STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Forestry and Wildlife
Honolulu, HI, 96813

February 24, 2012

Chairperson and Members
Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

Land Board Members:

SUBJECT: REQUEST FOR APPROVAL OF AMENDMENT TO INCIDENTAL TAKE LICENSE AND HABITAT CONSERVATION PLAN FOR LANAI METEOROLOGICAL TOWERS TO EXTEND TO 2016

BACKGROUND

The purpose of the Habitat Conservation Plan (HCP) and Incidental Take License (ITL) for the Lanai Meteorological Towers is to provide measures for avoidance, minimization, mitigation, and monitoring of incidental take of four endangered or threatened species, the Hawaiian petrel or ‘ua‘u (*Pterodroma sandwichensis*), Newell's shearwater or ‘a‘o (*Puffinus auricularis newelli*), Hawaiian stilt or ae‘o (*Himantopus mexicanus knudseni*), and Hawaiian hoary bat or ‘ōpe‘ape‘a (*Lasiurus cinereus semotus*). The HCP also provides measures to ensure a net recovery benefit to the species.

The Lanai Meteorological Towers were erected on the island of Lanai to collect data on wind speeds and patterns throughout the northern portion of the island to determine the suitability of the wind regime to develop a commercially viable wind energy facility. Because four endangered or threatened species were documented in the area, Castle & Cook developed a HCP to address potential incidental take.

On September 12, 2008, the Board of Land and Natural Resources (BLNR) approved the HCP, and the ITL was issued on October 10, 2008, with an expiration date of March 1, 2010.

On October 28, 2011, BLNR approved an after the fact amendment to the HCP for the purpose of extending the HCP to March 1, 2012, and an amended ITL was issued on January 4, 2012, with an expiration date of March 1, 2012.

On December 16, 2011, Castle & Cooke submitted a request to extend the HCP and ITL to March 1, 2016.

ITEM C-5

ANALYSIS

Castle & Cook is requesting an amendment to extend the HCP and ITL to 2016 for the purpose of allowing continued collection of data on wind speeds and patterns by one meteorological tower (with the option to reinstall the six other approved meteorological towers upon notification).

To date, there has been no take of any threatened or endangered species covered under the HCP and ITL. Despite the absence of take, Castle & Cooke has successfully completed the mitigation for Tier 1 take, which involved forest restoration on Lanaiahale and predator trapping.

On January 31, 2012, the Endangered Species Recovery Committee (ESRC) recommended approval of the amendment to extend the ITL and HCP to March 1, 2016.

RECOMMENDATION

The Department recommends that the Board:

1. Approve the amendment to the Incidental Take License and Habitat Conservation Plan for Lanai Meteorological Towers to extend to March 1, 2016, by the required two-thirds vote of the authorized membership.

Respectfully submitted,

Paul J. Conry, Administrator
Division of Forestry and Wildlife

APPROVED FOR SUBMITTAL:

William J. Aila, Jr., Chairperson
Board of Land and Natural Resources

Attachment A:	Amendment to Habitat Conservation Plan
Attachment B:	Amendment to Incidental Take License
Attachment C:	Original Habitat Conservation Plan (for reference)
Attachment D:	Original Incidental Take License (for reference)
Attachment E:	Amendment 01 to Incidental Take License (for reference)
Attachment F:	Endangered Species Recovery Committee Recommendations

General Amendment to the Habitat Conservation Plan For the Construction and Operation of the Lāna'i Meteorological Towers, Lāna'i, Hawai'i

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Location: Lāna'i, Maui County, Hawai'i

Applicant/Address: ***Castle & Cooke Resorts, LLC***
P.O. Box 630310
1311 Fraser Avenue
Lāna'i City, Hawai'i 96763
(808) 565-3820

Prepared by:
Tetra Tech EC, Inc.
1750 SW Harbor Way, Suite 400
Portland, OR 97201

December 16, 2011

TTEC-PTLD-2011-846

1 Summary

Applicant Castle and Cooke Resorts, LLC (Castle & Cooke) is requesting an extension to the *Habitat Conservation Plan (HCP) for the Construction and Operation of the Lanai Meteorological Towers, Lanai, Hawaii* and associated Incidental Take License (ITL) No. ITL-09 originally approved in 2008.

This extension would extend the term of the HCP and state ITL to March 1, 2016 and would take effect upon expiration of the 2-year extension to the state ITL on March 1, 2012. Castle & Cooke has requested a 6-year extension to the federal ITP which would expire on March 1, 2016. The conditions of the HCP and state ITL remain unchanged except for the elements described below and as previously approved by the Board of Land and Natural Resources October 28, 2011.

2 Requested Amendment

2.1 Reason for Extension

Castle & Cooke requested an extension of the license duration to allow continued collection of data on wind speeds and patterns by met tower 1, and will reserve the right to install all or any of the approved met towers.

2.2 Duration of Extension

The term of the original HCP and ITL/ITP expired on March 1, 2010. A two-year extension was filed by Castle & Cooke such that the state ITL currently expires on March 1, 2012. Castle & Cooke is currently requesting an additional 4-year extension to the state ITL such that it would expire on March 1, 2016. Castle & Cooke has requested a 6-year extension to the federal ITP which would also expire on March 1, 2016.

2.3 Monitoring and Reporting Requirements

With concurrence from USFWS and DOFAW, Castle & Cooke began implementing in 2010 the following monitoring and reporting requirements:

1. Carcass surveys are conducted one time per month (approximately every 30 days), provided the vegetation is managed to maintain a high searcher efficiency;
2. One carcass is placed at each active met tower at the beginning of each season of scavenging trials, as defined in the HCP, and its status is checked at the time of the next monitoring event. If a carcasses is removed, the search interval becomes once every 10 days and scavenging trials are implemented as defined in the HCP;
3. Reporting requirements are addressed by informal quarterly summaries or emails and one annual report. The informal report includes a summary of the surveys, summary of the scavenging trial and a photograph verifying vegetative management at each active tower;
4. A photograph of the vegetation conditions of the active met tower(s) is submitted at least one week prior to the beginning of the survey season (March-April) to confirm vegetative management.

Castle & Cooke will continue to comply with the current stipulations of the HCP. This includes notifying USFWS and DOFAW of observed dead or injured individuals of the four covered species within one working day by telephone and within five days by writing to the Pacific Islands Fish and Wildlife Office and DOFAW. As stated in the state ITL, DLNR will be notified within three days of any mortalities or injuries of downed wildlife.

2.4 Funding Assurances

Castle & Cooke ensures that the Performance Bond is secured to extend the assurance that Tier 2 mitigation funds would be available should the Tier 1 take limit be reached prior to March 1, 2016.

2.5 Other Provisions

Through the currently amended MOA, Castle & Cooke agrees to coordinate with DOFAW on ungulate removal from the Lanaihale.

2.6 Compliance with Revision and Amendment Procedure

In accordance with the procedure for amendments to the HCP as stated in Section 6.8 of the HCP, USFWS and DLNR have been consulted on the proposed amendment. According to Section 6.8, this permit amendment request is considered a minor amendment because it involves routine administrative revisions that do not diminish the level or means of mitigation, or materially alter the terms of the state ITL.

ATTACHMENT TO ITL-09

State of Hawaii
Department of Land and Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, Hawaii, 96813

Date of issue:
Valid until: March 1, 2016

INCIDENTAL TAKE LICENSE AMENDMENT 02

To accompany:

Incidental Take License (ITL) 09

and

Habitat Conservation Plan for the Construction and Operation of the Lanai Meteorological Towers, Lanai, Hawaii

The Board of Land and Natural Resources hereby grants permission, under the authority of Hawaii Revised Statutes §§ 195D-4(g) and 195D-21, to:

Castle and Cooke Resorts, LLC

P.O. Box 630310

1311 Fraser Avenue

Lanai City, Hawaii, 96763

For the purpose of:

Amending ITL-09 to be valid from date of issue of this amendment to March 1, 2016.

GENERAL CONDITIONS:

1. All General conditions of ITL-09 remain applicable.

SPECIAL CONDITIONS:

1. All Special conditions of ITL-09 remain applicable.

This Amendment shall be attached to and made part of ITL-09.

By: ____________________________________ Date ______________

William J. Aila, Chairperson and Member
Board of Land and Natural Resources

The undersigned has read, understands, and hereby agrees to abide by the General Conditions stipulated in this license.

Castle & Cooke Resorts, LLC

By: ___________________________________ Date ______________

Its: ___________________________________

Castle & Cooke Resort, LLC notarized signature is made a part of this document.

Cc: DOFAW
DOCARE
USFWS

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

GUY H. KAULUKUKUI
FIRST DEPUTY

WILLIAM M. TAM
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

February 24, 2011

TO: Honorable Chairperson and Members, Board of Land and Natural Resources

FROM: Endangered Species Recovery Committee

SUBJECT: Recommendation of approval of amendment to Incidental Take License and Habitat Conservation Plan for Lanai Meteorological Towers to extend to 2016

On January 31, 2012, the Endangered Species Recovery Committee recommended approval of the amendment to extend the Incidental Take License and the Habitat Conservation Plan for Lanai Meteorological Towers to March 1, 2016.

Prepared and Submitted by:

Scott Fretz, DLNR ESRC Designee

ATTACHMENT III

State of Hawaii
Department of Land and Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, Hawaii, 96813

Date of issue: JAN 4 2012
Valid until: March 1, 2012

INCIDENTAL TAKE LICENSE AMENDMENT 01

To accompany:

Incidental Take License (ITL) 09

and

Habitat Conservation Plan for the Construction and Operation of the Lanai Meteorological Towers, Lanai, Hawaii

The Board of Land and Natural Resources hereby grants permission, under the authority of Hawaii Revised Statutes § 195D-4(g), to:

Castle and Cooke Resorts, LLC

P.O. Box 630310

1311 Fraser Avenue

Lanai City, Hawaii, 96763

For the purpose of:

Amending ITL-09 to be valid from date of issue of this amendment to March 1, 2012

GENERAL CONDITIONS:

1. All General conditions of ITL-09 remain applicable.

SPECIAL CONDITIONS:

1. All Special conditions of ITL-09 remain applicable.

This Amendment shall be attached to and made part of ITL-09.

By: ____________________ Date 1.4.12

For William J. Aila, Chairperson and Member
Board of Land and Natural Resources

The undersigned has read, understands, and hereby agrees to abide by the General Conditions stipulated in this license.

Castle & Cooke Resorts, LLC

By: ____________________ Date DEC 2? 2011
HARRY A. SAUNDERS / RICHARD K. MIRIKITANI

Its: EXECUTIVE VICE PRESIDENT / VICE PRESIDENT & SECRETARY

Castle & Cooke Resort, LLC notarized signature is attached and made a part of this document.

Cc: DOFAW
DOCARE
USFWS

STATE OF HAWAII)
) SS.
City & COUNTY OF Honolulu)

On this 4 day of January, 20 12, before me personally appeared Guy H. Kaulukukui and ______________ to me known to be the person(s) described herein, and who, being duly sworn, did say that he/she/they is/are the said Deputy Director named in the foregoing instrument, and that he/she/they executed said instrument as his/her/their own free act and deed.

ALISON Y. KAWAMOTO
NOTARY
2000-483
PUBLIC
STATE OF HAWAII

(Notary Stamp or Seal)

Alison Y. Kawamoto
(Signature)

Alison Y. Kawamoto
(Signature)

Notary Public, State of Hawaii
My commission expires: 10/1/12

Doc. Date: – # of Pages: 3
Notary Name: Alison Y. Kawamoto 1st Circuit
Doc. Description:
Incidental Take Uicense Amendment 01 to Accompany Incidental Take License 09

Alison Y. Kawamoto 1/4/12
Notary Signature Date

NOTARY CERTIFICATION

(Notary Stamp or Seal)

ALISON Y. KAWAMOTO
NOTARY
2000-483
PUBLIC
STATE OF HAWAII

STATE OF HAWAII)
) SS.
CITY AND COUNTY OF HONOLULU)

On this 27th day of December, 2011, before me personally appeared HARRY A. SAUNDERS and RICHARD K. MIRIKITANI, to me personally known, who being by me duly sworn, did say that they are the Executive Vice President and Vice President and Secretary, respectively, of CASTLE & COOKE RESORTS, LLC, a Hawai'i Limited Liability Company, that this 2-page Incidental Take License Amendment 01 dated December 27, 2011 was signed on behalf of said corporation by authority of its Board of Directors; and the said officers acknowledged said instrument to be the free act and deed of said corporation. Said corporation does not have a corporate seal.

Rhonda Biffle
Notary Public, State of Hawaii
First Judicial Circuit

Rhonda Biffle
Printed Name of Notary

My commission expires: August 3, 2012

RHONDA BIFFLE
NOTARY PUBLIC
No. 08-271
STATE OF HAWAII

ATTACHMENT II

State of Hawaii
Department of Land & Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, Hawaii 96813

Incidental Take License No. ITL-09
Date of Issue: October 10, 2008
Valid Until: March 1, 2010

INCIDENTAL TAKE LICENSE

to accompany:

Habitat Conservation Plan for the
Construction and Operation of the Lāna'i Meteorogical Towers, Lāna'i, Hawai'i

The Board of Land and Natural Resources hereby grants permission under the authority of §195D-4(g) Hawaii Revised Statutes and all other applicable laws, to:

Castle and Cooke Resorts, LLC
P.O. Box 630310
1311 Fraser Avenue
Lana'i City, Hawai'i 96763

To: take of (if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity);

The following species:

Common Name	Scientific Name	No. of Specimens Over Term*		Location
		Tier 1	Tier 2	
'Ua'u, or "Hawaiian Petrel"	*Pterodroma sandwichensis*	7	14	Lands owned or otherwise controlled by Castle and Cooke Resorts, LLC on the Island of Lanai, Hawaii (2) 49-002-001
'A'o or "Newell's (Townsend's) Shearwater"	*Puffinus auricularis newelli*	2	NA	
Ae'o or "Hawaiian Stilt"	*Himantopus mexicanus knudseni*	2	NA	
'Ope'ape'a or "Hawaiian Hoary Bat"	*Lasiurus cinereus semotus*	2	NA	

*** - See Special Conditions #1-5.**

Subject to the following conditions:

I. GENERAL CONDITIONS

1. This license only authorizes the permittee to conduct incidental take of *Pterodroma sandwichensis*, *Puffinus auricularis newelli*, *Himantopus mexicanus knudseni*, and *Lasiurus cinereus semotus* on the lands owned or otherwise controlled by Castle and Cooke Resorts, LLC on the island of Lana'i, Hawaii (2) 49-002-001 at the time this license is issued pursuant to the "*Draft Habitat Conservation Plan for the Construction and Operation of the Lanai Meteorological Towers, Lana'i, Hawai'i*" dated October 2008 (hereafter "HCP").
2. This license is valid only if Castle and Cooke Resorts, LLC abides by the terms and conditions of the HCP for the duration of the HCP.
3. This license is valid for species protected by federal law only if accompanied by proper federal permits. Permit number for the required permit must be provided:

   USFWS 10(a)(1)(B) permit no. TE194350-0.
4. This license shall become valid upon completion of the following:
   i. A legal representative of Castle and Cooke Resorts, LLC has acknowledged understanding and agreement to abide by its conditions by signing two copies of Attachment 1, which is attached hereto and made a part of this license.
   ii. Both copies of the signed license must be returned to the Division of Forestry and Wildlife. Upon approval by the Chairperson of the Board of Land and Natural Resources, a copy of the license will be returned to the applicant.
5. The Board may suspend or revoke this license if the HCP is suspended or revoked. The Board may also suspend or revoke this license in accordance with applicable laws and regulations in force during the term of the license.

II. SPECIAL CONDITIONS

1. The allowable incidental take authorized by this license for *Pterodroma sandwichensis* and *Puffinus auricularis newelli* includes both observed, unobserved, direct and indirect take as defined in the HCP.
2. The estimation of incidental take for *Pterodroma sandwichensis* and *Puffinus auricularis newelli* will be conducted according to adjustments made to the observed direct take according to estimates of unobserved direct take, as detailed in the HCP.
3. The allowable incidental take authorized by this license for *Himantopus mexicanus knudseni* and *Lasiurus cinereus semotus* includes only observed take, as defined in the HCP.
4. The incidental take authorized by this license for *Pterodroma sandwichensis* is defined by two tiered levels, each of which is identified in the HCP. In the event that tier 1 is reached, incidental take at the tier 2 level is authorized, provided that Castle and Cooke Resorts, LLC abides by the terms and conditions of the HCP for the tier 2 level for the duration of the HCP.

5. DLNR will be notified within 3 days of any mortalities, injuries, or disease observed on the property. Injured individuals or carcasses will be handled according to guidelines in Appendix 9 of the HCP.

for LAURA H. THIELEN, Chairperson and
Member
Board of Land and Natural Resources

C: DOFAW Maui Branch
DOCARE
USFWS Pacific Islands Office, Honolulu
Senior Resident Agent, USFWS-Law Enforcement, Honolulu

Attachment No. 1 to INCIDENTAL TAKE LICENSE No. ITL-09

The undersigned has read, understands and hereby agrees to abide by General Conditions 1 - 5 and Special Conditions 1 - 5 stipulated on pages 1 through 3 in INCIDENTAL TAKE LICENSE No. ITL-09.

CASTLE & COOKE RESORTS, LLC

By: ______________________________
Harry A. Saunders
President

By: ______________________________
Richard K. Mirikitani
Vice President & Secretary

Date: 9 OCTOBER 2008

Final Habitat Conservation Plan
For the Construction and Operation of the
Lāna‘i Meteorological Towers, Lāna‘i, Hawai‘i

Location: Lāna‘i, Maui County, Hawai‘i

Applicant/Address: ***Castle & Cooke Resorts, LLC***
P.O. Box 630310
1311 Fraser Avenue
Lāna‘i City, Hawai‘i 96763
(808) 565-3820

Prepared by:
Tetra Tech EC, Inc.
737 Bishop Street, Suite 3020
Honolulu, HI 96813

October 2008

TTEC-PTLD-2008-235

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Acronyms and Abbreviations

Applicant	Castle & Cooke Resorts, LLC
BLNR	Board of Land and Natural Resources
CDUA	Conservation District Use Application
CDUP	Conservation District Use Permit
CFR	Code of Federal Regulations
DLNR	Department of Land and Natural Resources
DOFAW	Department of Forestry and Wildlife
EA	Environmental Assessment
ESA	Endangered Species Act
ESRC	Endangered Species Recovery Committee
FEMA	Federal Emergency Management Agency
HAR	Hawai'i Administrative Rules
HCP	Habitat Conservation Plan
hr	hour
HRS	Hawai'i Revised Statutes
ITL	Incidental Take License
ITP	Incidental Take Permit
Landowner	Castle & Cooke, Inc.
MBTA	Migratory Bird Treaty Act of 1918
met	meteorological
MISC	Maui Invasive Species Committee
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
PVC	polyvinyl chloride
TNC	The Nature Conservancy
TtEC	Tetra Tech EC, Inc.
USC	United States Code
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WRA	wind resource area

Habitat Conservation Plan For the Construction and Operation of the Lānaʻi Meteorological Towers

1 INTRODUCTION AND PROJECT OVERVIEW

1.1 Summary

Applicant Castle & Cooke Resorts, LLC (Castle & Cooke) has installed six of seven approved meteorological (met) towers on the island of Lānaʻi, Maui County, Hawaiʻi. The met towers are installed, on land owned by Castle & Cooke, Inc. which is affiliated with the applicant, to collect data on wind speeds and patterns throughout the northern portion of the island. This data will be used to determine the suitability of the wind regime to develop a commercially viable wind energy facility on the island of Lānaʻi, Hawaiʻi. Castle & Cooke is committed to developing renewable energy on the island of Lānaʻi while preserving the unique environmental, cultural, and historic resources found on the island. The state Board of Land and Natural Resources (BLNR) issued a Conservation District Use Permit (CDUP) for the installation of one of seven met towers (met tower 6), and conditional approval for the remaining six met towers on August 8, 2007; the Department of Land and Natural Resources (DLNR) authorized Castle & Cooke to install the additional six met towers in a letter dated December 10, 2007.

In accordance with the Endangered Species Act of 1973 (ESA), as amended, and the conditions stated in the CDUP LA-3419, Castle & Cooke is required to "comply with the Incidental Taking Permit requirements of the U.S. Fish and Wildlife Service (USFWS), including the preparation of the Habitat Conservation Plan." Therefore, in accordance with section 10(a)(1)(B) of the ESA and chapter 195-D, of the Hawaiʻi Revised Statutes (HRS), Castle & Cooke has prepared this Habitat Conservation Plan (HCP) in support of the incidental take permit (ITP) and incidental take license (ITL) requirements of the USFWS and DLNR/ Division of Forestry and Wildlife (DOFAW), respectively. Separately, to satisfy National Environmental Policy Act (NEPA) requirements, an Environment Assessment (EA) is being developed.

Four federally and state-listed endangered or threatened animal species have been documented on Lānaʻi within the vicinity of the wind resource area (WRA) where the met towers are located. The incidental take of listed species has the potential to occur as a result of the operation of the seven met towers within the WRA: Hawaiian petrel (*Pterodroma sandwichensis*), Newell's shearwater (*Puffinus auricularis newelli*), Hawaiian stilt (*Himantopus mexicanus knudseni*), and Hawaiian hoary bat (*Lasiurus cinereus semotus*). Individuals of these species may fly in the vicinity of a met tower and could be injured or killed if one collides with a met tower or associated guy wires. No habitat loss for listed wildlife species will occur. Additionally, no other listed, proposed or candidate wildlife species have been found or are known to be present in the project area.

The Hawaiian petrel is known to nest on Maui, Kauaʻi, Lānaʻi, Hawaiʻi, and possibly Molokaʻi. On Lānaʻi, the endangered Hawaiian petrel has been recently rediscovered to nest on the central portion of the island and has been observed flying over the WRA. The take limit for the

Hawaiian petrel, as a result of the operation of the seven met towers, is established by a tiered approach. Tier 1 authorizes a take limit of seven petrels over the 2-year project period. Tier 2 provides a contingency should Tier 1 take limits be reached and authorizes the take of up to 14 petrels over the 2-year project period.

The Newell's shearwater breeds on several of the Hawaiian Islands. Their breeding status on Lāna'i is unknown. DOFAW has heard vocalizations of Newell's shearwater on Lāna'i. The take limit of Newell's shearwater is two individuals over the 2-year project period.

The Hawaiian stilt is a permanent resident on Lāna'i, and is known to occur at the Lāna'i City wastewater treatment ponds. The Hawaiian stilt was documented once flying over the met tower project area. The take limit of Hawaiian stilt is two individuals over the 2-year project period.

Finally, little is known about the distribution or habitat use of the Hawaiian hoary bat in Hawai'i. It is believed to be most abundant on Hawai'i and in low numbers on Maui. The Hawaiian hoary bat has been recently sighted on Lāna'i, but its breeding status on the island is unknown. The take limit of Hawaiian hoary bats, resulting from the operation of seven met towers on Lāna'i, is two bats over the 2-year project period.

Botanical surveys conducted in April and late-November 2007 determined that no federally or state-listed plant species occur within any of the met tower footprints. Therefore, no impacts will occur to sensitive plant species as a result of this project.

An HCP was approved for the Kaheawa Pastures Wind Energy Generation Facility on Maui, Hawai'i in 2006 (Kaheawa Wind Power 2006), which addressed three of the four species covered in this HCP. The activities covered in the Kaheawa Pastures HCP are different than those addressed in this HCP; the Kaheawa Pastures HCP assessed impacts associated with 20, 65-meter turbines rather than the seven, 50-meter met towers. The Lāna'i met tower project is of a much smaller scale than the Kaheawa Pastures Wind Generation Facility but considers the framework established by the approved Kaheawa Pastures HCP.

1.2 Applicant History and Information

Castle & Cooke is the current applicant/proposed developer of the project and along with its affiliates owns 98 percent of the land on the island of Lāna'i. Castle & Cooke Hawai'i, a division of Castle & Cooke, Inc., was founded in 1851 and is one of the nation's oldest developers built around investing in Hawai'i. Castle & Cooke, Inc. was incorporated in Hawai'i on October 10, 1995, to be the successor to the real estate and resort business of Dole Food Company, Inc. In addition to wind energy development, Castle & Cooke is engaged in the development of other renewable energy technologies, including a proposed solar facility on the island of Lāna'i, as well as residential real estate, commercial real estate, and resorts located in Hawai'i, California, Arizona, and Florida.

On August 8, 2007, DLNR issued Castle & Cooke CDUP No. LA-3419 to approve the installation of one met tower at site number 6 and conditionally approve installation of the remaining six met towers (**Appendix 1**). Met tower 6 was erected on August 28, 2007, and met towers 1 through 5 were installed between January 7 and February 8, 2008. Met tower 7 has not yet been installed.

1.3 Regulatory Framework and Relationship to Other Plans, Policies, and Laws

The primary laws, regulations, and plans that affect development and implementation of an HCP, ITP, and the proposed activities are summarized below to assist the reviewer by adding additional context for the Lanai Meteorological Towers HCP.

1.3.1 Endangered Species Act

The ESA and its implementing regulations prohibit the take of any fish or wildlife species that is federally listed as threatened or endangered without prior approval pursuant to either section 7 or section 10 (a)(1)(B) of the ESA. Section 3 of the ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The term "harm" refers to any act that actually kills or injures a federally-listed species and has been extended by case law to include significant habitat modification or degradation (50 Code of Federal Regulations [CFR] §17.3). Section 9 of the ESA also details generally prohibited acts and section 11 provides for both civil and criminal penalties for violators regarding species federally-listed as threatened or endangered.

ESA section 4(f) requires the USFWS to develop and implement recovery plans for the conservation and survival of listed species unless it is found that the plan will not promote the conservation of the species. Recovery plans must describe specific management actions, establish objectives and measurable criteria for delisting, and estimate the time and cost to carry out measures needed to achieve recovery. The USFWS has developed a recovery plan for the Hawaiian petrel and Newell's shearwater, Hawaiian stilt (Hawaiian shorebirds), and Hawaiian hoary bat (USFWS 1983, 2005, and 1998, respectively).

