X	

Common Name	Scientific Name	Status[1]	MBTA	On Site	Off Site	Others
Nutmeg mannakin	*Lonchura punctulata*	NN		X		
Chestnut munia	*Lonchura malacca*	NN		X		
	Total species			**23**	**23**	**2**

[1] I=Indigenous, NN=Non-native, E=Endangered, En=Endemic, M=Migrant

3.1.2 Threatened and Endangered Species

On site

Hawaiian duck-mallard hybrids were the only ESA "related" listed species detected on site. SWCA biologists recorded 10 sightings of the Hawaiian duck-mallard hybrid flocks on site (five during point count surveys, four incidental sightings and one sighting during driving transects, Figure 6). Flock sizes ranged from one to 15 birds, with an average of four birds. Similar to the black-crowned night heron, other birds were observed in flight at the ponds on site (P01 and P02) or flying near the lower met tower on Kawailoa Road (T21) or in the area between the met tower and P01. However, one incidental sighting was also reported along the road between T28 and T07 (see Figure 6). No flocks were seen at the altitude of the RSZ of the proposed turbine model (50 m altitude or above).

Off-Site

SWCA biologists recorded six observations of the Hawaiian duck-mallard hybrids (three during point count surveys and three incidental sightings, Figure 6). Flock size ranged from one to three birds with an average of two birds. This species was observed in flight at ponds P03, P04 and P05. None were observed at P06 or P07 though it is likely that they would be present at these water bodies occasionally. Anecdotal evidence from employees of the hydroponic farm near P07, have indicated that ducks are occasionally present at P07; however, the species was not confirmed.

The Hawaiian duck-mallard hybrid was observed in flight on-site and off-site for all months of the year except January. The Hawaiian duck-mallard hybrid is likely to transit the project site and its vicinity year round.

One observation of the Hawaiian coot was made at P03 in early September 2010 (Figure 6). This individual was foraging in the pond and did not take flight. The individual was a rare color morph with a red frontal shield instead of white. Only 1 to 3% is the rare color morph, similar to the American coot, *Fulica americana* (Engilis and Pratt 1993). This individual was not present when P03 was revisited approximately three weeks later.

Hawaiian moorhen were present at P05 but observed in flight only once by SWCA biologists (December 2009) when two individuals made a short flight 7 m below the stream bank. Three individuals were seen or heard at P05 and have responded to moorhen call playbacks on three occasions, and were likely residents at P05. Three Hawaiian moorhen were also seen at two locations on a site visit to Ukoa Pond (vicinity of P04) on November 30, 2010. Hawaiian moorhen have not been seen at any other water bodies surveyed, and moorhen playbacks failed to elicit a response at any pond other than P05.

Ten resident moorhens are present at lotus ponds in Waimea Valley (Laurent Pool, Conservation Land Specialist, Waimea Valley, pers. comm.). SWCA biologists observed three moorhen adults and two chicks on a visit conducted on April 23, 2010.

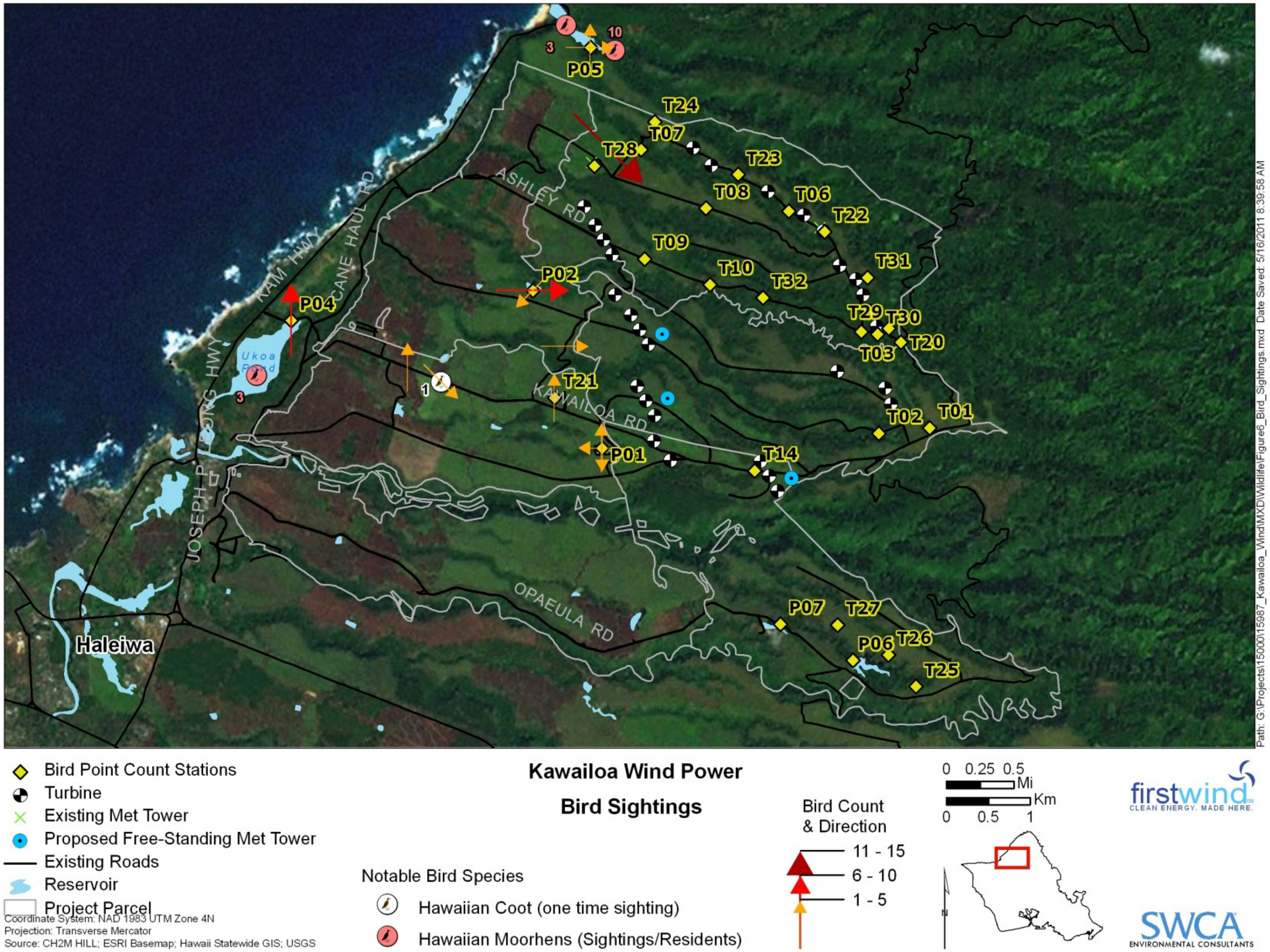


Figure 6. Distribution of Waterbird Activity On-site and Off-Site

3.1.3 Migratory Species

Migratory Pacific golden-plover (*Pluvialis fulva*) arrived at the project site in September and departed in May. These birds were most frequently seen on the roads, at the edges of ponds and in the cleared grassy areas around the met towers. No birds were observed to fly within the RSZ of either turbine type.

3.2 Bat Surveys

3.2.1 Acoustic Monitoring

SWCA biologists acoustically sampled 19 sites at Kawailoa Wind Power from October 2009 to April 2011 (Figure 2) for 2,466 detector nights (Table 2). Four hundred and thirty one (431) bat call sequences, resulting in 309 bat passes, were recorded from 14 locations (Table 6). Bat activity was relatively higher from March to November (Figure 7). February was excluded as a month with higher bat activity as 95% of the call sequences were detected on February 28. June and October were included in the higher bat activity period as it is bracketed by months that are considered "higher activity". Bat calls were recorded throughout the night (Figure 8). The data suggests that bats are present at Kawailoa Wind Power for most of the year. Relatively higher bat activity occurred at a rate of 0.15 bat passes/detector/night between March and November and occurred at a relatively lower rate of 0.045 bat passes/detector/night between December and February. The Kawailoa Wind Power site has an annual Hawaiian hoary bat activity rate of 0.12 bat passes/detector/night. The period of relatively low bat activity at Kawailoa Wind Power coincides with the bat migration period where individuals move to higher altitudes from the lowlands (Menard 2001).

When comparing detectors deployed from March to November (see Section 2.2.1 for selection criteria, Table 7), Anabat detectors A2, B2, E1, F3, F4, G2 and H1 had the higher activity rates (greater than 0.1 passes/detector night). These Anabats were deployed at different locations and habitats on site. B2, G2 and H1 were deployed along the forested ridge facing Waimea Valley, A2 was in a forested area at the southern end of the site, F4 was in a grassy clearing directly beneath the met tower, E1 is located at a small irrigation pond, and F3 was off-site and deployed two-thirds up the met tower at 40 m above ground. Hence, bat activity at Kawailoa Wind Power appears to be widespread and occurred to a greater or lesser degree throughout the site.

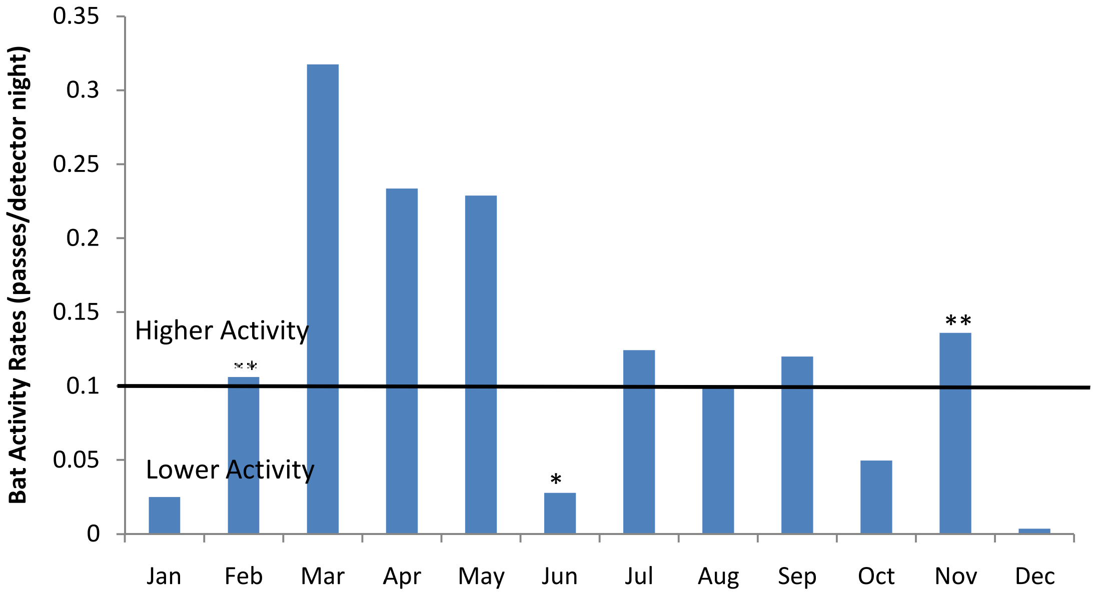


Figure 7. Distribution of Bat Passes Over Survey Period

Higher activity month = 0.1 passes/detector night or greater; Lower activity month= less than 0.1 passes/detector night

*the drop in June was probably due to the low sampling effort for that month (37 detector nights) which occurred due to operator error and equipment shortage

**the increases in November and February were due to a large number of calls recorded in one night (on November 15, 30 of 49 call sequences were recorded in a span of 30 minutes; on February 28, 36 of 39 call sequences were recorded in a span of 1.5 hrs)

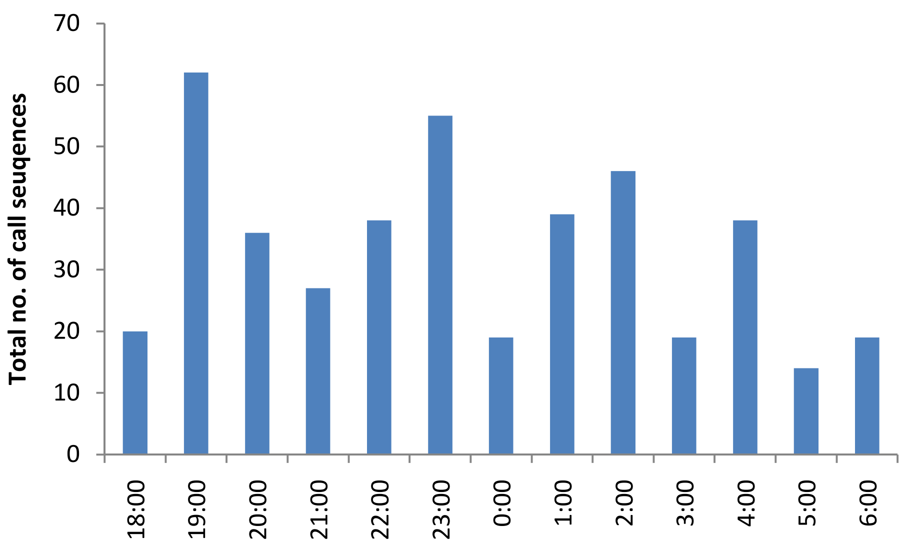


Figure 8. Time Distribution of All Bat Call Sequences Detected

Table 5. Distribution of Bat Passes by Anabat Location

Yellow highlights are the months the Anabat was deployed. Actual detector nights per month vary and are reflected in Table 2 above.

		Passes per Anabat																			
Year	**Month**	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**E1**	**F1**	**F2**	**F3**	**F4**	**G1**	**G2**	**H1**	**J1**	**J2**	**J3**	**Total Passes**
2009	Oct							1													**1**
2009	Nov																				**0**
2009	Dec																				**0**
2010	Jan																				**0**
2010	Feb																				**0**
2010	Mar																				**0**
2010	Apr																				**0**
2010	May					26											1				**27**
2010	Jun														1						**1**
2010	Jul	4											1			2	12				**19**
2010	Aug							1					7			1	11		1		**21**
2010	Sep		1					1					7	2			1				**12**
2010	Oct						6	1						3			1		1		**12**
2010	Nov						5							29							**34**
2010	Dec													1							**1**
2011	Jan						5			1							1				**7**
2011	Feb						2									22					**24**
2011	Mar		10							22				32		22					**86**
2011	Apr			2					12	47							3				**64**
																			Grand total		**309**

Table 6. Bat Activity By Anabat Location During Higher Activity Periods

Cells in green indicate Anabat locations with higher activity rates (greater than 0.1 passes/detector night). Data extracted from Table 2 and Table 7

Year	Month	A1	A2	A3	B1	B2	B3	C1	C2	E1	F1	F2	F3	F4	G1	G2	H1	J1	J2	J3
2010	May	19				26		31				19	4		7		6	6		
2010	Jun	9				3		1					2		14		5	2		
2010	Jul	23	3			26		26					10			26	26	10	3	
2010	Aug		31			31		30					28			31	31		31	
2010	Sep		15			1	6	3					14	16		15	15		15	
2011	Mar		31				23	31		31				31		30	21			28
2011	Apr			18			23		19	23				30		30	30			30
Nights per Anabat		**51**	**80**	**18**	**0**	**87**	**52**	**122**	**19**	**54**	**0**	**19**	**58**	**77**	**21**	**132**	**134**	**18**	**49**	**58**
Passes per Anabat		**4**	**11**	**2**	**0**	**26**	**0**	**2**	**12**	**69**	**0**	**0**	**15**	**34**	**1**	**25**	**28**	**0**	**1**	**0**
Bat Activity by Anabat Location		**0.08**	**0.14**	**-**	**-**	**0.3**	**0**	**0.02**	**-**	**1.278**	**-**	**-**	**0.26**	**0.44**	**-**	**0.19**	**0.21**	**-**	**0.02**	**0**

3.3 Estimated Fatality Rates of Hawaiian Duck-Mallard

Five flocks of Hawaiian duck-mallard hybrids, consisting of nine individuals, were observed at point counts within the airspace envelope of Zone 1 during the year-long avian survey. No ducks were observed at Zone 2 or Zone 3. The yearly passage rate was estimated at 0.054 individuals/hr/ha over the Zone 1 turbine string (Table 7).

Table 7. Calculation of Passage Rates of Hawaiian Duck-Mallard Hybrids Over the Project Site

	Variable	
A	Total point counts	53
B	No. of birds observed	9
C	Birds per point count B/A	0.17
D	Birds per hour C/15*60	0.68
E	Area sampled for 200 m radius point counts (ha) (200*200*3.14)/10,000	12.57
F	Passage rate (birds/hr/ha) D/E	0.054

Using flight altitudes observed on-site and at adjacent water bodies, no flocks were observed within the RSZ of the proposed turbine. Running this through the model would result in an expected fatality of zero; however, for modeling purposes, we assumed that 5% of all flights were within the RSZ and 95% below the RSZ.

The probability of a duck striking a blade (interaction probability) upon entering the RSZ was 14.8% (Table 8).

Table 8. Interaction Probability of Hawaiian Duck-Mallard Hybrids Striking a Turbine Blade

	Variable	
A	Duck flight speed (km/hr)	65
B	Duck length (m)	0.5
C	Width of turbine (m)	2
D	Length of blade (m)	50.5
E	Width of blade (m)	2
F	Speed of rotation (deg/s - max rotation speed at 16 RPM)	96
G	Total width plus duck length (m) B+C	2.5
H	Flight speed (m/s) A*1,000/(60*60)	18.06
I	Time to transit (s) G/H	0.14
J	Degrees covered by all three blades in transit time (deg) F*I*3	39.88
K	Area of sector (m2) J*L/360	887.02
L	Rotor swept area (m2) 3.14*D*D	8007.79
M	Area of blade (m2) D*E	101
N	Area of 3 blades (m2) D*E*3	303
O	Total area (m2) K+N	1190.02
P	Interaction Probability O/L	0.148

For the proposed turbine, the estimated fatality rate for Hawaiian duck-mallard hybrids entering the RSZ ranged between 0.009 and 0.094 Hawaiian duck-mallard hybrids ducks/RSZ/year assuming 99%and 90% collision avoidance rate respectively (Table 9a) Fatality rates due to Hawaiian duck-mallard hybrids striking the tubular towers of the turbines were at 0.004 and 0.036 Hawaiian duck-mallard hybrids/tower/year, assuming a 99% and 90% avoidance rate respectively (Table 9b). Combined, the estimated fatality rate for Hawaiian duck-mallard hybrids at the proposed turbine at Kawailoa Wind Power is between 0.013 and 0.130 birds/turbine/year.

Table 9. Estimated Fatality of Hawaiian Duck-Mallard Hybrids from Proposed Turbine
a. Fatality from Striking a Blade in the Rotor Swept Zone

	Variable	
	Movement rate	
A	mean movement rate (birds/hr/ha)	0.054
B	daily movement rate (birds/day/ha) A*12	0.649
C	fatality domain (days)	365
D	annual movement rate (birds/year) B*C	237
E	proportion birds flying within rotor swept zone (>49.5m and < 150.5m)	0.05
F	annual movement rate within rotor swept zone (>49.5m and <150.5 m) D*E*X	11.838
	Horizontal interaction probability	
G	Volume occupied by rotor swept zone (m^3)	539190.857
H	Vol of 1 ha area from minimum to maximum rotor height (>49.5 to <150.5) (m^3)	1010000.000
I	Horizontal interaction probability G/H	0.534
	Exposure index	
J	daily exposure index (birds/rotor swept zone/day) B*E*I	0.017
K	annual exposure index (birds/rotor swept zone/yr) F*I	6.319
	Fatality probability	
L	Probability of striking a blade on frontal approach	0.149
M	Probability of fatality if striking blade[1]	1
N	Probability of fatality if an interaction on frontal approach L*M	0.148
	Fatality index	
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/turbine/yr) K*N*0.1	0.094
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/yr) K*N*0.05	0.047
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/yr) K*N*0.01	0.009

[1]Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision is less than 100%.

b. Fatality from Striking the Tubular Tower

	Variable	
	Movement rate	
A	mean movement rate (birds/hr/ha)	0.054
B	daily movement rate (birds/day/ha) A*12	0.649
C	fatality domain (days)	365
D	annual movement rate (birds/year/ha) B*C	237
E	proportion birds below rotor swept zone (>49.5m)	0.95
F	annual movement rate below rotor swept zone (>49.5m) D*E	224.913
	Horizontal interaction probability	
G	Volume occupied by tubular tower (m^3)	802.433
H	Vol of 1 ha area below blade height (<32m) (m^3)	495000.000
I	Horizontal interaction probability G/H	0.002
	Exposure index	
J	daily exposure index (birds/tubular tower/day) B*E*I	0.001
K	annual exposure index (birds/tubular tower/yr) F*I	0.365
	Fatality probability	
L	Probability of striking a tubular tower if in airspace	1
M	Probability of fatality if striking tubular tower[1]	1
N	Probability of fatality upon interaction L*M	1
	Fatality index	
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/yr) K*N*0.1	0.036
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/yr) K*N*0.05	0.018
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/yr) K*N*0.01	0.004

[1]Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision is less than 100%.

Fatality rates due to Hawaiian duck-mallard hybrids striking the met towers are 0.002 to 0.021 birds /tower/year, assuming a 99% and 90% avoidance rate respectively (Table 10).

Table 10. Estimated Fatality of Hawaiian Duck-Mallard Hybrids from Collision with the Free-Standing Permanent Met Tower

	Variable	
	Movement rate	
A	mean movement rate (birds/hr/ha)	0.054
B	daily movement rate (birds/day/ha) A*12	0.649
C	fatality domain (days)	365
D	annual movement rate (birds/year) B*C	237
E	proportion birds below meteorological tower (<100m)	1
F	annual movement rate below meteorological tower (<100m) D*E	237
	Horizontal interaction probability	
G	Volume occupied by meteorological tower (m^3)	891.735
H	Vol of 1 ha area meteorological tower (<100m) (m^3)	1000000
I	Horizontal interaction probability G/H	0.0009
	Exposure index	
J	daily exposure index (birds/tower/day) B*E*I	0.0006
K	annual exposure index (birds/tower/yr) F*I	0.2111
	Fatality probability	
L	Probability of striking a met tower if in airspace	1
M	Probability of fatality if striking tubular tower[1]	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*0.1	**0.021**
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/tubular tower/yr) M*P*0.05	**0.011**
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/tubular tower/yr) M*P*0.01	**0.002**

[1]Used 100% fatality probability due to ESA definition of “take”; however, actual probability of fatality with collision is less than 100%.

4.0 DISCUSSION AND CONCLUSION

Introduced passerines dominate the bird flight activity at Kawailoa Wind Power project site. The black-crowned night heron and Hawaiian duck-mallard hybrids were the only native species observed transiting the lower portions of the site (Zone 1). Neither was observed in Zones 2 or 3. Both species are expected to transit the site year round in low numbers and thus may be at risk of colliding with the turbines and met towers in Zone 1. No Hawaiian duck-mallard hybrids were observed flying within the RSZ of the proposed turbine, but since the risk cannot be assumed to be absent, fatality rates were calculated based on the assumption that 5% of all Hawaiian duck-mallard hybrids transiting the site would be within the RSZ of the turbines. The Hawaiian duck-mallard hybrids may collide with the turbines at any time of the year but the fatality rate is expected to be low due to the infrequent passage through the area, and high avoidance rates.

Hawaiian hoary bats were detected throughout Kawailoa Wind Power in a variety of cover types, as well as off-site in surrounding areas. These bats were present at Kawailoa Wind Power throughout the year. Bat activity rates were higher during the months of March through November and lower from December through February. However, bat activity rates are not necessarily indicative of the number of bats (Kunz et al. 2007) as Anabat detectors cannot differentiate between many bats passing the detector once and one bat passing the detector multiple times. Thus, the higher activity rates observed at Kawailoa Wind Power could be due to an increase in bat numbers in the area or an increase in usage of the area by the same number of individuals or a combination thereof.

The reported bat activity rates are also relative rates, rather than absolute measures of bat activity at the site. While the Anabats were placed in a variety of locations and vegetation types to ensure good representation of the site, these Anabats were not randomly placed at each location but situated in spots sheltered from wind, along roads or edges of vegetation to maximize the probability of detecting a bat. Hence the average bat activity over the Kawailoa Wind Power site is likely to be much less than the measured rate.

5.0 REFERENCES

Baerwald, E.F., M.R. Barclay. 2009. Geographic Variation in Activity and Fatality of Migratory Bats at Wind Energy Facilities. *Journal of Mammalogy* 90(6):1341-1349.

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.

Carothers, S.W. 2008. Expert report: Evaluation of risks to avian (birds) and chiropteran (bats) resources. Gulf Wind Project, Kennedy County, TX.

Cooper, B.A., P.M. Sanzenbacher, and R.H. Day. 2009. Radar and visual studies of seabirds at the Proposed Kawailoa Wind Energy Facility, Oahu Island, Hawaii. Prepared for First Wind, LLC by ABR, Inc., Forest Grove, OR.

Cuddihy, L.W., and C.P. Stone. 1990. Alteration of native Hawaiian vegetation-effects of humans, their activities and introductions. Cooperative National Park Resources Studies Unit, University of Hawaii at Mānoa, Honolulu, HI.

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 for First Wind, LLC by ABR, Inc., Forest Grove, OR and Fairbanks, AK.

———. 2009. Radar and visual studies of seabirds at the proposed KWP II down-road alternative wind energy facility, Maui Island, HI.

DesRochers, D.W., H.K.W. Gee, and J.M. Reed. 2008. Response of Hawaiian Moorhens to broadcast of conspecific calls and a comparison with other survey methods. *Journal of Field Ornithology* 79: 448-457.

Engilis A.E., and T.K. Pratt. 1993. Status and population trends of Hawaii's native waterbirds, 1977-1987. *Wilson Bull*. 105:142-158.

Fiedler, J.K. 2004. Assessment of bat mortality and activity at Buffalo Mountain windfarm, Eastern Tennessee. Master's thesis, University of Tennessee, Knoxville, TN.

Gruver, J.C. 2002. Assessment of bat community structure and roosting habitat preferences for the hoary bat (*Lasiurus cinereus*) near Foote Creek Rim, Wyoming. Master's thesis, University of Wyoming, Laramie, WY.

Helber Hastert & Fee Planners. 2009. Naval Station Pearl Harbor Integrated Natural Resources Management Plan, Public Review Draft. Prepared for Commander, Navy Region Hawaii.

Hobdy, R.W. 2010. Biological Resources Survey for the Kawailoa Wind Farm, Kawailoa, Oahu, Hawaii. Prepared for CH2MHill.

Jain, A. 2005. Bird and bat behavior and mortality at a northern Iowa windfarm. Master's thesis, Iowa State University, Ames, IA.

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. 2010. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 4 Annual Report. First Wind Energy, LLC, Environmental Affairs, Boston, MA.

Kerns, J., W.P. Erickson, and E.B. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia, edited by E.B. Arnett pp. 24-95. In *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. http://www.batcon.org/windliterature. Accessed 1 September 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.

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.

Menard, T. 2001. Activity patterns of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) in relation to reproductive time periods. Master's thesis, Univ. of Hawaii, HI.

Sanzenbacher P.M., and B.A. Cooper. 2009. Radar and visual studies of seabirds at the proposed KWP II wind energy facility, Maui Island, Hawaii: Use of 2008 data to model annual collision fatalities at proposed wind turbines. Prepared for First Wind, Newton, MA.

Wilcox, C. 1998. *Sugar Water: Hawaii's Plantation Ditches*. Honolulu: University of Hawai'i Press.

Appendix 5

Life History Information on

Newell's Shearwater (*Puffinus auricularis newelli*),
Hawaiian Duck (*Anas wyvilliana*)and Hybrid,
Hawaiian Stilt (*Himantopus mexicanus knudseni*),
Hawaiian Coot (*Fulica alai*),
Hawaiian Moorhen (*Gallinula chloropus sandvicensis*),
Hawaiian Short-eared Owl (*Asio flammeus sandwichensis*),
and
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)

Compiled by:
SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, HI 96813

1.0 INTRODUCTION

Demographic factors were used to assess indirect take and loss of productivity in section 6.0 (Potential Impacts) and 7.0 (Mitigation) of the HCP. Indirect take and loss of productivity are defined as follows:

> Indirect Take - These are individuals that suffer mortality as the result of a direct take of another individual. For example, the loss of a parent may also result in the loss of eggs or young.
>
> Loss of Productivity - Productivity can be assessed in terms of chicks or fledglings produced per breeding adult per year or the number of fledglings that survive to adulthood per breeding adult per year. When a direct take occurs, loss of productivity can occur between the time the direct take occurs and the time that mitigation is provided. Productivity may also be lost if a juvenile is used as a replacement for the take of a breeding age adult. 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, and the type of mitigation provided.

Demographic factors for each species covered by the HCP were determined using existing literature. Preference was given to life history information available from Hawai‘i, followed by information available for the same species on the North American continent or other areas of the world. If specific information was lacking for any species, life history information for a closely related species was used as a surrogate.

The life history information for the Newell’s shearwater (*Puffinus auricularis newelli*), Hawaiian petrel (*Pterodroma sandwichensis*), Hawaiian duck (*Anas wyvilliana*)and hybrid, Hawaiian stilt (*Himantopus mexicanus knudseni*), Hawaiian coot (*Fulica alai*), Hawaiian moorhen (*Gallinula chloropus sandvicensis*), Hawaiian short-eared owl (*Asio flammeus sandwichensis*) and Hawaiian hoary bat (*Lasiurus cinereus semotus*) follow in the sections below.

1.1 Seabirds

<u>1.1.1 Newell’s Shearwater</u>

The following demographic factors and assumptions (from Ainley et al. 1997 and as otherwise noted) were used to assess indirect take and loss of productivity of the Newell’s shearwater.

<u>Breeding season:</u> The breeding season lasts from June to October each year.

<u>Age at First Breeding</u>: Assumed age 6.

<u>Adults Breeding/Year</u>: On the basis of estimates made by Telfer (1986), incidence of non-breeding is high for Newell’s Shearwater on Kaua‘i. Only 46% of pairs that actively use a burrow actually breed in a given year (range 30–62 %, *n* = 5 yr, 36– 47 burrows monitored/yr).

<u>Reproductive Success</u>: 66.0% ± 6.4 SD (range 49–75) of nests in which eggs are laid fledge young. Manx Shearwater populations have similar fledging rates (Brooke 1990). For the purposes of the HCP, a 70% average fledging rate is assumed.

<u>Survival to breeding age</u>: Annual adult survivorship of Newell’s Shearwater was estimated to be 0.904 ± 0.017 SE, on the basis of allometric equation relating survivorship to body mass in procellariiforms. This figure approximates that estimated for Manx Shearwater by more conventional means (Brooke 1990). Ainley et al. (2001) estimated the survival of fledglings to breeding age to be 24% with the current human induced mortality (powerline mortality,

predation and fallout). The expected survival without human induced factors was 33%. For the purposes of the HCP, a survival rate of 24% is assumed.

Number of Broods: One per year.

Clutch Size: One.

Relative Productivity of Males vs. Females: Relative productivity of males and females is assumed to be similar, as with the Hawaiian petrel described below. For the purposes of estimating lost productivity and indirect take, it is assumed that males and females each contribute 50% towards indirect take and the average annual productivity.

1.2 Hawaiian Waterbirds

1.2.1 Pure Hawaiian Duck and Hybrid

From the late 1968 to 1982, Hawaiian duck were reintroduced to O'ahu through captive propagation and release programs (Engilis et al. 2002). As mallards (*Anas platyrhynchos*) were not eradicated from O'ahu prior to introduction, extensive hybridization between Hawaiian duck and mallard has since been documented on O'ahu (Browne et al. 1993, Engilis pers. comm.). Studies on the life history of Hawaiian duck on O'ahu post 1968, may have in fact been studies of Hawaiian duck -mallard hybrids, but the extent of hybridization at that time is not known. With this in mind, productivity of pure Hawaiian ducks and Hawaiian duck hybrids are assumed to be the same and are treated together in this section. Thus, adjustments to the take of Hawaiian duck to account for lost productivity were developed based on Hawaiian duck demographic factors and assumptions by Chang (1990) and Engilis et al. (2002), unless otherwise noted. Reproductive observations by Chang (1990) were based solely in James Campbell National Wildlife Refuge, O'ahu and the life history summary by Engilis et al. (2002) includes data only from Kaua'i and the island of Hawai'i. Where life history information was not available, data for the closely related mallard is used from Drilling et al. (2002):

Breeding Season: Nesting occurs year round and the peak breeding season lasts from March to June each year. Breeding lasts approximately three months, witha one month incubation period followed by parental care for two months.

Age at First Breeding: The female Hawaiian duck can breed at age one. Some males may not breed until second year. Breeding age is assumed to be year one.

Adults Breeding per Year: Unknown. Assumed to be 100% though Hawaiian duck may not rear any broods in a given geographic area, particularly during drought years (Engilis and Pratt 1993).

Number of Broods: Likely only one per year for wild populations.

Clutch Size: Clutch sizes of the Hawaiian duck at James Campbell Wildlife Refuge on O'ahu average 7.3 eggs ± 0.16 SE (n = 174).

Reproductive Success: Chicks hatched/nest for Hawaiian duck on James Campbell Wildlife Refuge on O'ahu is 3.5 chicks ± 0.24 SE (n = 174, 48% hatching success). Hawaiian duck fledging success (fledglings/chick) is not available but fledgling success for the mallard is 35% in N. Dakota resulting in 1.225 (= 0.35*3.5) fledglings per pair.

Survival to Breeding Age: No survival data currently exists for the Hawaiian duck. It has been demonstrated that for mallards, survival rates generally do not differ significantly among geographic areas or years. The survival rates of mallard juvenile males is estimated to be 48–63% and for juvenile females 46–61% (Drilling et al. 2002). For the purposes of estimating lost productivity and to provide additional benefit to the species, it is assumed that survival to breeding age for the Hawaiian duck is 65%.

Relative Productivity of Males vs. Females

Nest construction and incubation are by the female Hawaiian duck only. To date, no other parental care information is available for the Hawaiian duck. However, the observed behavior by Hawaiian duck pairs is very similar to the parental care expressed by mallards. Using mallards as a surrogate species, parental care by mallards is as follows. Only mallard hens care and defend the young until they can fly. With regards to parental feeding, the hen leads the young to water and abundant food and the ducklings feed themselves. For the purposes of estimating indirect take, it is assumed that males contribute nothing to indirect take and females 100%.

Sex ratio: The sex ratio of mallards under natural conditions is male biased and the ratio approximates 1.1:1 (males:females, Ohde et al. 1984, Johnson and Sargeant 1977). The same ratio of 1.1:1 is assumed for Hawaiian duck.

1.2.2 Hawaiian Stilt

The following demographic factors and assumptions (from Robinson et al. 1999 and USFWS 2005a, unless otherwise noted) were used to assess indirect take and loss of productivity of the Hawaiian stilt.

Breeding Season: The breeding season lasts from February to August each year. Hawaiian Stilt breed for two months of the year (a one month incubation period followed by parental care for one month).

Age at First Breeding: Unknown for Hawaiian Stilt, but population data suggests majority will breed age 2 but may breed as early as age 1. The subspecies black-necked stilt (*H. mexicanus mexicanus*) breeds at age 2 in Utah. The age of first breeding is assumed to be year 2.

Adults Breeding per Year: Unknown. Assumed to be 100%.

Number of broods: One though two broods have been recorded for one pair Hawaiian stilt.

Clutch Size: Clutch sizes at different wetlands on the island of O‘ahu are very similar. At James Campbell NWR, the clutch sizes reported were 3.6 eggs ± 0.9 SD (range 2–7, n = 366; Coleman 1981) and 3.4±0.06 SE (n=243, Chang 1990). At Nu‘upia, O‘ahu, clutch size is 3.8 eggs (*n* = 47; Ueoka et al. 1976). An average clutch size of 3.6 is used in this instance.

Reproductive Success: Chicks hatched/nest for Hawaiian stilts is 2.18 chicks ± 1.6 SD (n = 982; compiled from years of USFWS monitoring) and Hawaiian stilt fledging success (number of fledglings per brood) is 0.934 fledglings ± 0.431 SD (weighted mean across 4 yr, 1985–1988, range 0.125–1.355, *n* = 131). For the purposes of the HCP, it is assumed that breeding adults will average 0.9 chicks per breeding pair..

Survival to Breeding Age: From two Hawaiian stilt cohorts, first year survival was 0.53 and 0.60; survival from first to second year for one cohort was 0.81 (Reed et al. 1998). Assuming breeding starts in the second year for most Hawaiian stilt, the survival of fledglings to breeding age is (0.6 x 0.81) 48.6%. For the purposes of this HCP, it is assumed that survival to breeding age is 50%.

Relative Productivity of Males vs. Females

Hawaiian stilt nests are incubated 95% of the time, and sexes equally likely to be incubating at any time (Coleman 1981). Feeding of young has never been observed in the wild, and young stilts survive in captivity with-out parents (Coleman 1981).

For the purposes of estimating lost productivity and indirect take it is assumed that males and females each contribute 50% towards indirect take and the average annual productivity.

Sex ratio: Studies indicate the Hawaiian stilt have a balanced sex ratio..

1.2.3 Hawaiian Coot

Adjustments to the take of Hawaiian coot to account for lost productivity were developed based on the Hawaiian coot demographic factors and assumptions (Chang 1990 and USFWS 2005a, unless otherwise noted) and when not available, information from the American coot was used (Brisbin et al. 2002):

Breeding Season: Nesting occurs year round and the peak breeding season lasts from March to September each year. Breeding lasts approximately four months, with a one month incubation period followed by parental care for three months.

Age at First Breeding: Unknown for Hawaiian coot but the closely related American coot breeds at age 1 though many yearlings remain unpaired.

Adults Breeding per Year: Unknown. Assumed to be 100%.

Number of Broods: No data exits for the Hawaiian coot. The American coot typically has one brood per year, or occasionally two. It is assumed here that the Hawaiian coot has one brood per year.

Clutch Size: Clutch sizes of Hawaiian coot at James Campbell Wildlife Refuge on O'ahu average 4.9 eggs ± 0.31 SE (n = 138). Byrd et al. (1985) reported a clutch size ranging from 3 to 10 eggs, with an average of 5 eggs.

Reproductive Success: Chicks hatched/nest for Hawaiian coots is 3.2 chicks ± 0.22 SD (n = 136, 67% hatching success) and Hawaiian coot fledging success (number of fledglings per brood) is 28% (35 chicks fledged out of a total of 127). Thus it is assumed that breeding adults will average 0.9 chicks per breeding pair (=3.2*0.28).

Survival to Breeding Age: No data for Hawaiian coot. For the American coot found west of Ontario and Mississippi River survival averaged 44% for juveniles. For the purposes this HCP, it is assumed that survival to breeding age is 50%.

Relative Productivity of Males vs. Females
No information exists for the Hawaiian coot. For the American coot, brood platforms are built almost exclusively by males. Although female may incubate at night early during laying period, after 3 or 4 eggs have been laid, male usually takes major share of incubation duties. The female relieves the male at dawn and both make and female have incubation shifts. Both parents help with the hatching process by removing vitelline membranes and eggshells from the nest. The young are intensively guarded and cared for by one or both parents at all times. Both parents also share in the feeding of young (Brisbin et al. 2002).

For the purposes of estimating lost productivity and indirect take, it is assumed that males and females each contribute 50% towards indirect take and the average annual productivity.

Sex Ratio: No data currently is available for the Hawaiian coot and the sex ratio is assumed to be 1:1.

1.2.4 Hawaiian Moorhen

The following demographic factors and assumptions (Chang 1990, Bannor and Kiviat 2002, and USFWS 2005a, unless otherwise noted) were used to account for indirect loss and loss of productivity of the common moorhen:

Breeding Season: Nesting occurs year round and the peak breeding season lasts from March to August each year. Each breeding period lasts approximately three and a half months, with a one month incubation period followed by parental care for two and a half months.

Age at First Breeding: The common moorhen breeds at age one.

Adults Breeding per Year: Unknown. Assumed to be 100%.

Number of Broods: Nagata (1983) reported one and likely two broods per year for common moorhens on O'ahu. Two broods per year is assumed.

Clutch Size: Clutch sizes of the common moorhen at James Campbell Wildlife Refuge on O'ahu average 4.9 eggs ± 0.13 SE (n = 87). Nagata (1983) reported clutch sizes of 6.2 eggs ± 1.76 SE in lotus fields on a marsh and lotus farms on O'ahu. Banko (1987) reported an average clutch size of 5.6 eggs (n=64) over a period of five years (1975-1980) on wetlands at Hanalei National Wildlife Refuge, Kaua'i. Polhemus and Smith (2005) report a clutch size of 5.2 eggs per clutch (range 3-7) for the Hamakua Marsh State Wildlife Sanctuary in 2004. An average clutch size of 5.3 eggs is used.

Reproductive Success: Chicks hatched/nest for common moorhen is 3.2 chicks ± 0.22 SD (n = 136, 47% hatching success) and common moorhen fledging success (number of fledglings per brood) is 42% (28 chicks fledged out of a total of 67). Thus it is assumed that breeding adults will average 1.3 chicks per breeding pair (=3.2*0.48).