In 1982, Congress amended the ESA to allow a private applicant to commit a taking that would otherwise be prohibited under section 9(a)(1)(B). When a non-federal landowner wishes to proceed with an activity that is legal in all other respects, but that may result in the incidental taking of a listed species, an ITP as defined under section 10 of the ESA is required. Incidental take is defined as take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." An HCP must accompany an application for an ITP to demonstrate that all reasonable and prudent efforts have been made to avoid, minimize, or mitigate for the effects of the requested incidental take. Although the USFWS and National Marine Fisheries Service (NMFS) have joint authority to administer the issuance of an ITP, the Lāna'i met tower project falls under the exclusive jurisdiction of the USFWS. The goals, criteria, and measures of the HCP and ITP are consistent with the actions and objectives of the recovery plans for the covered species.

The section 10 process for obtaining an ITP begins with the development of an HCP by the project applicant. Required contents of an HCP, defined in section 10 of the ESA, include:

- An assessment of impacts likely to result from the proposed taking of one or more federally listed species.
- Measures the permit applicant will undertake to monitor, minimize, and mitigate such impacts.
- The funding that will be made available to implement such measures.
- The procedures to deal with unforeseen or extraordinary circumstances.

- Alternative actions to the taking considered by the applicant, and the reasons why the applicant did not adopt such alternatives.
- Additional measures that the USFWS may require as necessary or appropriate.

1.3.2 Chapter 195D, Hawai'i Revised Statutes (Endangered Species; Habitat Conservation Plans)

Hawai'i Revised Statutes (HRS) section 195D-4 states that any species of aquatic life, wildlife or land plant that has been determined to be an endangered or threatened species under the ESA shall be deemed so under this State chapter, as well as any other indigenous species designated by DLNR as endangered or threatened by rule. The "take" of any endangered or threatened species is prohibited by both ESA and this state statute [section 195D-4(e)]. Similar to the ESA, section 195D-2 defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect endangered or threatened species of aquatic life or wildlife, or to cut, collect, uproot, destroy, injure, or possess endangered or threatened species of aquatic life or land plants, or to attempt to engage in any such conduct."

After consultation with the Endangered Species Recovery Committee (ESRC), the BLNR may permit a take otherwise prohibited under subsection 195D-4(e) if the take is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. In support of a temporary ITL, an applicant must develop, fund, and implement a BLNR-approved HCP to minimize and mitigate the effects of the incidental take.

Such take may be permitted provided the following criteria of sections 195D-4 and 195D-21, HRS are met:

- The taking will be incidental;
- The applicant, to the maximum extent practicable, shall minimize and mitigate the impacts of the take;
- The applicant shall provide adequate funding and/or guarantee that adequate funding for the implementation of the HCP plan will be provided;
- The applicant shall post a bond or similar financial tool, including depositing a sum of money in the endangered species trust fund created by section 195D-31, or provide other means approved by the BLNR, adequate to ensure monitoring of the species by the State and to ensure the applicant takes all actions necessary to minimize and mitigate the impacts of the take;
- The HCP shall increase the likelihood of survival and recovery of the species in the wild;
- The HCP plan will adequately consider the full range of the species on the island, address potential cumulative impacts on the species by the ITL, and provide net environmental benefits from such impacts;
- The activity permitted under the ITL does not involve the use of submerged lands, mining, or blasting;
- 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; and
- The BLNR may require the applicant to comply with other identified measures.

1.3.3 National Environmental Policy Act

The purpose of NEPA is to "encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation." The NEPA requires Federal agencies to evaluate and disclose the effects of their proposed actions on the human environment in a written statement as either an Environmental Impact Statement (EIS) or an EA. An EA is a concise public document that briefly discusses the need for alternatives to an action and provides sufficient evidence and analysis to support a determination of no significant impacts or a determination to prepare an EIS. With respect to HCPs in general, compliance with NEPA is not a direct obligation or requirement of the applicant for the section 10 permit. However, the USFWS must comply with NEPA when making their decisions on the application and implementing the federal action of issuing an ITP. Consequently, the appropriate environmental analyses must be conducted and documented before a section 10 permit can be issued. Although NEPA requirements include an analysis of impacts to the same species as does the ESA, the scope of NEPA goes beyond that of the ESA by considering the impacts of a Federal action not only on fish and wildlife resources, but also on non-wildlife resources of the human environment such as cultural resources and socioeconomic values.

Projects can be categorically excluded from a higher level of NEPA analysis if their anticipated impacts on the environment are recognized as negligible and any controversy associated with the project is addressed. An EA will also be prepared to evaluate the potential environmental impacts of issuing an ITP and approving the implementation of the proposed Lāna'i met tower HCP. The purpose of the EA is to determine if permit issuance and HCP implementation will significantly affect the quality of the human and natural environment. If the USFWS determines significant impacts are likely to occur, a comprehensive EIS for the proposed action would be required and distributed for public review. Otherwise, a Finding of No Significant Impact (FONSI) will be issued and is the anticipated determination for this Lāna'i met tower project.

1.3.4 Migratory Bird Treaty Act

Under the Migratory Bird Treaty Act of 1918 (MBTA), as amended (16 USC §§703-712), taking, killing or possessing migratory birds is unlawful. Birds protected under the act include all common songbirds, waterfowl, shorebirds, hawks, owls, eagles, ravens, crows, native doves and pigeons, swifts, martins, swallows and others, including their body parts (feathers, plumes etc), nests, and egg. A list of birds protected under MBTA implementing regulations is provided at 50 CFR §10.13. Unless permitted by regulations, under the MBTA 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. The MBTA provides no process for authorizing incidental take of MBTA protected birds. The two seabird species and stilt covered by this HCP are also protected under the MBTA. If the HCP is approved and USFWS issues an ITP to Castle & Cooke, the terms and conditions of that ITP will also constitute a special purpose permit under 50 CFR §21.27 for the take of the Hawaiian petrel, Newell's shearwater, and Hawaiian stilt under MBTA. Therefore, any such take of the covered species also will not be in violation of the MBTA. Although the MBTA provides for no incidental take authorization, other MBTA-listed birds that are not protected by the ESA and that may be adversely affected by the proposed met towers will not be covered by any take authorization. To avoid and minimize impacts to MBTA-listed species, Castle & Cooke plans to minimize the risk of collisions as much as possible by maximizing the visibility of the met towers and guy wires while ensuring that meteorological data collection is not compromised.

1.3.5 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended (16 U.S.C. §40 et seq.), requires federal agencies to take into account the effects of their actions proposed on properties eligible for inclusion in the National Register of Historic Places. "Properties" are defined herein as "cultural resources," which includes prehistoric and historic sites, buildings, and structures that are listed on or eligible to the National Register of Historic Places. An undertaking is defined as a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a federal agency; including those carried out by or on behalf of a Federal agency; those carried out with federal financial assistance; those requiring a federal permit, license or approval; and those subject to state or local regulation administered pursuant to a delegation or approval by a federal agency. The issuance of an incidental take permit is an undertaking subject to section 106 of the NHPA. No impacts to cultural resources will occur associated with this project.

1.4 Project Description

Castle & Cooke has approval to install seven 50-meter-tall (165-foot tall) met towers on the island of Lāna'i, Maui County, Hawai'i (**Figure 1-1**). Six met towers have been erected and one is pending. The towers are collecting data on wind speeds and patterns throughout the northern portion of the island. This data will be used to determine the suitability of the wind regime, over the proposed lands described above, to sustain a commercially viable wind energy facility. Met tower locations have been selected based on several factors including (1) adequate vertical and horizontal distribution throughout the wind resource area, (2) suitable erection areas (e.g., area, grade, soils, close proximity to existing access roads), and (3) avoidance of sensitive biological and archaeological resources.

The met towers are a standard design and made specifically for wind energy resource measurements. These lightweight towers are made of galvanized steel tubing. The tubes slide together without bolts or clamps, and are made from a combination of 1.5-meter (5-foot) and 3-meter (10-foot) sections. The sections are assembled horizontally on the ground and then tilted up using a ginpole and winch; the solar panel and communications equipment would then be installed. The towers rest on a steel base plate approximately 0.8 square meter (9 square feet) in size and are supported with aircraft cable guy wires in four directions at each guy level. The guy wire radius is 30.5 to 33.5 meters (100 feet to 110 feet). The guy wires are anchored with standard dead-man type anchors to a depth of 1.5 to 2.4 meters (5 to 8 feet). A figure illustrating a typical meteorological tower structure with associated guy wire locations is included in **Appendix 2**.

Installation of the towers requires minimal ground disturbance. No cranes or concrete foundations are required for the installation of these met towers. No new access roads are created as part of the proposed action. Only minimal excavation is required with a small backhoe to install the anchor points. A small trench approximately 0.61 meter (2 feet) wide by 1.8 meters (6 feet) long by 1.2 to 1.8 meters (4 to 6 feet) deep is excavated so the guy wire steel rod anchors can be inserted into the ground at each site. Tower installation personnel access each tower site via existing roads, existing four-wheel-drive trails, and by foot. A pickup-sized flatbed truck with a trailer is used, although some locations may require manual transport of

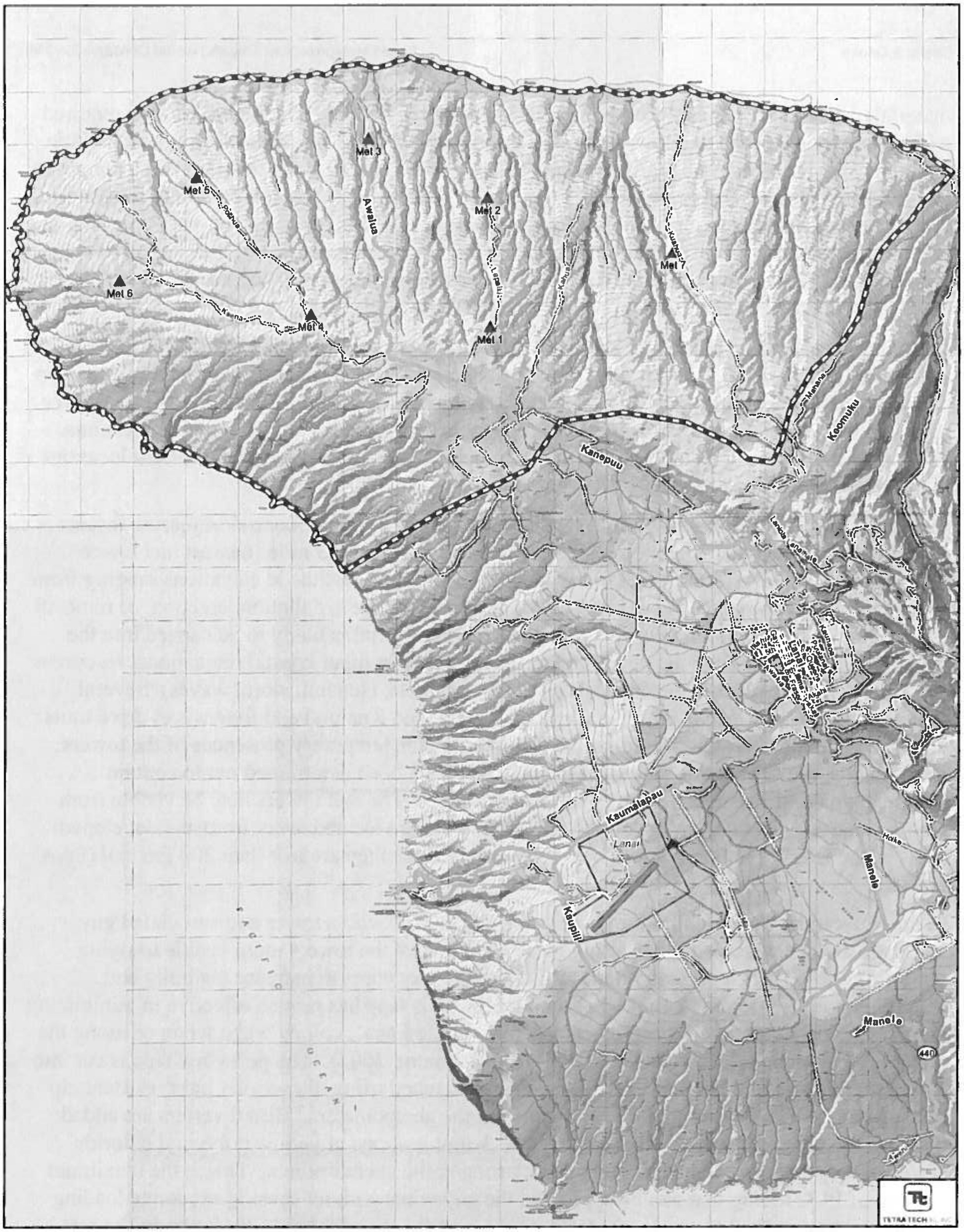


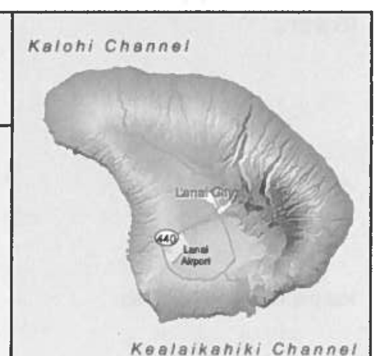
Figure 1-1. Lāna'i Proposed Location of Meteorological Towers
Castle and Cooke Lāna'i Meteorological Towers Project
Maui County, Hawaii

Project Facilities
▲ Proposed Met Towers
WRA

Water Bodies
Streams

Existing Transportation
Highway
Major Road
Local Road

1:70,000
0 0.5 1 2
Miles
June 30, 2008



materials. At each tower site, low-lying brush is removed by hand and the backhoe as required within the guy wire area to allow for safe erection of the towers. Brush is also removed within the temporary tower assembly areas outside of the guy wire areas. The width of these temporary tower assembly areas is approximately 3 meters (10 feet) wide to accommodate assembly of the tower sections. No fencing is proposed for the tower sites, although some non-native vegetation may be cleared after installation to improve the ability to locate carcasses. Installation of each tower requires approximately three to five days once the anchors are installed. Following erection of the towers, all installation equipment is removed from the site.

The six towers were installed by February 8, 2008. The term for the temporary met towers is two years through March 2010. If the take limits established for each species are reached without an approved amendment, however, the met towers will be taken down. Because the wind resource varies greatly depending on the terrain, it is desirable to sample several geographic locations. The deployment plan calls for the met towers to be used to collect data from different locations within the project area.

The type and scale of the activities do not have the potential to alter coastal or marine resources or ecosystems. The data collection would take place from over 0.3 mile (nearest met tower location) to 2.3 miles (farthest met tower location) from the coastline at elevations ranging from 132 to 1,563 feet above mean sea level. It does not involve the installation, erection, or removal of materials near the shoreline or in a place where the material is likely to be carried into the water. Neither does it have the potential to affect beaches or other coastal recreational resources or to increase the exposure to coastal hazards (for example, tsunami, storm waves). Several remote access roads (Kaena, Polihua, Lapaiki, Kahua, and Kuahua) and four-wheel drive trails with access to the shoreline would not be disturbed by the temporary presences of the towers. Additionally, data collection is limited to areas that have been determined not to contain significant natural, archaeological, or cultural resources. The met towers may be visible from public vantage points depending on the topography but are located away from any developed areas of the island. No lighting will be on the towers since they are less than 200 feet tall (FAA 2007).

In order to reduce the potential for listed species to collide with a tower and associated guy wires, Castle & Cooke is implementing measures to make the towers more visible to flying wildlife. White, 1-inch polyvinyl tape is fitted to the guy wires to increase visibility and subsequently increase the likelihood of avoidance. This tape has proven effective in minimizing petrel collisions with fencing and other structures at the Lāna'i colony when wrapped along the length of the fencing (USFWS and DOFAW, pers. comm. 2007). The polyvinyl tape is cut into 4-foot segments, folded in half over the wire, and attached using ultra-violet light resistant zip ties, leaving at least 6-foot gaps above and below the anemometers. Bird diverters are added between the taped sections. Additionally, two 3-foot sections of yellow polyvinyl chloride (PVC) tubing are placed on each guy wire, starting at the anchor points. This is the maximum amount of PVC tubing that can be applied to the guy wires without causing excessive loading and drag. **Appendix 2** shows a schematic of the how the diverter hardware looks on the met towers.

2 DESCRIPTION OF HABITAT CONSERVATION PLAN

2.1 Purpose

The met towers have the potential to incidentally impact four federally-listed wildlife species known or presumed to fly in the vicinity of the proposed met towers. These species have the potential to collide with the met towers or with the associated guy wires supporting the towers, resulting in injury or mortality. The four species include the endangered Hawaiian petrel, Hawaiian stilt, and Hawaiian hoary bat and the threatened Newell's shearwater. The seabirds only nest on the Hawaiian Islands; and the Hawaiian hoary bat is the only native land mammal in the Hawaiian Islands. Because of their low overall populations numbers and somewhat relatively unknown breeding distributions, these species are protected under the ESA. In accordance with the conditions imposed by the CDUP approving the met tower project, and pursuant to the ESA section 10(a)(1)(B), as amended, and chapter 195-D, HRS, an HCP and ITP/ITL are required if the take of a listed species is anticipated in connection with a proposed action. This HCP has been prepared to fulfill application requirements for a federal ITP and a state ITL. Upon issuance of the permit and license, Castle & Cooke will be authorized for the incidental take of these four species in connection with the construction and operation of the seven met towers for a period of two years.

Purpose: For Castle & Cooke, the purpose of this HCP is to determine the potential impact that the met towers could have on the listed species; to address the potential incidental take of the listed species by setting forth measures that are intended to ensure that any take caused by the met towers will be incidental; that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; that procedures to deal with changed and unforeseen circumstances will be provided; that adequate funding for the HCP will be provided; and that the take of the listed species will not appreciably reduce the likelihood of the survival and recovery of these species in the wild.

Need: For Castle & Cooke, as a non-federal entity, the ESA allows for the exemption of the "take" of listed species from the prohibitions of section 9 of the ESA when such a taking incidental to an otherwise lawful activity and when such a taking has been authorized under section 10(a)(1)(B) of the ESA. In order to obtain such authorization, Castle & Cooke must prepare an HCP that meets the USFWS issuance criteria for an incidental take permit. Furthermore, Castle & Cooke as a business entity requires a stable operating and regulatory environment. The HCP assists Castle & Cooke with regulatory compliance under the ESA, serving as a vehicle for obtaining regulatory certainty as well as stability.

2.2 Scope and Term

The met towers will enable Castle & Cooke to determine the feasibility of locating the first commercial wind energy generation facility on Lāna‘i. The scope of this HCP, however, pertains solely to the construction and operation of the met towers, and the adverse impacts these facilities would potentially have on the four federally listed species: Hawaiian petrel, Newell's shearwater, Hawaiian stilt and Hawaiian hoary bat. Through successful implementation of this HCP, Castle & Cooke proposes to offset the risk of impact and provide a net conservation benefit to these four species.

The goal of this HCP is to balance the potential adverse effects of the met tower project on these four listed species with plans to protect and enhance these populations on Lāna‘i and statewide.

One of the challenges in formulating this HCP has been the limited amount of information available concerning the occurrence, behavior, and breeding status of these species in the project area, and in the greater Hawaiian Islands. In order to address these information gaps, Castle & Cooke has responded by conducting site specific surveys, in coordination with USFWS and DOFAW. The understanding gained by pre-construction surveys can then be augmented by post-construction surveys and monitoring that are outlined in this HCP. With monitoring and review by the USFWS and DOFAW, the provisions for adaptive management will allow for the appropriate mitigation of potential project impacts. Castle & Cooke anticipate a 2-year project life, throughout which this HCP would be in effect.

2.3 Survey and Resources

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

- Previous reports prepared for the applicant by Tetra Tech EC, Inc. (TtEC) that provided general information on biological resources, cultural resources, land use, aviation, meteorology and communications on the project area and vicinity.
- CDUA submitted April 20, 2007.
- An unpublished paper by ABR Inc., "Radar and Audiovisual Studies of Hawaiian petrels near Proposed Met Towers and Wind Turbines on Northwestern Lāna'i Island, May-July 2007" (see **Appendix 3**).
- Brian Cooper, ABR Inc., provided personal communication about the initial results of the pilot avoidance behavior study. This study is critical to document and more fully understand avoidance behavior rates of Hawaiian petrels at met towers, communication towers, and wind turbines.
- A spring 2007 avian study conducted to determine avian use and species composition of the project area. This study, "Spring Avian Survey Lāna'i Resource Area, Maui County, Hawai'i," was conducted by TtEC and is attached as **Appendix 4**.
- Personal communications with various DOFAW and USFWS biologists on the occurrence of these species on Lāna'i and current and/or proposed studies.

3 ENVIRONMENTAL SETTING

3.1 Regional Location

The island of Lāna'i is the third smallest of the main Hawaiian Islands and covers a land area of about 36,900 hectares (90,000 acres) (**Figure 3-1**). It is protected from extreme northeast trade winds by the islands of Maui and Molokai. It is a generally hilly island that rises gradually to 1,027 meters (3,369 feet) above sea level at Lāna'ihale, or Mount Palawai. The Kalohi Channel separates the island of Lāna'i from the island of Molokai to the north, and Auau Channel separates Lāna'i from the island of Maui to the east. The northeastern coast is fringed by wide sandy beaches, while the southwestern coast is dominated by sea cliffs. Lāna'i is unusual among the Hawaiian Islands in that the human population is small. The population is concentrated in the central and southern portion of the island away from the project area.

3.2 Characteristics of the Met Tower Sites and Surrounding Lands

The proposed Lāna'i met towers are situated on private land in the northwestern portion of the island. Much of the terrestrial habitat for biological resources on Lāna'i has been disturbed by several factors, including the establishment of the Cook Island pine (*Araucaria columnaris*), 100 years of island-wide Dole pineapple plantations, cattle grazing, the release of non-native game species, and the incidental release of non-native terrestrial species such as house cats (*Felis domesticus*), Norway rats (*Rattus norvegicus*), and black rats (*Rattus rattus*). All of these factors have negatively impacted much of the native endemic species and have altered the ecology of the island. However, there are still areas of uninhabited beaches, some native vegetation communities, some of which occur on the coastlines of the island, and relatively pristine coral reefs.

3.3 Land Use

The proposed project area is situated on private land owned by Castle & Cooke in the remote northwestern portion of the island (Figure 1-1). Approximately 98 percent of the island of Lāna'i is owned by Castle & Cooke (Maui County Council 1998). The proposed project area is remote, with a few dirt roads that allow access to the shoreline. There are no nearby existing structures. Lāna'i City is located about five miles southeast of the nearest met tower (met tower site 1). The Lāna'i Airport is located about seven miles south of the nearest met tower (met tower site 1).

Private land use in Hawai'i is regulated by a dual system of state and county laws, under a statewide zoning law. State land use law (esp. chapter 205, HRS) establish a framework of land use management whereby all lands in the state of Hawai'i are classified into one of four Districts: conservation, agricultural, rural, and urban. A large portion of the proposed project area is located in the state-zoned conservation district limited subzone land. Under this subzone, met towers are an identified land use that may allow issuance of a CDUP. Under Hawai'i Administrative Rules (HAR) §13-5-22 and §13-5-23, land in the Protective and Limited subzones require a departmental permit for data collection (P-1) and a board permit for public purpose uses (P-6). The met towers would be permissible uses under P-1 Data Collection, which expressly authorizes under subpart C-1 "basic data collection, research, education, and resource evaluation which involves a land use with incidental ground disturbance from installation of equipment (e.g., rain gauges or meteorological towers)."

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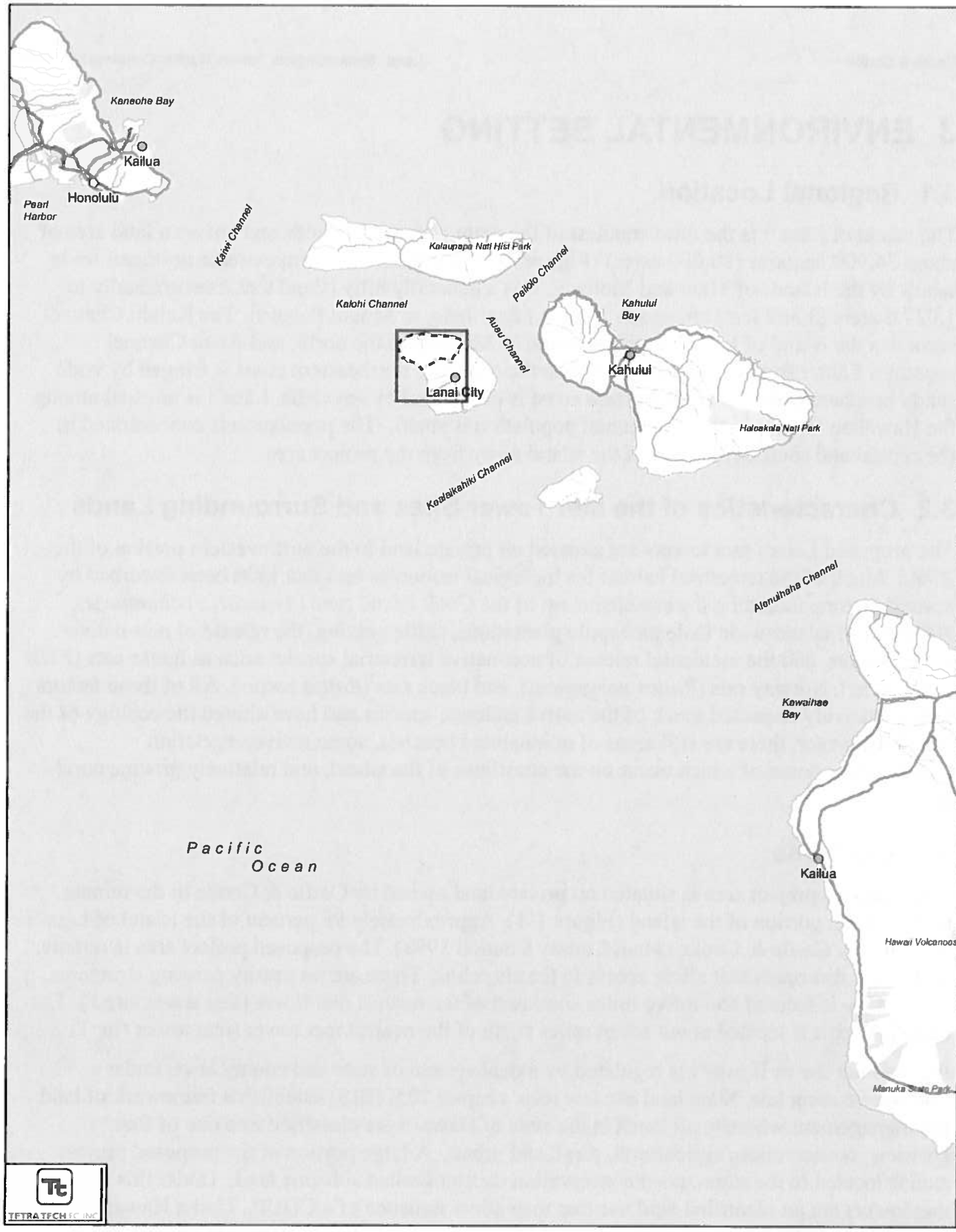

Figure 3-1. Vicinity Map
Castle and Cooke Lāna'i Meteorological Towers Project
Maui County, Hawaii

3.4 Topography and Geology

Lāna'i is geologically part of the four-island complex comprising Maui, Molokai, Lāna'i, and Kahoolawe, known together as Mau Nui (Greater Maui). These four islands were once connected by a broad lowland plain in the last ice age, about 12,000 years ago. Lāna'i was formed from a single shield volcano built by eruptions at its summit and along three rift zones.