Survival to Breeding Age: No data for the common moorhen or related moorhens. As moorhens (Family Rallidae, Genus *Gallinule*) are closely allied to coots (Family Rallidae, Genus *Fulica*), particularly the American coot (Nagata 1983), the survival rate for the American coot is thus also used for the common moorhen. The American coot found west of Ontario and Mississippi River has a survival rate that averages 44% for juveniles. For the purposes of this HCP, it is assumed that survival to breeding age for the common moorhen is 50%.

Relative Productivity of Males vs. Females

Typically, common moorhen are monogamous and a single breeding pair defends a breeding territory. Both sexes participate in construction and maintenance of nests. Males reportedly do most of the collecting of materials, while females do most of the arranging of materials at the nest site. Both sexes incubate. Cooperative nesting, where two or more females share a mate as well as a nest has not been reported for the common moorhen in Hawaii.

For the purposes of estimating lost productivity and indirect take, it is assumed that males and females each contribute 50% towards indirect take and the average annual productivity.

Sex ratio: The sex ratio of common moorhen in Cambridgeshire, United Kingdom is 1:1 (McRae 1996)

1.3 Hawaiian Short-eared Owl

Very little life history information is available for the Hawaiian short-eared owl. The demographic factors for the short-eared owl (*Asio flammeus flammeus*) are used instead (Wiggins et al. 2006) unless otherwise noted. The following demographic factors and assumptions were used to account for indirect take and loss of productivity of the Hawaiian short-eared owl:

Breeding Season: Nesting occurs year round. The breeding period lasts approximately two months (nesting and incubation).

Age at First Breeding: The short-eared owl breeds at age one.

Adults Breeding/Year: Unknown and assumed to be 100%

Reproductive Success: Reproductive success of short-eared owl is highly variable and closely linked to food availability and predation. The mean clutch size for North America is 5.6 (range 1–11, n = 186). Thus it is assumed that breeding adults will average 5.6 chicks per breeding pair.

Survival to Breeding Age: No data is available for the survival rates of juveniles of short-eared owls. Burrowing owls (*Athene cunicularia*) have a survival rate of 19% in Florida, 30% in California and 57% in North Dakota (Haug et al. 1993, Davies and Restani 2006). Barn owls (*Tyto alba*) also have very low survival rate with only 25-35% of barn owls surviving to year one in the north temperate regions (Marti et al 2005). Data from burrowing owls were chosen because as a species, they are ground nesters like the Hawaiian short eared owl and barn owls are known to live in similar habitat as short-eared owl both on the North American continent and in Hawaii. Both burrowing owl and barn owl also mature at age one like the short-eared owl, thus juvenile mortality measurements are more likely to be comparable. To provide additional benefit to the species, Hawaiian short-eared owl survival is estimated to be 40%.

Number of Broods: One, though double brooding has been recorded.

Clutch Size: The average clutch size of the short-eared owl in North America is 5.6 (range 1-11).

Pair Productivity: Based on the above demographics and assumptions, the average annual productivity (*i.e.*, annual production of breeding age adults) of an adult pair is estimated as follows (from Kaheawa Wind Power, LLC 2006):

Relative Productivity of Males vs. Females: Males and females contribute equally to parental care of the nestlings. While the female builds the nest and broods, the male feeds the female and defends the nest. The male also provided food for the female to feed to the nestlings.

For the purposes of estimating lost productivity it is assumed that males and females each contribute 50% to the average annual productivity.

Sex Ratio: The sex ratio of the short-eared owl is likely 1:1. The sex ratio reported by Arroyo et al (2000) is 9:12 of 21 nestlings examined. The results were however not significantly different from unity.

1.4 Hawaiian Hoary Bat

Little life history information exists for the hoary bat (*Lasiurus cinereus cinereus*) found on continental America. Because these bats are migratory, do not hibernate and are not colonial, they are difficult to study. Even less life history information is available for the Hawaiian hoary bat. Hence, adjustments to the take of the Hawaiian hoary bat to account for lost productivity were developed based on the following demographic factors and assumptions using information from the hoary bat from continental America or other bat species when necessary:

Breeding Season: The pregnancy and lactating period for the female Hawaiian hoary bat occurs from April to Augustr each year. The breeding lasts approximately four months, with a three month gestation period followed by parental care of one month (NatureServe 2008).

Age at First Breeding: Hoary bats on the continental US breed at age one (Gannon 2003, Koehler and Barclay 2000)

Adults Breeding/Year: Estimated at 100% for colonial bats (Gannon 2003), no data available for the hoary bat. Adults beeding/year is assumed to be 100 % for the Hawaiian hoary bat for purposes of this HCP.

Reproductive Success: A study following young of the hoary bat in Manitoba, Canada records that 23 out of 25 young fledged, resulting in a reproductive success of 92% (Koehler and Barclay 2000). Reproductive success is typically high for bats as they have a life history strategy where they have few young, low reproductive rates and are long lived compared to mammals of equivalent size (Kunz et al. 2005).

Survival to breeding age: No data exists for the Hawaiian hoary bat or the hoary bat on the American continent. However, survival is low for female little brown bats (*Myotis lucifugus* 20.4-47.2%) and female big brown bats (*Eptesicus fuscus,* 10.5-31.9%, Humphrey 1982). Survival rates of Hawaiian hoary bats probably approximate those of the big brown bat more closely than the little brown bat, given that they similar life history strategies such foliage roosting and the ability to commonly have two young at a time. The survival rate of Hawaiian hoary bats is estimated to be 30%.

Number of Broods: One per year.

Litter Size: Both Bogan (1972) and Koehler and Barclay (2000) in separate observations record that 6 females located before parturation gave birth to a total of 11 young, resulting in an average litter size of 1.83. Thus it is assumed that breeding adults will average 1.8 juveniles per breeding pair.

Relative Productivity of Males vs. Females: Male hoary bats only contribute sperm to the breeding process. Females are solely responsible caring and feeding the young till fledging. For the purposes of estimating inidirect take, it is assumed that males contribute nothing to indirect take and females 100%.

Sex Ratio: Sex ratios of Hawaiian hoary bats inferred from samples obtained during different seasons indicate that during the pre-pregnancy and breeding season (April to August), sex ratios in the lowlands are approximately 1:1. During the post-lactation period (September to December) the sex ratio of females to males in the lowlands increases to 4:1 (Menard 2001).

2.0 LITERATURE CITED

Ainley, D. G., R. Podolsky, L. DeForest, G. Spencer, and N. Nur. 2001. The status and population trends of the Newell's shearwater on Kaua'i: insights from modeling. Studies in Avian Biology No. 22: 108-123.

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.

Arroyo, B.E., T. DeCornulier and V. Bretagnolle. 2000. Sex and Age Determination of Short-eared Owl Nestlings. The Condor 102: 216-219

Banko. W.E. 1987. Historical synthesis of recent endemic Hawaiian birds. Part I. Population histories - species accounts, freshwater birds: Hawaiian Gallinule, 'Alae –'ula. Cooperative National Park Resources studies unit, University of Hawaii at Manoa, CPSU/UH Avian History report No. 12.

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.

Bogan M.A. 1972. : Observations on paturation and development in the hoary bat *Lasiurus cinereus* Journal of Mammalogy 53(3):611-614

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.

Brooke M. 1990. The Manx shearwater**.** London: Poyser.

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., R.A. Coleman, R.J. Shallenberger and C.S. Arume. 1985. Notes on the Breeding Biology of the Hawaiian Race of the American Coot. ‘Elepaio 45: 57–63.

Chang, P.R. 1990. Strategies for Managing Endangered Waterbirds on Hawaiian National Wildlife Refuges. M.S. thesis, Univ. of Massachusetts.

Coleman, R.A. 1981. The Reproductive Biology of the Hawaiian Subspecies of the Black-necked Stilt, *Himantopus mexicanus knudseni*. Ph.D. diss., Pennsylvania State Univ., University Park.

Davies J.M. and M. Restani. 2006. Survival and Movements of Juvenile Burrowing Owls During the Post Fledgling Period. The Condor 108:282-219

Drilling, N., R. Titman and F. Mckinney. 2002. Mallard (Anas platyrhynchos), 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/658
doi:10.2173/bna.658

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 T.K. Pratt. 1993. Status and Population Trends of Hawaii’s Native Waterbirds, 1977-1987. Wilson Bulletin 105:142-158.

Gannon W.L. 2003.Bats pp 56-74 in Feldhamer G.A. Thompson B.C. and Chapman J.A. (eds) Wild Mammals of North America: Biology, Management, and Conservation. John Hokins University Press, Baltimore

Haug, E.A., B.A. Millsap and M.S. Martell. 1993. Burrowing Owl (Athene cunicularia), 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/061doi:10.2173/bna.61

Humphrey 1982. Bats, Vespertilionidae and Molossidae. Pp 52-70 in Chapman J.A. and Feldhamer G.A. (eds) Wild mammals of North America: Biology, management, and economics. John Hokins University Press, Baltimore

Johnson, D. H., and A. B. Sargeant. 1977. Impact of red fox predation on the sex ratio of prairie mallards. U.S. Fish and Wildl. Serv. Wildl. Res. Rep. 6. 56pp.

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

Koehler and Barclay 2000. Post-natal growth and breeding biology of the hoary bat (Lasiurus cinereus) Journal of Mammalogy 81(1): 234-244

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.

McRae 1996 Family values: costs and benefits of communal nesting in the Moorhen. Animal Behavior. 52: 225–245.

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.

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.

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).

Ohde, B.R., R. A. Bishop, J. J. Dinsmore. 1984. Mallard Reproduction in Relation to Sex Ratios. The Journal of Wildlife Management 47(1):118-126

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

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.

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.

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.

USFWS. 2005a. Draft Revised Recovery Plan for Hawaiian Waterbirds, Second Draft of Second Revision. U.S. Fish and Wildlife Service, Portland, OR.

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

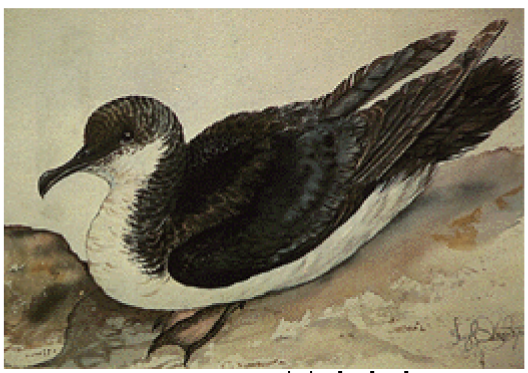
Appendix 6

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 (Newell's shearwater, Hawaiian duck, Hawaiian stilt, Hawaiian coot, Hawaiian moorhen, Hawaiian short-eared owl 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

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.



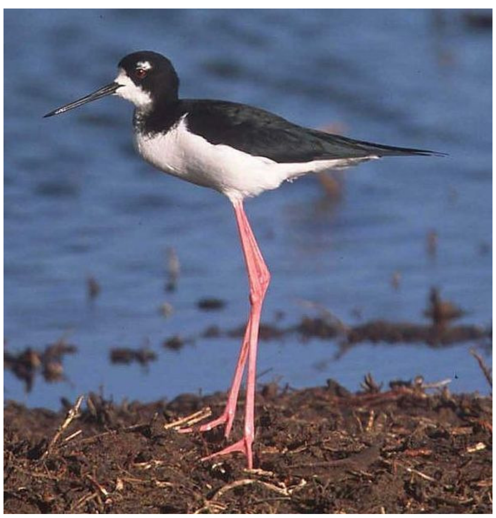
Painting by Sheryl Ives Boynton

source: http://pacificislands.fws.gov/wesa/ao.html

source: http://audubon2.org/webapp/watchlist/viewSpecies.jsp?id=141

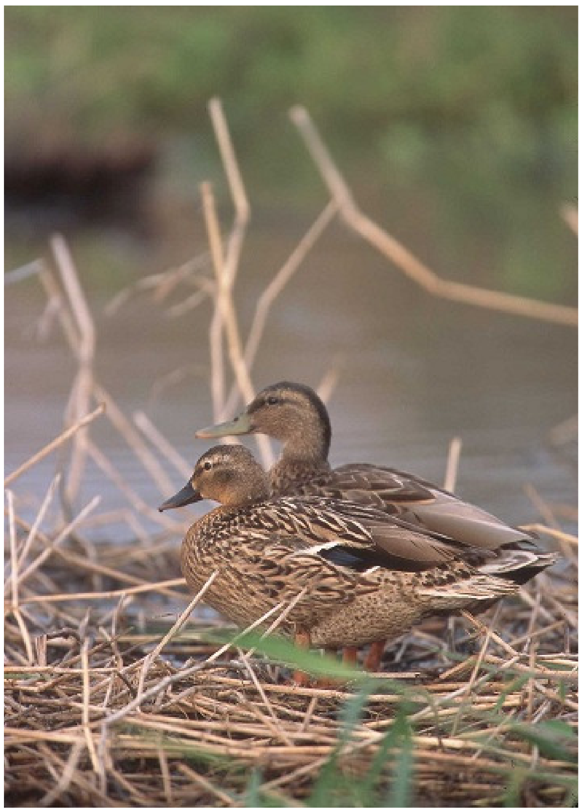
source: http://www.birdinghawaii.co.uk/XNewells2.htm

Hawaiian Stilt	
Description	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.
Voice	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.
Habits	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.



source: http://en.wikipedia.org/wiki/Image:Black-necked_Stilt.jpg *source: http://en.wikipedia.org/wiki/Image:Bnstiltpair.jpg*

Hawaiian Duck or Koloa Maoli	
Description	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.
Voice	The koloa has a quack like a mallard, but are quieter and less vocal.
Habits	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.



Source: http://en.wikipedia.org/wiki/File:Hawaiian_duck.jpg

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.

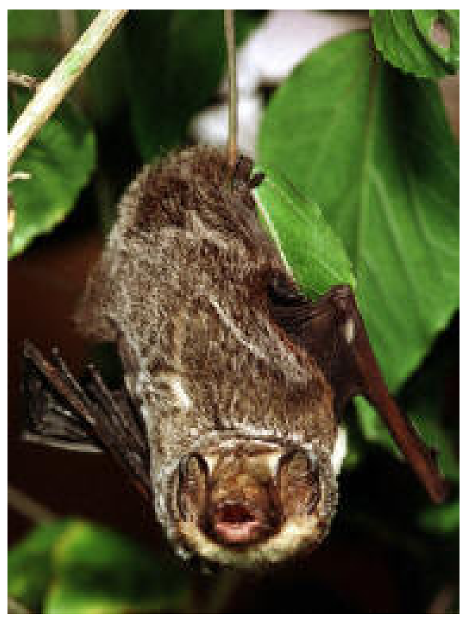
Source: http://en.wikipedia.org/wiki/File:Fulica_alai.jpg

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

Hawaiian 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

Hawaiian Hoary Bat	
Description	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.
Voice	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.
Habits	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.
 *source: http://pacificislands.fws.gov/wesa/hrybatindex.html*	 *source: http://www.honoluluzoo.org/hawaiian_bat.htm*

Wildlife Education and Observation Program
Kahuku Wind Power
Observation Form

Observer's Name:			**Date:**	
Temperature:	**Wind Direction:**	**Wind Speed:**	**Precipitation:**	**Cloud Cover:**

Species Observed	
Location	
Proximity to Turbine	
Approximate Altitude	
Direction Traveling	
Other Species in Area	
Comments	

Appendix 7

Kawailoa Wind Power Proposed Post-Construction Monitoring Protocol

This monitoring protocol outlines the search methods that Kawailoa Wind Power proposes to use to locate downed wildlife, as well as scavenger and searcher efficiency trials that will be conducted to improve the accuracy of take estimates. A three year intensive monitoring protocol is proposed to establish an average long-term observed fatality rate for each Covered Species. In order to determine total fatality rates (see Appendix 9), the observed fatality rate for each species will be adjusted based on results from searcher efficiency (SEEF) and carcass removal (CARE) trials. The total fatality rates from the intensive monitoring period will inform if the rate of take at the facility for each Covered Species is likely to remain at Baseline or Lower levels or whether Higher levels of take can be expected over the life of the project. SEEF and CARE trials can also be used to adjust the search protocols to increase the accuracy of subsequent take estimates.

After the initial 3-year intensive sampling period, intensive sampling with SEEF and CARE trials will occur at 5-year intervals, to determine if conditions have changed over time. Intensive sampling protocols may be modified over the life of the project to make searches more efficient as data and new technologies become available. All modifications will be made with the concurrence of USFWS and DOFAW. A reduced, periodic sampling regime will be conducted in the interim years.

The actual monitoring protocol will be determined with the concurrence of USFWS and DOFAW and will be implemented before the start of operations of Kawailoa Wind Power.

<u>Sampling</u>

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 should be of a frequency where majority of the carcasses will be discovered before they are scavenged. Sampling of turbines within a site should be sufficient to account for the spatial variation that exists among turbines, as well as across seasons of the year to account for temporal variation in collision risk.

The accuracy of a mortality estimate 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. Correcting for searcher efficiency will account for fatalities that are not found by searchers for various reasons, such as heavy vegetation cover.

The field methods proposed below build upon the methods that have been used at KWP since operations began in June 2006 (Kaheawa Wind Power 2006), and incorporate refinements that have been developed for KWPII and Kahuku Wind Power (SWCA 2009a, SWCA 2009b). 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). Advice from Manuela Huso, a wind wildlife statistician from Oregon State University, was also solicited during the development of this protocol.

<u>Factors Considered for Carcass Removal (CARE) and Searcher Efficiency (SEEF) Trials</u>

Carcass removal (CARE) and searcher efficiency (SEEF) rates can be affected by seasonal differences, vegetation types and carcass sizes. Trials should therefore be appropriately stratified to account for these variations.

Carcass retention times may vary due to seasonal changes in the density of scavengers on site, or seasonal changes in scavenger behavior. For the monitoring protocol at Kawailoa Wind Power, the year is divided into two seasons, the winter/spring season (December – May) and summer/fall (June – November). The outcome of SEEF trials are not expected to vary with season.

Different vegetation types can affect the outcome of both scavenger and SEEF trials (e.g., more complex vegetation structures will likely result in lower searcher efficiency). Dominant vegetation cover types (e.g., bare ground, short grass, shrubs) will be defined prior to initiation of trials to allow for appropriate stratification of trials.

To account for the affects of varying carcass sizes, three size classes have been established to reflect the size classes of the Covered Species: bat size, medium birds (seabirds and waterbirds) and large birds (owls). 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 at randomly selected locations within the search plots. For example, random points can 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 and minimum distance of the point from the vegetation zone boundary. 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. The distance of each point from the boundary of the vegetation zone will ensure that carcasses will be within the specified vegetation zone and not be placed on edges or within transition zones. These points will subsequently be loaded into a GPS as waypoints to allow the accurate placement of the carcasses.

Procurement of Carcasses for Trials

If state or federally protected species are used 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. 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 four Covered Species. For example, Wedge-tailed shearwaters and mallards both exhibit close taxonomic resemblance to the covered seabird species, Newell's shearwater and the waterbird, the Hawaiian duck. 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 gray francolin (*Francolinus pondicerianus*) and rock dove (*Columba livia*). Use of species protected under ESA or MBTA will require permission from DLNR and USFWS.

Carcass Removal (CARE) Trials

The objective of performing carcass removal studies at Kawailoa 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. Carcass removal trials have been ongoing at the KWP facility since November, 2005. To date a total of 27 trials have been conducted using a variety of species and numbers of specimens. Carcass retention times average 6.6 days for small (n=7) carcasses and 10.3 days for medium sized carcasses (n=59), while large birds typically remain visible to observers for the standard two week duration of trials or longer (Kaheawa Wind Power, 2008b, 2009, 2010a,b). Within a season (summer/fall and winter/spring), at least ten carcasses of each size class will be placed in each vegetation type.

Each carcass removal trial will consist of placing a pre-determined number of carcasses (up to a maximum of twelve specimens) of varying size classes on the ground at random locations within representative vegetation classes. If carcasses of the covered species are not available, carcasses of surrogate species will be used. 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 along the length of the project area to represent a range of elevations, habitat conditions, vegetation cover types, 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 from the trials will provide a correction factor that will account for carcasses scavenged before they are found (see Appendix 9). This correction factor can then be incorporated into the calculation of total direct take for the facility. The results from CARE trials also provide a basis for adjusting the search frequency as necessary to ensure that the majority of birds and bats are not scavenged before they can be detected by searchers. 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 according to vegetation and carcass size classifications.

Table 1. Possible Sampling Scheme for Kawailoa CARE Trials for One Season

Vegetation types	**Season**	**Size class**	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Trial 6**	**Trial 7**	**Trial 8**	**Total sample size**
Bare ground	Winter / Spring	Bats	2	2	2	2	2	2	2	2	**16**
		Med birds	2	1	2	1	2	1	2	1	**12**
		Large birds	1	2	1	2	1	2	1	2	**12**
Grass	Winter / Spring	Bats	2	2	2	2	2	2	2	2	**16**
		Med birds	2	1	2	1	2	1	2	1	**12**
		Large birds	1	2	1	2	1	2	1	2	**12**
		Total	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**80**

Searcher Efficiency (SEEF) Trials

Searcher Efficiency (SEEF) trials represent an important component of downed wildlife monitoring and provide an estimate of carcass detection probability. 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 vegetation classification and 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 twice weekly monitoring period but dates will be chosen randomly, as far as practicable. Each trial will consist of a varying number of carcasses to decrease the predictability of each trial for the test subjects. One to twelve bird carcasses and/or bats or bat surrogates may be used for each trial. At least 15 carcasses will be used for each size class within each vegetation type. Prior to a search commencing, each carcass will be placed within chosen vegetation zones, as described above, at randomly selected locations that will be searched on the same day. 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. Data will be analyzed according to vegetation and carcass size classifications. More trials will be conducted for select vegetation types or carcass sizes if analyses indicate that more trials are needed to provide statistical confidence in the resultant values to enable mean searcher detection probabilities to be ascertained for the project site. Results from the trials will provide a correction factor that will account for carcasses not discovered during the searches (see Appendix 9). This correction factor can then be incorporated into the calculation of total direct take for the facility.

Searcher efficiency rates at KWP using Wedge-tailed Shearwaters as surrogates for the two Covered seabird species have ranged from an average of 64 -70% in shrubs (n=90), 78 - 81%% in grass (n=145) to 97 - 100% detectability on bare ground (n=51). Using house sparrows and Zebra doves as surrogates for bats at KWP, the average searcher efficiency rates ranged from 33 - 42% in shrubs (n=15), to 36 – 50% in grass (n=20), and 67 – 97% detection on bare ground (n=30) (Kaheawa Wind Power 2009, 2010a). Using carcasses of bats (if available), small mammals, seabirds and waterbirds as surrogates for each Covered Species in SEEF trials performed during the initial three years of study will provide a better representation of detection variability among differing vegetation and terrain conditions for the different sized Covered Species, resulting in greater confidence in this species-specific adjustment variable.

Search Areas Beneath Meteorological Towers

The search area beneath the temporary met towers will be circular and extend 10 m beyond the supporting guy wire anchors. The search area beneath the permanent unguyed met tower (100 m) will also be circular and with a search radius half the height of the tower (50m).

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). Based on the data presented, it appears that only a very small proportion (0% to less than 5%) of bat fatalities are likely to land beyond 50% turbine height.

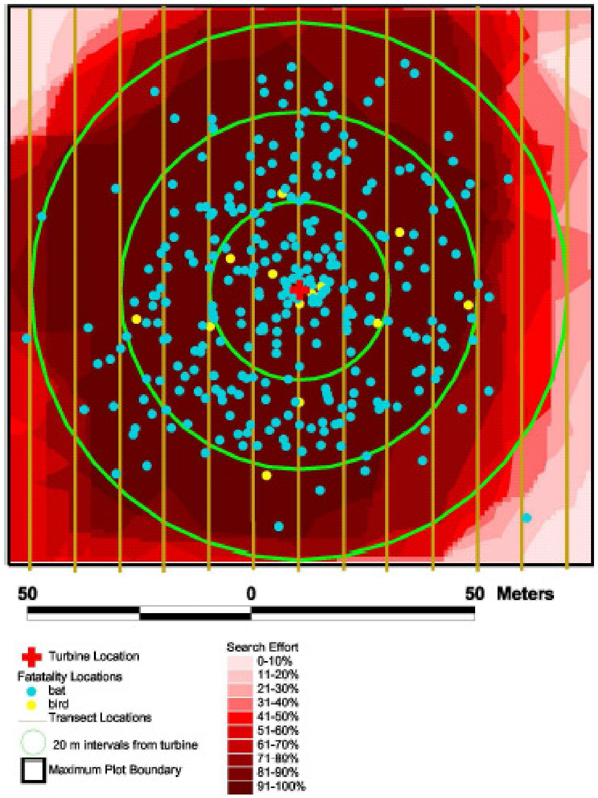


Figure 1a. Bat and bird fatalities (n=466 bats) at all turbines combined at Meyersdale Wind Energy Center in Pennsylvania, 2 August to 13 September 2004 (Arnett 2005). The maximum turbine height was 115 m.

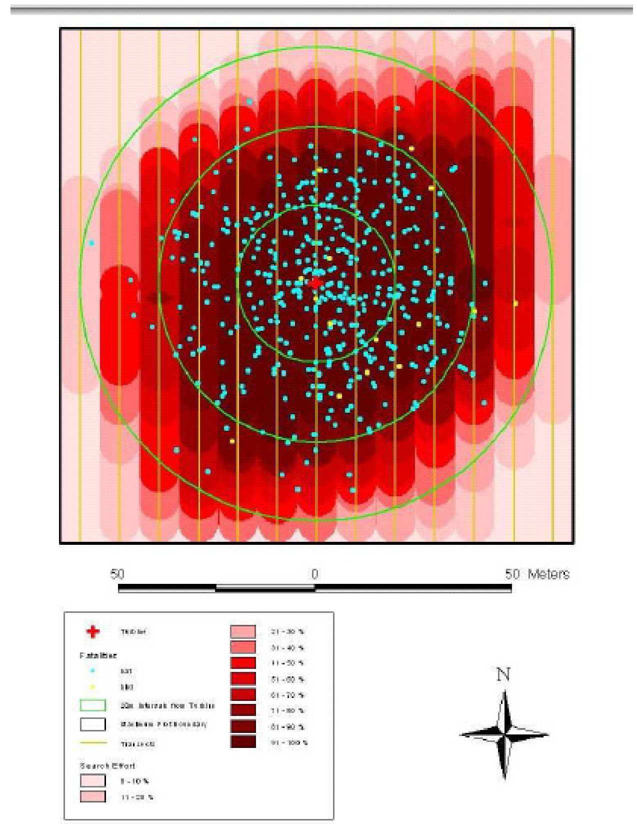
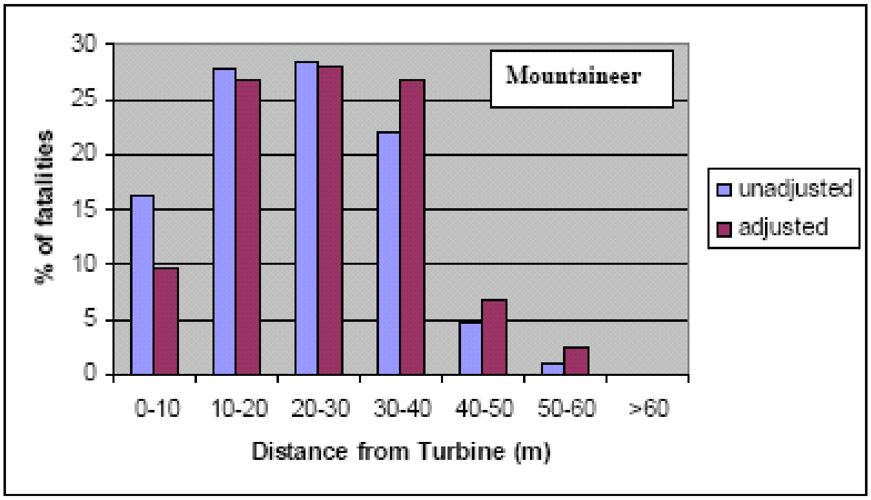
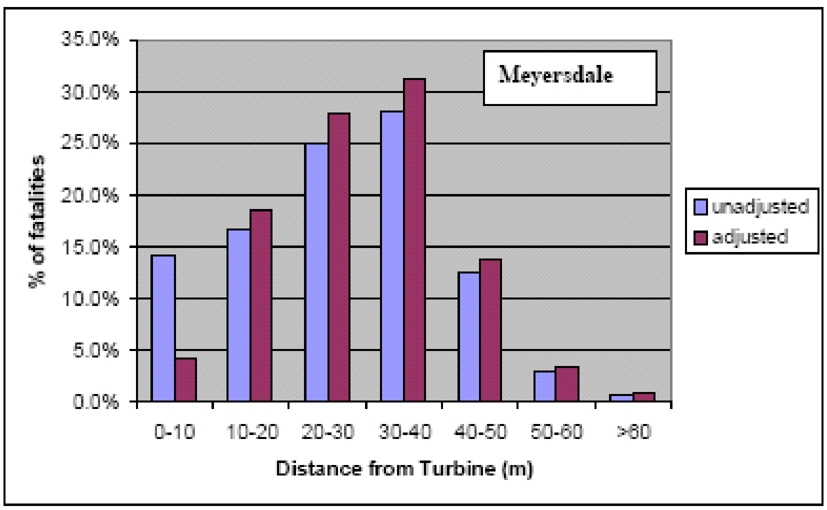


Figure 1b. Bat and bird fatalities (n=499 bats) at all turbines combined at Mountaineer Wind Energy Center in West Virginia, 31 August to 11 September 2004 (Arnett 2005). The maximum turbine height was 104.5 m.

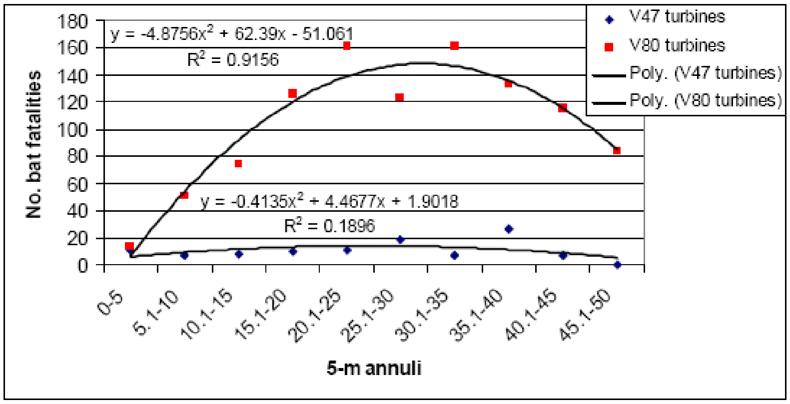


a

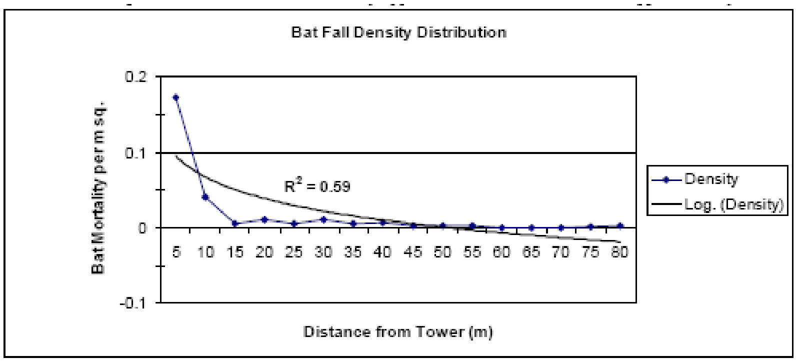


b

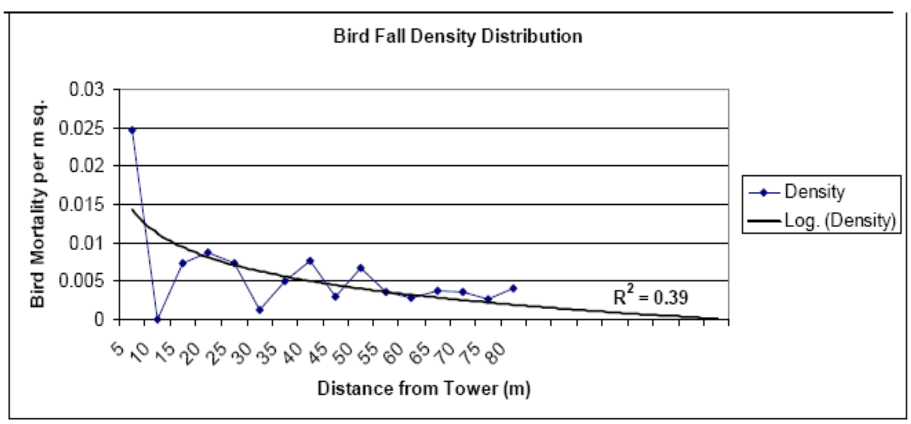
Figure 2a, b. Distribution of fatalities (birds and bats) as a function of distance from a turbine for Mountaineer and Meyersdale sites based on unadjusted counts, and counts adjusted for searcher detection and sampling effort (figures from Arnett 2005). The maximum turbine height was 104.5 m.



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.

The Covered seabird species (Newell's shearwater) and the Covered waterbird species (Hawaiian duck, Hawaiian stilt, Hawaiian coot, Hawaiian moorhen) are characterized as medium-sized fast flying birds. The Covered owl species (Hawaiian short-eared owl) is a large bird with slower flight speeds than the seabirds and waterbirds. Examination of available literature and existing data for the carcass distribution of medium to large-bodied fast flying birds (n=26) plus owls (n=2) showed that over 85% of these carcasses fell within the 50% search area of the turbine specific to that wind project. The raw data is presented in Appendix A of this document.

Therefore, medium to large bodied fast flying birds and owls seem to follow similar carcass distribution patterns to bats.

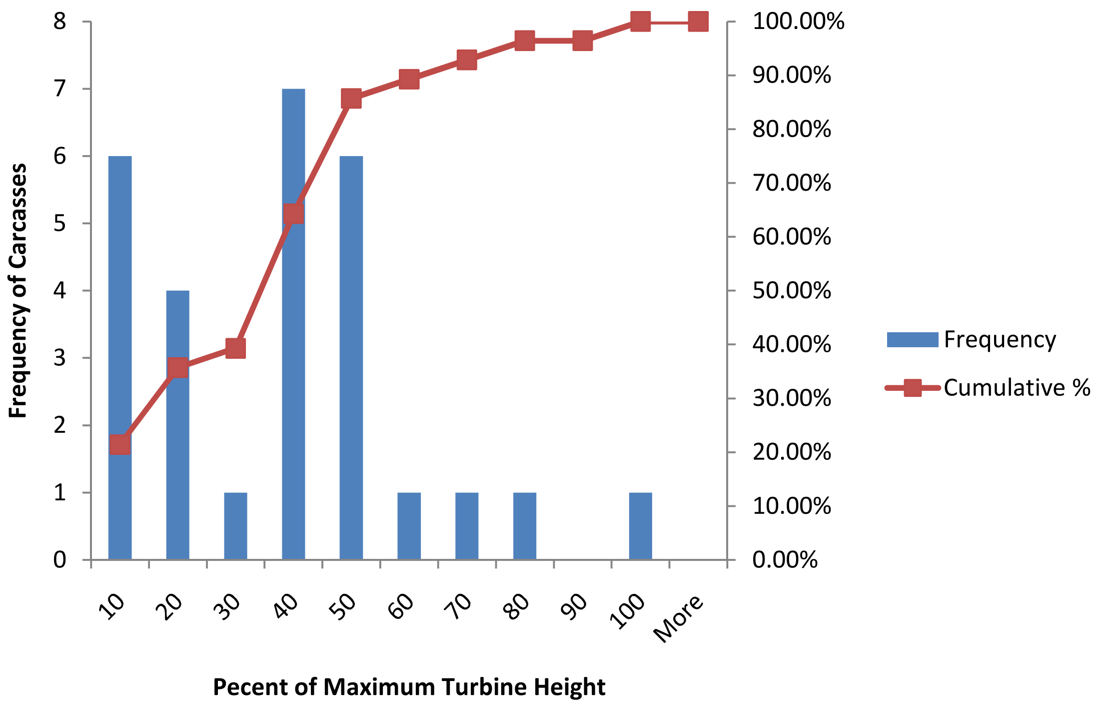


Figure 3. Distance distribution of medium to large fast flying bird and owl carcasses and (n=28). See Appendix A for raw data.

Spatial and Temporal Sampling Scheme During the First Year of Intensive Sampling

Given the considerations detailed above, it is proposed that areas where Covered birds and bats are most likely to fall (>95% chance for bats and 85% chance or more for birds) are searched frequently to maximize the probability of detecting carcasses. Areas beyond the 50% search plot will be searched less frequently, but regularly, to allow for an accounting of fatalities that may land at greater distances. This is reasonable, given the longer carcass retention times of medium to large birds. .

The initial search protocol at Kawailoa Wind Power is proposed to consist of twice weekly searches (Figure 4). During the first search of the week, all turbines will be searched to 50% turbine height (75 m radii). During the second search three to four days later, half the turbines will be searched to 75% turbine height (113m) while the remaining half will be searched again to 50% turbine height. The next week, all turbines will be searched out to 50% turbine height at the beginning of the week. Three to four days later, the opposite set of turbines will be searched to 75% height, while the remaining half will be searched again to

50% turbine height. Thus, each turbine will be searched out to 50% turbine height twice a week with a search interval of 3-4 days, and out to 75% turbine height once every 14 days (every two weeks).

Plot Maintenance

Search plots at Kawailoa Wind Power will consist either of bare ground or short stature grass/shrubs and will be maintained throughout the life of the project. Due to the rugged terrain of the surrounding area, some areas within the 50% to 75% search area may include terrain with steep slopes. These areas may be hazardous to search and could also pose erosion issues if cleared of the existing vegetation. At the discretion of the Applicant, these areas may be classified as unsearchable and will not maintained or searched on a systematic basis. The proportion of unsearchable area at the project site will be taken into account when adjustments are made to the take calculations.

Intensive Sampling During the Second and Third Year

After the first year, search plots and search frequencies may be adjusted to optimize the sampling regime based on results from the SEEF and CARE trials. Any changes in the sampling regime will require the approval of DLNR, USFWS and if determined by the agencies, the ESRC.

Trapping may also be conducted to depress scavenger populations and increase carcass retention times if deemed necessary or desirable. All applicable permits will be obtained as necessary.

Post Three-Year Intensive Sampling Period

The goal of the intensive monitoring period is to provide a robust estimate of the ongoing mortality rates of the covered species, determine whether take is occurring at or below the Baseline level, and in turn whether mitigation is sufficient to offset take over the life of the project. Spatial and temporal variation on site should also be well understood at the end of the second or third year of intensive sampling, enabling reasonable 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. As a general goal, it is expected that the systematic monitoring effort will be scaled back by about 50%. It is also proposed that intensive fatality monitoring be repeated after the three year intensive sampling period be conducted at the beginning of 5-year bins; e.g., years 6, 11 and 16, resulting in a total of 6 years of intensive 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 assessments (RRA) of each search plot will be conducted in the interim years. 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.

Starting from Year 6, the intensive 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 Kawailoa Wind Power in consultation with ESRC, USFWS, DLNR, statisticians and wind energy experts after the initial 3-year intensive sampling period.