The dominant geologic feature in the met tower study area are the numerous gulches, such as Kahua, Lapaiki and Kuahua gulches, and the puus or hills that dot the high ridgeline (Lāna'ihale). Additional geologic features include the pinnacle rock formations at the far western point of the Lāna'ihale ridge. The coastline along the project area is dominated by sandy beaches such as Polihua and Hulopoe beaches, rather than sea cliffs like those found on the southwestern coast of the island.

The proposed met towers would be placed along the sloping buttes that descend from the Lāna'ihale ridge, mountainside to oceanside along the northwest face of the island (Figure 1-1). The area experiences high winds that blow through the Kalohi channel to the north and wind intensity increases from east to west across the site.

3.5 Soils

The general soil association of the project area is defined as a "Very stony land–Rock land association" and described as gently sloping to very steep, rocky and stony land types on uplands and in gulches and valleys. The predominant soils of the project area in the *ahupua'a* of Ka'ā and Paoma'i are classified as "rVT2 Very Stony Land Eroded", and "rRK Rock Land." The "rVT2" strongly weathered soils consist of large areas of severely eroded soils on Moloka'i and Lāna'i. The predominant soils of the *ahupua'a* of Kamoku and Mahana are classified as "rVS Very Stony Land" and "KRL Koele Badland Complex." The "rVS" land type consists of stones and boulders underlain by soft, weathered rock and bedrock (USDA 1972).

Based on United States Department of Agriculture (USDA) mapping, soils are generally between less than 0.3 meters (1 foot) and 1.5 meters (5 feet) in depth, consisting mostly of silt to clay with some sand and boulders. In most areas, the soil grades into bedrock and consists predominantly of volcanic ash (tuff) throughout the project area.

3.6 Hydrology and Water Resources

Located in the rain shadow of Maui, Lāna'i receives very little rainfall, approximately 25 centimeters (10 inches), except in the summit surrounding Lāna'ihale where it can receive as much as 89 centimeters (35 inches). Much of the water in the island's aquifer comes from moisture from fog pulled from clouds by trees and ferns in higher elevations. Natural communities in the project vicinity include intermittent streams and gulches; however, there are no perennial streams or lakes on Lāna'i.

Federal Emergency Management Agency (FEMA) maps are not available for the island of Lāna'i (FEMA 2007). The areas proposed for met towers do not appear to be located in any major floodplains given their location along ridges. Additionally, existing roads do not appear to be located in any major floodplains.

3.7 Vegetation

The Lāna'i met tower project area is located within the Dry Tropical Forest/Tropical Low Shrublands ecoregion in Maui County, Hawai'i (National Geographic 2007). The main habitats on Lāna'i are primarily lowland dry communities and coastal communities. Since the 1920s, most of the central plateau has been in pineapple (*Ananas comosus*) production. The majority of the island's endemic habitat has been disturbed by invasive species, widespread cattle grazing, and habitat loss from pineapple plantations (DOFAW 2005a).

Based on site visits conducted on April 11 and 12, 2007 and throughout 2007-2008 by a Tetra Tech biologist, the vegetation in the project area was found to consist of mixed shrub and grassland. Habitat within the proposed met tower footprints ranges from barren eroded soils to shrub/scrub, interspersed with open grassland areas. The dominant shrub/scrub species included the non-native kiawe (*Prosopis pallida*), verbena (*Lantana camara)*, bull thistle (*Cirsium vulgare*), and the native 'ilima (*Sida fallax*). The open grass areas included alien invasive species such as buffel grass (*Cenchrus ciliaris*) and native grass species such as pili grass (*Heteropogon contortus*). These grasses were interspersed with occurrences of 'ilima (*Sida fallax*), 'a'ali'i *(Dodonaea viscosa)* and 'uhaloa (*Waltheria indica*) that were observed in the upper elevations throughout the project area.

Located outside the met tower project area is The Nature Conservancy (TNC) Preserve, Kānepu'u. This preserve includes remnants of a dry native lowland dry forest and shrubland that possibly once covered much of that area of Lāna'i (**Figure 3-2**). The Kānepu'u Preserve contains the largest remnants of olopua/lama dryland forest in Hawai'i and is home to 49 plant species found only here, including three species that are federally endangered: the sandalwood ('iliahi-*Santalum* spp.), the Hawaiian gardenia (na'u-*Gardenia brighamii*), and the vine *Bonamia menziesii.*

Critical habitat exists for 37 plant species on Lāna'i (USFWS 2003). The critical habitat designations on Lāna'i are in six separate critical habitat units that are designated for the three species; *Bidens micrantha* ssp. *kalealaha, Portulaca sclerocarpa,* and *Tetramolopium remyi.* One of the six designated critical habitat units is located in the dry native shrub and grassland habitat in the met tower project area, and is the largest of the six units: Critical Habitat Unit 1, 373 acres or 151 hectares (USFWS 2003). This critical habitat unit, in the project boundary, is designated for *Tetramolopium remyi*, a multi-island species. Met tower 3 was moved downslope and outside of the critical habitat unit to avoid causing any adverse impacts to this habitat.

In addition to *Tetramolopium remyi*, there is potential for the occurrence of other listed plant species including *Hibiscus brackenridgei* and *Abutilon eremitopetalum.* Many of these rare species can lie dormant in the seed bank until a major rain event. Although no listed plant species were observed during previous field assessments, Castle & Cooke conducted a second, botanical survey within a minimum 100-meter by 100-meter (330 by 330-foot) area surrounding the location of each of the seven met towers to determine the presence of federally or state protected plant species. The surveys were conducted November 26-28, 2007, and the summary report is provided in **Appendix 5**. No rare or listed plant species were observed within the vicinity of the proposed met tower locations.

3.8 Wildlife (General Species)

The wildlife diversity in the Hawaiian Islands was historically high; however, a combination of habitat destruction and invasion by non-native predators has caused the decline of many endemic

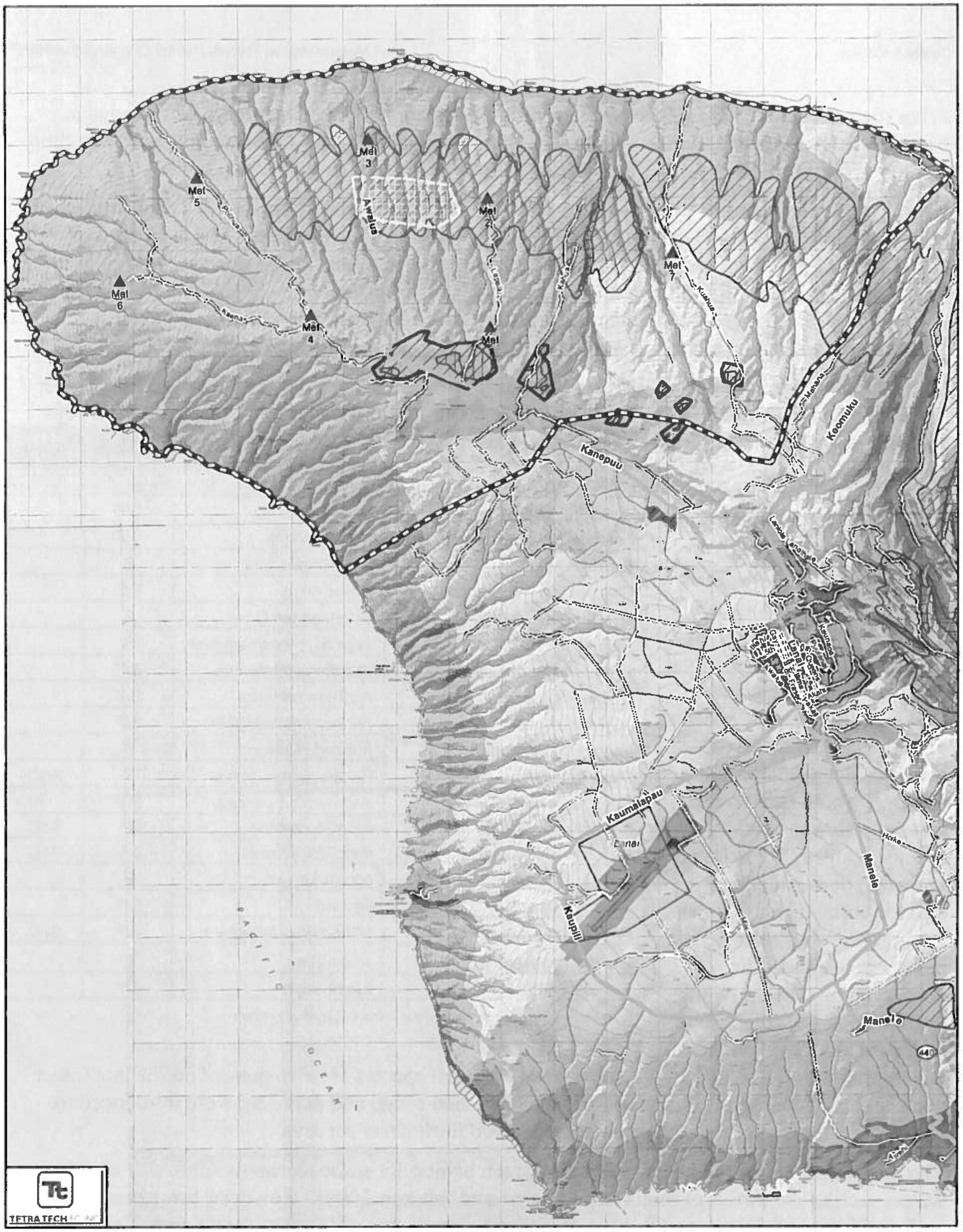

Figure 3-2. Biological and Land Use Constraints
Castle and Cooke Lāna'i Meteorological Towers Project
Maui County, Hawaii

Proposed Met Towers
WRA
Nature Conservancy Preserve
USFWS Designated Critical Habitat

NWI Wetlands
Freshwater Pond
Freshwater Emergent Wetland
Estuarine and Marine Deepwater
Streams

State Land Use Districts
Conservation
Agriculture
Rural
Urban

Remaining Native Vegetation
Lowland Dry Shrubland & Grassland
Lowland Dry Forest & Shrubland
Lowland Mesic Forest & Shrubland
Dry Cliff

Existing Transportation
Highway
Major Road
Local Road

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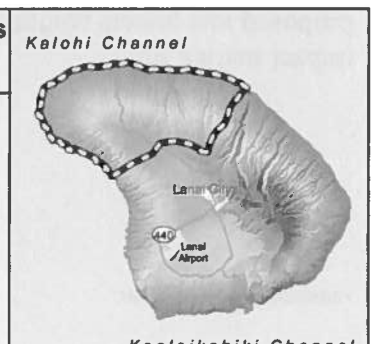


avian species (Hirai 1978). There are currently 37 threatened or endangered avian species in Hawai'i (Bishop Museum 2002). The dry shrub and grasslands that dominate vegetation on the met tower sites provide habitat for endemic and exotic bird species.

Avian point count surveys were conducted by TtEC in spring 2007 (**Appendix 4**) and continued in fall 2007 to evaluate avian use, behavior, and species composition at the WRA. A total of 5,464 acres of the Lāna'i WRA were surveyed during spring point count surveys, covering approximately 20 percent of the total area of the WRA. Nineteen bird species were observed during the spring and fall 2007 avian surveys conducted by Tetra Tech (**Table 3-1**). No threatened or endangered species were observed during these avian surveys.

Of the birds detected, the most abundant birds were common mynas (20.4 percent), northern mockingbirds (14.7 percent), sky larks (12.4 percent), and Japanese white-eyes (11.0 percent). All of these are non-native species. Each remaining species comprised 7.4 percent or less of the total number of birds detected (Table 3-1). A single species of raptor, the short-eared owl, was detected during the surveys. Short-eared owls primarily flew at low altitudes; however, males are known to perform higher altitude aerial displays when mating. The short-eared owl has been listed as a bird of conservation concern by the USFWS and is a state listed endangered species on the island of O'ahu (DOFAW 2007). Introduced mammal species are also present on the met tower project area. Game species such as European mouflon sheep and axis deer were introduced to Lāna'i, and feral cats and rats have been observed during site surveys.

Table 3-1. Bird Species Observed at the Proposed Met Tower Sites During Spring and Fall Point Count Surveys

Scientific Name	Common Name	Season	State Status
Birds			
Acridotheres tristis	common myna	S/F	
Francolinus pondicerianus	gray francolin	S/F	
Fregata minor	great frigate bird	S	
Carpodacus mexicanus	house finch	S/F	
Lonchura malabarica	Indian silverbill	S	
Cettia diphone	Japanese bush-warbler	S	
Zosterops japonicus	Japanese white-eye	S/F	
Cardinalis cardinalis	northern cardinal	S/F	
Mimus polyglottos	northern mockingbird	S/F	
Lonchura punctulata	nutmeg manikin	F	
Pluvialis fulva	Pacific golden plover	F	SoC
Phasianus colchicus	ring-necked pheasant	S/F	
Arenaria interpres	ruddy turnstone	F	SoC
Asio flammeus sandwichensis	short-eared owl	S/F	SoC
Streptopelia chinensis	spotted dove	F	
Alauda arvensis	sky lark	S/F	
Phaethon lepturus	white-tailed tropicbird	S/F	SoC
Meleagris gallopavo	wild turkey	S	
Geopelia striata	zebra dove	S/F	

Season: S=spring, F=fall; Status : SoC= state species of concern

The shore areas of Lāna'i provide suitable beach habitat for some marine wildlife that exit the water, such as sea turtles or monk seals (Baker and Jahanos 2004). However, these beaches that include Shipwreck Beach and Polihua Beach are outside the met tower project area. The proposed met towers would be located upslope and away from the coastline and would not impact marine life.

3.9 Wildlife (listed species)

3.9.1 Hawaiian Petrel

The endemic u'au or Hawaiian petrel is one of the larger species in the *Pterodroma* group. This species formerly nested in large numbers on all of the main islands in the Hawaiian chain except Ni'ihau. Currently, Hawaiian petrels nest at high elevations on Maui, primarily in Haleakala National Park, and in smaller colonies on Kaua'i, Hawai'i, Molokai, and in a more recent discovery, on Lāna'i. Population estimates for the species are mainly based on at-sea numbers with the total population of Hawaiian petrels estimated to be 20,000, with an estimated 4,500 to 5,000 nesting pairs on Kauai and Maui (DOFAW 2005b). The estimated number of nesting pairs on Lāna'i is currently not known.

During the non-breeding season, Hawaiian petrels are found far offshore, primarily in equatorial waters of the eastern tropical Pacific. The breeding season occurs over a period of 9 months each year, from pre-breeding activities to fledging of chicks. Adult Hawaiian petrels return to their colonies, and to the same burrows, each year between March and April. Petrels create burrows in the soil beneath uluhe fern (*Dicranopteris linearis, Diplopterygium pinnatum*), 'ohi'a (*Metrosideros polymorpha*) forests, or in cracks in lava tubes. One egg is laid by the female, which is incubated alternately by both parents, for approximately 55 days. The egg is not replaced if it is lost to predation. When eggs hatch in July or August, both adults make nocturnal flights out to sea to bring food back to the nestlings. In October and November, the fledged young depart for the open ocean. Hawaiian petrels do not breed until age 5 or 6. Although only an estimated 89 percent of birds breed each year, they all return to the colony (USFWS 1983; DOFAW 2005b).

A variety of threats have been documented for the Hawaiian petrel but predation remains one of the most serious threats to the species (USFWS 1983; DOFAW 2005c). Depredation of eggs and young by feral predators, notably cats, barn owls, and mongooses can decimate a nesting colony. Predation therefore is a serious threat to adult seabirds and their eggs and chicks. In addition, fledgling petrels sometimes collide with power lines, fences, and other structures (Hodges 1994) or become disoriented by lights (Telfer et al. 1987). On Lāna'i, petrels were observed colliding with a watershed protection fence (USFWS and DOFAW, pers. comm. 2007). Adults apparently are not attracted to lights to the same degree as fledglings, but adults do collide with power lines. Development of new fisheries may directly or indirectly harm seabird populations; harvest of skipjack and yellowfin tuna (*Thunnus albacares*) could eliminate predatory fish needed to drive prey species to surface. Also, live bait needed for the fishery could potentially decrease prey items. Development of a fishery for squid, their primary food source, could also impact Hawaiian petrels (USFWS 1983). Finally, avian malaria was found in blood samples of Hawaiian petrels in the 1960s and this disease may have killed off low elevation breeders.

The USFWS' "Recovery Plan for the Hawaiian Dark-rumped Petrel (*Pterodroma sandwichensis*) and Newell's Townsend's shearwater (*Puffinus auricularis newelli*)" includes three objectives: (1) reduce annual fallout (when seabirds become disoriented around bright lights and crash or fall to the ground), (2) provide long-term protection for the known nesting colonies, and (3) develop efficient predator control methods for use in and around isolated nesting sites (USFWS 1983). Several measures are currently being implemented or considered to better understand and protect the Lāna'i colony. These measures include predator control, the use of artificial nesting burrows, restoration of key habitats, radar studies, and creation of Bird Salvage-Aid Stations.

A breeding colony of the Hawaiian petrel was rediscovered on Lāna'i in 2006, near the summit of Lāna'ihale. Although the petrel colony was historically known to occur, its status was unknown and thought to have dramatically declined until surveys were conducted in 2006 (DOFAW, pers. comm. 2008). These birds attend the colony at night and nest in burrows in the ground, under dense uluhe ferns. The nesting habitat used by the Hawaiian petrel colony on Lāna'i is delineated by the approximate area of the uluhe ferns. While the population size has not been estimated with statistical confidence, it is estimated that at least a thousand birds are using the habitat within the Lāna'ihale (Penniman, pers. comm. 2007).

To better understand the potential presence and movement of Hawaiian petrel, Newell's shearwater, and Hawaiian hoary bat within the WRA, Castle & Cooke contracted to have radar and audio-visual surveys conducted within the project vicinity. ABR, Inc. conducted surveys to collect data on the movements, behavior, and flight altitudes of the seabirds and bat to estimate fatality rates, exposure risks, and use of the area by these species. The initial survey was conducted in late May-June 2007 at three sites within the WRA (**Figure 3-3**). The late May-June sampling was conducted at three sites for 15 nights of sampling. During subsequent meetings with DOFAW and USFWS, the agencies requested revisions to the survey protocol. DOFAW and USFWS recommended that the surveys be conducted to correspond with the periods of time when the maximum number of birds are expected to be on the island, during the fledging period, and at all seven met tower locations. Three survey windows were established: pre-breeding/spring (April–May), breeding/summer (July–August), and fledging/fall (late October–December). DOFAW's initial studies of the petrel colony indicated this population may breed and fledge approximately one month behind petrel colonies on other islands (Penniman, pers. comm. 2007). The summer sampling survey was conducted late June to July 2007 at the seven proposed met tower sites for 35 nights of sampling. Radar surveys were conducted early November through early-December 2007 (fledging) and April through May 2008 (spring). Fledging season radar surveys ended on December 7, 2007 upon confirmation from DOFAW that petrels had fledged and most birds had left the island. A summary report for the May-June and June-July 2007 surveys is provided in **Appendix 3**. The summary report for all data collected to date is not yet available.

The Lāna'i Hawaiian petrel colony is located approximately seven miles from the nearest proposed met tower location and approximately 11 miles from the westernmost met tower location. During the spring and summer surveys, audio-visual observations were recorded of 33 petrels and two unidentified petrels/shearwaters. The radar sampling recorded 170 petrel/shearwater targets and 427 probable petrel targets in spring and summer surveys, respectively. Movement rates showed that fewer targets flew over the western portion of the study area during both surveys. The overall movement rates observed on Lāna'i (0.5 to 7.1 targets/hr) tended to be much lower than the rates observed during similar radar studies on Kauai (8 to 569 targets/hr) and East Maui (3.6 to 134 targets/hr). Movement rates were similar to Hawai'i (0 to 25.8 targets/hr). Mean movement rates in the western portion of the WRA on Lāna'i were lower than rates recorded at nearly all other locations studied on the Hawaiian Islands (**Appendix 3**).

Seabirds are known to show avoidance of objects. For example, petrels must navigate and avoid trees and other objects when flying into and away from their burrows in the colony at night. However, no data is available to document their avoidance behavior rate. This is an important element used in the models to estimate fatality rates. Castle & Cooke has commissioned an avoidance behavior study by ABR, Inc. to initially include two smaller communication and weather towers at the Lāna'ihale colony and at met tower 6. The objectives of this study are to

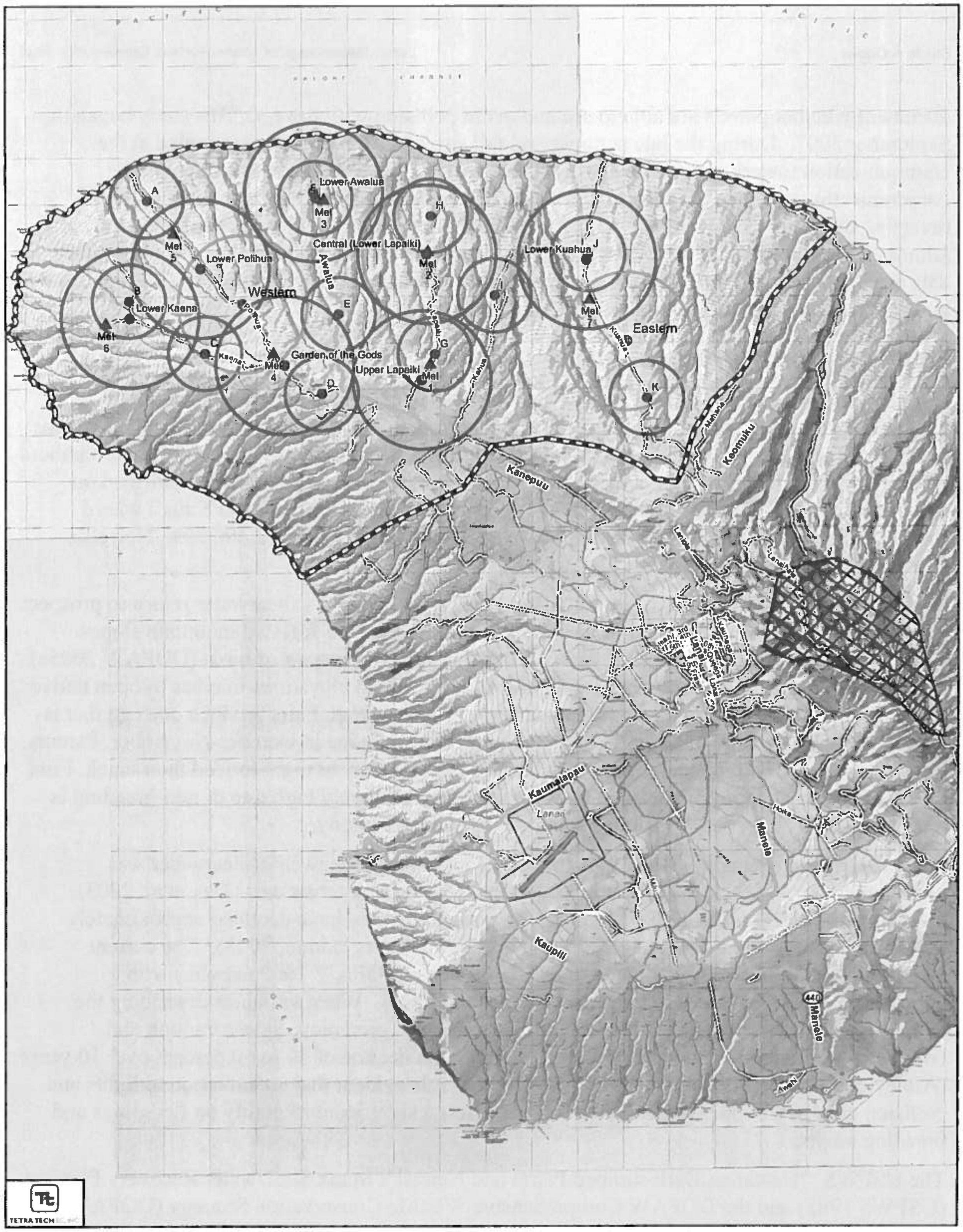
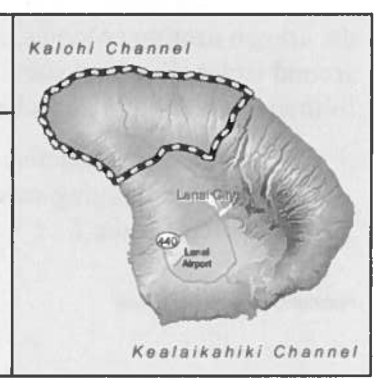


Figure 3-3. Lāna'i Survey Sampling Locations
Castle and Cooke Lāna'i Meteorological Towers Project
Maui County, Hawaii



document whether petrels are able to see and avoid collision with towers. This study began in September 2007. During the late summer and fall surveys, 25 nights were sampled at the communication towers and met tower 6. Twenty petrels were observed approaching the communication towers and exhibiting avoidance behavior by changing their flight path or reversing their direction (Cooper, pers. comm. 2007). No petrels were observed at met tower 6. Although the communication towers are not the same type of structure as the met towers, the data are important to demonstrating that petrels can exhibit avoidance behavior. The applicant aims to continue this study and publish its findings.