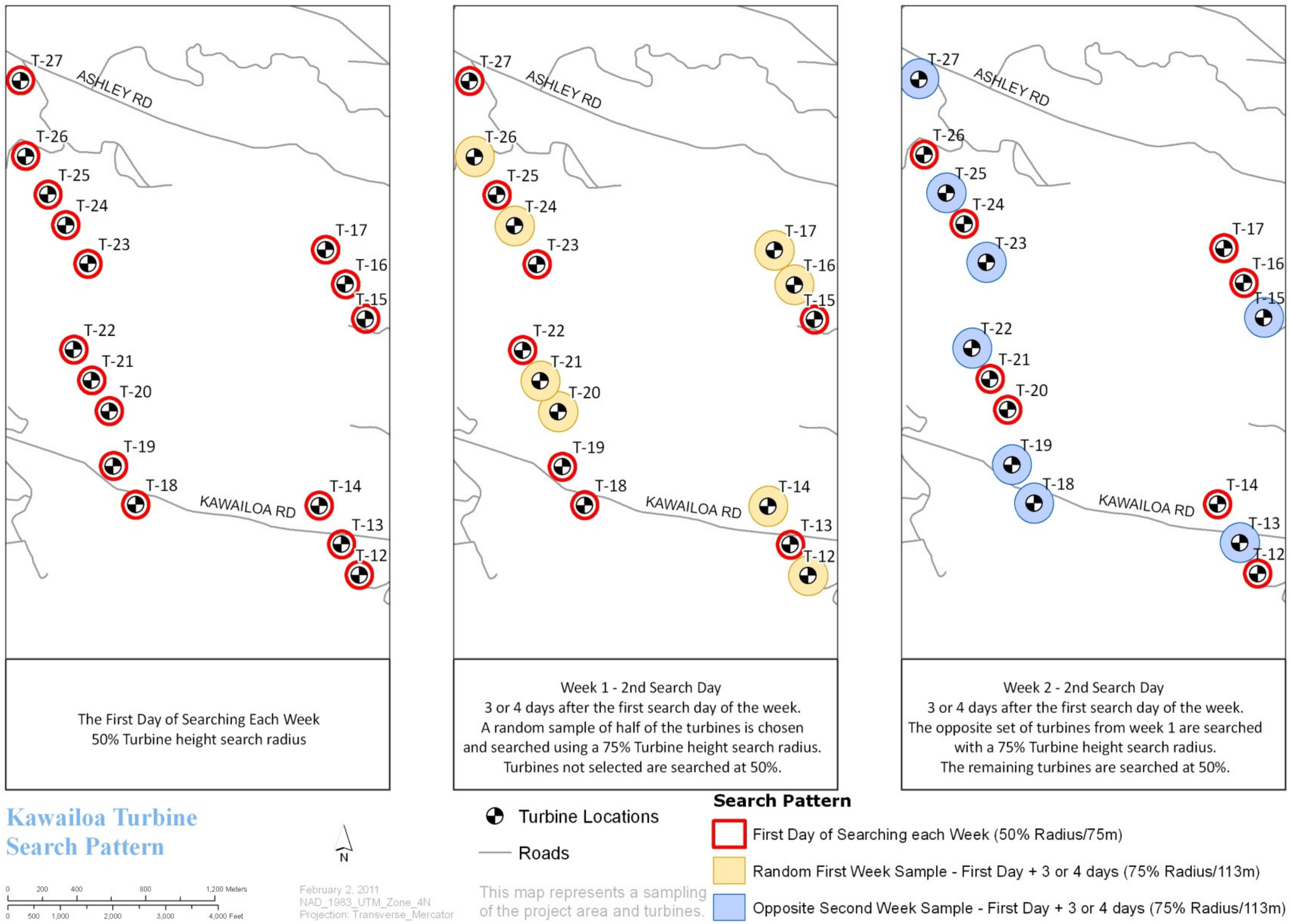


Figure 4. Proposed search protocol during intensive monitoring

Years																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IM	IM	IM	RRA	RRA	IM	RRA	RRA	RRA	RRA	IM	RRA	RRA	RRA	RRA	IM	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					CRT				
1st 5-year bin					2nd 5-year bin					3rd 5-year bin					4th 5-year bin				

IM = intensive monitoring; RRA = regular rapid assessment;
CRT= carcass removal trials

Total direct take = total direct take for IM + 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.

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.

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

Kaheawa Wind Power, LLC. 2010a. Kaheawa Pastures Wind Energy Facility, Habitat Conservation Plan: Year 4 Annual Report. First Wind Energy, LLC, Environmental Affairs, Portland, ME 35pp.

Kaheawa Wind Power, LLC. 2010b. Kaheawa Pastures Wind Energy Facility, Habitat Conservation Plan: Q1-Year 5 Progress Report. First Wind Energy, LLC, Environmental Affairs, Portland, ME 10pp.

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.

SWCA 2009a. Kahuku Wind Power Habitat Conservation Plan. Prepared for Kahuku Wind Power LLC. March 2010.

SWCA 2009b. Kaheawa Wind Power II Draft Habitat Conservation Plan. Prepared for Kaheawa Wind Power II LLC. Nov 2010.

Appendix A

Data Sources:

Stantec Consulting Services Inc. (Stantec). 2010. Cohocton and Dutch Hill Wind Farms Year 1 Post-Construction Monitoring Report, 2009, for the Cohocton and Dutch Hill Wind Farms in Cohocton, New York. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC, Portland, Maine. Prepared by Stantec, Topsham, Maine. January 2010.

Johnson, G.D., W.P. Erickson, and J. White. 2003. Avian and bat mortality at the Klondike, Oregon Phase I Wind Plant. Technical report prepared for Northwestern Wind Power by WEST, Inc.

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and bat mortality associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 study year. Technical Report prepared by WEST, Inc. for Umatilla County Department of Resource Services and Development, Pendleton, Oregon. 21pp.

Vlietstra, L.S. 2008. Common and roseate tern exposure to the Massachusetts Maritime Academy wind turbine: 2006 and 2007. Report to the Massachusetts Division of Fisheries and Wildlife, Natural Heritage Program, Westborough, MA.

Kaheawa Wind Power LLC. 2010. Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 4 Annual Report. First Wind Energy, LLC, Environmental Affairs, Boston, MA.

Species	Size	Flight Speed (mph)	Type	Rotor tip ht (m)	Carcass distance from nearest turbine (m)	Percent Rotor Ht	Source	Location
Western grebe	med	40	Clipper	130	52	40	First Wind	Milford 1 Utah
Western grebe	med	40	Clipper	130	41	32	First Wind	Milford 1 Utah
Western grebe	med	40	Clipper	130	51	39	First Wind	Milford 1 Utah
Western grebe	med	40	GE	121	13	11	First Wind	Milford 1 Utah
Western grebe	med	40	GE	121	50	41	First Wind	Milford 1 Utah
Canada goose	large	45	?	100	1	1	Johnson et al 2003	Oregon Kondike Wind
Canada goose	large	40-50	?	100	3	3	Johnson et al 2003	Oregon Kondike Wind
Gray partridge	med	35	660kw Vestas	63.5	12.7	20	Erickson et al 2000	Oregon Vansycle Wind Project
Gray partridge	med	30-40	660kw Vestas	63.5	3	5	Erickson et al 2001	Oregon Vansycle Wind Project
Unidentified partridge	med	30-40	660kw Vestas	63.5	58	91	Erickson et al 2002	Oregon Vansycle Wind Project
Laughing gull	med	25	660kw Vestas	73.5	30	41	Vlietstra 2008	Massachusetts Maritime Academy
Great black-backed gull	med	25	660kw Vestas	73.5	10	14	Vlietstra 2008	Massachusetts Maritime Academy
Osprey	large	40	660kw Vestas	73.5	25	34	Vlietstra 2008	Massachusetts Maritime Academy
Hawaiian Petrel	med	30	GE1.5MW	90	41	46	Year 4 KWP-HCP report	Kaheawa Wind Power
Nene	large	40	GE1.5MW	90	35	39	Year 4 KWP-HCP report	Kaheawa Wind Power
Nene	large	50*	GE1.5MW	90	35	39	Year 4 KWP-HCP report	Kaheawa Wind Power
Nene	large	50*	GE1.5MW	90	23	26	Year 4 KWP-HCP report	Kaheawa Wind Power
Nene	large	50*	GE1.5MW	90	43	48	Year 4 KWP-HCP report	Kaheawa Wind Power
Nene	large	50*	GE1.5MW	90	33.5	37	Spencer pers comm.	Kaheawa Wind Power
Nene	large	50*	GE1.5MW	90	13.5	15	Spencer pers comm.	Kaheawa Wind Power
White-tailed tropic bird	med	25	GE1.5MW	90	50	56	Year 4 KWP-HCP report	Kaheawa Wind Power

Species	Size	Flight Speed (mph)	Type	Rotor tip ht (m)	Carcass distance from nearest turbine (m)	Percent Rotor Ht	Source	Location
White-tailed tropic bird	med	25	GE1.5MW	90	70	78	Spencer pers comm.	Kaheawa Wind Power
Barn owl	med	40	GE1.5MW	90	40.1	45	Year 4 KWP-HCP report	Kaheawa Wind Power
Hawaiian short-eared owl	med	40	GE1.5MW	90	60.5	67	Year 4 KWP-HCP report	Kaheawa Wind Power
Spotted dove	med	30	GE1.5MW	90	1	1	Year 4 KWP-HCP report	Kaheawa Wind Power
Spotted dove	med	30	GE1.5MW	90	1.2	1	Spencer pers comm.	Kaheawa Wind Power
Sharp-shinned hawk	large	30	Clipper	119	10	8	Stantec 2010	Cohocton-Dutch Hill 2009
Semipalmated sandpiper	med	55	Clipper	119	50	42	Stantec 2010	Cohocton-Dutch Hill 2009

Appendix A. Distribution of carcasses around turbine base

Appendix 8

Funding Matrix
Kawailoa Wind Power Habitat Conservation Plan

	Item/Activity	One-time Cost	Annual Cost	Years 1-5	Remaining 15 Years	20-year Permit Duration
General Measures	Bat and Short-eared owl monitoring during construction	$10,000				$10,000
	Wildlife Education and Observation Program (WEOP)		$3,000	$15,000	$45,000	$60,000
	Maximum Cost	**$10,000**	**$3,000**	**$15,000**	**$45,000**	**$70,000**
Seabird Mitigation (Tier 1)	Cat trap development and testing	$130,000	$50,000	$50,000		$180,000
	Maximum Cost	**$130,000**	**$130,000**	**$50,000**		**$180,000**
Mitigation for Tier2 Rates of Take	Development of translocation protocols and its implementation or contributing to a restoration fund		$100,000		$200,000	$200,000
	Maximum Cost		**$100,000**		**$200,000**	**$200,000**
	Item/Activity	**One-time Cost**	**Annual Cost**	**Years 1-5**	**Remaining 15 Years**	**20-year Permit Duration**
Waterbird Mitigation (Tier 1)	Permitting	$30,000				$30,000
	Ungulate eradication and predator control	$10,000	$25,000	$100,000	$100,000	$210,000
	Monitoring		$16,000	$80,000	$32,000	$112,000
	Fencing	$77,000				$77,000
	Fence maintenance		$7,500	$30,000	$30,000	$60,000
	Vegetation removal		$42,500	$85,000		$85,000
	Replanting		$75,000	$150,000		$150,000
	Weed control		$40,000	$120,000	$110,000	$230,000
	Biological oversight		variable	$24,000		$24,000
		$117,000	**$206,000**	**$589,000**	**$272,000**	**$978,000**
Mitigation Measures at Tier 2 Levels of Take	Increased mitigation efforts at same site or another site				$177,000	$177,000
	Maximum Cost				**$177,000**	**$177,000**
Short-eared Owl Mitigation (Tier 1)	Program to support owl research and rehabilitation	$12,500				$12,500
	Funding for management	$25,000				$25,000
	Maximum Cost	**$37,500**				**$37,500**
Mitigation at Tier 2 Levels of Take	Additional funding to support owl research and rehabilitation	$6,250				$6,250
	Additional funding for management	$12,500				$12,500
	Maximum Cost	**$18,750**				**$18,750**
Bat Mitigation (Tier 1) Wetland Restoration	Ungulate eradication and predator control	$10,000	$15,000	$60,000	$60,000	$130,000
Alternative 1	Monitoring		$8,000	$40,000	$32,000	$72,000
	Fencing	$100,000				$100,000
	Fence maintenance		$5,000	$20,000	$25,000	$45,000
	Vegetation removal		$42,500	$85,000		$85,000
	Weed control		$40,000	$120,000	$110,000	$230,000
	Alien tree removal		$100,000	$200,000		$200,000
	Replanting		$75,000	$150,000		$150,000
	Biological oversight		variable	$24,000		$24,000
	Research		$30,000	$90,000	$90,000	$180,000
	Total cost for restoration	**$110,000**	**$315,500**	**$789,000**	**$317,000**	**$1,216,000**
Forest Restoration (Alternative 2)	**Forest restoration**		**variable**	**$500,000**	**$500,000**	**$1,000,000**
Other measures	Bat monitoring on wind farm site for 6 years		$12,500	$75,000		$75,000
	Maximum Cost	**$110,000**	**$328,000**	**$864,000**	**$317,000**	**$1,291,000**

Additional Measures for Tier 2 and Tier 3 Rates of Take	Funding for management		variable		$1,578,000	$1,578,000
	Increased site-specific bat studies using enhanced audio-visual technologies to characterize activity levels and document bat interactions at facility		$10,000		$100,000	$100,000
	Maximum Cost		**$10,000**		**$1,678,000**	**$1,678,000**
Bat Contingency Fund	**Initial Value**	**$350,000**			**Escalated Value Yr 20**	**$559,528**
	Item/Activity	**One-time Cost**	**Annual Cost**	**Years 1-5**	**Remaining 15 Years**	**20-year Permit Duration**
Downed Wildlife Monitoring	HCP compliance (monitoring, reporting, vegetation maintenance		$475,000	$1,905,000	$2,160,000	$4,065,000
	3rd Party QA/QC and Proctoring of Searcher Efficiency Trials		$30,000	$90,000	$90,000	$180,000
	Equipment and Supplies	$280,000	$25,000	$125,000	$375,000	$780,000
	Estimated Cost	**$280,000**	**$530,000**	**$2,120,000**	**$2,625,000**	**$5,025,000**
Contingency in the event project requires Third-Party fatality monitoring and reporting (add 1x baseline)	**Estimated Cost**		**$235,000**	**$945,000**	**$1,425,000**	**$2,370,000**
State Compliance Monitoring	**Estimated Cost**		**$25,000**	**$75,000**	**$225,000**	**$300,000**
Changed Circumstances	If necessary, funding will be made available in conjunction with ongoing costs for implementation and other requirements according to the terms of the HCP.					

Estimated Project Sub-Totals		**One-time Cost**	**Years 1-5**	**Remaining 15 Years**	**20-year Permit Duration**
	Tier 1				
	Minimization and General Measures	$10,000	$15,000	$45,000	$70,000
	Seabird Mitigation	$130,000	$50,000	$0	$180,000
	Waterbird Mitigation	$117,000	$589,000	$272,000	$978,000
	Short-eared Owl mitigation	$37,500	$0	$0	$37,500
	Hawaiian Hoary Bat Mitigation	$110,000	$864,000	$317,000	$1,291,000
	Sub-Total	**$404,500**	**$1,518,000**	**$634,000**	**$2,556,500**
	Tier 2 (and Tier 3 for Bats)				
	Seabird Mitigation	$0	$0	$200,000	$200,000
	Waterbird Mitigation	$0	$0	$177,000	$177,000
	Short-eared Owl Mitigation	$18,750	$0	$0	$18,750
	Hawaiian Hoary Bat Mitigation	$0	$0	$1,678,000	$1,678,000
	Sub-Total	**$18,750**	**$0**	**$2,055,000**	**$2,073,750**
	Monitoring and Reporting				
	Downed Wildlife Monitoring	$280,000	$2,120,000	$2,625,000	$5,025,000
	Third-party Monitoring Contingency	$0	$945,000	$1,425,000	$2,370,000
	State Compliance Monitoring	$0	$75,000	$225,000	$300,000
	Sub-Total	**$280,000**	**$3,140,000**	**$4,275,000**	**$7,695,000**

Grand Total Including Expected Cost for Tier 1 Mitigation*	**$7,292,500**
Grand Total Including Maximum Cost for Tier 1 Mitigation	**$7,881,500**
Grand Total Tier 1 + 3rd Party Monitoring Contingencies	**$10,251,500**
Grand Total for Tier 1 + Tier2 (+ Tier 3 for Bats) + 3rd Party Monitoring Contingencies	**$12,325,250**

* consists of cost for 20 year Minimization and General Measures, Tier 1 Mitigation for Years 1-5 plus One Time Costs, 20 year Downed Wildlife Monitoring and State Compliance Monitoring

Appendix 9

<u>Calculating Total Direct Take</u>

Monitoring efforts at Kawailoa Wind Power as prescribed in the Kawailoa Wind Power HCP will result in identification of “observed” mortality, which is a statistical sampling of all mortality directly attributable to project operations. Identifying the total mortality (or “total direct take”) requires accounting for individuals that may be killed by collision with project components but that are not found by searchers for various reasons, including heavy vegetation cover and scavenging. The calculation for estimating total direct take is:

Total Direct Take = Observed Direct Take + Unobserved Direct Take

Searcher efficiency (SEEF) trials and carcass removal (CARE) trials (see Appendix 7) are conducted to arrive at estimates of unobserved direct take. SEEF trials measure how effective searchers are in finding carcasses within the search areas and CARE trials measure the length of time carcasses remain in the field before being removed by scavengers. CARE trials are often used to determine the frequency at which turbines and met towers can be searched to maximize the likelihood of searchers detecting carcasses while maintaining a cost-effective survey schedule. Factors to be considered for SEEF trials and CARE trials for Kawailoa Wind Power include season, carcass size, and vegetation type.

Numerous estimators have been developed for the calculation of unobserved direct take. The variables these estimators often include are searcher efficiency, search intervals, and carcass retention rates within the search intervals. Newer estimators are frequently incremental improvements over older estimators as data has accumulated and the biases and deficiencies of each estimator have become better understood. Kawailoa Wind Power, LLC examined three estimators, Shoenfeld (2004), Jain (2007), and Huso (2010), in the development of the calculation to be used for determination of total direct take for its project.

The estimators are presented below:

Estimator by Shoenfeld (2004)

$$m = \left(\frac{N * I * C}{k * t * p}\right)\left(\frac{e^{I/t} - 1 + p}{e^{I/t} - 1}\right)$$

N= total number of turbines
I = interval between searches in days
C = total number of carcasses detected for the period of study (total direct take)
k= number of turbines sampled
t = mean carcass removal time in days
p = searcher efficiency (proportion of carcasses found)
e = natural log

Shoenfeld (2004) and its derivatives were found to bias total direct take calculations low as carcass retention rates (t) increased, particularly when search intervals (I) were small (Smallwood 2007, Huso 2008a, b). The weakness of the estimator resulted from the t/I not being a good estimate of scavenger efficiency (or proportion of carcasses remaining) and this bias also became more pronounced as searcher efficiency (p) became low (Huso 2008a, b).

Estimator by Jain (2007)

$$`C = \frac{C}{S_c \times S_e \times P_s}$$

$`C$ = total number of carcasses for the period of study (total direct take)
C = number of carcasses found
S_c = scavenger efficiency (proportion of carcasses remaining)
S_e = searcher efficiency (proportion of carcasses found)
P_s = proportion of towers searched

Jain (2007) tried to avoid the bias present in the Shoenfeld (2004) estimator by directly incorporating scavenger efficiency or proportion of carcasses remaining (S_e) into his proposed estimator. Jain (2007) assumed that carcasses had equal probability of occurring on any day between search intervals, thus the average number of days a carcass was present was half the number of days between searches and S_e was determined empirically in scavenger trials for a specified time period (in this case half the search interval). This method proposed for determining S_e is fairly simplistic as scavenger efficiency is non-linear but approximates a logarithmic function (Smallwood 2007). Methods to estimate S_e have subsequently been improved on by Huso (2008a, b, 2010).

Estimator by Huso (2010)

$$\hat{m}_{ij} = \frac{c_{ij}}{\hat{r}_{ij}\hat{p}_{ij}\hat{e}_{ij}}$$

$\mathbf{m_{ij}}$ = estimated total direct take at turbine *i* over interval *j*
$\mathbf{c_{ij}}$ = observed direct take
$\mathbf{r_{ij}}$ = estimated proportion of carcasses remaining after scavenging
$\mathbf{p_{ij}}$ = estimated searcher efficiency (proportion of carcasses found)
$\mathbf{e_{ij}}$ = effective search interval

The recently introduced estimator by Huso (2008a, b, 2010) has several improvements over the previous two estimators. For estimating the scavenger efficiency or the proportion of carcasses remaining within a specified search interval (r_{ij}), Huso (2008a, b, 2010) accounts for the logarithmic nature of carcass removal, and also accounts for the removal of older carcasses over time while newer carcasses are being simultaneously deposited during the search interval. Huso (2008 a, b, 2010) has further developed methods to determine effective search intervals (e_{ij}) for cases where search intervals are much longer than the estimated carcass retention times (i.e. carcasses deposited early on in the search interval are 99% removed by scavengers before the subsequent search). Simulations run to determine the degree of bias for the different estimators has shown that the Huso (2010) estimator is the least susceptible to bias over a wide range of values for each variable and is currently the most precise of the commonly used estimators (Huso 2008a, b).

Estimating Total Direct Take at Kawailoa Wind Power

In light of the recent improvements to estimators for calculating total direct take, Kawailoa Wind Power, LLC proposes to apply the Huso (2010) estimator to the monitoring protocol proposed for Kawailoa Wind Power in Appendix 7. Three factors will be considered for scavenger trials and SEEF trials - season, carcass size, and vegetation type. The values obtained from the scavenger and SEEF trials will then be applied to the Huso (2010) estimator using the following protocol:

1. Determine proportion of different vegetation types (bare ground, grass) under all turbines for search area less than 50% height and from 50-75% turbine height. Proportion of areas classified as unsearchable are also determined. Please see Appendix 7 for the definition of search areas.

2. Conduct SEEF trials for each vegetation type. Calculate variances for SEEF trials for each vegetation type. Conduct statistical tests to determine if searcher efficiency varies with vegetation type. Pool SEEF values for vegetation types that are not significantly different.

3. Determine mean carcass removal time for each vegetation type. Calculate variances for carcass removal time for each vegetation type per season. Conduct statistical tests to determine if carcass removal rates vary with vegetation type or season. Pool carcass removal rates for vegetation types or seasons that are not significantly different.