3.9.2 Newell's Shearwater

A highly pelagic species, Newell's shearwater forages over deep water east and south of Hawai'i. Historically, Newell's shearwater was once abundant on all the main Hawaiian Islands. Newell's shearwater is known to nest on Kaua'i and Hawai'i and may also nest in small numbers on Maui, Moloka'i, O'ahu and Lehua (off Ni'ihau), but breeding has not been confirmed on these smaller sites. Numbers of both colonies and individuals are greatest on Kaua'i where shearwaters nest in mountains in terrain between elevations of 500 and 2,300 feet. Newell's shearwaters are not known to nest on Lāna'i.

The breeding season for this species begins in April when Newell's shearwater return to prospect for sites. The Newell's shearwater nest in burrows under ferns on forested mountain slopes. Nesting burrows are used year after year and usually by the same pair of birds (DOFAW 2005a). Most Newell's shearwater breeding colonies are found at high elevations in areas of open native forest dominated by 'ohia with a dense understory of uluhe ferns. Pairs produce one egg that is incubated for an average of 53 or 54 days and most chicks fledge in October-November. Parents forage hundreds of kilometers offshore and return to the colony at night to feed their chick. First breeding occurs at approximately six years of age and a relatively high rate of non-breeding is reported even by experienced adults present at the summer colony.

From at-sea counts conducted in 1994, the total population for Newell's shearwater was estimated to be 84,000 birds (Spear et al. 1995). Recent radar target data (Day et al. 2003), however, from 1993 to 1999-2001 indicate the population may have declined approximately 60% from those estimates (Day et al. 2003; Nick Holmes pers. comm. 2008). The current breeding population size is estimated to be 14,600 birds (DOFAW 2005 unpubl.) with approximately 75 percent occurring on the island of Kaua'i. When variables describing the anthropogenic mortality suffered by Newell's shearwater (predation, light attraction and collision) were included, models predicted a population decline of 30 to 60 percent over 10 years (Ainley et al. 2001). As noted by DOFAW (2005a), it is evident that an attraction to lights and collision with power lines and other structures exacts a significant mortality on fledglings and breeding adults.

The USFWS' "Hawaiian Dark-rumped Petrel and Newell's Manx Shearwater Recovery Plan" (USFWS 1983) and the DOFAW Comprehensive Wildlife Conservation Strategy (DOFAW 2005c) include three objectives: (1) reduce annual fallout, (2) provide long-term protection for the known nesting colonies, and (3) develop efficient predator control methods for use in and around isolated nesting sites. In order to meet these goals, DOFAW (2005c) recommend the following short-term goals be accomplished first:

1. Increase reproductive success at a minimum of two Newell's shearwater colonies.
2. Increase fledging success by decreasing fallout at a specified location such as the north shore of Kaua'i.

3. Assess the effects of predators on Newell's shearwater reproduction.
4. Monitor overall population trends on Kaua'i and improve knowledge of Newell's shearwater breeding distribution throughout Hawai'i, especially on O'ahu, Lāna'i, Moloka'i, and Maui.
5. Monitor results of restoration/conservation activities at specific sites.

ABR (see **Appendix 3**) indicated that other researchers consider Newell's shearwater to be rare and doubt the species nest on Lāna'i. Jay Penniman, DOFAW biologist, has heard Newell's shearwater vocalizations during night time surveys at the Hawaiian petrel colony on Lāna'i but does not know whether they are breeding at the colony (Penniman, pers. comm. 2007). No Newell's shearwaters were observed during the 2007 audio-visual survey or confirmed during the radar surveys on Lāna'i.

3.9.3 Hawaiian Stilt

The Hawaiian stilt, a waterbird, is considered a distinct subspecies from the complex of North and South American stilts. This slender wading bird forages in ephemeral wetlands and feeds opportunistically on a variety of shallow water animals. The Hawaiian stilt frequently moves between wetland habitats, although little is known of their movement patterns on Lāna'i.

Hawaiian stilts were historically documented on all the major islands except Lāna'i and Kahoolawe. Currently, Hawaiian stilts inhabit seven of the Hawaiian Islands; Hawai'i, Kaua'i, Maui, Moloka'i, O'ahu, Ni'ihau, and Lāna'i. The existence of Hawaiian stilts on Lāna'i may be due to recent re-colonization from other islands (Englis and Pratt 1993). The Lāna'i population is permanent breeding residents at the Lāna'i City wastewater treatment plant (WWTP) ponds. They have been recorded there since the ponds were operational in 1989. Nesting and breeding habitat differ, and the stilts move between these two habitat types daily during the breeding season. The nesting season extends between March and August but varies between years based on water levels. Hawaiian stilts nest on freshly exposed mudflats interspersed with vegetation or on islands in fresh or brackish ponds. Both parents incubate three to four eggs and fledglings remain with their parents for several months.

The Hawaiian stilt uses ephemeral wetlands, below 660 feet, for foraging and they are quick to colonize newly created wetlands. Hawaiian stilts require specific wetland conditions with a water depth of thirteen centimeters or less for optimal foraging (USFWS 2005). There is some evidence that Hawaiian stilts move seasonally between islands as they travel between wetland habitats and that those movements can be extensive (Reed et al. 1998).

Semi-annual waterbird counts for all the islands between 1993 and 2003 document an average annual population of approximately 1,300 Hawaiian stilts. Counts from across the Hawaiian Islands for the Hawaiian stilt suggest the population is stable to increasing; however, count numbers are variable. The population on Lāna'i is small with a yearly average of 55 adults between 1999 and 2003 from winter counts, with a high of 100 birds (USFWS 2005). The main threats to the population include habitat loss of coastal plain wetlands and introduced predators such as feral cats, rats and dogs.

Although Hawaiian stilts are known to occur in Lāna'i City, they are believed to have a low potential for occurrence in the project area. Spring and summer 2007 radar surveys recorded a Hawaiian stilt flying near met tower site 1. The Hawaiian stilt was observed flying south at 200 m above ground level at dusk on 3 July 2007. Only one stilt was recorded during 485 radar sampling sessions (0.005 stilts/hr), and no stilts were observed during spring and fall avian point count surveys.

3.9.4 Hawaiian Hoary Bat

The Hawaiian hoary bat is the only fully terrestrial native mammal in the Hawaiian Islands. This species is half the size of its North American relatives and primarily forages for flying insects between sunset and sunrise. Relatively little research on this has been conducted on this endemic Hawaiian bat and data regarding its habitat and population status are very limited.

Reports of the Hawaiian hoary bat are known from all the main islands except Ni'ihau (HBMP 2007), although this species is most often seen on Hawai'i, Maui and Kaua'i (Kepler and Scott 1990). Today, the largest populations and only known breeding populations are thought to occur on Kaua'i and Hawai'i. Breeding activity takes place between April and August with pregnancy and birth of twin young occurring from April to June, lactation from June to August and post-lactation from September to December (Menard 2001). While the Hawaiian hoary bat may migrate inter-island and within topographical gradients on the islands, long distance migration like that of the North American hoary bat are unknown (USFWS 1998). Seasonal and altitudinal differences in bat activity have been suggested (Menard 2001) but the timing and extent of this variation are unknown.

The Hawaiian hoary bat has been observed in a variety of habitats that include open pastures and more heavily forested areas in both native and non-native habitats. Typically, this species feeds over streams, bays, or along the seacoast, over lava flows or at forests edges. Hawaiian bats are known to roost solitarily in tree foliage and have only rarely been seen exiting lava tubes, leaving cracks in rock walls, or hanging from man made structures. They are found in both wet and dry areas from sea level to 13,000 feet elevation, with most observations occurring up to 7,500 feet.

Population estimates for this species have ranged from hundreds to a few thousand; however, these estimates are based on limited and incomplete data due to the difficulty in estimating patchily distributed bats (USFWS 2007). The main threats to the Hawaiian hoary bat may be reduction in tree cover, pesticide use, prey availability due to the introduction of nonnative insects and predation. It is unknown what effect these threats have on the population. Observation and specimen records do suggest, however, that these bats are now absent from historically occupied ranges. The magnitude of any population decline is unknown.

At the beginning of the met tower project planning phase, in early 2007, Hawaiian hoary bats were believed to have the potential to occur on Lāna'i because of its proximity to Maui where hoary bats have been documented. On July 3 near the Garden of the Gods, ABR, Inc. made one visual sighting of a Hawaiian bat. This one sighting was the only bat recorded during 485 sampling sessions (0.005 bats/hr) (**Appendix 3**). During the avoidance behavior study, ABR recorded four sightings of Hawaiian bats during that survey period near the summit of Lāna'ihale. Jay Penniman, a DOFAW biologist, noted two bat visual sightings near met tower 6 in September 2007 (Penniman, pers. comm. 2007). Although Hawaiian hoary bat presence has been documented on Lāna'i, their breeding status is not known.

4 CONSERVATION MEASURES AND GOALS

4.1 General

The HCP addresses potential incidental impacts to individuals of a species rather than habitat-based potential impacts. The proposed met towers will have only negligible or no impacts on the amount or quality of habitat for the listed species of concern: Hawaiian petrel, Newell's shearwater, Hawaiian stilt, and Hawaiian hoary bat. No major alternation, degradation, or loss of habitat will occur from operation of the existing and six proposed met towers. However, the met towers have the potential to directly impact the four listed wildlife species if an individual were to collide with a met tower or associated guy wires. HCP avoidance and minimization measures, goals, and objectives are therefore based on individuals or populations of these species rather than habitat.

Castle & Cooke has been working with USFWS and DLNR/DOFAW to identify the potential for incidental impacts to the four protected wildlife species. Castle & Cooke is in the process of implementing species- and site-specific studies to assess the occurrence of these species within the project area and to identify appropriate measures to minimize the potential for impacts.

The biological goals of this HCP are to:

- Minimize and mitigate the effects of take caused by potential collisions of these four federally- and state- listed wildlife species with one or more of the seven met towers.
- Adhere to the goals of the existing recovery plans for the Hawaiian petrel, Newell's shearwater, Hawaiian stilt, and Hawaiian hoary bat.
- Increase the knowledge of these four listed wildlife species population biology and behavior in the project vicinity and on Lāna'i.
- Adhere to the goals of DOFAW and USFWS for increasing the knowledge and understanding of the Hawaiian petrel colony on Lāna'i.
- Provide a net conservation benefit to each of the four species.

The biological objectives for accomplishing these goals are to:

- Minimize potential collisions by attaching bird diverters and flagging to the met tower guy wires to increase visibility to avian and bat species.
- Continue to conduct radar and avoidance behavior studies to increase the level of knowledge concerning these listed species on Lāna'i.
- Provide immediate and long-term benefit to the covered species by implementing a mitigation plan that includes both predator control and habitat restoration. The objective of the predator control in the vicinity of the petrel colony is to increase the survival of both chicks and adult birds, and the objective of the habitat restoration adjacent to the colony would produce additional breeding opportunities for three of the four species to more than offset take levels.
- Increase the survival of Hawaiian stilt chicks and adults by conducting predator control in the vicinity of the WWTP where the Hawaiian stilt is known to occur.

- Document the effectiveness of habitat restoration as a tool for listed seabird recovery on Lāna'i through implementation of a mitigation and monitoring plan.

4.2 Project Alternatives

Section 10(a)(2)(A)(iii) of the ESA requires that alternatives to the taking of listed species be considered and that reasons such alternatives are not implemented be discussed. For this project and HCP, the No Action and Proposed Action alternatives are the two alternatives considered and are presented below.

4.2.1 Alternative 1: No Action Alternative

NEPA requires the evaluation of a No Action Alternative, defined in CEQ regulations as a continuation of present conditions (40 CFR § 1502.14). Under the No Action Alternative for this project, the ITP/ITL would not be granted, and therefore the condition of the CDUP requiring an ITL/ITP would not be met. As a result, the six installed towers would be removed, met tower 7 would not be installed, and no additional information on wind patterns would be available to assess the area's potential to provide wind-generated electricity. Without the additional information on wind resources in the area, Castle & Cooke would be unable to evaluate whether this site meets standards for a viable operation to provide renewable energy to energy consumers.

Hawai'i has established a renewable portfolio standard (RPS) (sections 269-91 through 269-95, HRS) from which the electric utilities are to provide 10 percent of their electricity from renewable sources and energy efficiency by the year 2010, 15 percent by 2015, and 20 percent by 2020. It is anticipated that the addition of renewable energy will lessen the need for imported fossil fuels and will result in dependable electricity benefiting the public. Wind energy is among the most cost-competitive renewable resources but there is limited land available on the Hawaiian Islands for this use. Should data collected via the proposed met towers provide evidence that a wind farm is feasible on Lāna'i, it could provide a significant contribution towards the State of Hawai'i's RPS goal.

4.2.2 Alternative 2: Proposed Action

The Proposed Action consists of issuance of an ITP/ITL to address potential impacts to four listed wildlife species associated with the operation of seven 50-meter tall met towers on privately owned lands by Castle & Cooke (see Figure 1-1). The towers collect data on wind patterns; these data would be used to determine the suitability of the wind regime to sustain a wind energy facility. Minor adjustments to these locations (that is, micro-siting) were implemented in the field if necessary to avoid unexpected sensitive resources or installation issues. Seven towers are required to best assess the wind data across the entire wind resource area.

No feasible alternatives to the Proposed Action were found other than the No Action alternative. Alternate locations for the seven tower sites were considered and dismissed because the towers must be located where the representative wind resource is likely to occur. A single alternative, the No Action alternative, is therefore the only alternative to the Proposed Action.

DLNR issued Castle & Cooke CDUP No. LA-3419 on August 8, 2007, to conditionally approve the installation of one met tower at site number 6 and preliminarily approve installation of the remaining six met towers (**Appendix 1**). Pursuant to DLNR approval on December 10, 2007, five additional met towers were erected by February 8, 2008. Two of the permit conditions provided below and subsequent coordination with DOFAW and the USFWS resulted in the determination that an EA and HCP should be prepared for the met tower project to address potential impacts to federal- and state-listed wildlife species under section 10 of the ESA. The pertinent CDUP conditions state:

> "7. Should an impact with flying wildlife occur, the applicant shall remove the tower(s) until such time as the tower(s) are covered by an Incidental Take License and accompanying (amended) Habitat Conservation Plan;
>
> 8. Subsequent tower construction shall proceed only after review and approval by the Division of Forestry and Wildlife and the Office of Conservation and Coastal Lands, based on positive avian survey results and the successful actions of the applicant to mitigate potential avian impacts;"

Condition 7 was clarified by DLNR in a letter dated September 7, 2007, that "flying wildlife" only pertained to listed wildlife species (**Appendix 1**).

With a steadily increasing demand for power, Hawai'i currently uses fossil fuels for 90 percent of its electric generation, which results in very high electricity prices. The proposed met towers are critical to making an informed decision on whether a wind farm is feasible on Lāna'i. It is anticipated that an additional source of renewable energy would lessen the need for fossil fuels and will result in dependable electricity benefiting the public. Castle & Cooke is dedicated to assisting the state in meeting its renewable energy requirements and goals.

4.3 Avoidance and Minimization of Impacts

Complete avoidance of risk to the four listed wildlife species is not possible for the project. Therefore, Castle & Cooke plans to minimize the risk of collisions as much as possible by maximizing the visibility of the met towers and guy wires while ensuring that meteorological data collection is not compromised. These measures include the following:

- Towers are sited primarily on the western side of the WRA to maximize the distance from the petrel colony.
- Each of the met towers are painted white and utilize white, 1-inch poly tape, fitted to the guy wires, to increase visibility and subsequently increase the likelihood of avoidance by the seabirds and bat. This tape has proved effective in minimizing petrel collisions with fences on other projects within the Hawaiian Islands when wrapped along the length of the wire (USFWS and DOFAW, pers. comm. 2007; **Appendix 2**).
- The poly-vinyl tape are cut into 4-foot segments, folded in half over the wire, and attached using ultra-violet light resistant zip ties, leaving at least 6-foot gaps above and below the anemometers. Bird diverters are added between the sections of white tape. Additionally, two, 3-foot sections of yellow PVC tubing are placed on each guy wire, starting at the anchor points. This is the maximum amount of PVC tubing that can be applied to the guy wires without causing excessive loading and drag; more tubing could significantly impact the quality of the meteorological data collected (**Appendix 2**).
- Castle & Cooke removed met tower number 8 from further consideration to minimize the number of towers erected and to reduce the potential for collision with a met tower or guy wire.
- No lighting is needed for the met towers because they are less than 200 feet high (FAA 2007).

- Vegetation clearing is minimal for the erection of each tower.
- Radar and visual studies are being conducted to identify the movements, behavior, and flight altitudes for the seabirds and bats.
- Established take limits to ensure that take does not exceed the expected levels, and that mitigation more than compensates for any impacts.
- Three or six acres of native habitat will be restored that is expected to provide nesting habitat for Hawaiian petrels and Newell's shearwaters and roosting and foraging habitat for Hawaiian hoary bats.
- A monitoring and adaptive management program will be implemented to ensure that take limits are not exceeded and that the habitat restoration and predator control programs are achieving their expected benefits.

5 ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION

5.1 Assessment of Potential Impacts to Listed Species

Studies summarized by Erickson et al. (2005) show that millions of birds each year are killed in the U.S. by a variety of anthropogenic causes. These sources include collision with human-made structures such as buildings, windows, communication towers, power lines, wind turbines, electrocution, cat predation, pesticides and other contaminants. This and other studies reviewed show that the magnitude of bird mortality at wind energy facilities is low compared to mortality resulting from collisions with other man-made structures. Erickson et al. (2005) estimated annual avian mortality from wind turbines was 20,000 to 37,000 birds. In comparison, the National Audubon Society estimates that over 100 million birds are killed each year by house cats alone (Erickson et al. 2005). Most of the available literature focuses on mortality associated with wind turbines or other structures rather than met towers. However, a few studies summarizing results of mortality monitoring at turbines have made reference to carcasses found at met towers if monitored. Young et al. (2003) reported bird fatalities at guyed met towers at Foote Creek Rim wind power project in Wyoming.

To better understand the potential presence and movement of Hawaiian petrels, Newell's shearwaters, Hawaiian stilts, Hawaiian hoary bats, and other avian species within the WRA, Castle & Cooke contracted to have radar and audio-visual surveys and avian point count surveys conducted within the project vicinity. These surveys are described in **Appendices 3 and 4** and summarized in Section 3.9.

The issuance of an ITP/ITL requires establishing the number of individuals authorized for take during a defined period. The met towers are temporary structures that will be operated up through March 1, 2010. Rather than estimating a take limit per year for each listed species, USFWS and DOFAW recommended establishing a maximum take for each species over the 2-year period and providing appropriate mitigation that would compensate for these maximum take limits. A take limit of two individuals has been established each for the Hawaiian stilt, Hawaiian hoary bat, and Newell's shearwater. Based on radar data and expected avoidance behavior, a tiered approach to the take limit and associated compensatory mitigation was established for the Hawaiian petrel. Should the Tier 1 take limit for the petrel be reached before the end of the 2-year period, a higher, Tier 2 take limit would be established. Tier 2 mitigation would be implemented as a contingency to account for greater than anticipated Tier1 take levels. Tier 1 mitigation developed for the petrel will also mitigate for potential impacts to Newell's shearwater and Hawaiian hoary bat.

If Tier 2 take limits are reached without an approved amendment to the HCP, the towers will be taken down. However, if Tier 2 take limits are reached at the end of the fledging season but prior to the following years' spring breeding season, the met towers would be removed approximately two weeks prior to the beginning of the seabird breeding season, pending approval by DLNR and USFWS. In the event towers need to be removed before project completion, tower removal would be initiated within 3 days and be completed 10 days after initiation of tower removal.

5.1.1 Hawaiian Petrel

The Lāna'i Hawaiian petrel colony is located approximately seven miles from the nearest proposed met tower location and approximately 11 miles from the westernmost met tower location. During the spring and summer 2007 radar surveys, audio-visual analyses recorded 33 petrels and two unidentified petrel/shearwater targets. Radar sampling documented 170 petrel/shearwater targets and 427 probable petrel targets during spring and summer surveys, respectively. Movement rates showed that fewer targets flew over the western portion of the study area during both surveys. The overall movement rates observed on Lāna'i (0.5 to 7.1 targets/hr) tended to be much lower than the rates observed during similar radar studies on Kaua'i (8 to 569 targets/hr) and East Maui (3.6 to 134 targets/hr). Movement rates were similar to Hawai'i (0 to 25.8 targets/hr). Mean movement rates in the western portion of the Lāna'i WRA were lower than rates recorded at nearly all other locations studied in the Hawaiian Islands (**Appendix 3**).

Although there is no petrel-specific literature data on avoidance of met towers or other structures, data is available indicating that other seabird species detect and avoid wind turbines and other manmade structures in low-light conditions (Dirksen et al. 1998, Winkleman 1995, 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 paths) 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 wind turbines in Europe (Dirksen et al. 1998).

Hawaiian petrels have flight characteristics different from these other species. However, they are adept at flying through forests to and from their nests during low-light conditions. Preliminary results of an avoidance behavior study for the Lāna'i project indicate that petrels do see and are able to avoid objects such as communication towers when in their flight path. For example, two different petrels avoided a communications tower on the Lāna'ihale by turning 180 degrees on approaching the tower and flying in the opposite direction. Other petrels observed avoided the tower by adjusting their flight direction away from the structure (Cooper, pers. comm. 2007 and 2008). It is reasonable to assume that a fairly high proportion of petrels would detect and avoid other large structures under average conditions of weather and visibility due to the following elements: 1) petrels have the behavioral and physical capabilities to avoid towers, and 2) although a small sample size, petrels have demonstrated a high avoidance rate of structures at the Lāna'ihale during summer and fall avoidance studies.

Using movement-rate (see **Appendix 3**) and flight height data collected during the spring and summer of 2007, Castle & Cooke developed a range of estimated annual fatality rates for each met tower by assuming that 0, 50, 95, and 99 percent of all Hawaiian petrels flying near a proposed met tower see and avoid the tower. The estimated range of petrel fatalities at met towers 1 through 7 over a 2-year period is 5 to 25 birds, using avoidance rates of 95 and 99 percent and avian data. These fatality rates do not take into account several factors including the results of the recent 2007 fledging season radar surveys where lower numbers of birds were observed, compared to spring and summer. Also, petrels had fledged by December 7, and the model used to estimate the fatality rates assumed the fledging period ends at the end of December. Finally, the model assumptions do not consider the use and effects of flagging, diverters, and tower painting, all of which increase tower visibility and likely reduce the risk of collisions. Thus, these three factors would lower estimated annual fatality rates presented for the spring and summer surveys (Cooper, pers. com. 2007).

In consultation with USFWS and DOFAW, Castle & Cooke established Tier 1 and Tier 2 take limits of seven and fourteen Hawaiian petrels, respectively, as a result of collision with one or more of the proposed met towers over a 2-year period. Since an active breeding colony of petrels exists at the Lāna'ihale, there is the potential that indirect take of petrels could occur if an adult is killed while incubating an egg or rearing a chick. However, because petrels can abandon young several weeks prior to fledging, and young die from natural causes such as predation, loss of an adult during the nesting season may not always be associated with the loss of that year's young. During the spring season, a large number of non-breeders may also be present on the island. Indirect take of petrels is accounted for through the Tier 1 and 2 mitigation in an analysis conducted to determine the area to be restored within the colony (see Section 5.3.5).

5.1.2 Newell's Shearwater

Radar and visual studies to date have not verified the presence of Newell's shearwaters within the WRA, although a few unidentified petrel/shearwater targets were documented. This species has not been confirmed to breed on the island. Thus, the potential for take of shearwaters as a result of collision with the met towers is extremely low. However, because DOFAW has documented their presence by vocalizations on at least one occasion in the Lāna'ihale petrel colony, the potential for take must be considered. In consultation with USFWS and DOFAW, Castle & Cooke established a take limit of two Newell's shearwaters as a result of collision with one or more of the proposed met towers over a 2-year period.

5.1.3 Hawaiian Stilt

Hawaiian stilts on Lāna'i reside at the WWTP ponds in Lāna'i City, which are roughly 12 miles from the closest met tower. Although no foraging or nesting habitat occurs within the vicinity of the met tower locations, Hawaiian stilt would have the potential to collide with met towers or guy wires while traveling between wetland sites or to tidal flats on other parts of Lāna'i or other islands. Reports of waterbird fatalities associated with met towers are limited, but some wind turbine facility studies have documented waterbird fatalities, such as grebes and coots (Johnson et al. 2002, Anderson et al. 2005).

One Hawaiian stilt was observed flying over near met tower 1 (at 200 meters above ground level) during 485 radar sampling sessions, and no observations were made during spring and fall point count surveys. Thus, the potential for take of Hawaiian stilts as a result of collision with met towers is very low if any. However, in the slight chance that a Hawaiian stilt would collide with one of the met towers, the stilt has been included as a covered species in this HCP. In consultation with USFWS and DOFAW, Castle & Cooke established a take limit of two Hawaiian stilts as a result of collision with one or more of the met towers over a 2-year period.

5.1.4 Hawaiian Hoary Bat

One Hawaiian hoary bat was recorded during 485 radar sampling sessions (0.005 bats/hr) within the WRA (**Appendix 3**), and there have been limited observations of the bat on the island. Thus, the potential for take of a hoary bat as a result of collision with the met towers is low. Hawaiian hoary bats forage for insects in open areas such as grasslands and shrublands at variable heights but tend to roost in tree foliage, which is absent from the met tower locations. Hawaiian hoary bats are not known to roost on Lāna'i and are believed to occur on the other Hawaiian Islands in greater numbers. Population estimates range from hundreds to a few thousand (USFWS 2007).