4. Apply values to Huso (2010) formula for 50% and 50-75% search areas (see example).

5. Methods to determine variances and confidence intervals for total direct take are currently being developed by M. Huso (Huso pers. comm.). When such methods become available, Kawailoa Wind Power will evaluate their applicability to this project and use as appropriate to improve the estimated total direct take.

An example of using Huso (2010) to calculate the total direct take of a medium-sized bird (waterbird) for one season (Winter and Spring) is presented. For illustrative purposes, an observed take of three waterbirds within the 50% search area and one waterbird in the 50-75% search area is assumed. The theoretical search protocol is as follows:

Each turbines on site will be searched twice weekly to 50% turbine height (at a search interval or 3 to 4 days), and at an interval of 14 days out to 75% turbine height (see Appendix 7 for a detailed search protocol).

Example of Calculation of Direct Take Using Huso (2009) for Hawaiian Petrel in Summer

Main equation

$$\hat{m}_{ij} = \frac{c_{ij}}{\hat{r}_{ij}\hat{p}_{ij}\hat{e}_{ij}}$$

Eq 1

$$If \;\; f(x) = \lambda e^{-\lambda x}; \; S(x) = e^{-\lambda x}$$

Eq 2

$$d_{99} = \min(x : S(x) = 0.01, I), \;\; \hat{e} = \frac{d_{99}}{I}$$

Eq 3

$$\hat{\lambda} = 1/\bar{t};$$

Eq 4

$$\hat{r} = \frac{\int_0^{d_{99}} e^{-\lambda x} dx}{d_{99}} = \frac{(1 - e^{-\lambda d_{99}})}{\lambda d_{99}}$$

$\mathbf{m_{ij}}$	estimated mortality
$\mathbf{r_{ij}}$	estimated proportion of carcasses remaining after scavenging
$\mathbf{p_{ij}}$	estimated searcher efficiency
$\mathbf{c_{ij}}$	observed take
I	search interval
$\mathbf{e_{ij}}$	effective search interval
$\mathbf{d_{99}}$	days to 99% of carcasses removed
t	mean carcass retention time (scavengers)

Example of Calculating Direct Take Using Huso (2010) for Waterbirds in Winter and Spring

Search area	50% turbine height			50-75% turbine height	
Vegetation type	**bare ground**	**grass**	**unsearchable**	**grass**	**unsearchable**
Proportion	0.25	0.75	0.00	0.90	0.1
Waterbird Size (SEEF) likelihood of detection (p_{ij})	1.00	0.81		0.81	
Mean Carcass removal time (t) (days)	11	11		11	
No of carcasses (c_{ij})	1	2		1	
λ (Eq3)	0.09	0.09		0.09	
d_{99}	49.28	49.28		49.28	
I	4	4		14	
d_{99} (Eq 2 applied)	4	4		14	
e_{ij}	1	1		1	
Eq4					
λd_{99}	0.37	0.37		1.31	
r_{ij}	0.83	0.83		0.56	
m_{ij}	1.20	2.96		2.21	
total mortality	4.16			2.21	
total mortaity including unsearchable areas	4.16			2.43	
Total direct take for entire area	**6.59**				

References:

Huso M. 2008a. Estimators of wildlife fatality: a critical examination of methods in Proceedings of the NWCC Wind Wildlife Research Meeting VII. Milwaukee, WI October 28-29, 2008. Prepared for the Wildlife Workgroup of the National Wind Coordinating Collaborative by RESOLVE, Inc., Washington, DC, Susan Savitt Schwartz, ed. 116 pp...................................

Huso M. 2008b. Estimators of wildlife fatality: a critical examination of methods PowerPoint Presentation. Available at: http://www.nationalwind.org/pdf/HusoManuela.pdf

Huso M. 2010. An estimator of wildlife fatality from observed carcasses. Environmetrics, n/a. doi: 10.1002/env.1052

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual Report for the Maple Ridge Wind Power Project Postconstruction Bird and Bat Fatality Study – 2006. Final Report. Curry and Kerlinger, LLC.

Shoenfeld, P. 2004. Suggestions regarding avian mortality extrapolation. Prepared for the Mountaineer Wind Energy Center Technical Review Committee

Smallwood, K. S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:(8)2781–2791.

Appendix 10

BIOLOGICAL RESOURCES SURVEY

for the

FIRST WIND KAWAILOA WIND FARM PROJECT

MOUNT KA’ALA MICROWAVE COMMUNICATION FACILITIES

MOUNT KA’ALA, KAMANANUI, WAIALUA, O’AHU

Prepared by:
Robert W. Hobdy
Environmental Consultant

August, 2010

For: CH2M HILL

TABLE OF CONTENTS

	page
Introduction	3
Site Description	3
Biological History	3
Survey Objectives	4
Botanical Survey Report	4
Survey Methods	4
Description of the Vegetation	4
Native Plant List - Endemic & Indigenous	5
Discussion and Recommendations	6
Plant Species List	7-10
Fauna Survey Report	11
Survey Methods	11
Results	11
Discussion and Recommendations	12
Figure 1 - Map of Project area	13
Literature Cited	14

INTRODUCTION

The Mount Ka'ala Microwave Communication Facilities lie on two small parcels of land situated on adjacent ridge tops on the north slope of Mount Ka'ala about 5 miles southwest of Waialua Town, TMK 6-7-03:24 (portion). These sites are served by a paved road but are otherwise surrounded by steep forested lands within the Mokuleia Forest Reserve. This document summarizes the results of a biological study that was initiated by management in fulfillment of environmental requirements of the planning process.

SITE DESCRIPTION

Both sites which each have footprints of only about 0.1 acre presently have small structures that have been in place for several decades. The first site which is adjacent to the road at 3,600 feet elevation has a small building with an adjacent antenna. The second site lies about 0.25 mile down a separate ridge from the road and is connected to it by an existing set of old cement stairs. This site lies at about 3,200 feet elevation and has one old antenna dish on it. Both of these sites were formerly cleared and presently are vegetated with grasses, sedges and rushes. The surrounding slopes are densely forested with diverse native wet vegetation with an abundance of ferns. Soils are entirely of the Tropohumults-Dysdrandepts Association (rTP) which is a well-drained, acidic, reddish-brown silty clay that is typical of wet, steep, mountainous slopes, and is often underlain by a layer of precipitated ironstone (Foote et al, 1972). Rainfall averages between 75 inches and 90 inches per year with maximum amounts falling during the winter months (Armstrong, 1983).

BIOLOGICAL HISTORY

The upper slopes of Mount Ka'ala have always been one of Oahu's best examples of intact wet native forest. Numerous species of rare plants inhabit its steep terrain. The adjacent Mount Ka'ala Natural Area Reserve and the nearby Pähole Natural Area Reserve provide enhanced levels of protection from destructive ungulates such as pigs and goats. While many of the native plants that grow on the lower slopes of the Wai'anae Mountains have been heavily impacted and have suffered endangerment, those species that extend into the upper slopes are faring better.

The ridge where Site 2 is located has been a hiking trail (known as the Dupont Trail) for many years and as a result has a number of non-native weeds scattered along its length, but the slopes on either side of it are quite intact and nearly weed free. The slopes around Site 1 are likewise an example of beautiful native forest. With the current levels of protective management these upper forests are expected to thrive well into the future.

SURVEY OBJECTIVES

This report summarizes the findings of a flora and fauna survey of the proposed Mount Ka'ala Microwave Communication Facilities project which was conducted in July, 2010. 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 to assess each of these two sites. For each site the entire ridge top habitat was surveyed as well as a 30 foot buffer down slope on either side to capture any species that could be marginally impacted. Notes made on plant species, distribution and abundance as well as on terrain and substrate.

DESCRIPTION OF THE VEGETATION

The vegetation on the two small project sites is mostly low, non-native and open from previous clearing work, and has been maintained in this condition for over 30 years. It is dominated by species of grasses, sedges and rushes. These areas, however, are fringed by steep expanses of nearly pure native forests. These fringes were also surveyed out to distances of about 30 feet to assess the species makeup of this adjacent forest.

A total of 63 plant species were recorded during the survey with 30 species being non-native weeds and a couple ornamentals, and 33 native species. The non-native plants did not extend into the dense fringing native forest. Five plant species were found to be common on the two sites including uluhe (*Dicranopteris linearis*), narrow-leaved carpetgrass (*Axonopus fissifous*), 'öhi'a (*Metrosideros polymorpha* varieties *glaberrima* and *polymorpha*) and broad-leaved plantain (*Plantago major*).

A total of 22 native species are endemic to the Hawaiian islands:

'äkolea	*Athyrium microphyllum*
'ama'u	*Sadleria cyatheoides*
'ama'u	*Sadleria pallida*
häpu'u pulu	*Cibotium glaucum*
häpu'u 'i'i	*Cibotium menziesii*
uluhe lau nui	*Diplopterigium pinnatum*
pai	*Adenophorus hymenophylloides*
palai hinahina	*Hymenophyllum lanceolatum*
hoi kuahiwi	*Smilax melastomifolia*
olomea	*Perottetia sandwicensis*
'öhelo	*Vaccinium calycinum*
naupaka kuahiwi	*Scaevola mollis*
pü'ahanui	*Broussaisia arguta*
käpana	*Phyllostegia grandiflora*
kämakahala	*Labordia waiolani*
'öhi'a	*Metrosideros polymorpha var. glaberrima*
'öhi'a	*Metrosideros polymorpha var. polymorpha*
lehua 'ähihi	*Metrosideros tremuloides*
'ala'ala wai nui	*Peperomia macraeana*
pilo	*Coprosma longifolia*
manono	*Kadua affinis*
kükae moa	*Melicope clusiifolia*

An additional 11 species are indigenous to Hawaii as well as to other Pacific islands:

uluhe	*Dicranopteris linearis*
wawae 'iole	*Lycopodiella cernua*
päkahakaha	*Lepisorus thunbergianus*
-----------------	*Cyperus polystachyos*
'uki	*Machaerina angustifolia*
-----------------	*Carex meyenii*
'uki'uki	*Dianella sandwicensis*
'ie'ie	*Freycinetia arborea*
käwa'u	*Ilex anomala*
pükiawe	*Leptecophylla tameiameiae*
mäkole	*Coprosma granadensis*

All of these endemic and indigenous native species are relatively common, and all but three of them, the O’ahu endemics käpana, lehua ‘ähihi and the pilo are found on more than one island.

DISCUSSION AND RECOMMENDATIONS

The vegetation recorded in this survey can be segregated into two components in two ways. First they can be segregated into vegetation growing on the two cleared ridge top sites and the vegetation growing on the steep, forested, fringing slopes. Secondly the vegetation on the cleared ridge top sites can be characterized as being almost exclusively non-native while the vegetation on the steep, forested fringes can be characterized as being almost exclusively native in makeup.

The ridge top sites have been maintained in their cleared, open state for several decades and are dominated by low-statured, non-native grasses, sedges, rushes and other herbaceous species. The fringing forests have not been disturbed by previous construction activities associated with installation of the existing antennas and they are in excellent condition and retain a good diversity of species.

The existing antennas have small footprints within the ridge top clearings. The components of these antennas were airlifted into place, minimizing site disturbances. Plans for the proposed structures call for a similar method of deployment of components by helicopter. This should result in similar results with minimal site disturbances beyond the antenna footprints.

Access by personnel to facilitate construction work on site 2 will be on foot down the existing 0.25 mile long concrete stairway. This should minimize additional disturbance along this ridge line route.

No federally listed Threatened or Endangered plant species were encountered within the ridge top clearing or the fringing native forests, and none were encountered that are candidates for such status. None the less, the overall quality of the forests fringing these sites is excellent and every effort should be made to prevent collateral damage during installation. There is adequate space for such a low impact installation to safely occur and this should be a priority during the process.

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 three groups: Ferns, Monocots and Dicots. Taxonomy and nomenclature 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.

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			
ATHYRIACEAE (Lady Fern Family)			
Athyrium microphyllum (Sm.) Alston	'äkolea	endemic	rare
BLECHNACEAE (Chain Fern Family)			
Sadleria cyatheoides Kaulf.	'ama'u	endemic	rare
Sadleria pallida Hook. & Arn.	'ama'u	endemic	uncommon
DICKSONIACEAE (Tree Fern Family)			
Cibotium glaucum (Sm.) Hook. & Arn.	häpu'u pulu	endemic	uncommon
Cibotium menziesii Hook.	häpu'u 'i'i	endemic	uncommon
GLEICHENIACEAE (False Staghorn Fern Family)			
Dicranopteris linearis (Burm.f.) Underw.	uluhe	indigenous	common
Diplopterygium pinnatum (Kunze) Nakai	uluhe lau nui	endemic	uncommon
GRAMMITIDACEAE (Grammitis Fern Family)			
Adenophorus hymenophylloides (Kaulf.) Hook. & Grev.	pai	endemic	rare
HYMENOPHYLLACEAE (Filmy Fern Family)			
Hymenophyllum lanceolatum Hook. & Arn.	palai hinahina	endemic	rare
LYCOPODIACEAE (Club Moss Family)			
Lycopodiella cernua (L.) Pic. Serm.	wäwae'iole	indigenous	uncommon
POLYPODIACEAE (Polypody Fern Family)			
Lepisorus thunbergianus (Kaulf.) Ching	päkahakaha	indigenous	rare
THELYPTERIDACEAE (Marsh Fern Family)			
Christella parasitica (L.) H. Lev.	-------------------	non-native	rare
MONOCOTS			
CYPERACEAE (Sedge Family)			
Carex meyenii Nees	-------------------	indigenous	rare
Cyperus compressus L.	------------------	non-native	rare
Cyperus polystachyos Rottb.	------------------	indigenous	uncommon
Machaerina angustifolia (Gaud.) T. Koyama	'uki	indigenous	uncommon
HEMEROCALLIDACEAE (Day Lily Family)			
Dianella sandwicensis Hook. & Arn.	'uki'uki	indigenous	rare
JUNCACEAE (Rush Family)			
Juncus bufonius L.	toad rush	non-native	uncommon
Juncus effusus L.	Japanese mat rush	non-native	rare
Juncus planifolius R. Br.	-------------------	non-native	uncommon
ORCHIDACEAE (Orchid Family)			
Arundina graminifolia (D.Don)	bamboo orchid	non-native	rare
PANDANACEAE (Screwpine Family)			
Freycinetia arborea Gaud.	'ie'ie	indigenous	uncommon
POACEAE (Grass Family)			
Axonopus fissifolius (Raddi.) Kuhlm.	narrow-leaved carpetgrass	non-native	common

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Melinis minutiflora P. Beauv.	molasses grass	non-native	rare
Paspalum conjugatum Bergius	Hilo grass	non-native	uncommon
Paspalum urvillei Steud.	Vasey grass	non-native	uncommon
Pennisetum clandestinum Chiov.	Kikuyu grass	non-native	rare
Polypogon viridis (Gouvan) Breistr.	water bent	non-native	rare
Sacciolepis indica (L.) Chase	Glenwood grass	non-native	uncommon
Vulpia myuros (L.) C.C. Gmelin	rat-tail fescue	non-native	rare
SMILACACEAE (Catbrier Family)			
Smilax melastomifolia Sm.	hoi kuahiwi	endemic	rare
DICOTS			
AQUIFOLIACEAE (Holly Family)			
Ilex anomala Hook. & Arn.	kāwa'u	indigenous	rare
ASTERACEAE (Sunflower Family)			
Conyza bonariensis (L.) Cronq.	hairy horseweed	non-native	rare
Erigeron karvinskianus DC.	daisy fleabane	non-native	uncommon
Pluchea carolinensis (Jacq.) G. Don	sourbush	non-native	rare
Youngia japonica (L.) DC.	Oriental hawksbeard	non-native	rare
BALSAMINACEAE (Touch-me-not Family)			
Impatiens walleriana J.D. Hook.	impatiens	non-native	rare
BEGONIACEAE (Begonia Family)			rare
Begonia fuchsioides var. *miniata* (Planchon) A.de Candolle	dwarf fuschia-flowered begonia	non-native	rare
CARYOPHYLLACEAE (Pink Family)			
Cerastium fontanum Baumg.	common mouse-ear chickweed	non-native	uncommon
CELASTRACEAE (Bittersweet Family)			
Perottetia sandwicensis A. Gray	olomea	endemic	rare
ERICACEAE (Heath Family)			
Leptecophylla tameiameiae (Cham. & Schlectend) C.M.Weiller	pukiawe	indigenous	uncommon
Vaccinium calycinum Sm.	'ōhelo	endemic	uncommon
GOODENIACEAE (Goodenia Family)			
Scaevola mollis Hook. & Arn.	naupaka kuahiwi	endemic	uncommon
HYDRANGIACEAE (Hydrangia Family)			
Broussaisia arguta Gaud.	pü'ahanui	endemic	uncommon
HYPERICACEAE (St. John's Wort Family)			
Hypericum mutilum L.	St. John's wort	non-native	rare
LAMIACEAE (Mint Family)			
Phyllostegia grandiflora (Gaud.) Benth.	käpana	endemic	uncommon
LOGANIACEAE (Logania Family)			
Labordia waiolani Wawra	kämakahala	endemic	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D.Don	Koster's curse	non-native	rare
MYRTACEAE (Myrtle Family)			
Metrosideros polymorpha Gaud. var. *glaberrina* (H. Lev.) St. John	'öhi'a	endemic	common
Metrosideros polymorpha Gaud. var. *polymorpha*	'öhi'a	endemic	common
Metrosideros tremuloides (A. Heller) Kunth	lehua 'ähihi	endemic	uncommon
Psidium cattleianum Sabine	strawberry guava	non-native	rare
PIPERACEAE (Pepper Family)			
Peperomia macraeana C. DC.	'ala'ala wai nui	endemic	rare
PLANTAGINACEAE (Plantain Family)			
Plantago lanceolata L.	narrow-leaved plantain	non-native	uncommon
Plantago major L.	broad-leaved plantain	non-native	common
ROSACEAE (Rose Family)			
Rubus argutus Link	prickly Florida blackberry	non-native	uncommon
Rubus rosifolius Sm.	thimbleberry	non-native	rare
RUBIACEAE (Coffee Family)			
Coprosma granadensis (L.f.) Heads	mäkole	indigenous	rare
Coprosma longifolia A. Gray	pilo	endemic	rare
Kadua affinis DC.	manono	endemic	rare
RUTACEAE (Rue Family)			
Melicope clusiifolia (A.Gray) T.G.Hartley & B.C.Stone	kükaemoa	endemic	rare
SCROPHULARIACEAE (Snapdragon Family)			
Buddleia asiatica Lour.	dog tail	non-native	rare
VERBENACEAE (Verbena Family)			
Verbena littoralis Kunth	öwī	non-native	uncommon

FAUNA SURVEY REPORT

SURVEY METHODS

A walk-through survey method was used in conjunction with the botanical survey. All parts of the two small sites were covered. Field observations were made with the aid of 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. It was not possible to conduct an evening survey for the Hawaiian hoary bat (*Lasiurus cinereus semotus*) because of military security restrictions to access at this time of day.

RESULTS

MAMMALS

No mammals or their signs were observed on either of these two small sites during the survey.

The habitat is the type often frequented by pigs but no sign of pig activity was observed. Also expected within this habitat are mice and rats which feed on seeds, fruits and herbaceous vegetation, as well as a few feral cats and mongoose which hunt for these rodents and birds.

While not surveyed for, the Hawaiian hoary bat could possibly visit this forested habitat at least seasonally. These bats are thought to be rare on O'ahu, but recent detections have been made in rural and forested parts of the island indicating that at least a moderate population may be present. Mount Ka'ala would appear to provide good habitat for these Endangered bats.

BIRDS

Avian diversity and numbers appeared to be rather sparse in this cloud forest habitat, although the survey was limited to a single day due to access restrictions. Just four species of non-native birds were observed or heard. That even the O'ahu ‘amakihi and the ‘apapane were not seen or heard was surprising, given the good quality of the forest. Taxonomy and nomenclature follow American Ornithologists' Union (2010).

COMMON NAME	SCIENTIFIC NAME	STATUS	ABUNDANCE
Japanese bush-warbler	*Cettia diphone*	non-native	uncommon
Red-vented bulbul	*Pycnonotus cafer*	non-native	rare
Japanese white-eye	*Zosterops japonicus*	non-native	rare
House finch	*Carpodacus mexicanus*	non-native	rare

Unquestionably native forest birds still frequent this pristine native forest. Most likely to be seen would be the O'ahu ‘amakihi (*Hemignathus flavus*) and the ‘apapane (*Himantione sanguinea*). Rarer of occurrence would be the O'ahu ‘elepaio (*Chasiempis ibidis*) and the ‘i'iwi (*Vestiaria coccinea*). A non-native bird that also would occur here is the red-billed leiothrix (*Leiothrix lutea*) which is common in O'ahu wet forests.