A Hawaiian hoary bat would have the potential to collide with the tower or guy wires while foraging. Reports of bat fatalities associated with met towers are limited, but some studies discuss bat mortality as a result of collision with turbines. Monitoring studies completed since 2001 have indicated that some wind energy facilities have killed a number of bats. Studies seem to indicate that bats are struck by the moving rotor blades rather than colliding with the turbine or non-operational turbine (Kunz et al. 2007). Therefore, it may be that moving parts represent the larger threat to the bats rather than collisions with stationary structures such as met towers. Furthermore, tree-roosting bats that migrate long distances are more commonly killed by turbines than other bat species. The highest number of bat fatalities in North America at wind energy facilities appears to be along forested ridge tops in the eastern US and lowest in relatively open landscapes in the mid-west and western states (Kunz et al. 2007). Hawaiian hoary bats do not migrate to any degree as hoary bats do on the mainland, and roosting habitat is absent from the met tower locations. Therefore, potential impacts from collision with met towers are expected to be very low if any. However, in the slight chance that a bat would collide with one of the met towers, the Hawaiian hoary bat has been included as a covered species by this HCP. In consultation with USFWS and DOFAW, Castle & Cooke established a take limit of two hoary bats as a result of collision with one or more of the met towers over a 2-year period.

5.1.5 Listed Plant Species

No listed plant species were observed during biological surveys of the met tower locations conducted in April 2007 and November 2007. Therefore, no impacts to federally listed plant species are anticipated as a result of met tower installation and operation.

5.2 Take Limits

The take limits were established for each of the four listed species based on the 2007 spring and summer radar survey data, spring and fall point count surveys, and consultation with DOFAW and USFWS. The estimated range of petrel fatalities at met towers 1 through 7 over the 2-year period is 5 to 25 birds, using avoidance rates of 99 and 95 percent, respectively. Observations of one Hawaiian stilt and one Hawaiian hoary bat were recorded, and no shearwaters were observed during these surveys. Thus, based on these data and consideration of the avoidance measures implemented, the following take limits were derived:

Table 5-1. Tiered Take Limits

Species	Tier 1 Take Limit	Tier 2 Take Limit
Hawaiian Petrel	7	14
Newell's Shearwater	2	N/A
Hawaiian Stilt	2	N/A
Hawaiian Hoary Bat	2	N/A

Take of a particular species includes not only the direct take that is observed (for example, injury or mortality), but may also include unobserved direct take and indirect take. Each of the following components are considered to determine estimated take for each species and establish the appropriate level of mitigation to compensate for direct and indirect take:

1. **Observed Direct Take**. Regular carcass searches will be conducted at each of the met towers during the operation period to document the number of individual birds and/or

bats that have been killed or injured as a result of collision with one of the met towers. The detailed, post-construction or downed wildlife monitoring protocol is provided in **Appendix 6**.

2. **Unobserved Direct Take**. Downed wildlife may be overlooked by searchers, or scavenged by local predators such as cats. The monitoring protocol presented in **Appendix 6** includes methods for estimating searcher efficiency and scavenging rates, which together provide a basis for estimating the number of individuals that are taken but that go undetected. Scavenging and searcher efficiency data will be used to assess the frequency at which carcass searches should be conducted so as to minimize removal of any downed birds or bats by scavengers. Any changes to the monitoring protocol will be approved by DOFAW and USFWS and reviewed by the ESRC.
3. **Indirect Take.** These are individuals that are indirectly taken as the result of a direct take of another individual. For example, eggs or young may be lost due to the loss of a parent. Indirect take is accounted for in the mitigation plan.

Searcher efficiency trials will be conducted a minimum of three times per season and will be applied to the results from the carcass surveys (observed direct take) to calculate the adjusted direct take for seabird species. When (and if) carcasses are found, the searcher efficiency results will be applied to the total number of carcasses found, up to that point, to determine whether the take limit has been reached for a particular species. Searcher efficiency will not be applied to observed direct take for bats or stilts because it is highly unlikely that incidental take of one of these species would occur. There is a very low probability that bats or stilts would be using the project area based on radar studies, location of sitings on Lāna'i, lack of habitat within the project area, and other literature. However, searcher efficiency trials will be conducted for bats but not for stilts.

As an example, if a second petrel carcass is found in the ninth month of the project, and searcher efficiency up to that point is 75 percent, then the adjusted direct take would be calculated as follows:

Component	Take
Direct Observed Take = 2 Hawaiian petrels	-2.0
Direct Unobserved Take = Take of 2 based on 75% detection rate	-0.66
Adjusted Take	**-2.66**

Therefore, an adjusted direct take of 2.66 petrels would be applied to the Tier 1 take limit of seven. Please note that this example does not incorporate search frequency and scavenging removal times that would be used to calculate real adjusted take estimates (see **Appendix 6**).

Take of listed species is not limited to mortality. By its definition in the ESA, take of a listed species also includes "harassment". In the case of the Lāna'i meteorological project, one or more of the four listed species may be required to alter their flight patterns and/or behavior due to the presence of the met towers. Additionally, the potential exists that birds or bats may avoid areas where met towers are located. The petrel, shearwater, and bat also have the potential to be harassed as a result of habitat restoration activities in the Lāna'ihale. The majority of habitat restoration work will be conducted during the winter and spring, before the petrels return to the colony, to minimize the risk of harassment to petrels. Restoration work that occurs in the summer and fall will be conducted in areas that are not in close proximity to active nesting areas within the colony. Further, habitat restoration monitoring will be conducted in a manner that minimizes harassment of petrels and other listed species. Therefore, no additional take or disturbance is expected for any of these four species.

5.3 Mitigation for Potential Impacts

Mitigation measures under an HCP may include a wide variety of options. In considering mitigation for this project, several criteria were considered in developing the proposed mitigation plan. These include:

- Mitigation programs should be based on sound biological principles, be practical, and commensurate with the impacts to be addressed.
- Mitigation should be species-specific.
- Mitigation measures can contribute to recovery or have a net benefit to the species.
- Mitigation can include habitat enhancement or restoration of degraded or former habitats.
- Mitigation alternatives may include studies/strategies that provide new information for a poorly documented species, which could in turn have merit when this information helps identify efforts to improve survival and productivity.

The take for all four species would have a low risk of adverse population impacts on the Lāna'i populations. As discussed in meetings with DOFAW and USFAW, the basic population biology (e.g., distribution, abundance, population, and threats) has not been established for the Hawaiian petrel, Newell's shearwater, Hawaiian stilt, and Hawaiian hoary bat on Lāna'i. Additionally, the petrel colony at Lāna'ihale was only recently rediscovered in 2006, and the presence of Hawaiian stilts, Hawaiian hoary bats, and Newell's shearwaters was only recently documented on the island. While the petrel population size has not been estimated with statistical confidence, it is estimated that at least a thousand birds are using the habitat within the Lāna'ihale (Penniman, pers. comm. 2007). The Newell's shearwater population was estimated at 84,000 birds at-sea (Spear et al. 1995) but current numbers are expected to be lower in Hawai'i (Day et al. 2003; Nick Holmes pers. comm. 2008). The Hawaiian stilt occurs primarily on the island as a result of man-made habitat at the city WWTP but larger numbers are documented on the other Islands. Research is ongoing to more fully document the extent of the Hawaiian hoary bat population, although it is expected to occur in higher numbers on Hawai'i and Kauai. Mitigation is proposed to provide a net benefit to these species as on-going studies will serve to better understand each species' population biology.

5.3.1 Tiered Mitigation Approach

Castle & Cooke consulted with biologists from DOFAW and USFWS to identify appropriate mitigation measures to compensate for potential take of the four listed wildlife species. This mitigation plan outlines a two-tiered approach, based on the recommendations provided by DOFAW and USFWS. DOFAW and USFWS determined that the recommended mitigation measures would address potential impacts to all four species. Therefore, a comprehensive mitigation plan is provided below rather than four separate mitigation plans for each species.

The first tier of mitigation (Tier 1) would compensate for a take limit of seven Hawaiian petrels, two Newell's shearwaters, two Hawaiian stilts, and two Hawaiian hoary bats. The mitigation has been structured to compensate for direct take and indirect take. Should the Tier 1 take limit be reached for the petrel, additional mitigation would be implemented (Tier 2). Thus, Tier 2 mitigation would compensate for the take of 14 Hawaiian petrels.

Castle & Cooke proposes to fund a project-specific mitigation plan that will be integrated into the on-going interagency seabird conservation project and the watershed enhancement program on Lāna'i. This collaboration ensures that a coordinated and cost effective program will be implemented by DOFAW. The mitigation plan includes two primary components: predator control and habitat restoration. The combination of these two mitigation measures will provide immediate- and long-term benefits for each species by increasing adult and juvenile survival, nest success, and suitable nesting habitat required for the long-term productivity of these species.

Subsequent monitoring of the mitigation measures implemented by DOFAW will allow the agencies to assess the effectiveness of the mitigation methods. The monitoring results can be used to enhance the effectiveness of the management activities here and at other seabird colonies throughout Hawaii. This could result in a greater net benefit to bird and bat populations beyond the initial net benefit to the birds and bats on Lāna'i.

Castle & Cooke does not anticipate reaching the maximum Tier 1 authorized take limits but will fund the mitigation measures proposed that compensate for the Tier 1 take limits established in this HCP. Castle & Cooke will also implement a wildlife education and observation program for all staff members who will be at the project area on a regular basis.

5.3.2 Predator Control

Predation of young and adults is considered one of the primary threats to all four species. Feral cats, barn owls, and rats are the predators known to occur on Lāna'i that may kill adult or young Hawaiian petrels or Newell's shearwaters. Although the total impact of cats on the colony is not known at this time, preliminary data indicates that cats are a threat to petrels and shearwaters. An active feral cat population has been documented in the vicinity of the petrel colony, and DOFAW has established traps in locations around the colony. Ungulates have created trails throughout Lāna'ihale that have increased access to the colony for cats. Increasing the trapping efforts for predators would logically have the potential to decrease the number of adult and juvenile petrels and Newell's shearwaters killed and have a net positive effect on both populations. Increases in survival and productivity at seabird colonies through predator control are well-documented in Hawai'i and elsewhere (Winter and Wallace 2006).

As part of the Tier 1 mitigation plan for the met towers, Castle & Cooke will provide funding to augment DOFAW's current predator-control program at the petrel colony (**Appendix 7**). Tier 1 funding provides for materials and for the hire of two DOFAW staff members to set and monitor 20 additional traps throughout the Lāna'ihale for the 2-year period; locations will be determined by DOFAW. Care will be taken to locate traps in previously disturbed areas; creating new trails through the colony would only provide increased access for the cats to the birds and burrows. In addition to funding for personnel to set and monitor traps, Castle & Cooke will provide DOFAW with the full-time use of a vehicle on Lāna'i during the 2-year period to implement the predator control program.

DOFAW confirmed that cats are present and have been trapped in the vicinity of the WWTP. Therefore, it can be assumed that predation of stilts by cats occurs and could have an adverse effect on the resident stilt population (DOFAW, pers. comm. 2007 and 2008). DOFAW does not currently have the staff or resources to implement a regular predator control program at the WWTP to protect the Hawaiian stilt. Castle & Cooke will provide DOFAW 12 additional traps to be placed around the perimeter of the WWTP. DOFAW staff implementing the petrel colony predator control and habitat restoration program will maintain these traps at the WWTP. This program will be implemented with the Tier 1 funds and would provide a net benefit to the stilts.

If Tier 2 mitigation is required, the efforts of the predator control program will be increased at the colony. An additional 15 traps will be set in the vicinity of the colony for a total of 35 traps. More traps would increase the potential to remove more predators preying on the colony and provide a net benefit to the seabirds.

5.3.3 Habitat Restoration

At Lāna'ihale, much of the potential nesting habitat for Hawaiian petrels and Newell's shearwaters has been degraded by the introduction of ungulates and subsequent establishment of invasive species such as strawberry guava (*Psidium cattleianum*). Restoration of degraded habitat through the removal of invasive species and reintroduction of uluhe fern and other native species should ultimately increase the size of the breeding population. DOFAW identified an appropriate area of degraded habitat for restoration that has existing access as shown in the scope of work provided in **Appendix 7**. DOFAW may consider installing artificial burrows to encourage colonization, thus reducing the time needed to recognize a net benefit to the species.

This habitat restoration program would also benefit the Hawaiian hoary bat by increasing foraging and roosting habitat. The following provides a summary of the restoration measures to be implemented by DOFAW and the Maui Invasive Species Committee (MISC).

- Invasive species such as strawberry guava will be cleared from the identified area. This includes manual labor to remove the plants and treat stumps with herbicide.
- If the natural seed bank does not facilitate regeneration of native uluhe fern and other native species such as *Metrosideros*, *Rubiaceae* or *Tetraplasandra*, uluhe fern, and other native plants may need to be planted in select locations after invasive plant removal.
- The restoration area will require maintenance for the 2-year period to control weeds and other invasive species and protect the native plant species. Tier 1 funding also will support DOFAW staff to maintain and monitor habitat restoration activities.
- DOFAW may consider installing artificial burrows to encourage colonization if the birds do not start using the restored habitat on their own.
- Restoration activities will be conducted so as to minimize any disturbance to the petrel colony during the breeding season and potentially to Hawaiian hoary bats if indeed bats breed on Lāna'i. Clearing activities will not occur in the vicinity of active petrel burrows during the breeding season. The sensitive period for bats is July 1 through September 30. During that time period, five consecutive days of negative bat detections must occur for DOFAW to be able to cut trees greater than three meters in height.

Appendix 7 provides a detailed scope of work and milestones for the predator control and habitat restoration work. A Memorandum of Agreement (MOA) was developed between Castle & Cooke and DOFAW that outlines the responsibilities for each party associated with the mitigation plan.

Should the Tier 1 take level for petrels be reached, Tier 2 mitigation would be implemented. Tier 2 mitigation would double the acreage of Tier 1 habitat restoration. Additional funds would be provided to DOFAW/MISC to clear the additional acreage of invasive vegetation. DOFAW has the option to restore the entire six acres in 2009 with the Tier 1 funds. Tier 2 funds would be provided to DOFAW only if the petrel Tier 1 take limit is reached. The three- or six-acre restoration area(s) will be maintained by the DOFAW employees hired under the Tier 1 mitigation plan. DOFAW may choose to reallocate the Tier 1 staffing funds to conduct and maintain the entire six-acre restoration parcel for the project period if Tier 2 is not initiated.

5.3.4 Net Benefit of Mitigation to Listed Species

Mitigation proposed for each of the four listed species is designed to not only compensate for take that may occur as a result of collision with met towers but also provide a net conservation benefit for the species addressed. Site-specific radar and avian point count surveys have determined that, of the four listed species addressed within this HCP, the Hawaiian petrel represents the species at greatest risk of take from collisions with met towers; observations of the other three species within the WRA were extremely low. Castle & Cooke consulted with DOFAW and USFWS to determine that, of the mitigation strategies available, a combination of habitat restoration and predator trapping in the Lāna'ihale would both compensate for take and result in a net conservation benefit for the petrel. These mitigation measures also would provide a net benefit for shearwaters and bats, incidentally, as these species occur within the same habitat. Similarly, predator trapping at the WWTP ponds would provide a net benefit for stilts.

As the Hawaiian petrel colony on Lāna'i was only recently rediscovered, DOFAW has not yet identified the size of the colony or its population dynamics. However, DOFAW speculates that the colony may number in the thousands. While DOFAW cannot identify with certainty the amount of acreage needed to mitigate for a take limit of seven Hawaiian petrels (Tier 1), DOFAW biologists have collected some colony-specific data which can be used in combination with values provided in the literature to estimate an approximate acreage.

The following equation illustrates the method by which the restoration acreage was calculated:

$$T_{ha} = T_t P_f F_{ha} + T_t P_a (A_{ha} + FA_{ha})$$

Where:

- T_{ha} = Restoration acreage needed to offset take of 7 petrels
- T_t = Tier 1 take limit of 7 petrels; total number of observed and unobserved (i.e. observed adjusted for search efficiency and scavenge removal) birds taken
- P_f = Percent of petrels that are fledglings
- F_{ha} = Sufficient acreage to compensate for one fledgling killed by a tower
- P_a = Percent of petrels that are adults
- A_{ha} = Sufficient acreage to compensate for one fledgling killed by a tower
- FA_{ha} = Sufficient acreage to compensate for possible loss of a fledgling when an adult is killed

The calculation assumes that for every fledgling killed by a tower, a sufficient acreage of habitat would need to be restored to produce one fledgling. This acreage is calculated as

$$F_{ha} = [(FS)\,(BD)]^{-1}$$

Where

- FS = Fledging success or 0.55 fledglings/attempt (DOFAW unpublished data)
- BD = Breeding density or 25 attempts/ha (DOFAW data per 10/4/07 DLNR letter)

Recent surveys conducted by DOFAW suggest that breeding densities on Lāna'i may be one burrow per 400 square meters. This is a very high breeding density in comparison to what has been reported on Haleakala (nearly 3 times higher). However, preliminary data at Lāna'ihale suggest that these densities can be achieved with appropriate habitat management.

Thus, the acreage needed to mitigate the loss of a fledgling is

$$F_{ha} = (0.55)^{-1} (25)^{-1} = 0.07 \text{ ha}$$

The calculation also assumes that for every adult killed by a tower, a sufficient acreage of habitat would need to be restored to mitigate the loss of that adult plus any fledgling that may die as a result of the loss of that parent. Thus, the acreage needed to mitigate the loss of the adult is

$$A_{ha} = [(S_A) (FS) (BD)]^{-1} = 0.27 \text{ ha}$$

Where:

SA = Survival to adulthood, or 0.269 (Simons 1984)

For any fledgling whose parent is killed, it also is assumed that the fledgling will also perish. The acreage needed to mitigate for the possible loss of a fledgling when an adult is killed is

$$FA_{ha} = (F_{ha}) (P_B) = 0.065 \text{ ha}$$

Where

PB = the probability that the adult is breeding = 0.89

Simon 1984 found that 89 percent of adults that return to the colony breed each year. The calculation also assumes that half of the birds killed by the tower are adults and half are fledglings, or

$$P_a = P_f = 0.50$$

Thus, for a take limit of seven Hawaiian petrels ($T_t = 7$ birds), the restoration acreage estimated to mitigate for that take is 1.4 ha or 3.5 acres. DOFAW's existing predator control program within the Lāna'ihale will be augmented with the Tier 1 funding, and this program, in combination with the three acres of Tier 1 habitat restoration, will provide a net benefit for the seabirds and bats.

Predator control has been proven to significantly enhance seabird populations on islands. Alien predators such as cats, rats, and mongoose can have devastating effects on bird populations especially seabirds, as the native birds did not evolve with these mammalian predators and have no effective defenses against them (Winter and Wallace 2006). A number of studies have documented the effects of predation on the reproductive success of bird species including seabirds. Winter and Wallace also summarized studies that document the impact of feral and free-ranging cats in Hawai'i on seabirds and other native bird species. A single cat can have a devastating effect on a breeding seabird colony while "cat colonies" (such as on Lāna'i) pose an even greater threat. The Bonin petrel on the Midway Atoll has declined dramatically as a result of black rat predation (Seto and Conant 1996).

Nogales et al. (2004) conducted a review of feral cat eradication programs in island communities worldwide to provide information for future island conservation programs. On Marion Island (sub-Antarctic island, South Africa), it was estimated that cats preyed on approximately 455,199 seabirds per year (including Guadalupe Storm Petrel), which constitutes a kill rate of more than 200 birds per cat (Veitch 1985). On Mauna Loa, Hawai'i, Hawaiian petrel burrows were monitored for cat predation. A single cat was removed and no evidence of predation was noted following the capture. Nest success that year (1995) was 61.5 percent. The following year when trapping was not conducted, nest success dropped to 41.7 percent primarily due to cat predation (Hu et al. 2001). Cat predation was also documented to have a negative effect on Hawaiian stilt and other water bird species in Hawai'i (Winter and Wallace 2006).

DOFAW currently conducts cat trapping on the Lāna'ihale to protect and increase the numbers of Hawaiian petrels in the Lāna'i colony. Of cats trapped by DOFAW, 20 percent contained petrel remains in their stomachs. As part of the mitigation strategy for the Lāna'i met towers project, Castle & Cooke will augment DOFAW's current predator trapping program. While it is clear from the literature that the removal of one cat from the Lāna'ihale might more than compensate for the Tier 1 and Tier 2 take limits for the Hawaiian petrel, the goal is to remove as many cats as is feasible within the 2-year project timeline. Thus, the combination of restoring three acres (or six acres if the Tier 1 limit is reached) of habitat and conducting predator removal within the Lāna'ihale will compensate for Tier 1 and Tier 2 take limits and provide a net conservation benefit for the Hawaiian petrel and, incidentally, Newell's shearwater and Hawaiian hoary bat. As DOFAW has documented the presence of cats at the WWTP, predator control at the WWTP ponds in Lāna'i City also will provide a net benefit for the Hawaiian stilt.

5.3.5 Funding

Castle & Cooke will provide DOFAW funding to implement the proposed mitigation measures as outlined above and detailed in **Appendix 7** as well as a vehicle and chipper for their use on Lāna'i during the 2-year period. DOFAW, in turn, will coordinate the mitigation efforts with the MISC and the Pacific Cooperative Studies Unit, University of Hawai'i. The design and scope of each year's effort are determined in consultation with USFWS and DOFAW biologists and formalized in writing in the MOA. The details of the funding are outlined in Section 6.7.

5.4 Other Measures

Castle & Cooke will prepare a Wildlife Education and Observation Program for all staff members who will be on the property on a regular basis. This will enable staff to identify the listed native species that may occur in the area and understand the appropriate steps to be taken when a downed bird or bat is discovered. This program includes a handout that shows a photograph of each of the listed species and the protocol to follow when a downed bird or bat is found.

6 PLAN IMPLEMENTATION

6.1 Responsibilities

Castle & Cooke is responsible for providing the identified funds to DOFAW to implement the mitigation measures expressly described in this HCP. Management of the monies set aside to cover the costs associated with the HCP mitigation measures will be the responsibility of DOFAW. DOFAW will provide a detailed report that accounts for the money spent to implement the specific mitigation activities identified in the HCP and will provide annual reports to Castle & Cooke that summarize the results of mitigation and monitoring activities.

Castle & Cooke must submit annual reports to DLNR and USFWS by August 31 each year of the project to summarize overall findings and status. Therefore, DOFAW must submit the monitoring reports summarizing the progress of the mitigation activities to Castle & Cooke by August 15 of each year during the project. DOFAW will also provide Castle & Cooke with monthly status reports regarding the habitat restoration and predator control activities. The annual reports to DOFAW and USFWS will summarize 1) the results of the post construction mortality monitoring, 2) any take that has occurred, 3) the progress of the mitigation activities as provided by DOFAW, and 4) any recommended changes to the monitoring protocols to be considered by these agencies. These reports will also be reviewed by the Endangered Species Recovery Committee. Any incidental take of one of these covered species will be reported within 24 hours and the cumulative adjusted take reported within two weeks.

Castle & Cooke is responsible for implementation of the HCP and shall have completed its involvement for this project once the stipulations identified in this HCP are fulfilled during the two-year project period. Castle & Cooke is responsible for providing data collected in relation to the HCP within 30 days of request by DOFAW and USFWS unless otherwise identified. DOFAW and USFWS will provide Castle & Cooke and/or its consultants sufficient notice prior to conducting a site visit to enable appropriate project staff to participate. Agency staff may also conduct compliance monitoring without prior notice. The MOA between Castle & Cooke and DOFAW will serve as a cooperative agreement to be executed between the two parties to ensure that 1) DOFAW is completing the mitigation and maintenance activities as identified in this HCP, 2) DOFAW is providing Castle & Cooke with regular updates on the status of the mitigation, maintenance, and monitoring activities, and 3) DOFAW is provided access to the mitigation site for maintenance and monitoring up to February 2018 or the time nesting and/or fledging success in the restoration area is achieved, whichever occurs first. All maintenance and monitoring activities and costs associated with the restoration area after the term of this HCP will be the responsibility of DOFAW. Castle & Cooke will not be responsible for any additional actions or costs that are not identified in the HCP, as long as the HCP is properly implemented and functioning.

6.2 Scope and Duration

This HCP is designed to address the authorized potential incidental take of four listed wildlife species. Tier 1 and Tier 2 incidental take limits for Hawaiian petrels are seven and 14 birds, respectively. The incidental take limits established for the other three species are two Newell's shearwaters, two Hawaiian stilts, and two Hawaiian hoary bats. The first tier of mitigation (Tier 1) would compensate for two Newell's shearwaters, two Hawaiian stilts, two Hawaiian hoary bats, and the Tier 1 take limit of seven Hawaiian petrels. Should Tier 1 take levels be reached for the petrel, Tier 2 mitigation would be implemented, compensating for take of 14 Hawaiian petrels.

Castle & Cooke proposes to enter into the met tower HCP to cover the potential take of these four listed species as a result of operation of seven met towers within the WRA. The term of the HCP is for a period of two years, through March 1, 2010. If no amendment is in place, and the Tier 2 take limit for the Hawaiian petrel is reached, the towers will be taken down and removed upon reaching a take limit.

6.3 Monitoring

Monitoring is an important tool in an adaptive management approach and should be designed in a way that ensures data will be properly collected, analyzed, and used to adjust management strategies, as appropriate. Monitoring is required at each of the met tower locations to ensure that the authorized levels of take are not exceeded, and that the effects of take are minimized and mitigated to the extent possible.

Castle & Cooke will conduct post-construction mortality monitoring (downed wildlife surveys) to document injuries or fatalities of listed and non-listed species. Post-construction monitoring is being conducted at each of the met tower locations according to the protocol approved by USFWS and DOFAW (**Appendix 6**). The monitoring protocol is adapted from standardized protocols used in peer-reviewed literature, available technical reports, other Tetra Tech EC projects, and the monitoring plan previously approved for met tower 6 (**Appendix 6**; Arnett et al. 2005, Erickson et al. 2004, Johnson et al. 2002, Young et al. 2003). A Downed Wildlife Protocol is included in the plan for the recovery, handling, and reporting of downed wildlife based on the protocol approved by DOFAW for met tower 6 (**Appendix 6**). All on-site personnel will be trained in the protocol.

Post-construction monitoring will identify whether threatened or endangered bird and bat species are injured or killed from collision with one or more of the towers and will document impacts to other non-listed species. In the event an injured or dead petrel, shearwater, stilt, or bat is documented, Castle & Cooke would immediately assess the impact and adapt the program accordingly. Should monitoring reveal that authorized take of petrels is higher at one of the tower locations as a result of collision with a met tower, Castle & Cooke would closely evaluate the data and consider removing the tower in question.

Brief, quarterly reports will be submitted to DOFAW and USFWS. These reports will summarize the results of the post-construction monitoring surveys, document take, if any, of each species, and identify any recommended changes to the monitoring protocols. Any incidental take of one of these covered species will be reported within 24 hours and the cumulative adjusted take reported within two weeks. Castle & Cooke will also conduct semi-annual meetings with DOFAW and USFWS to discuss the monitoring program, compare the monitoring results to estimated take levels, discuss the progress of the mitigation measures, and develop any recommendations for revising on-going activities. As Castle & Cooke will be funding efforts for DOFAW to implement predator control and habitat restoration activities, DOFAW will be responsible for monitoring these efforts. Castle & Cooke must submit annual reports to DLNR and USFWS by August 31 each year of the project to summarize overall findings and status. Therefore, DOFAW must submit monitoring reports summarizing the progress of the mitigation activities to Castle & Cooke by August 15 of each year during the project.

6.4 Performance and Success Criteria

The 2-year time frame of this HCP corresponds to the maximum expected time frame data is collected from the met towers in order to determine the viability of a wind farm at this location. The Tier 1 and Tier 2 take limits for Hawaiian petrels are seven and 14 petrels, respectively. The take limit for the three other species is two Newell's shearwater, two Hawaiian stilts, and two Hawaiian hoary bats over the 2-year period, as stated in this HCP.

Castle & Cooke will coordinate with DOFAW during this period regarding the status of these mitigation activities. A cooperative agreement will be developed between DOFAW and Castle & Cooke for a vehicle and chipper to be provided and committed to DOFAW full-time on Lāna'i for the 2-year period. The vehicle will be maintained in good operating condition and fuel will be provided by DOFAW. This equipment is required to implement the mitigation measures.

A minimum, nonrefundable endowment of $252,203 (Total Tier 1 Costs) will be disbursed by Castle & Cooke to DOFAW. An initial payment was made in February 2008 so that the restoration work could begin in 2008. The remainder will be submitted within 10 working days of the permittee's receipt of the approved ITL/ITP.

If potential take of individuals of any of these four listed species exceeds the established take limits stated in this HCP without an approved modification of the HCP, any excess taking will be considered in violation of the ESA and HRS and enforcement actions will be at the discretion of the USFWS. If Tier 2 take limits are reached for the Hawaiian petrel without an approved amendment to the HCP, the met towers will be removed.

6.5 Unforeseen/Changed Circumstances/No Surprises

Section 10 regulations require that an HCP specify the procedures to be used for dealing with unforeseen circumstances that may arise during the implementation of the HCP. In addition, the HCP Assurances ("No Surprises") Rule (50 CFR §17.22[b][5], Federal Register 63 8859) defines "unforeseen circumstances" and "changed circumstances" and describes the obligations of the permittee and USFWS.

Changed Circumstances

Changed circumstances means changes in circumstances affecting a species or geographic area covered by a conservation plan or agreement, that can reasonably be anticipated by plan or agreement between developers and the USFWS, and that can be planned for (e.g., the listing of new species, or a fire, hurricane, major storm event, other natural catastrophic event in areas prone to such events, or when access to met tower sites is not available due to these type events).

Given the limited term of this HCP and the infrequency of events such as hurricanes and fires which could affect the implementation of the HCP, the only circumstance that is identified as a changed circumstance is a storm event that could prevent access to the met tower sites for monitoring purposes. Such a change is, therefore, provided for in this HCP and does not constitute unforeseen circumstances or require the amending of this HCP. Castle & Cooke will notify DLNR and USFWS within two days of such an event. Castle & Cooke owns the necessary equipment and has sufficient staff to commit to repair the roads or provide other access as necessary as soon as possible and will assist DLNR and USFWS in any related response or remediation efforts. It is anticipated that access will be restored within 5 days of any such event, and that monitoring will resume within 24 hours of reestablishing access. In the unlikely event that a storm occurs that affects the benefits of the habitat restoration efforts, the

DOFAW staff funded by Castle & Cooke under the Tier 1 take limit scenario is expected to be sufficient to address such effects without additional staff or funding. Castle & Cooke will implement additional conservation and mitigation measures deemed necessary to respond to changed circumstances as provided for and specified in the HCP's adaptive management strategy (50 CFR § 17.22(b)(5)(i and ii) and 50 CFR § 17.32(b)(5)(i and ii). If such measures were not provided for the HCP, 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 Castle & Cooke (50 CFR §17.22(b)(5)(i and ii) and 50 CFR §17.32(b)(5)(i and ii).

Unforeseen Circumstances and "No Surprises"

Unforeseen circumstances means changes in circumstances surrounding an HCP that were not or could not be anticipated by HCP participants and the USFWS and DLNR that result in a substantial and adverse change in the status of a covered species.

- The purpose of the No Surprises Rule is to provide regulatory assurances to non-federal landowners participating in habitat conservation planning under the ESA that no additional land restrictions or financial compensation will be required for species adequately covered by a properly implemented HCP, in light of unforeseen circumstances, without the consent of the permittee. The "No Surprises" policy provides certainty for private landowners in ESA and HRS Habitat Conservation Planning through assurances.
- In negotiating "unforeseen circumstances" provisions for HCPs, the USFWS and DLNR shall not require the commitment of additional land or financial compensation beyond the level of mitigation which was otherwise adequately provided for a species under the terms of a properly functioning HCP. Moreover, the USFWS and DLNR shall not seek any other form of additional mitigation from a permittee, except under extraordinary circumstances.
- If additional mitigation is subsequently deemed necessary to provide for the conservation of a species that was otherwise adequately covered under the terms of a properly functioning HCP, the obligation for such measures shall not rest with the permittee.

The Hawaiian petrel, Newell's shearwater, Hawaiian stilt, and Hawaiian hoary bat are considered adequately addressed under this HCP and are, therefore, covered by the USFWS' No Surprises policy assurances. In the event that it is demonstrated by the USFWS and DLNR that Unforeseen Circumstances exist during the life of the ITP, and additional conservation and mitigation measures are deemed necessary to respond to Unforeseen Circumstances, the USFWS may require additional measures of the Permittee where the HCP is being properly implemented, but only if such measures are limited to modifications within the HCP or related permit documents, and maintain the original terms of the HCP to the maximum extent practicable. Notwithstanding the foregoing, the USFWS and DLNR shall not:

- Require the commitment of additional land, water, or financial compensation by the Permittee without the consent of the Permittee; or
- Impose additional restrictions on the use of land, water, or natural resources otherwise available for use by the Permittee under the original terms of the HCP, including additional restrictions on covered actions that are permitted under the HCP.

- The USFWS and DLNR shall have the burden of demonstrating that such extraordinary circumstances exist, using the best scientific and commercial data available. Their findings must be clearly documented and based upon reliable technical information regarding the status and habitat requirements of the affected species.
- In determining whether any event constitutes an unforeseen circumstance, the USFWS and DLNR will consider, but not be limited to, the following factors: (a) size of the current range of affected species; (b) percentage of range adversely affected by the HCP; (c) percentage of range conserved by the HCP; (d) ecological significance of that portion of the range affected by the HCP; (e) level of knowledge about the affected species and the degree of specificity of the species' conservation program under the HCP; and (f) whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.
- The USFWS and DLNR shall not seek additional mitigation for a species from an HCP permittee where the terms of a properly functioning HCP agreement were designed to provide an overall net benefit for that species and contained measurable criteria for the biological success of the HCP which have been or are being met.
- Nothing in this policy shall be construed to limit or constrain the USFWS, DLNR, or any other governmental agency from taking additional actions at its own expense to protect or conserve a species included in an HCP.

6.6 Adaptive Management

The USFWS and DOFAW often incorporate adaptive management concepts into the HCP process. The primary reason for using adaptive management in HCPs is to allow for changes in the management strategies that may be necessary to reach the long-term goals (or biological objectives) of the HCP, and to ensure the likelihood of survival and recovery of the species in the wild.

Adaptive management includes using results of the monitoring and reporting program to evaluate that the level of take is within limits authorized by this HCP. The Tier 1 and 2 levels of take and mitigation outlined for the petrel establishes a contingency should the Tier 1 take limit be reached within the 2-year period. This tiered approach allows for a quick transition to a higher authorized take limit and avoids delays that would be associated with an amendment to the HCP.

Castle & Cooke will utilize monitoring results to evaluate the spatial distribution of take and determine whether one or more of the met towers are contributing higher than anticipated take levels. If it is determined that one or more of the towers is yielding disproportionately higher take levels, Castle & Cooke will consider removal of that tower(s), prior to the completion of the 2-year data collection period.

DOFAW will use an adaptive management approach to implementing the mitigation activities. Staff will adapt management activities in both the habitat restoration and predator control programs as new data or technology becomes available so as to maximize the benefit for the covered species.

The Lāna‘i petrel population and biology is relatively unknown at this time, and the presence of Hawaiian stilt and Hawaiian hoary bat were only recently documented on Lāna‘i in the WRA; Newell's shearwaters have yet to be documented within the WRA. USFWS, DOFAW, and Castle & Cooke will move forward in a cooperative manner recognizing that these studies and mitigation measures outlined in the HCP will help provide a better understanding of these species population dynamics on Lānaʻi and provide a net benefit to these four covered species.

6.7 Funding and Assurances

The ESA and HRS requires that the HCP detail the funding that will be made available to implement the proposed mitigation program. Measures requiring funding in an HCP typically include onsite measures during project implementation or construction (for example, pre-construction surveys and biological monitors), as well as onsite and offsite measures required after completion of the project or activity (for example, acquisition of mitigation lands).

The estimated costs for the mitigation are provided in **Table 6-1** and are based on a cost estimate provided by DOFAW, garnered from their experience with similar activities associated with the existing interagency seabird conservation program and watershed enhancement partnership. MISC conducted a site visit on November 13, 2007 to develop a site-specific cost estimate to complete the initial habitat clearing and associated activities.

Castle & Cooke has sufficient financial assets to implement the terms of this HCP. Castle & Cooke will be responsible for funding the post construction fatality monitoring and mitigation and understands that failure to provide adequate funding and a consequent failure to implement the terms of this HCP in full could result in a temporary permit suspension or permit revocation.

Castle & Cooke has already funded spring and fall avian point count surveys, several radar and visual surveys, a seabird avoidance behavior study, and a rare plant survey. In addition to expenditures already made, Castle & Cooke will, consistent with the terms of this HCP, cover the costs of having searchers conduct the PCMP. Monitoring was conducted for met tower 6 in 2007 and was initiated in March 2008 to include all met towers from March 15 to December 15 (or when the birds are known to be present on the island) during the period the towers are in operation and according to the PCMP provided in **Appendix 6**. Downed wildlife monitoring costs are estimated at $75,000 per year.

Table 6-1. Estimated Costs of Predator Control, Habitat Restoration, and Maintenance activities for the Lānaʻi Met Tower Project – Tier 1 and Tier 2

Activity	Tier 1 Year 1	Tier 2 Year 1	Tier 1 Year 2	Tier 2 Year 2	Total Cost per 3 Acres	Total Cost per 6 Acres
Initial Habitat Clearing						
MISC crew (estimate)	$22,128	$48,500	$0	$0	$22,128	$70,628
Herbicide and equipment	$8,500	$1,500	$0	$0	$8,500	$10,000
Chipper	C&C to provide	C&C to provide			NA	C&C to provide
Subtotal	**$30,628**	**$50,000**	**$0**	**$0**	**$30,628**	**$80,628**
Predator and Habitat Restoration Maintenance						
Personnel	$60,000	Provided in Tier 1 costs	$60,000		$120,000	$120,000
Supervisor (0.3 FTE)	$15,000		$15,000	Provided in Tier 1 costs	$30,000	$30,000
Fringe (30%)	$22,500		$22,500		$45,000	$45,000
PCSU/UH Costs (10%)	$10,725		$10,725		$21,450	$21,450
Vehicle (includes maintenance)	C&C to provide	C&C to provide	C&C to provide	C&C to provide	NA	NA
Traps and materials	$4,285	$3,214	$840	$0	$5,125	$8,339
Subtotal	**$112,510**	**$3,214**	**$109,065**		**$221,575**	**$224,789**
TOTAL	**$143,138**	**$53,214**	**$109,065**	**$0**	**$252,203**	**$305,417**

Notes: C&C - Castle & Cooke
FTE - full-time employee
NA - not applicable
PCSU/UH - Pacific Cooperative Studies Unit, University of Hawaiʻi

Issuance of ITL pending satisfactory arrangement for vehicle.

Castle & Cooke will enter into an agreement with and provide monies to DOFAW to fund the predator control and habitat management program. A minimum non-refundable endowment of $252,203 for the Tier 1 mitigation will be disbursed by Castle & Cooke in two payments according to the MOA. The first payment ($143,138) was provided to DOFAW in February 2008 for Year 1 of Tier 1 and the remainder of Tier 1 costs ($109,065) will be paid within 10 working days of the permittee's receipt of the approved ITP/ITL. DOFAW will provide a letter to Castle & Cooke and the USFWS acknowledging the receipt of the funding and committing its use for seabird and bat habitat restoration and predator control. After receipt of these funds, DOFAW will provide follow-up letter reports to Castle & Cooke and the USFWS stating the progress made through the use of these funds and accounting for their expenditure. DOFAW will provide Castle & Cooke with an annual summary report by August 15 of each year of the project to be included in Castle & Cooke's annual report to DLNR and USFWS by August 31 of each year of the project.

If Tier 2 mitigation is deemed necessary based on monitoring results, additional funds, as outlined in **Table 6-1**, will be provided. Castle & Cooke will provide financial assurances for the Tier 2 funds and the estimated costs for post-construction monitoring at the towers over the 2-year period ($150,000). These funds will be assured through a financial instrument such as a bond, letter of credit or other similar mechanism as approved by DLNR and USFWS. This financial assurance for the mitigation and monitoring costs, not delegated to DOFAW via check, will be approximately $203,135 and will be in place prior to the effective date of the ITL/ITP. Tier 2 mitigation funds will be released 20 days after reaching the Tier 1 take limit for the Hawaiian petrel.

DOFAW has the option to restore the entire 6 acres in 2009 with the Tier 1 funds. Tier 2 funds would be provided to DOFAW only if the petrel Tier 1 take limit is reached. The 3- or 6-acre restoration area(s) will be maintained by the DOFAW employees hired under the Tier 1 mitigation plan. DOFAW may choose to reallocate the Tier 1 staffing funds to conduct and maintain the entire 6-acre restoration parcel for the project period if Tier 2 is not initiated. If DOFAW initiates restoration for the entire 6-acre parcel, this eliminates a delay in the initiation of Tier 2 habitat restoration work should Tier 1 take limits be reached at the end of the project period. However, additional predator control mitigation could be implemented immediately upon reaching Tier 1 take limits.

6.8 Revisions and Amendments

This section presents the procedures for amendments to the HCP.

Amendment Procedure

It is necessary to establish a procedure whereby the ITP/ITL can be amended. However, it is important that the cumulative effect of any amendments will not jeopardize any endangered species or other rare species. Amendments must be evaluated based on their effect on the habitat as a whole. The USFWS and DLNR must be consulted on all proposed amendments that may affect any federally listed species.

Amendments to Locally Approved Development Plans

It is acknowledged that the state and/or local agencies having land use regulatory jurisdiction are authorized in accordance with applicable law to approve, without consulting the USFWS, amendments to development plans for the subject project area which do not encroach on any endangered species habitat which is not presently contemplated to be taken as a consequence of the project, and which do not alter the conditions set forth in the HCP.

Minor Amendments to the HCP

Minor amendments involve routine administrative revisions, changes to the operation and management program, or minor changes to the development area and that do not diminish the level or means of mitigation. Such minor amendments do not materially alter the terms of the ITP/ITL. Upon the written request of the Permittee, the USFWS and DLNR are authorized to approve minor amendments to the HCP.

All Other Amendments

All other amendments will be considered an amendment to the ITP/ITL, subject to any other procedural requirements of federal law or regulation that may be applicable to amendment of such a permit.

7 CONCLUSION

Castle & Cooke is working with USFWS and DLNR to obtain an ITP/ITL for potential incidental take of the Hawaiian petrel, Newell's shearwater, Hawaiian stilt, and Hawaiian hoary bat that may result from construction and operation of seven met towers. Castle & Cooke plans to implement the HCP in cooperation with these agencies to achieve a net benefit for these identified species as a result of the proposed project and to further the knowledge of these species' population biology on Lāna'i.

8 PERSONAL COMMUNICATIONS

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6. The applicant shall obtain the approval of the "Post-Construction Monitoring Protocol for the Meteorological Towers at the Lanai Wind Farm, Lanai, Hawaii", prior to installing any tower;

7. Should an impact with flying wildlife occur, the applicant shall remove the tower(s) until such time as the tower(s) are covered by an Incidental Take License and accompanying (amended) Habitat Conservation Plan;

8. This approval permits the installation of one (1) meteorological tower at site No 6. Subsequent tower construction shall proceed only after review and approval by the Division of Forestry and Wildlife and the Office of Conservation and Coastal Lands, based on positive avian survey results and the successful actions of the applicant to mitigate potential avian impacts;

9. Before proceeding with any work authorized by the Board, the applicant shall submit four (4) copies of the construction and grading plans and specifications to the Chairperson or his authorized representative for approval for consistency with the conditions of the permit and the declarations set forth in the permit application. Three (3) of the copies will be returned to the applicant. Plan approval by the Chairperson does not constitute approval required from other agencies;

10. In issuing this permit, the Department has relied on the information and data that the applicant has provided in connection with this permit application. If, subsequent to the issuance of this permit, such information and data prove to be false, incomplete or inaccurate, this permit may be modified, suspended or revoked, in whole or in part, and/or the Department may, in addition, institute appropriate legal proceedings;

11. Should historic remains such as artifacts, burials or concentration of charcoal be encountered during construction activities, work shall cease immediately in the vicinity of the find, and the find shall be protected from further damage. The contractor shall immediately contact SHPD (692-8015), which will assess the significance of the find and recommend an appropriate mitigation measure, if necessary;

12. The applicant understands and agrees that this permit does not convey any vested rights or exclusive privilege;

13. Prior to construction, the applicant shall have a wildlife biologist survey the area within a 125-yard radius of each proposed tower to re-confirm the absence of notable wildlife (e.g. nesting birds). If sensitive wildlife or nesting activities are noted, the applicant shall coordinate with DOFAW to tailor the methods and timing of installation to minimize the risk of adverse impacts;

14. Best management practices for prevention of introducing exotic species to the site shall be observed;

15. Upon the end of the duration of data collection or the end of the equipment lifecycle or within three years, all equipment shall be removed and the land shall be restored to its original condition;

16. The applicant acknowledges that the approved work shall not hamper, impede or otherwise limit the exercise of traditional, customary or religious practices in the immediate area, to the extent such practices are provided for by the Constitution of the State of Hawaii, and by Hawaii statutory and case law;

17. Other terms and conditions as may be prescribed by the Chairperson; and

18. Failure to comply with any of these conditions shall render this Conservation District Use Permit null and void.

Please have the applicant acknowledge receipt of this permit, with the above noted conditions, in the space provided below. Please sign two copies, retain one, and return the other within thirty (30) days of the date of this letter.

Should you have any questions on any of these matters, please feel free to contact Michael Cain at 587-0048.

Aloha,

Samuel Lemmo, Administrator

Receipt acknowledged

____
Signature

____
Date

cc: Chairman's Office
Caste & Cooke Resorts, LLC
Maui Board Member
Maui Land Agent
County of Maui Planning Department
DOFAW
DOCARE
HPD
USFWS

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

Office of Conservation and Coastal Lands
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

LAURA H. THIELEN
INTERIM CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ALLAN A. SMITH
INTERIM DEPUTY DIRECTOR - LAND

KEN C. KAWAHARA
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

AUG 10 2007

File No.: LA-3419

Mr. Charlie Karustis
TETRA TECH EC, INCORPORATED
737 Bishop Street, Suite 3020
Honolulu, HI 96813

Dear Mr. Karustis:

This is to inform you that on August 8, 2007, the Chairperson of the Board of Land and Natural Resources approved your client's application for the installation of one (1) metrological tower at site Number 6, and preliminarily approved installation of the remaining six (6) meteorological measurement towers on the Island of Lanai, TMK (2) 4-9-002:01, subject to the following conditions:

1. The applicant shall comply with all applicable statutes, ordinances, rules, and regulations of the Federal, State and County governments, and the applicable parts of Section 13-5-42, Hawaii Administrative Rules;

2. The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury or death arising out of any act or omission of the applicant, its successors, assigns, officers, employees, contractors and agents for any interference, nuisance, harm or hazard relating to or connected with the implementation of corrective measures to minimize or eliminate the interference, nuisance, harm or hazard;

3. The applicant shall comply with all applicable Department of Health administrative rules;

4. Where any interference, nuisance, or harm may be caused, or hazard established by the use the applicant shall be required to take measures to minimize or eliminate the interference, nuisance, harm, or hazard within a time frame and manner prescribed by the Chairperson;

5. Any work done on the land shall be initiated within one year of the approval of such use, and unless otherwise authorized be completed within three years of the approval. The applicant shall notify the Department in writing when construction activity is initiated and when it is completed;

Appendix 1
CDUP Letters from DLNR

LINDA LINGLE
GOVERNOR OF HAWAII

LAURA H. THIELEN
INTERIM CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

KEN C. KAWAHARA
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
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LAND
STATE PARKS

STATE OF HAWAI`I
DEPARTMENT OF LAND AND NATURAL RESOURCES
Office of Conservation and Coastal Lands
POST OFFICE BOX 621
HONOLULU, HAWAI`I 96809

ref: OCCL:MC

CDUP LA-3419

SEP 27 2007

Timothy A. Hill, Executive Vice President
Castle & Cooke Lāna`i
PO Box 630310
Lāna`i City, HI 96763

Dear Mr. Hill,

SUBJECT: CONSERVATION DISTRICT USE PERMIT (CDUP) LA-3419
Clarification on Condition 7, Meteorological Towers
Northwest Lāna`i, Lahaina District, Maui
TMK (2) 4-9-02:01

The Office of Conservation and Coastal Lands (OCCL) has reviewed you request to clarify Condition (7) of CDUP LA-3419 for the Lāna`i Meteorological Towers.

Condition (7) reads:

Should an impact with flying wildlife occur, the applicant shall remove the tower(s) until such time as the tower(s) are covered by an Incidental Take License and an accompanying (amended) Habitat Conservation Plan.

Castle & Cooke Lāna`i point out that there is no mechanism to acquire an Incidental Take Permit for wildlife that is not covered by the Endangered Species Act. The applicant concludes that Condition (7) should only apply to state or federally listed threatened or endangered species.

OCCL concurs with this, and will interpret Condition (7) as applying to state or federally listed threatened or endangered species, namely but limited to the `ua`u, Hawaiian petrel (*Pterodroma sandwichensis*); the `a`o, Newell's Shearwater (*Puffinus newelli*); and the `ope`ape`a, Hawaiian hoary bat (*Lasiurus cinereus semotus*).

Should you have any questions please feel free to contact Michael Cain at 587-0048.