No sightings or signs of any native seabirds such as the Newell's shearwater *(Puffinus newelli*) were detected in this area, although the open ridgetop habitat around site 2 would seem to be suitable for these birds.

INSECTS

Insects in general were not tallied but there are a few Endangered species of *Drosophila* fruit flies and a few Candidate species of *Megalagrion* damsel flies listed on O'ahu that were looked for. None were observed. *Drosophila* species feed on decomposing vegetation and other plant exudates, and one O'ahu damselfly (*Megalagrion koelense*) is known to breed in the wet axils of the 'ie'ie vine (*Freycinetia arborea*). None of these activities were seen. The small sites involved in this survey provided a very limited search area. The large expanse of intact native forest surrounding these sites undoubtedly harbors some of the above organisms as well as other native insects and their associations.

SNAILS

A total of 41 species of *Achatinella* snails are known from O'ahu. All of these are on the Endangered list. Those known from the Waianae Range are restricted to lower elevations in mesic forests. No *achatinella* were seen during the survey. A few of the more common *Succinea* snails were seen on manono plants (*Kadua affinis*) in the edges of the fringing forest.

DISCUSSION AND RECOMMENDATIONS

Most of the wildlife observed on and around both of the two small sites associated with this project was non-native in Hawaii. Only one relatively common native snail of the genus *Succinea* was recorded. This is due not only to the small size of the two sites, but to the fact that they have been cleared of native vegetation a long time ago and have been maintained in this state. Four species of non-native birds were seen but no native mammals or insects were found. Thus there were no federally listed Endangered or Threatened species present.

The high quality of the surrounding native forests and their obviously valuable potential for providing habitat for an array of native wildlife organisms is, however, striking and is deserving of great care and protection.

It is recommended that an installation plan be created to ensure that materials and antenna components to be airlifted into each site be deposited well within the cleared areas, and that construction work be done so that the fringing forests are not damaged.

The two antennas proposed for installation will have concrete footings, steel lattice towers and 8 foot diameter parabolic dish antennas. The site 1 tower will be 40 feet tall and will clear the forest canopy by about 10 feet. The site 2 tower will be 20 feet tall and will clear the forest canopy by less than 10 feet. No guy wires will be used. Both antennas will be clearly visible and should not pose significant strike hazards for seabirds, forest birds or bats.

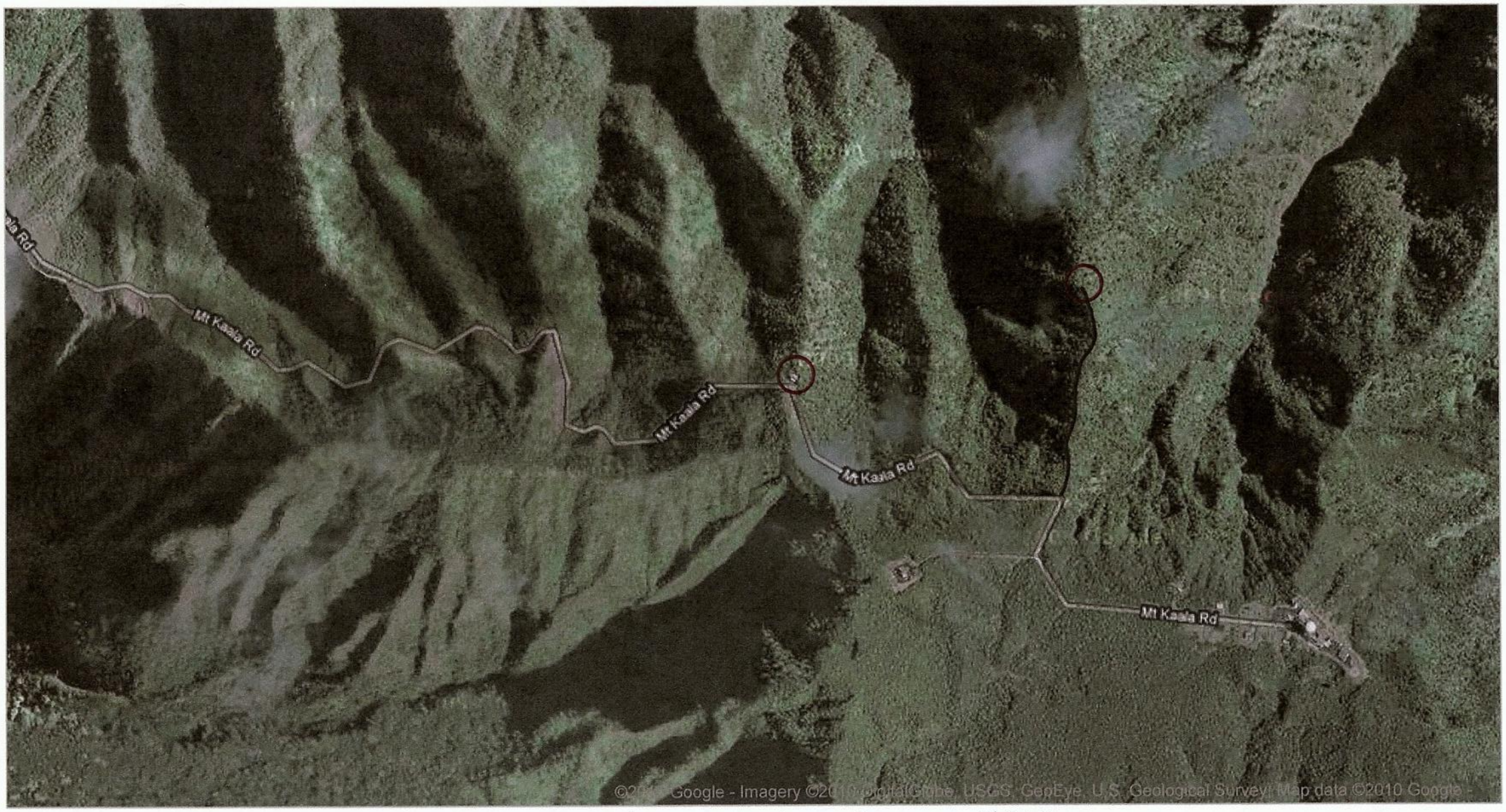


Figure 1. Mount Ka'ala Microwave Communication Facilities

Site 1 - situated adjacent to Mount Ka'ala Road

Site 2 - Situated 0.25 mi. down ridge via concrete stairway

Literature Cited

American Ornithologists' Union 2010. 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.

U.S. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and Plants. 50 CFR 17.11 & 17.12 (update of 1999 lists).

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 11

Downed Wildlife Protocol

Kawailoa Wind Power

Habitat Conservation Plan

Purpose	To identify and document any wildlife injury or fatality incident that involves Covered and MBTA Species at the Kawailoa Wind Power site incidental to and during regular monitoring.
Applicability	This protocol applies to all employees of Kawailoa Wind Power and its affiliates, and extends to all consultants, contractors, or other personnel who work on the site.
Covered Species	Covered Species include the federally *endangered* Hawaiian Petrel, Hawaiian Stilt, Hawaiian Moorhen, Hawaiian Coot, Hawaiian Duck or hybrids, Hawaiian Hoary Bat, state *endangered* Hawaiian short-eared owl, and the federally *threatened* Newell's Shearwater. MBTA species include all species covered under the provisions of the federal Migratory Bird Treaty Act.
Overall Approach	Downed wildlife may be located during the course of regular monitoring or opportunistically during routine site work. In addition to the project's monitoring program, which is a component of the project's Habitat Conservation Plan, project consultants and personnel will routinely look for and exhibit awareness of the potential to encounter downed wildlife when working at individual turbine sites, when traveling along site roads by vehicle, and when traveling the site on foot. Should any downed wildlife be found or reported, the responsible party (Senior Wildlife Biologist, Site Compliance Officer, or their official designee) shall contact Oahu DLNR Forestry and Wildlife Division immediately to initiate response coordination: (Oahu Wildlife Program Manager) at 808-973-9786, 808-295-5896. . A written report that provides documentation and details of the incident will be submitted to DLNR/DOFAW and USFWS within 5 business days following the incident. All downed wildlife will be left in place until agency personnel arrive or unless directed by USFWS or DLNR personnel. Injured wildlife may require, if instructed directly by DLNR or USFWS, that the responsible party transport the downed individual in an appropriate container (e.g. ventilated pet carrier) either to a qualified veterinarian or other facility specified by DLNR or USFWS, as described below, as soon as possible and appropriate (e.g., if the individual is alive, it shall be transported immediately). The responsible party will also complete a Downed Wildlife Monitoring Form and an official Incident Report will be submitted to DLNR and USFWS within 5 business days following the incident.
Facility Information	TBD Phone:
Kawailoa Wind Power Contact Information	Gregory Spencer, Senior Wildlife Biologist Phone: (808) 298-5097

Kawailoa Wind Power, LLC

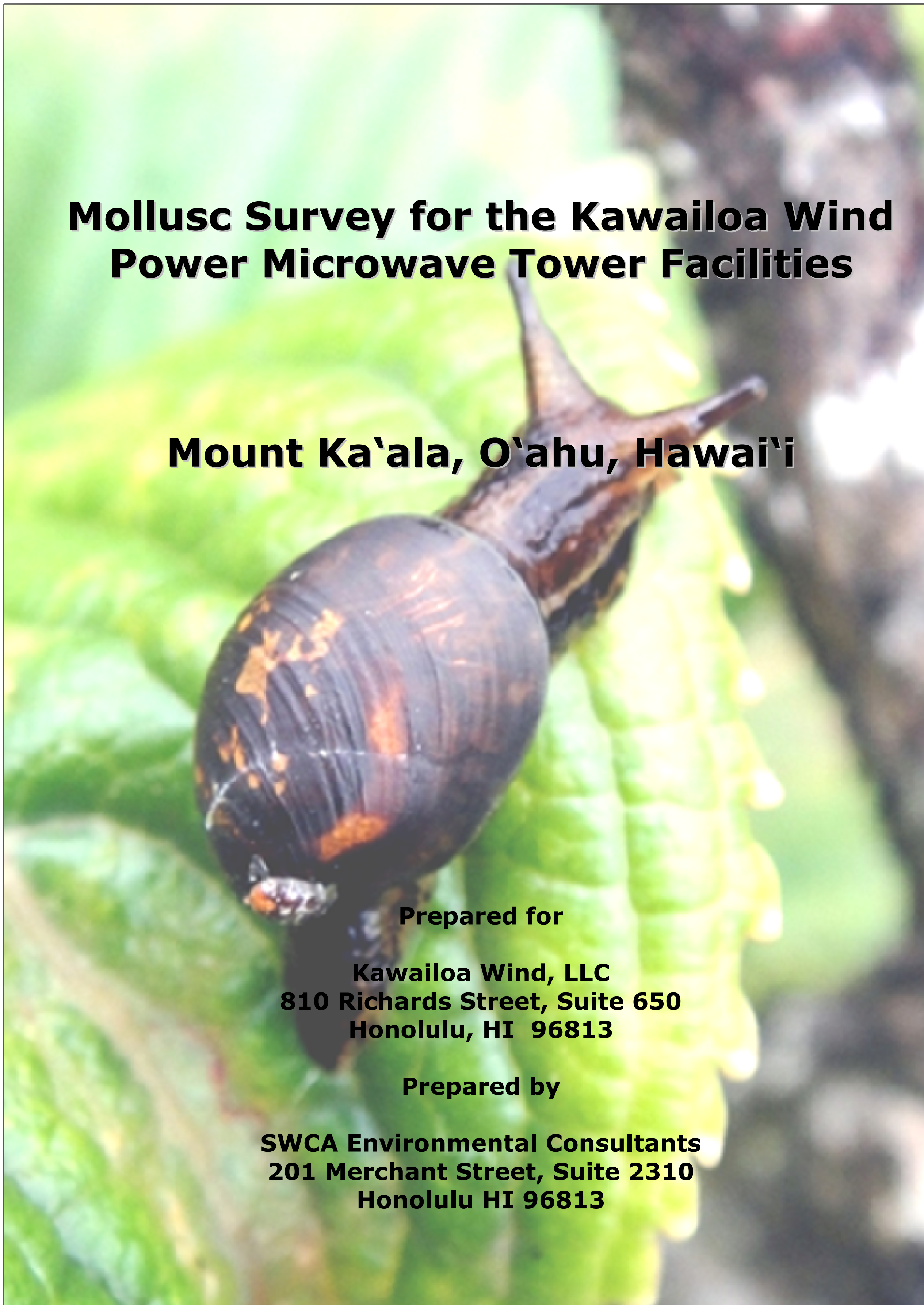
Habitat Conservation Plan – Downed Wildlife Incident Documentation Form

SAMPLE

Observer Name:	
Date:	
Species (common name):	
Time Observed (HST):	
Time Initially Reported (HST):	
Time Responders Arrive (HST):	
Location:	
GPS Coordinates (specify units and datum):	
Date Last Surveyed:	
Distance to Base of nearest WTG:	
Bearing from Base of nearest WTG:	
Ground Cover Type:	
Wind Direction and Speed (mph):	
Cloud Cover (%):	
Cloud Deck (magl):	
Precipitation:	
Temperature (^{o}F):	

Condition of Specimen:
Probable Cause of Injuries and Supportive Evidence:
Action Taken:

Appendix 12



Mollusc Survey for the Kawailoa Wind Power Microwave Tower Facilities

Mount Ka‘ala, O‘ahu, Hawai‘i

Prepared for

Kawailoa Wind, LLC
810 Richards Street, Suite 650
Honolulu, HI 96813

Prepared by

SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu HI 96813

Introduction

SWCA Environmental Consultants (SWCA) was tasked by First Wind to conduct a terrestrial mollusc survey at two potential microwave tower sites on Mount Kaʻala, Oʻahu, Hawaiʻi (Figure 1). The survey was prepared in support of the Federal Environmental Assessment (EA) and Habitat Conservation Plan (HCP) and State Environmental Impact Statement (EIS) being drafted for the proposed Kawailoa Wind Power project.

The study sites are located at Mount Kaʻala within the northern portion of the Waiʻanae Mountain Range. The Hawaiian Telcom site is located at roughly 1,120 m (3,675 ft) elevation along Mt Kaʻala Road. A building and antenna exist at the site and the triangular shaped area is partially enclosed by a low fence. The Repeater Station site, located at roughly 1,150 m (3,773 ft) elevation, is accessed via a 0.4 km (0.25 mile) long trail off Mt Kaʻala Road. This site contains two small microwave towers and an old shed. Each site is approximately 400 sq m (0.1 ac) in area and relatively flat. Both sites are within the Mokuleia State Forest Reserve and the Repeater Station is immediately adjacent to the Kaʻala Natural Area Reserve.

The vegetation at the two study sites has been previously cleared and continuously maintained. Both sites are dominated by non-native grasses and sedges. However, the adjacent steep slopes are mostly covered in plants native to the Hawaiian Islands (Hobdy 2010). Several species of rare terrestrial molluscs have been documented in the area, including federally listed endangered species (DOFAW 1990).

The objectives of the survey were to:

1. Identify and document the presence and relative abundance of terrestrial molluscs within the survey areas;
2. Provide a general description of habitats for molluscs found within the survey areas;
3. Identify any State or Federally listed candidate, threatened, or endangered molluscs, species of concern and/ or rare (either locally or State-wide) species found or known to occur within the survey areas.

Methods

All field work was conducted on August 14, 2010. A single transect was placed in each 400 sq m site, extending 10 m (33 ft) beyond the sites at both ends. The transect lengths at the Hawaiian Telcom and Repeater Station sites were approximately 25 m and 35 m (82 and 115 ft), respectively. Visual searches were conducted by two biologists at regular intervals every 5 m (~ 2.5 m radius) along each transect for 5-10 minutes each. Searched areas included all available snail habitats (*e.g.* leaf litter, shrubs and low lying vegetation, and trees). Additionally, incidental observations were also recorded along the trail to the Repeater Station site, approximately 50 m (164 ft) from the site. The purpose of these observations was to compare mollusc diversity at the Repeater Station site to that along the native plant dominated trail.

An indication of the relative abundance of each species, expressed in terms of the number of individuals found per search effort (one-man hour), was defined according to the following:

Rare	0-1 individuals
Uncommon	2-5 individuals
Common	5-10 individuals
Abundant	10-15 individuals
Highly Abundant	More than 15 individuals

All molluscs encountered were collected and identified to the lowest level in the field. Native species were recorded with digital images and returned to the habitats in which they were found. All non-native snails and slugs were retained and preserved as vouchers. No Federally listed species (*i.e.* subfamily Achatinellinae) were collected or harassed, as none were encountered in these locations. All sites were mapped using GPS.

Results

A list of species recorded at each site along with their relative abundances is given in Table 1. Additionally, the general description of habitat types for each species found is given in Table 2. No State or Federally listed candidate, threatened, or endangered molluscs or species of concern were found or are known to occur within the survey area. However, one of the endemic species found during the survey, *Kaala subrutila*, may be assessed for candidate species listing in the near future (C. King, DOFAW, personal communication). Snails in the family Achatinellidae are widely distributed throughout the Pacific Islands; however, they are most diverse in Hawaiʻi. Most of the snails observed could not be identified to the species level, and genetic testing would be required to reach a positive identification. Therefore, with the exception of *K. subrutila*, SWCA cannot positively say that the others found are indeed endemic.

The majority of the native snail diversity was found on native plants along the edges of each site. The most abundant native taxa observed during the survey were *Succinea* spp. Only two non-native mollusc species (*Oxychilus alliarius and Deroceras laeve*) were found during the survey. These two species were found primarily in areas disturbed previously by construction activities. *Oxychilus alliarius* is known to feed on other molluscs and represents a potential ecological threat to native molluscs at Mt. Kaʻala. The invasive slug *Deroceras laeve* competes with other molluscs and is also considered a treat to native ecosystems in Hawaiʻi.

<u>Hawaiian Telcom Station site</u>: The area surrounding this installation has been cleared previously by construction activity and the only snail species found in the immediate area was the non-native *Oxychilus alliarius*. The other snail species found at this site was *Succinea* sp*.* However, this native snail was found only along the edges of this area outside of the green fence, where the vegetation is primarily native.

<u>Repeater Station site</u>: The 3 m (10 ft) study radius surrounding the towers and shack contained primarily native mollusc species, most of which were common in the area. The predatory snail *Oxychilus alliarius* was observed at the trailhead; however, there was no evidence of the species on the trail toward the site. This snail is most likely spread via equipment and supplies transported to and from sites. The endemic snail *Kaala subrutila*, while not found at the Repeater Station site, may occur at or near the site as it was documented along the trail at 50 m to the Repeater Station.

Recommendations

Prior to entry and exit to each site, boots and equipment should be cleaned to prevent the spread of non-native species to and from sites. In particular, care should be taken to not advance the spread of the predatory snail *Oxychilus alliarius* from the trailhead to areas with high native snail diversity along the Repeater Station trail and adjacent slopes. If equipment is placed on the ground at any point, particularly along the trail to the Repeater Station, the equipment needs to be rechecked for any non-native molluscs (hitchhikers).

<u>Hawaiian Telcom Station site</u>: Due to the abundance of the predatory snail *Oxychilus alliarius* at the site, if vegetation is cleared, all the cleared vegetation should be left at the site and not removed to prevent the spread of non-native species.

<u>Repeater Station site</u>: As native mollusc species are dominant at the site, the footprint of any construction at the site should be as small as possible. If vegetation clearing is required, hand clearing of vegetation is recommended and cut plants should be placed near adjacent vegetation of similar species to enable the snails to move on to new plants. Leaf litter should be collected before the area is graded and distributed to the surrounding area. If a large amount of vegetation is cleared, it may be helpful to have a biologist on-site to monitor the vegetation clearing and placement of cut vegetation and leaf litter. Additionally, personnel should stay on the trail leading to the Repeater Station site to prevent accidental trampling of the endemic *Kaala subrutila* present in the leaf litter.

Literature Cited

DOFAW (Department of Land & Natural Resources), State of Hawaii. 1990. Mount Kaala Natural Area Reserve Management Plan.

Hobdy, R.W. 2010. Biological Resources Survey for the First Wind Kawailoa Wind Farm Project, Mount Kaʻala Microwave Communications Facilities, Mount Kaʻala, Kamananui, Waialua, Oahu. Prepared for CH2MHill.

King, Cynthia. DOFAW, State of Hawaii Entomologist, personal communication.

Table 1: List of species recorded at each location along the transect in each site.