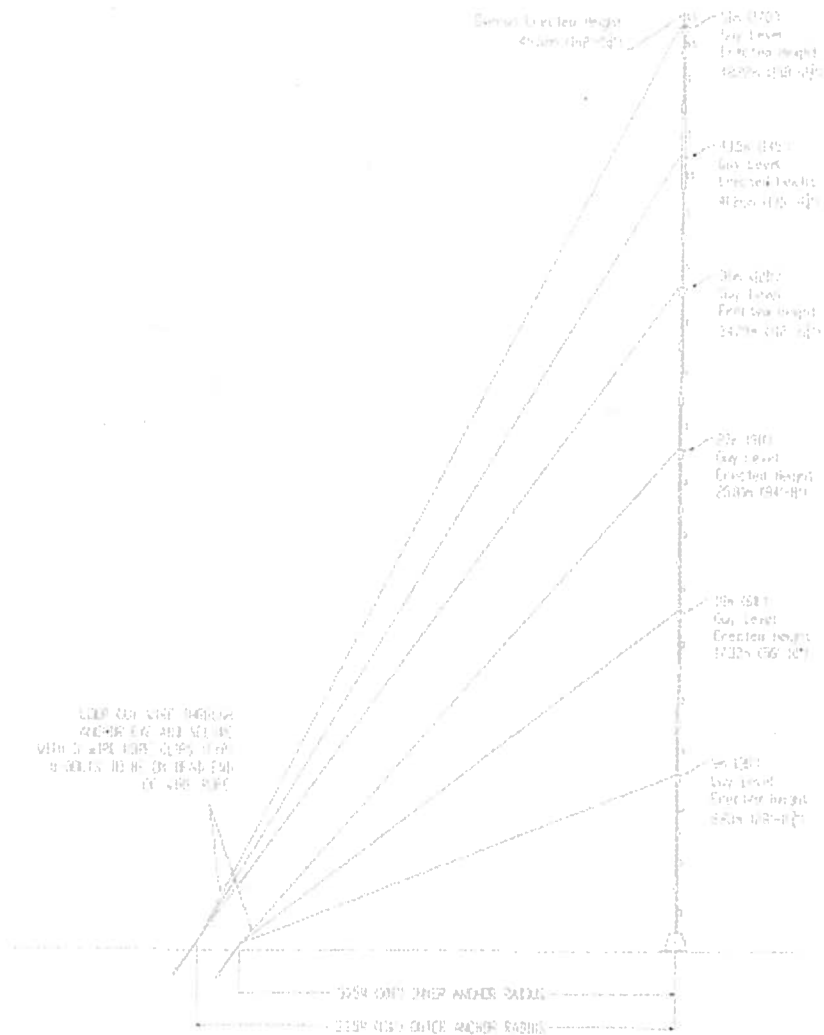
Sincerely,

Samuel J. Lemmo, Administrator
Department of Land and Natural Resources

cc: *DLNR – Chair, DOFAW*
Charlie Karustris, Tetra Tech, Inc., 737 Bishop Street, Suite 3020 Honolulu, HI 96813
USFWS

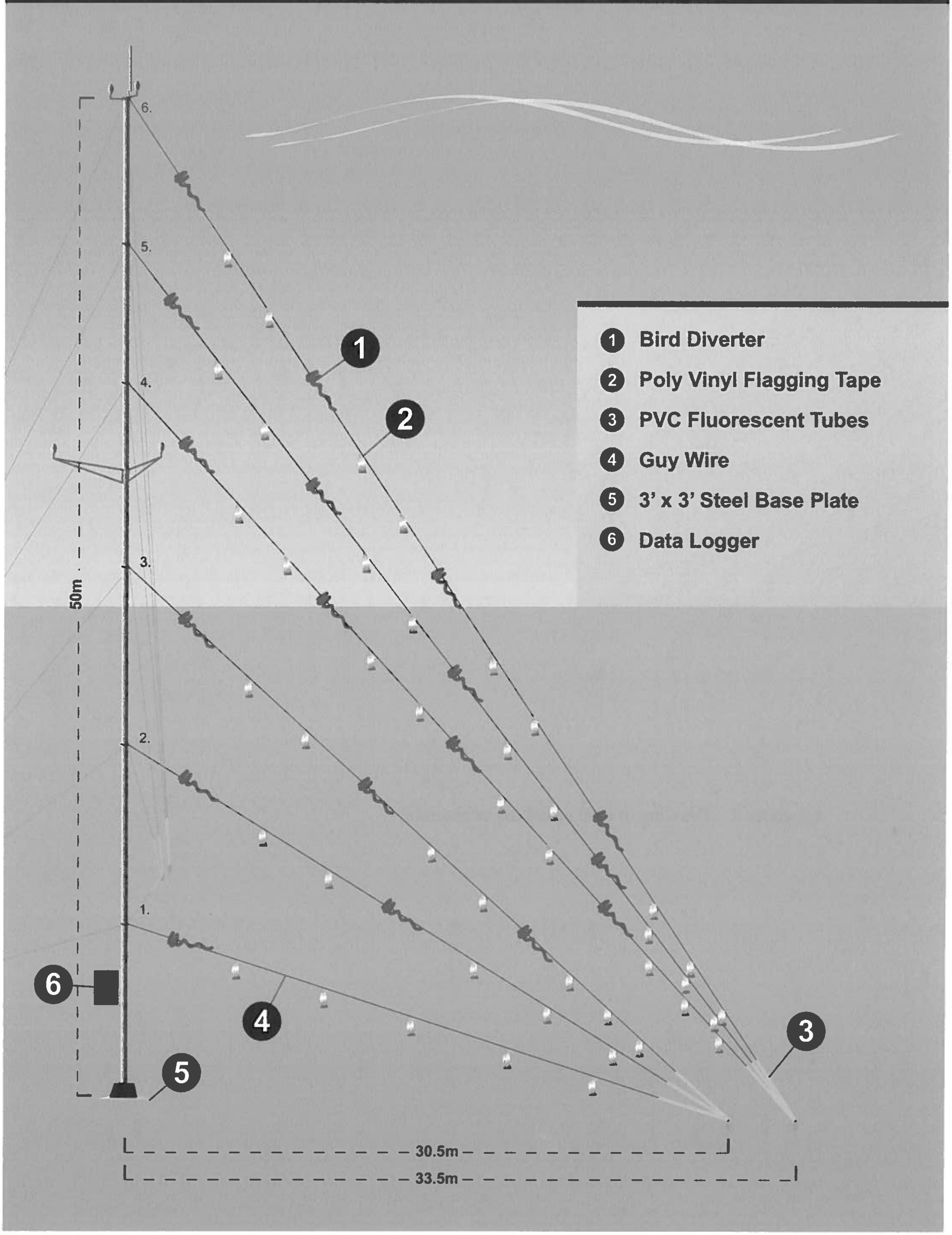
Appendix 2

Example of a Typical Met Tower and Wildlife Diversion Measures



Appendix 2. Drawing of a 50 m tall tower assembly

Wildlife Diversion Measures



Appendix 3

Radar Survey Report

RADAR AND AUDIOVISUAL STUDIES OF HAWAIIAN PETRELS NEAR PROPOSED METEOROLOGICAL TOWERS AND WIND TURBINES ON NORTHWESTERN LANA'I ISLAND, MAY–JULY 2007

FINAL REPORT

Prepared for

KC Environmental, Inc.
P.O. Box 1208
Makawao, HI 96768

and

Tetra Tech EC
1750 SW Harbor Way, Suite 400
Portland, OR 97201

Prepared by

Brian A. Cooper
Robert H. Day
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ABR, Inc.—Environmental Research & Services

P.O. Box 249
Forest Grove, OR 97116

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P.O. Box 80410
Fairbanks, AK 99708-0410

October 2007

Printed on recycled paper.

EXECUTIVE SUMMARY

- We used radar and audio-visual methods to collect data on the movements, behavior, and flight altitudes of the endangered Hawaiian Petrel (*Pterodroma sandwichensis*), threatened Newell's (Townsend's) Shearwater (*Puffinus auricularis newelli*), and endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) at nine sites total on Lana'i Island in May–July 2007. We conducted sampling at 3 sites during 15 nights of sampling in late May–early June ("late spring" sampling period) and at 7 sites, including 1 site that was sampled during the previous period, during 35 nights of sampling in late June–early July ("summer" sampling period). The objectives of the study were to: (1) conduct surveys of endangered seabirds and bats in the vicinity of the proposed wind-resource area (WRA); and (2) obtain information to help assess use of the area by these species.
- We recorded 170 radar targets that fit our criteria for petrels and shearwaters during the 15 nights of sampling in late spring 2007. Of these targets, we recorded 37 at the Western site, 73 at the Central site, and 60 at the Eastern site. This pattern of fewer targets in the western portion of the study area also was seen in summer 2007: out of 427 probable petrel targets, we recorded 11 at Lower Ka'ena, 42 at Lower Polihua, 43 at Garden of the Gods (all in the western WRA), 70 at Lower Awalua, 83 at Central, 50 at Upper Lapaiki (all in the central WRA), and 128 at Lower Kuahua (in the eastern WRA). Movement rates also reflected this pattern of fewer petrels in the western portion of the study area.
- In late spring, mean movement rates of landward-flying targets ranged from 0.24–1.96 targets/h in the evening to 0 targets/h during the morning, whereas seaward rates ranged from 1.92–3.48 targets/h in the evening to 0.96–3.68 targets/h in the morning. In summer, mean movement rates of landward-flying targets ranged from 0.0–3.56 targets/h in the evening to 0.0–0.12 targets/h during the morning, whereas seaward rates ranged from 0.48–3.56 targets/h in the evening to 0.60–4.92 targets/h in the morning.
- The overall mean movement rates that we observed on radar at Lana'i tended to be much lower than did rates observed during similar radar studies on Kaua'i and East Maui and were slightly lower than rates on West Maui; however, Lana'i movement rates were similar to rates on Hawai'i.
- We sampled only one location (Central) in both late spring and summer; movement rates at that site were similar between the two periods.
- Seaward movement rates (west or northwest, away from the colony) were higher than landward rates (east or southeast, toward the colony) for all sites, times of day (evening and morning), and sampling periods; however, rates did vary among hours within evening and morning periods. In addition, landward rates in the evening always were equal to or greater than landward rates in the morning, and morning rates usually were 0 targets/h. In contrast, seaward rates did not show a consistent difference between evening and morning. The only sites at which evening rates of seaward-flying targets were higher were the two farthest-inland sites, both of which were located along the east–west spine of the island.
- During audio-visual sampling, we recorded 33 Hawaiian Petrels and 2 unidentified petrels/shearwaters. Petrels were visually observed at all sites except for the Western site. For instance, in late spring, we recorded 5 petrels, with 0 at the Western site, 3 at the Central site, and 2 at the Eastern site. In summer, we recorded 30 petrels, with 1 at Lower Ka'ena, 2 at Lower Polihua, 3 at Garden of the Gods, 6 at Lower Awalua, 6 at Central, 2 at Upper Lapaiki, and 10 at Lower Kuahua.
- The mean (± SE) flight altitude of Hawaiian Petrels and unidentified petrels/shearwaters observed from all sites, times of day, and sampling periods was 47 ± 8 m agl. The mean flight altitude of Hawaiian Petrels and unidentified petrels/shearwaters flying in a landward direction was 34 ± 9 m agl, whereas

the mean seaward flight altitude was higher (71 ± 15 m agl).

- In addition to Hawaiian Petrels, we recorded one Hawaiian Hoary Bat during 485 sampling sessions (i.e., a rate of 0.005 bats/h). Thus, bats were present in the proposed WRA, but they occurred there in very low densities.
- Based on flight-altitude data from Lana'i, we estimate that 64% of the birds flying through this area are flying at altitudes low enough to interact with proposed met towers (i.e., ≤50 m agl) and that 94% of the birds flying through this area are flying at altitudes low enough to interact with proposed wind turbines (i.e., ≤125 m agl).
- To determine risk, we used petrel movement rates, petrel flight altitudes, and dimensions and characteristics of the proposed met towers and proposed wind turbines to generate an estimate of exposure risk. We corrected that estimate by the fatality probability (i.e., the probability of death if a bird does collide with a structure) and a range of estimates for avoidance rates to estimate the annual fatality that could be expected at the proposed met towers and wind turbines.
- Based on data from summer 2007, we estimate annual movement rates of ~983; ~3,660; ~3,365; ~6,046; ~7,629; ~4,278; and ~11,250 Hawaiian Petrels within 1.5 km of the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and Lower Kuahua radar sites, respectively.
- We estimated annual fatality rates for the proposed met tower associated with each site by assuming that 0%, 50%, 95%, or 99% of all Hawaiian Petrels flying near a proposed met tower or wind turbine will see and avoid the tower. Based on these scenarios, annual fatality rates for proposed met towers near the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and Lower Kuahua radar sites would be 0.1–6.7, 0.3–25.0, 0.2–23.0, 0.4–41.3, 0.5–52.1, 0.3–29.2, and 0.8–76.8 Hawaiian Petrels/tower, respectively. Based on the same set of assumptions about possible avoidance rates, annual fatality rates for proposed wind turbines near the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and Lower Kuahua radar sites are estimated to be 0.02–2.2, 0.1–8.2, 0.1–7.5, 0.1–13.5, 0.1–17.0, 0.1–9.5, and 0.2–25.1 Hawaiian Petrels/turbine, respectively. We caution, however, that these assumptions for avoidance rates are not based on empirical data and do not consider effects of potential deterrents (such as white flagging) that might reduce fatality rates.

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ACKNOWLEDGMENTS

The funding for this research came from Castle and Cooke LLC. At KC Environmental, we thank Charlie Fein for project management and Tom Kekona for help with logistics and the audio-visual sampling. At TetraTech EC, Charlie Karustis and Alicia Oller provided thoughtful questions and expertise on wind energy and George Redpath provided logistical assistance. At ABR, Todd Mabee provided field help and report review; Mike Davis, Adam Harris, and Hanna Mounce provided field help; Tom DeLong provided fiscal support; Susan Cooper, John Rose, John Shook, and Delee Spiesschaert helped with logistics; and Pam Odom produced the report.

INTRODUCTION

Castle and Cooke Resorts is interested in developing a windfarm in the western half of Lana'i Island, Hawaii (Fig. 1). As part of the siting and permitting process, Castle and Cooke wanted to obtain initial information on endangered seabirds and bats in the proposed development area. Ornithological radar and night-vision techniques have been shown to be successful in studying these species on Kaua'i (Cooper and Day 1995, 1998; Day and Cooper 1995, Day et al. 2003b), Maui (Cooper and Day 2003), Moloka'i (Day and Cooper 2002), and Hawai'i (Reynolds et al. 1997, Day et al. 2003a), so ABR was hired to survey seabirds and bats in the area with similar techniques. This report summarizes the results of a radar and audio-visual study of seabirds conducted during May–July 2007. The objectives of the study were to: (1) conduct surveys of endangered seabirds and bats in the vicinity of the proposed wind-resource area; and (2) obtain information to help assess use of the area by these species.

BACKGROUND

Two nocturnal seabird species occur on Lana'i Island: the endangered Hawaiian Petrel (*Pterodroma sandwichensis*), which nests there, and the threatened Newell's (Townsend's) Shearwater (*Puffinus auricularis newelli*), which appears to occur there in very small numbers but whose breeding status is unknown. The Hawaiian Petrel ('Ua'u) and the Newell's Shearwater ('A'o) are tropical Pacific seabirds 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 Hawaiian Islands but now are restricted in most cases to scattered colonies in more inaccessible locations (Ainley et al. 1997b, Simons and Hodges 1998). The main exception is Kaua'i Island, which has no introduced Indian Mongooses (*Herpestes auropunctatus);* there, colonies are still widespread and populations are substantial in size, although Newell's Shearwaters have declined there substantially since the early 1990s (Day et al. 2003b). Because of their low overall population numbers and restricted breeding distributions, both of these species are protected under the Endangered Species Act.

The Hawaiian Petrel nests on most of the Main Islands 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), Kaua'i (Telfer et al. 1987, Gon 1988, Day and Cooper 1995; Ainley et al. 1997a, 1997b; Day et al. 2003b), and, to a lesser extent, Hawai'i (Banko 1980a, Conant 1980, Hu et al. 2001, Day et al. 2003a) and Lana'i (Shallenberger 1974; Hirai 1978a, 1978b; Conant 1980). Recent information from Moloka'i (Day and Cooper 2002) also suggests breeding. Probably several thousand Hawaiian Petrels occur on Kaua'i and Maui (Harrison et al. 1984, Harrison 1990, Day and Cooper 1995, Spear et al. 1995, Ainley et al. 1997a, Simons and Hodges 1998, Day et al. 2003b; Day and Cooper, unpubl. data), and the colony on Lana'i is now considered to be "large" (J. Penniman, State of Hawaii Department of Land and Natural Resources, Division of Fish and Wildlife [DOFAW], in litt. 15 June 2007), possibly being even larger than the colony on Maui.

The Newell's Shearwater breeds on several of the Main Islands, with the largest numbers clearly occurring on Kaua'i (Telfer et al. 1987, Day and Cooper 1995, Ainley et al. 1997b, Day et al. 2003b). These birds also nest on Hawai'i (Reynolds and Richotte 1997, Reynolds et al. 1997, Day et al. 2003a), almost certainly nest on Moloka'i (Pratt 1988, Day and Cooper 2002), probably nest on Maui (Cooper and Day 2003), and may still nest on O'ahu (Sincock and Swedberg 1969, Banko 1980b, Conant 1980, Pyle 1983; but see Ainley et al. 1997b). Although there have been a few recent records of Newell's Shearwaters on Lana'i, there is no evidence of nesting at this time (J. Penniman, DOFAW, pers. comm.). Several tens of thousands of Newell's Shearwaters are estimated to nest on Kaua'i (Harrison et al. 1984, Harrison 1990, Day and Cooper 1995, Spear et al. 1995, Ainley et al. 1997b, Simons and Hodges 1998, Day et al. 2003b; Day and Cooper, unpubl. data), which is the world center of abundance of this species. Finally, although Banko (1980a) listed no historical or recent records of this species on Lana'i, a downed Newell's Shearwater was found in Lana'i City on

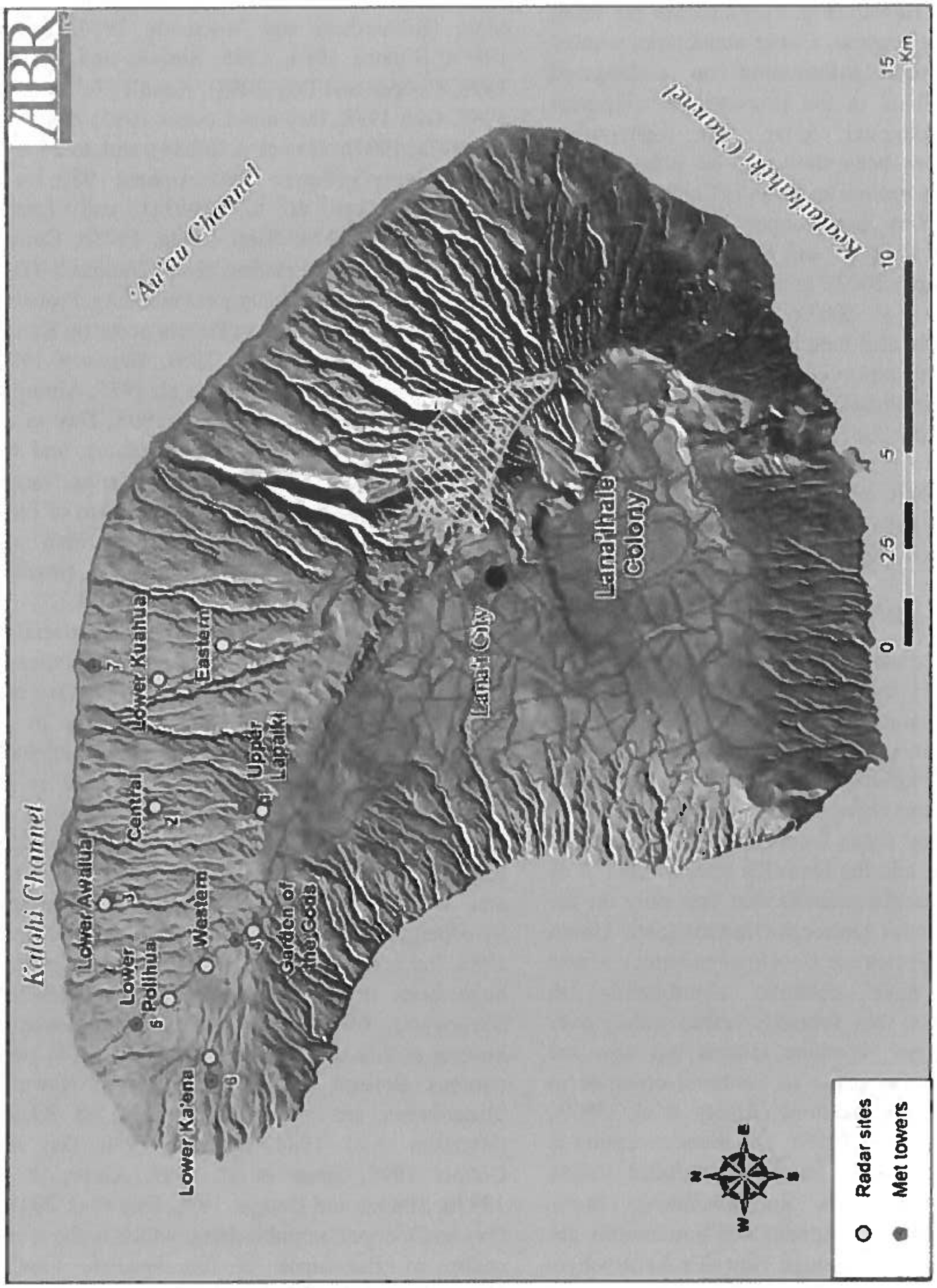

Figure 1. Location of radar-sampling sites and proposed met towers on Lana'i Island, Hawai'i, late spring and summer 2007. Information on the location of the nesting colony of Hawaiian Petrels is from J. Penniman (State of Hawaii DLNR, DOFAW, pers. comm.).

10 October 1983 (Pyle 1984a); the date of the record suggests that the bird was a juvenile. Because this city is located several kilometers inland, it is doubtful that the lights attracted this bird from the ocean; hence, it probably was produced on the island.

HISTORY OF HAWAIIAN PETRELS ON LANA'I

Hawaiian Petrels have been known on Lana'i for many years. Although Munro (1960) had stated that introduced pigs (*Sus scrofus*) and cats (*Felis catus*) had exterminated this species on Lana'i, a nesting population of Hawaiian Petrels still survives there. This island is the only Main Island other than Kauai that is mongoose-free, which may explain the long-term persistence of the species on Lana'i. Shallenberger (1974) reported a Hawaiian Petrel at ~820 m elevation above Kaiholena Gulch on Lana'ihale (the highest point on the island) on 26 October 1973; the bird was attracted to lights set up for insect collecting on a foggy night, suggesting from that fact and the date of the record that it may have been a juvenile.

A colony of ~100 Hawaiian Petrels was found at Kunoa Gulch, along the Munro Trail, on 23 June 1976; this colony was located at ~850 m elevation in the mountain forest (Hirai 1978a, 1978b) and was located just on the other side of the ridge from the Kaiholena Gulch mentioned above. Hirai (1978b) saw Hawaiian Petrels at this site again on 29 May 1977 and suggested that scattered Hawaiian Petrels heard calling at scattered locations along the Munro Trail in June 1976 might represent either adults flying to the one known nesting colony or scattered nesting attempts. Birds also were recorded on Lana'ihale in the summers of 1978 (Pyle 1978) and 1980 (Ralph and Pyle 1980), suggesting breeding.

One Hawaiian Petrel was found downed in the lights of Lana'i City on 5 November 1980 (Pyle and Ralph 1981), with the light-attraction and the date of the record suggesting that the bird was a juvenile; the authors indicated that this species is now "seen and heard by the hundreds each spring" in the mountains of Lana'i. A Hawaiian Petrel fledgling also was picked up at Lana'i City on 8 November 1986 (Pyle 1987); the author indicated that fledglings had been found at this location in previous years, perhaps referring to the 1980 record.

Hawaiian Petrels again were seen and heard in "good numbers" in the mountains of Lana'i in the summer of 1981, and an injured Hawaiian Petrel was found in the Palawai Basin on 19 May 1981 (Pyle and Ralph 1981). Observers also heard five pairs vocalizing and saw six single Hawaiian Petrels before dark at a probable nesting location at Lana'ihale on 24 June 1982 (Pyle 1982).

Hawaiian Petrels also were seen and heard near a small weather station at ~2,000 ft (~610 m) on Lana'ihale on 12 June 1983 (Pyle 1983). At least 50 Hawaiian Petrels were seen or heard near this station again on 26 May 1984; this count was considered low because observation conditions were so poor (Pyle 1984b).

Recent research on Lana'i has indicated that the population of Hawaiian Petrels there is large—probably being even larger than that on Maui (J. Penniman, DOFAW, *in litt.*). The belief is that the Lana'ihale colony was able to survive until protection of the nesting habitat, especially 'uluhe ferns (*Dicranopteris linearis*), from ungulates allowed regrowth of the habitat to a point where the colony could expand. That restoration of habitat appears to have allowed the colony to grow dramatically in the past 20 yr.

HAWAIIAN HOARY BATS

The Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), or 'Ope'ape'a, is the only terrestrial mammal native to Hawaii. It is classified as endangered at both the federal and state levels, primarily because so little is known about its status and population trends. It is a nocturnal species that does not roost communally during the daytime; instead, it roosts solitarily within the forest. This bat occupies a wide variety of habitats, from sea level to >13,000 ft (Baldwin 1950, Fujioka and Gon 1988, Fullard 1989, David 2002). It also occurs on all of the Main Islands, including Lana'i (Baldwin 1950, van Riper and van Riper 1982, Tomich 1986, Fullard 1989, Kepler and Scott 1990, Hawaii Heritage Program 1991, David 2002).

Recent data from Appalachian ridge tops in the eastern US (Erickson 2004, Kerns 2004) have indicated that substantial kills of bats, including Hoary Bats, sometimes occur at windpower projects. Most of the bat fatalities documented at windfarms to date have been of migratory species during seasonal periods of dispersal and migration in late summer and fall. Several hypotheses have been posited, but none have been tested, to explain the cause(s) of these fatalities (Arnett 2005, Kunz et al. 2007). Because of this recent mortality of migratory Hoary Bats at windfarms on the US mainland, there was interest in collecting preliminary visual data on Hawaiian Hoary Bats during this study, even though the Hawaiian subspecies is non-migratory.

STUDY AREA

The proposed windfarm is located in the western half of Lana'i (Fig. 1). This proposed windfarm would include seven 50-m-high meteorological (met) towers (Fig. 1). Each tower would be anchored by six guy wires in each of four directions. All guy wires would be marked with an alternating array of spiral vibration dampers and strips of reflective tape at ~5-m intervals. Each of the ~270 proposed Vestas V90 wind turbines would have a generating capacity of ~1.5 MW, for a total installed capacity of ~400 MW. The currently proposed monopole towers would be ~80 m in height, and each turbine would have three rotor blades. The length of each rotor blade and hub would be ~45 m, thus, the total maximal height of a proposed turbine would be ~125 m at the top of the rotor-swept area.

The Island of Lana'i was formed by a single volcano. The highest point of the island, Lana'ihale, is 3,370 ft (1,027 m) above sea level (asl) and receives ~30–35 in (~75–90 cm) of annual precipitation (Carlquist 1980). There is a large colony of Hawaiian Petrels on the ridge encompassing Lana'ihale (Fig. 1), and native vegetation such as 'ohia trees (*Metrosideros polymorpha*) and 'uluhe ferns dominate the valleys and slopes of Lana'ihale. These two plant species also form the preferred nesting habitat for Newell's Shearwaters (Sincock and Swedberg 1969, Ainley et al. 1997b). In addition to the vegetation, the steepness of the slopes surrounding Lana'ihale suggests suitable nesting habitat in the area for both petrels and shearwaters (Hirai 1978b), as it does on Kaua'i (T. Telfer, DOFAW [retired] pers. comm.) and Maui (Brandt et al. 1995).

In contrast to the top of Lana'ihale, the Wind Resource Area (WRA) in the western half of Lana'i is lower and drier and does not contain any known petrel colonies. Elevations in the WRA range from sea level to ~1,600 ft (~500 m) asl, and the area receives only ~10–20 in (~25–50 cm) of annual precipitation (Carlquist 1980). For many years, the area was used as a cattle ranch and pineapple plantation. The proposed WRA is situated in a highly-eroded area of sloping scrubland, barren areas, and grasslands. The dominant "shrubs" in the area include the non-native kiawe (*Prosopis pallida*), verbena (*Lantana camara*), bull thistle (*Circium vulgare*), and 'ilima (*Sida fallax*; Redpath 2007). The open grasslands include alien invasive species such as buffel grass (*Cenchrus ciliaris*) and native grass species such as pili grass (*Heteropogon contortus*). At the lowest elevations along the coast, kiawe is prevalent and grows to ~5 m in height.

METHODS

DATA COLLECTION

We collected data on the movements, behavior, and flight altitudes of Hawaiian Petrels at nine sites total on Lana'i Island in 2007 (Fig. 1): at 3 sites during 15 nights of sampling in late May–early June ("late spring" sampling period) and at 7 sites, including 1 site that was sampled during the late-spring period, during 35 nights of sampling in late June–early July ("summer" sampling period; Tables 1 and 2). We sampled with ornithological radar and visual equipment for 3 h in the evening and ~2 h in the morning; these two periods correspond to the evening and morning peaks of movement of these birds (Day and Cooper 1995). During sampling, we collected radar and audio-visual data concurrently so that we could use the radar to help the visual observer locate birds for identification and data collection. In return, the visual 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 day.