Location	Coordinates	Elevation	Family	Species found	Native?	Relative Abundance
Hawaii Telcom Station	N 21.30.658 W 158.08.958	1120 m ± 2 m	Zonitidae	*Oxychilus alliarius*	No	abundant
			Succineidae	*Succinea* spp.	Yes	highly abundant
Repeater Station	N 21.30.749 W 158.08.726	1150 m ± 3 m	Succineidae	*Succinea* spp.	Yes	highly abundant
			Succineidae	*Catinella rotundata*	Yes	abundant
			Succineidae	*Catinella* sp.	Yes	common
			Agriolimacidae	*Deroceras laeve*	No	rare
			Achatinellidae	Tornatellininae spp.	Yes	common
			Achatinellidae	Pacificellinae spp.	Yes	common
			Achatinellidae	Auriculellinae spp.	Yes	common
			Achatinellidae	Tornatellidinae spp.	Yes	abundant
~50 m before Repeater Station (on trail)	N 21.30.720 W158.08.723	1167 m ± 2 m	Succineidae	*Succinea* spp.	Yes	highly abundant
			Succineidae	*Catinella rotundata*	Yes	abundant
			Achatinellidae	Tornatellininae spp.	Yes	abundant
			Achatinellidae	Tornatellidinae spp.	Yes	abundant
			Helicarionidae	*Philonesia* spp.	Yes	rare
			Helicarionidae	*Kaala subrutila*	Yes	rare

Table 2. List of habitat recorded for each species.

Family	Species	Habitat	Habitat Example
Achatinellidae	Auriculellinae spp.	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia*
Achatinellidae	Pacificellinae spp.	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia*
Achatinellidae	Tornatellidinae spp.	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia, Machaerina angustifolia*
Achatinellidae	Tornatellininae spp.	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia*
Agriolimacidae	*Deroceras laeve*	Leaf litter only	Soil, under rocks/leaves/dead branches
Helicarionidae	*Kaala subrutila*	primarily leaf litter; also found on low lying vegetation	Soil, under rocks/leaves/dead branches, *Freycinetia arborea*
Helicarionidae	*Philonesia* spp.	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia*
Succineidae	*Catinella rotundata*	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia*
Succineidae	*Catinella* sp.	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia*
Succineidae	*Succinea* spp.	Low lying vegetation and shrubs	*Freycinetia arborea, Metrosideros polymorpha, Cibotium* spp, *Broussaisia arguta, Melicope clusiifolia, Machaerina angustifolia*
Zonitidae	*Oxychilus alliarius*	Primarily leaf litter; also found on low lying vegetation	Grass, soil, *Freycinetia arborea*

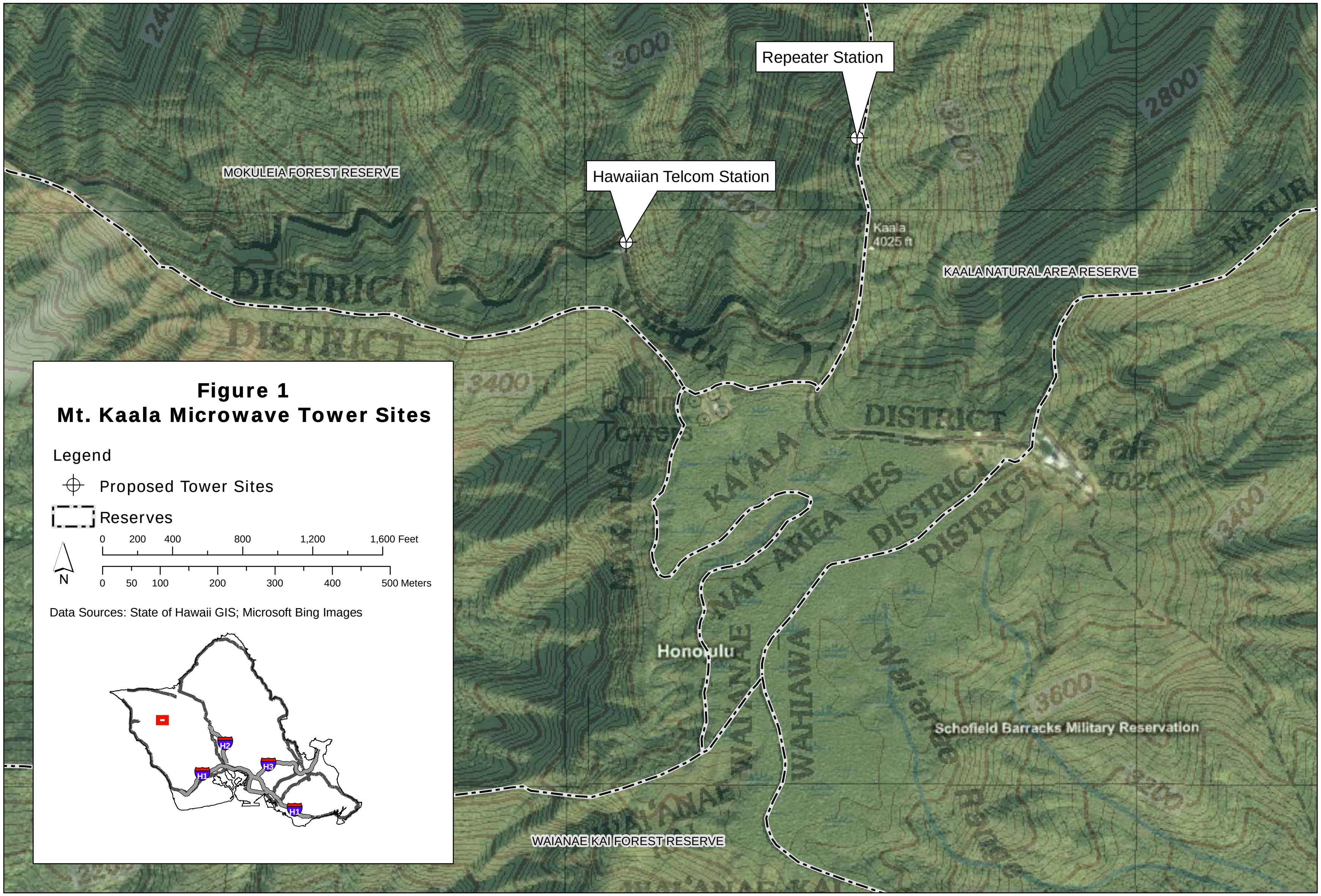


Figure 1
Mt. Kaala Microwave Tower Sites
Legend
Proposed Tower Sites
Reserves
0 200 400 800 1,200 1,600 Feet
0 50 100 200 300 400 500 Meters
N
Data Sources: State of Hawaii GIS; Microsoft Bing Images
Repeater Station
Hawaiian Telcom Station
MOKULEIA FOREST RESERVE
KAALA NATURAL AREA RESERVE
WAIANAE KAI FOREST RESERVE
Schofield Barracks Military Reservation
Kaala
4025 ft
Honolulu
DISTRICT
WAHIAWA
WAIANAE
H1
H2
H3

Appendix 13

Species	Annual commitment	Time of payment/Execution	Length of commitment	Purpose	Relevant HCP text
Seabirds					
	$130,000	prior to commercial operation date (COD)	one time	development of cat trap design	For Tier 1, mitigation measures will support the development of improved traps for predators and in subsequent utilization at a Newell's shearwater colony on Kauaʻi or Maui……The study will be designed by Goodnature Limited and Kawailoa Wind Power will be responsible for the implementation of the study by the first Newell's shearwater breeding season after the trap becomes commercially available.
	$50,000	after cat trap development	one time	pilot study of cat trap	
Waterbirds					
	$77,000	prior to COD	one-time	fencing of Ukoa pond	• A one-time contribution of $77,000 towards the construction of a fence around the 40 ac unit (Year 1);
	$30,000	prior to COD	one-time	relevant permitting for fencing	• $30,000 for costs associated with permitting for fence construction (Year 1);
	$27,500	by June 1 after Year 1	4 years	predator trapping	• $110,000 for four years of predator trapping and ungulate removal by a qualified contractor or personnel approved by USFWS and DLNR (Year 2 to 5);
	$16,000	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	5 years	monitoring	• $80,000 for five years for monitoring of the management effort (Year 1 to 5);
	$30,000	by June 1 after Year 1	4 years	weed control	• $120,000 for four years of weed control (Year 2 to 5) and
	$42,500	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	2 years	vegetation removal	• $85,000 for vegetation removal in the first two years;
	$75,000	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year		replanting	• $150,000 for replanting of native flora in the first two years;
	$7,500	by June 1 after Year 1	4 years	fence maintenance	• $30,000 for four years of fence maintenance (Year 2 to 5);
	$2,000-$12,000	as needed	5 years	biological oversight	• $24,000 for the biological oversight of third-party contractor work if necessary
Short-eared Owl					
	$12,500	prior to COD	one-time	research or rehabilitation	Prior to the start of operations, Kawailoa Wind Power will contribute a total of $12,500 to appropriate programs or facilities for research or rehabilitation of owls.
	$25,000	within 5 years of COD	one-time	management	When practicable management actions that will aid in the recovery of Hawaiian short-eared owl populations are identified on Oʻahu, Kawailoa Wind Power will provide additional funding of $12,500 up to a maximum of $25,000 to implement a chosen management measure as agreed upon by USFWS and DLNR.

Hawaiian Hoary Bat	$17,500	by June 1 for each year starting in Year 2	4 years	predator control	Removal of the ungulates within the restored and forested area.
Alternative 1	$8,000	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	5 years	monitoring	the management measures outlined in Section 7.4.1 for waterbirds (fencing, trapping, vegetation maintenance and monitoring) will correspondingly be increased to ensure that the entire restored area is also managed for waterbirds.
	$100,000	prior to COD	one time	fencing	Fencing of the restored wetland and forested area.
	$5,000	by June 1 for each year starting in Year 2	4 years	fence maintenance	the management measures outlined in Section 7.4.1 for waterbirds (fencing, trapping, vegetation maintenance and monitoring) will correspondingly be increased to ensure that the entire restored area is also managed for waterbirds.
	$42,500	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	2 years	vegetation removal	Removal of invasive vegetation to re-create bodies of open water
	$40,000	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	3 years	weed control	Control and removal of alien vegetation in the wetland interior to allow for the natural recruitment of native species that are already present.
	$100,000	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	2 years	alien tree removal	Managing 40 ac. of trees around the periphery of the pond by the selective removal of alien trees and replanting to provide night roosts and potentially day roosts.
	$75,000	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	2 years	replanting	Suitable areas will replanted with native vegetation if necessary.
	$2,000-$12,000	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	5 years	biological oversight	the management measures outlined in Section 7.4.1 for waterbirds (fencing, trapping, vegetation maintenance and monitoring) will correspondingly be increased to ensure that the entire restored area is also managed for waterbirds.
	in-house or $30,000	The first annual payment is paid before COD, subsequent yearly funding is provided by June 1 of each year (to be combined with in-house monitoring - see below)	first 3 years then year 5, 11 and 15	research	Bat activity, mist-netting and visual surveys will continue for three years post-restoration, and at subsequent five-year intervals.
Alternative 2	variable	The first annual payment is paid before COD , subsequent yearly funding is provided by June 1 of each year	up to 20 years	forest restoration	Alternatively, if wetland restoration is not selected, then Kawailoa Wind Power proposes to restore forest habitat to increase habitat available to bats. Based on the current recommendations of USFWS and DOFAW, 400 ac. of native forest will restored, and restoration measures will include fencing, ungulate control, removal of invasive species and replanting of native species.
On-site monitoring (regardless of alternative chosen)	in-house		Years 0,1 and 2, 5, 10, 15	survey for bats within and in the vicinity of Kawailoa Wind Power	The Applicant will continue to survey for and monitor Hawaiian hoary bats within and in the vicinity of the Kawailoa Wind Power site. 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. These on-site surveys are also expected to advance avoidance and minimization strategies that wind facilities in Hawai'i and elsewhere can employ in the future to reduce bat fatalities.

Appendix 14

O'FARRELL BIOLOGICAL CONSULTING

13 June 2011

Ling Ong
SWCA Environmental Consultants
201 Merchant Street, Suite 2310
Honolulu, Hawaii 96813

RE: Bat Mitigation for Kawailoa

Dear Ms. Ong:

Per your request, I am providing my best biological evaluation concerning proposed mitigation strategies for the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus,* associated with a proposed wind energy facility at Kawailoa. I understand that the currently proposed mitigation provides a tiered approach incorporating habitat conservation and enhancement, a research component, and adaptive management. There are two major limiting factors for hoary bats: 1) adequate available roost sites, and 2) suitable foraging space. The hoary bat is an obligate tree-roosting species that utilizes foliage rather than cavities, fissures, or exfoliating bark that other bats use, which presents a much wider range of accessible roost sites. The abundance of trees in Hawaii would suggest that availability of roost sites is not a primary limiting factor. Past acoustic monitoring indicates diffuse and sporadic occurrence of hoary bats throughout the project site with little evidence of any attractant feature that would result in concentration of bat activity. I believe that habitat enhancement would provide the necessary foraging patches that would result in increased usage and contribute to the growth of the local population.

Ukoa pond is an approximately 170-acre wetland southwest of the project site and is being proposed for habitat restoration as Tier 1 mitigation. Currently it is dominated by invasive weedy species that compromise the usage by waterfowl and bats. Mitigation for waterfowl calls for initial restoration of 40 acres, which would be ideal for the experimental evaluation of the benefits to bats. I would suggest that the most efficacious approach would be to use acoustic monitoring. Being highly mobile and flying at night, bats present a significant challenge. Night vision or infrared camera monitoring would only allow the examination of a minute volume of space actually being used by bats and would not allow identification of individuals but would allow determination of how many individuals were present simultaneously within the sampling volume. Radiotelemetry would allow identification of individuals and the ability to follow marked individuals over the lifetime of the battery, usually less than 2 weeks. However, radiotracking does not provide information on the presence of unmarked bats and is limited by a variety of

7320 HEGGIE AVENUE. • LAS VEGAS, NV • 89131
PHONE: (702) 658-5222 • FAX: (702) 645-5688 E-MAIL: mike@mammalogist.org

physical factors that may affect continuous detection of the signal; further, a 2-week examination of few individuals does not provide an unrestricted, non-invasive examination of the dynamics of space use through an annual cycle. Acoustic monitoring cannot identify individuals or exact numbers of individuals present but does allow examination of a larger sampling volume than visual methods and can be used to sample multiple locations simultaneously for true comparisons of spatial usage.

Ukoa pond is large enough to allow a meaningful evaluation of the effects of habitat restoration. As I understand the current conditions at the pond, open water surface is lacking having been supplanted by invasive weedy species. Removal of this vegetation will allow the return of native emergent vegetation around the periphery of open water thus creating edge habitat rich in foraging potential. Restoration of edge habitat should provide a sufficient foraging base to increase the carrying capacity of the local area. Permanent acoustic monitoring stations designed to record bat activity all night every night would sample representative sites within the 40-acre treatment area and the adjacent 130 acres not to be treated. Sampling would be accomplished at all sites prior to treatment. Post-treatment sampling would then provide a quantitative basis for assessing the effects of treatment with the untreated acreage serving as control sites. The baseline metric for bat activity would be the number of minutes of activity at each site. The selection of 40 acres for the treatment site is based on the waterfowl mitigation proposal. It should be of sufficient size to adequately assess the effects of treatment but increasing it to 80 acres would result in treatment and control areas of relatively equal size and provide a greater number of sampling locations. Ideally, a full year of acoustic monitoring could be accomplished before habitat treatment occurs. Then the same locations should be monitored for 2 years post-treatment.

Measuring success is somewhat arbitrary with acoustic data, however I would argue so would assigning a number of individuals. Simply knowing that a certain number of individuals have been recorded for a site does not provide any relevant biological information. For example, are each of the individual bats observed resident on the site, is it transient only, does it use the area for foraging? However, even the questions are vague and uncertain. To be a resident does the individual need to have its roosting and foraging activities contained within the site? For bats in general and for a known migratory species capable of long-range movements, it would be simplistic to believe that a finite area of a 10's to 100's of acres would be adequate for an individual throughout its annual cycle. We know that many bats utilize multiple roost sites within a geographic region and change among these either nightly or within short periods of time. It is also common for bats to use multiple foraging areas throughout a night and alter these through time as the availability of insects change. Some migratory species, such as Brazilian free-tailed bats (*Tadarida brasiliensis*), are know to travel in excess of 40 miles one way in a single night to visit foraging grounds. Therefore, it is valid and desirable to assign a measure of success that is readily measurable and that has biological significance. I put forward the assumption that the longer a group of bats utilize an area for foraging the more relevance that habitat has for the long-term benefit for the bats of that geographic area. Based upon numerous long-term acoustic monitoring studies that I have conducted throughout western North America, encountering a doubling of activity (# minutes/month) indicate meaningful changes in the number of individuals present and suggest a concomitant change in foraging resources. For the current proposed study, I would expect the amount of activity to more than double for the restored habitat and would suggest that exceeding a five fold increase in activity levels would signify success in offsetting the take of a single individual per year from the operational facility activities.

If wetland habitat restoration was not successful, then forest restoration (170 acres) has been proposed. Although I agree that creation of more forestlands would be desirable and potentially beneficial for the hoary bat, simply creating forest would not be expected to significantly increase the population in order to mitigate for take losses. It has been recognized for almost 20 years that tracts of forest tend to be relatively devoid of bats. The presence of trees does not equate to presence of adequate foraging and roosting habitat. Bats tend to filter through tracts of forest in small numbers but will congregate in forest openings and along forest roadways. The edge habitat created by roads and openings presents rich foraging areas and are critical for sustained use by bats. Rather than creating a patch of forest over the span of several decades, I would argue that determining the optimal ratio of edge to forest would be of greater benefit to the species and should adequately mitigate for the proposed take. Application of such data would add significant habitat enhancement to existing blocks of forest as well as for creating new habitat and would result in building a more robust population throughout its range.

I would propose that a large block of existing forest be selected that would allow establishment of acoustic monitoring stations throughout. Once a baseline of bat use has been established, then a portion of the forest can be subjected to establishment of roads. The amount of road edge can be added incrementally to evaluate varying ratios of edge to forest. Simultaneous monitoring of control portions of forest would provide necessary comparison. As with wetland habitat restoration, ideally a full year of monitoring prior to treatment would be followed by at least 2 years of post-treatment monitoring. Measuring success would be identical to that given above for wetland restoration.

Either restoration effort has individual but differing merit. By opening much of the water surface as well as replacing the emergent vegetation around the pond edge with native species should dramatically increase available insect biomass. Further establishment of bat-friendly trees around the wetland would not only provide additional edge for foraging but furnish suitable day and night roosts. Increasing forage biomass and providing additional roost opportunities would be expected to not only increase the amount of site usage but account greater breeding success and additional reproductive recruitment. There are a limited number of wetlands that could be managed similarly so the methodology, if successful, would be of somewhat limited value, from a metapopulation perspective.

Forest restoration, as proposed with a mosaic of edges, would have the same general benefit as the above wetland restoration. It would provide many opportunities for roost selection and would increase the foraging potential with the creation of edge habitat. When the optimal edge to forest ratio is established, the methodology would have widespread application because forest patches are fairly widespread throughout the range of the species.

If you need further information, please contact me.

Sincerely,

Michael J. O'Farrell
Principal

Appendix 15

Goodnature Automatic Cat Trap Development Project

Months		Task	Sub-tasks
0-6		**Feral Cat trigger set-off study**	
	0-4		Exploration of trigger technology for cats
	0-4		Exploration of composition and orientation
	0-4		Exploration of species ability to trigger differing mechanisms
	1-4		Fabricate lab assessable mechanisms
	2-5		Fabricate iterative testing rigs to consistent activation
	2-5		Observe rig interactions and evaluate
	3-6		Modify tested rigs for continued observations
	3-6		Prototype concepts.
	3-6		Test and evaluate.
		Deliverable: month 6	**Consistent target activation of trigger**
0-9		**Humane kill mechanism**	
	0-4		Observe target species
	0-4		Fabricate iterative testing rigs
	0-4		Observe rig interactions and evaluate
	2-6		Modify test rigs for continued observations
	2-6		Fabricate mechanisms
	6-9		Apply mechanisms and undertake animal welfare study
		Deliverable: month 9	**Animal Welfare Humane evaluation**
2-6		**Non-target developments**	
	2-3		Research field requirements
	2-5		Propose methods of attachment/establishment systems
	3-5		Create test rigs
	(3-12+)		(Long and short term testing)
	4-6		Evaluate and develop
	2-6		Consider social and market requirements investigations
		Deliverable: month 6	**Non-target requirements adopted by design**
9-12		**Production development for trial**	
	9-10		Convert design and prototypes for manufacture.
	9-10		Exploration of differing materials suited to environmental conditions
	9-12		Exploitation of existing tools and production methods
	11-12		Prototype concepts
	11-12		Test and evaluate
		Deliverable: month 12	**Delivery of field units**