Table 1. Radar and audio-visual sampling effort on Lana'i Island, Hawai'i, late spring 2007.

Date	Study site	Sampling type	
		Radar	Audio-visual
26 May	Western	1900–2200; 0400–0630	1900–2200; 0400–0630
27 May	Eastern	1900–2200; 0400–0630	1900–2200; 0400–0630
28 May	Central	1900–2200; 0400–0600	1900–2200; 0400–0600
29 May	Western	1900–2200; 0400–0600	1900–2200; 0400–0600
30 May	Eastern	1900–2200; 0400–0600	1900–2200; 0400–0600
31 May	Central	1900–2200[1]; 0400–0600	1900–2200; 0400–0600
1 June	Western	1900–2200; 0400–0600	1900–2200; 0400–0600
2 June	Eastern	1900–2200; 0400–0600	1900–2200; 0400–0600
3 June	Central	1900–2200; 0400–0600	1900–2200; 0400–0600
4 June	Western	1900–2200[2]; 0400–0600	1900–2200; 0400–0600
5 June	Eastern	1900–2200; 0400–0600	1900–2200; 0400–0600
6 June	Central	1900–2200; 0400–0600	1900–2200; 0400–0600
7 June	Western	1900–2200; 0400–0600	1900–2200; 0400–0600
8 June	Eastern	1900–2200; 0400–0600	1900–2200; 0400–0600
9 June	Central	1900–2200; 0400–0600	1900–2200; 0400–0600

[1] One radar session cancelled because of equipment problems.
[2] Parts of two radar sessions cancelled because of rain.

The ornithological radars used in this study were Furuno Model 1510 X-band radars 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). Each radar's antenna face was tilted upward by ~10–15°, and we operated the radars at a range setting of 1.5 km and a pulse-length of 0.07 µsec.

Radar operators had to deal with two issues at each site: ground clutter and shadow zones. Whenever energy is reflected from the ground, surrounding vegetation, and other objects that surround the radar unit, a ground-clutter echo appears on the radar's display screen. Because ground clutter can obscure targets of interest (e.g., birds and bats), we attempted to minimize it by picking optimal sampling locations. Ground clutter was minor at all nine sites and, in our opinion, did not cause us to miss any targets. Shadow zones are areas of the screen where birds were likely to be flying at an altitude that would put them behind a hill, row of vegetation, etc., where they could not be detected. Shadow zones at all sampling sites were minimal; however, because of the unusually low flight altitudes of petrels in this area (see below), it is likely that some birds flew within these zones, especially those toward the edge of the radar screen, and thus were not detected by radar.

We sampled for six 25-min counts during the period 1900–2200 and for four 25-min counts during the period 0400–0600 (Tables 1 and 2). Each 25-min sampling period was separated by a 5-min break for collecting weather data and for switching observers. We attempted to collect data only for petrel-like targets, following methods developed by Day and Cooper (1995). Thus, to help eliminate species other than those of interest (e.g., slowly-flying birds, insects), we recorded data only for those targets flying ≥30 mi/h (≥50 km/h; corrected in real-time for wind speed and direction, per methods described below) and removed otherwise-countable targets (based on target velocity and flight characteristics) identified by visual observers as those of other bird species.

We also conducted audio-visual sampling for birds and bats concurrently with the radar sampling, to help identify targets observed on radar and to obtain flight-altitude information. During

Table 2. Radar and audio-visual sampling effort on Lana'i Island, Hawai'i, summer 2007.

		Sampling type	
Date	Study site	Radar	Audio-visual
21 June	Lower Kuahua	1900–2200; 0400–0630	1900–2200; 0400–0600
22 June	Lower Ka'ena	1900–2200; 0400–0630	1900–2200; 0400–0600
	Upper Lapaiki	1900–2200; 0400–0600	1900–2200; 0400–0600
23 June	Lower Awalua	1900–2200; 0400–0600	1900–2200; 0400–0600
	Garden of the Gods	1900–2200; 0400–0600	1900–2200; 0400–0600
24 June	Lower Polihua	1900–2200; 0400–0600	1900–2200; 0400–0600
	Central	1900–2200; 0400–0600	1900–2200; 0400–0600
25 June	Lower Kuahua	1900–2200; 0400–0600	1900–2200; 0400–0600
	Lower Ka'ena	1900–2200; 0400–0600	1900–2200; 0400–0600
26 June	Upper Lapaiki	1900–2200; 0400–0600	1900–2200; 0400–0600
	Garden of the Gods	1900–2200; 0400–0600	1900–2200[1]; 0400–0600[1]
27 June	Lower Awalua	1900–2200; 0400–0600	1900–2200; 0400–0600
	Central	1900–2200; 0400–0600	1900–2200; 0400–0600
28 June	Lower Polihua	1900–2200; 0400–0630	1900–2200; 0400–0600
	Lower Kuahua	1900–2200; 0400–0630	1900–2200; 0400–0600
29 June	Lower Ka'ena	1900–2200; 0400–0600	1900–2200; 0400–0600
	Upper Lapaiki	1900–2200; 0400–0600	1900–2200; 0400–0600
30 June	Garden of the Gods	1900–2200; 0400–0600	1900–2200; 0400–0600
	Lower Awalua	1900–2200; 0400–0600	1900–2200; 0400–0600
1 July	Central	1900–2200; 0330–0600	1900–2200; 0400–0600
	Lower Polihua	1900–2200; 0400–0600	1900–2200; 0400–0600
2 July	Lower Kuahua	1900–2200; 0330–0600	1900–2200; 0400–0600
	Lower Ka'ena	1900–2200; 0400–0600	1900–2200; 0400–0600
3 July	Garden of the Gods	1900–2200[1]; 0400–0600	1900–2200; 0400–0600
	Upper Lapaiki	1900–2200[1]; 0400–0600[1]	1900–2200[1]; 0400–0600[1]
4 July	Central	1900–2200; 0330–0600	1900–2200; 0400–0600
	Lower Awalua	1900–2200; 0400–0630	1900–2200; 0400–0600
5 July	Lower Kuahua	1900–2200; 0330–0630	1900–2200; 0400–0600
	Lower Polihua	1900–2200; 0400–0600	1900–2200; 0400–0600
6 July	Upper Lapaiki	1900–2200; 0400–0600	1900–2200; 0400–0600
	Lower Ka'ena	1900–2200; 0400–0600	1900–2200; 0400–0600
7 July	Lower Awalua	1900–2200; 0400–0600	1900–2200; 0400–0600
	Garden of the Gods	1900–2200; 0400–0600	1900–2200; 0400–0600
8 July	Lower Polihua	1900–2200; 0400–0600	1900–2200; 0400–0600
	Central	1900–2200; 0330–0600	1900–2200; 0400–0600

[1] One or more sessions cancelled because of rain or other factors.

this sampling, we used 10× binoculars during crepuscular periods and used PVS-7 night-vision goggles during nocturnal periods to look for targets that were detected on the radar. The magnification of these Generation 3 goggles was 1×, and their performance was enhanced with the use of a 3-million-Cp floodlight that was fitted with an IR filter to avoid blinding and/or attracting these nocturnal birds. During our audio-visual sampling, we also used a Pettersson D-100 heterodyne bat detector to conduct acoustic surveys for bats. During acoustic sampling, we set the bat detector to detect calls in the peak range for Hawaiian Hoary Bats (25–30 KHz) and recorded the number of calls heard during each 25-min session. The bat detector was placed ~0.5 m above ground level and was oriented vertically, so that it sampled the airspace directly overhead.

During the summer study period, we also conducted acoustic surveys to investigate the possibility that some petrels could be nesting away from the main colony and within the WRA. On 15 nights between 22 June and 8 July, one observer (T. Kekona, KC Environmental, Makawao, HI) listened at specific locations along all roads within the proposed WRA for vocalizations typically heard in petrel breeding areas. Survey points were established every ~0.5 mi (~0.8 km) along each of eight roads, resulting in 50 total sampling points. Acoustic surveys were conducted between 1930 and 2300, during which time the observer listened for 10 min at each of as many points as possible along one or more road transects. Each point was visited 2–3 times during the study, with the sampling order of points along each road changed between visits. A hand-held digital audio recorder with a customized hand-held microphone and adjustable pre-amp (built by Bill Evans, Old Bird, Inc., Ithaca, NY) was used to record potential petrel vocalizations. The microphone was designed to eliminate wind noise (<3 KHz), and the pre-amp both allowed the sensitivity of the microphone to be modified to maximize the detection of petrel calls and boosted the signal sent to the audio recorder.

Before each 25-min sampling session, we also collected a series of environmental and weather data, including wind speed (to the nearest 1 mi/h [1.6 km/h]) and wind direction (to the nearest 1°). If the wind speed was >10 mi/h (>16 km/h) and the ground speed of the target was near the 30-mi/h cutoff speed and in such a direction that the target was encountering either a headwind or tailwind, we factored in wind speed to help determine whether those marginal targets made the 30-mi/h cutoff for a petrel target. Following Mabee et al. (2006), airspeeds (i.e., groundspeed corrected for wind speed and relative direction) of surveillance-radar targets were computed with the formula:

$$V_a = \sqrt{V_g^{\,2} + V_w^{\,2} - 2V_gV_w\cos\theta},$$

where V_a = airspeed, V_g = target groundspeed (as determined from the radar flight track), V_w = wind velocity, and θ is the angular difference between the observed flight direction and the direction of the wind vector.

In addition to wind speed and wind direction, we recorded the following standardized weather and environmental data:

- 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; 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 a large suite of data:
- species (if known);
- number of organisms (if known);
- time;
- direction of flight (to the nearest 1°);
- transect crossed (the four cardinal points—000°, 090°, 180°, or 270°; also used in reconstructing flight paths);

- tangential range (the minimal distance to the target when it passed closest to the lab; used in reconstructing actual flight paths, if necessary);
- flight behavior (straight, erratic, circling);
- velocity (to the nearest 5 mi/h [8 km/h]); and
- flight altitude (if known).

We also plotted the flight path of each bird target on a transparent overlay of the radar screen for later digitizing into a GIS.

For each bird (or bat) seen during night-vision sampling, we recorded:

- time;
- species (to the lowest practical taxonomic unit [e.g., Hawaiian Petrel, unidentified petrel/shearwater]);
- number of organisms in the target;
- flight direction (the eight ordinal points); and
- flight altitude (meters agl).

For any birds detected during auditory sampling, we recorded species, number of call bouts, direction of call, and approximate distance.

DATA ANALYSIS

We entered all radar and audio-visual data into Microsoft Excel databases. Data files were checked visually for errors after each night's sampling, then were checked electronically for irregularities at the end of the field season, prior to data analyses. All data summaries and analyses were conducted with SPSS 14.0 statistical software (SPSS 2005). For quality assurance, we cross-checked results of the SPSS analyses with hand-tabulations of small subsets of data whenever possible.

We tabulated counts of numbers of 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; some sampling time was lost to rain or other factors, so we had to standardize estimates by actual sampling effort. To calculate movement rates, we divided the number of targets recorded during a sampling session by the number of minutes actually sampled during that session, then multiplied that number (expressed as targets/min) by 60 min/h to estimate the movement rate (targets/h) for that session. We then used all of the estimated movement rates across sampling sessions at a site to calculate the mean ± 1 standard error (SE) nightly movement rate by site, by time period (evening, morning), and by flight direction (landward, seaward). Note that data from 0530 to 0600 were excluded from all analyses for the late spring study because of severe contamination of the radar data from non-petrel species such as Common Mynas (*Acridotheres tristis*). Further, only known petrel/shearwater targets or unknown targets with appropriate speeds (i.e., with appropriate target size, flight characteristics, and groundspeeds ≥30 mi/h) were included in data analyses of movement rates, flight directions, and flight behavior; all other species were excluded from those analyses.

We calculated the mean flight direction for all targets seen on radar. We also classified general flight directions of each radar target as inland, seaward, or "other" and summarized those directional categories by site, date, and time of day. To categorize the general flight direction of each target, we defined a landward flight as a radar target flying toward the Lana'ihale petrel colony and within 75° of either side of the approximate outer boundaries of that colony (Table 3). Targets flying in the opposite directions were considered seaward targets (again, with a 75° buffer). For each site, the few remaining flight vectors that were somewhat perpendicular to the direction to the colony were classified as landward or seaward based on their direction relative to the coastline.

We summarized the audio-visual data in terms of species, number, and flight direction. We also tabulated data on minimal flight altitudes of petrels recorded during the visual sampling and used those data for the vertical component in our fatality models (see below).

EXPOSURE AND FATALITY INDICES

To describe potential risk to Hawaiian Petrels within the area potentially occupied by the proposed met towers or wind turbines, we developed Exposure Indices (estimated number of times that a petrel would pass within the airspace

Table 3. Information on met tower covered, time period sampled, and criteria for landward and seaward categories of petrel flight directions at each site, Lana'i Island, Hawai'i, during late spring (LS) and summer (S) 2007.

Site	Met tower(s) covered	Sampling period[1]	Flight direction	
			Landward	Seaward
Lower Ka'ena	6, 8	S	015–194°	195–014°
Lower Polihua	5	S	045–224°	225–044°
Western	4	LS	045–224°	225–044°
Garden of the Gods	4	S	020–199°	200–019°
Lower Awalua	3	S	050–229°	230–049°
Central	2	LS; S	050–229°	230–049°
Upper Lapaiki	1	S	030–209°	210–029°
Lower Kuahua	7	S	070–249°	250–069°
Eastern	none	LS	055–234°	235–054°

[1] MY–JN = late spring (LS); JN–JL = summer (S).

occupied by the proposed met towers and their guy wires or pass by the proposed wind turbines each night). The Exposure Index for proposed met towers is equal to the number of target/km expected to be flying at or below met-tower height (i.e., ≤50 m agl) each night; this index is calculated by multiplying movement rates from surveillance radar by the percentage of seabirds with flight altitudes ≤50 m agl (maximal height of the proposed met towers). The Exposure Index for proposed wind turbines is more complex and comprises (1) the number of target/km flying at or below turbine height (i.e., ≤125 m agl) each night (calculated by multiplying movement rates from surveillance radar by the percentage of petrels with flight altitudes ≤125 agl [maximal height of the rotor-swept area]); and (2) the turbine area that petrels would encounter when approaching turbines from the side (parallel to the plane of rotation) or from the front (perpendicular to the plane of rotation).

We consider these estimates to be indices because they are based on several simplifying assumptions. The assumptions for this specific project include: (1) a worst-case scenario that the entire met-tower area encompassed by the outermost guy wires is solid, so there is no way that a petrel could fly through it without hitting a wire or pole; (2) a similar worst-case scenario for wind turbines, with the entire disk created by the rotor-swept area assumed to be a solid; (3) that there are minimal (i.e., side profile) and maximal (i.e., front profile, including the entire rotor-swept area) areas occupied by the proposed wind turbines relative to the flight directions of petrels; and (4) a worst-case scenario in which the rotor blades turn constantly (i.e., we used the entire rotor-swept area, not just the area of the blades themselves, to help calculate total turbine area). Note that our Exposure Indices estimate how many times petrels would be exposed to proposed met towers or turbines, not the number of birds that would actually collide with met towers or turbines: some unknown proportion of petrels would detect and avoid these structures, and, in the case of wind turbines, some could pass through the blades without collision. In addition, the Exposure Index calculates the number of exposure incidents, not the number of individuals—i.e., the index takes into account the fact that a single individual could be exposed to towers or turbines multiple times while crossing the WRA.

The Exposure Index is used to estimate daily numbers of birds flying within the airspace occupied by turbines or the proposed met towers and their guy wires. To calculate a Fatality Index, we expand those estimates for a 270-d year that birds are present on this island (late March through late December; J. Penniman, DOFAW, pers. comm.) and, hence, will be exposed to the proposed met towers and wind turbines. The fatality model then combines these estimates of interaction rates with the fatality probability to estimate fatality rates under a worst-case scenario of no collision avoidance (Fig. 2). Finally, it presents possible levels of fatality based on possible levels of collision avoidance by these birds.

RESULTS

RADAR-BASED OBSERVATIONS

MOVEMENT RATES

We recorded 170 targets that fit our criteria for petrels and shearwaters during the 15 nights of sampling in late spring 2007. Of those targets, we recorded 37 at the Western site, 73 at the Central site, and 60 at the Eastern site (Table 4). This pattern of fewer targets in the western portion of the study area also was seen in summer 2007: out of 427 probable petrel targets, we recorded 11 at Lower Ka'ena, 42 at Lower Polihua, 43 at Garden of the Gods (all in the western WRA), 70 at Lower Awalua, 83 at Central, 50 at Upper Lapaiki (all in the central WRA), and 128 at Lower Kuahua (in the eastern WRA; Table 5). Movement rates also reflected this pattern of fewer petrel targets in the western portion of the study area and more in the eastern portion of it, in both the evening and the morning (Figs. 3 and 4).

In late spring, mean movement rates of landward-flying targets ranged from 0.24–1.96 targets/h in the evening to 0 targets/h during the morning, whereas seaward rates ranged from 1.92–3.48 targets/h in the evening to 0.96–3.68 targets/h in the morning (Table 6). In summer, mean movement rates of landward-flying targets ranged from 0.0–3.56 targets/h in the evening to 0.0–0.12 targets/h during the morning, whereas seaward rates ranged from 0.48–3.56 targets/h in the evening to 0.60–4.92 targets/h in the morning. We sampled only one location (Central) in both late spring and summer; movement rates at that site were fairly similar between the two periods.

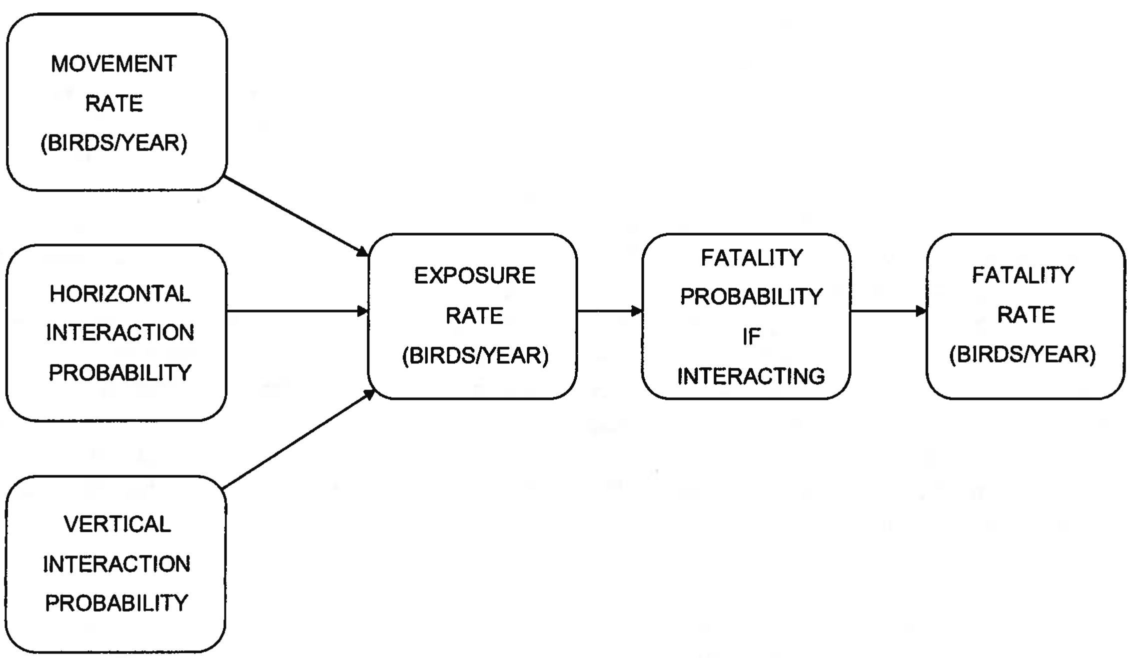

Figure 2. Major variables used in estimating possible fatality of Hawaiian Petrels at proposed met towers and wind turbines on Lana'i Island, Hawai'i. See Tables 13 and 14 for details on calculations.

Table 4. Number of probable Hawaiian Petrel targets observed on surveillance radar at Lana'i Island, Hawai'i, in late spring 2007, by study site, date, time of day, and flight direction. *n* = number of sampling sessions.

		Evening (1900–2200)		Morning (0400–0530)	
Site	Date	Landward (*n*)	Seaward (*n*)	Landward (*n*)	Seaward (*n*)
Western	26 May	1 (6)	4 (6)	0 (3)	3 (3)
	29 May	0 (6)	0 (6)	0 (3)	1 (3)
	1 June	0 (6)	3 (6)	0 (3)	1 (3)
	4 June	0 (6)	1 (6)	0 (3)	3 (3)
	7 June	2 (6)	16 (6)	0 (3)	2 (3)
	Total	3 (30)	24 (30)	0 (15)	10 (15)
Central	28 May	0 (6)	4 (6)	0 (3)	1 (3)
	31 May	1 (5)	4 (5)	0 (3)	2 (3)
	3 June	0 (6)	4 (6)	0 (3)	4 (3)
	6 June	5 (6)	13 (6)	0 (3)	10 (3)
	9 June	2 (6)	17 (6)	0 (3)	6 (3)
	Total	8 (29)	42 (29)	0 (15)	23 (15)
Eastern	27 May	4 (6)	2 (6)	0 (3)	1 (3)
	30 May	11 (6)	7 (6)	0 (3)	1 (3)
	2 June	1 (6)	5 (6)	0 (3)	1 (3)
	5 June	2 (6)	4 (6)	0 (3)	0 (3)
	8 June	6 (6)	14 (6)	0 (3)	3 (3)
	Total	24 (30)	32 (30)	0 (15)	6 (15)

At all sites, times of the day, and sampling periods, mean seaward movement rates always were higher than landward rates were (Table 6). The one exception was at Lower Kuahua, where evening movement rates in summer were identical between landward and seaward targets. In addition, landward rates in the evening always were equal to or greater than landward rates in the morning, and morning rates usually were 0 targets/h. In contrast, seaward rates did not show a consistent difference between evening and morning. It appears, however, that the only sites at which evening rates of seaward-flying targets were higher (Garden of the Gods and Upper Lapaiki) were the two farthest-inland sites, both of which were located along the east–west spine of the island (Fig. 1).

FLIGHT DIRECTION

The flight-direction data also reflected the pattern of higher seaward counts than landward counts. In spring 2007, most probable petrel targets were flying toward the west or northwest (i.e., away from the Lana'ihale colony) in both the evening (Fig. 5) and the morning (Fig. 6). At the Western site, however, an appreciable number also were heading toward the southwest in the evening.

The flight-direction pattern seen in summer 2007 was similar to that seen in late spring 2007: most probable petrel targets were heading toward the west or northwest, away from the colony, in both the evening and the morning (Figs. 7 and 8). In addition, targets were seen heading toward the colony only in the evening. However, the only site at which a substantial number of evening targets was heading southeasterly, toward the colony, was at Lower Kuahua, which was that site located closest to the colony (Fig. 7). In addition, a substantial number of targets at the Upper Lapaiki site were heading in a southerly direction.

We were able to collect flight-path data on a subset of 11 targets that were seen concurrently by the radar and verified as a petrel by audio-visual

Table 5. Number of probable Hawaiian Petrels observed on surveillance radar at Lana'i Island, Hawai'i, in summer 2007, by study site, date, time of day, and flight direction. *n* = number of sampling sessions.

		Time of day			
		Evening (1900–2200)		Morning (0400–0600)	
Site	Date	Landward (*n*)	Seaward (*n*)	Landward (*n*)	Seaward (*n*)
Lower Ka'ena	22 June	0 (6)	1 (6)	0 (4)	3 (4)
	25 June	0 (6)	0 (6)	0 (4)	0 (4)
	29 June	0 (6)	2 (6)	0 (4)	1 (4)
	2 July	0 (6)	1 (6)	0 (4)	1 (4)
	6 July	0 (6)	2 (6)	0 (4)	0 (4)
	Total	0 (30)	6 (30)	0 (20)	5 (20)
Lower Polihua	24 June	1 (6)	0 (6)	0 (4)	4 (4)
	28 June	0 (6)	1 (6)	0 (4)	0 (4)
	1 July	1 (6)	1 (6)	0 (4)	3 (4)
	5 July	2 (6)	6 (6)	0 (4)	1 (4)
	8 July	2 (6)	12 (6)	0 (4)	8 (4)
	Total	6 (30)	20 (30)	0 (20)	16 (20)
Garden of Gods	23 June	0 (6)	9 (6)	0 (4)	4 (4)
	26 June	0 (6)	9 (6)	0 (4)	3 (4)
	30 June	1 (6)	3 (6)	0 (4)	2 (4)
	3 July	0 (5)	8 (5)	0 (4)	0 (4)
	7 July	0 (6)	4 (6)	0 (4)	0 (4)
	Total	1 (29)	33 (29)	0 (20)	9 (20)
Lower Awalua	23 June	1 (6)	5 (6)	0 (4)	5 (4)
	27 June	0 (6)	6 (6)	1 (4)	2 (4)
	30 June	3 (6)	10 (6)	0 (4)	4 (4)
	4 July	1 (6)	9 (6)	0 (4)	5 (4)
	7 July	1 (6)	6 (6)	0 (4)	11 (4)
	Total	6 (30)	36 (30)	1 (20)	27 (20)
Central	24 June	4 (6)	10 (6)	0 (4)	9 (4)
	27 June	0 (6)	4 (6)	0 (4)	3 (4)
	1 July	2 (6)	5 (6)	0 (4)	7 (4)
	4 July	2 (6)	8 (6)	0 (4)	10 (4)
	8 July	1 (6)	8 (6)	0 (4)	11 (4)
	Total	9 (30)	35 (30)	0 (20)	40 (20)
Upper Lapaiki	22 June	2 (6)	5 (6)	0 (4)	4 (4)
	26 June	2 (6)	1 (6)	0 (4)	3 (4)
	29 June	4 (6)	5 (6)	0 (4)	2 (4)
	3 July	1 (5)	3 (5)	0 (2)	0 (2)
	6 July	5 (6)	11 (6)	0 (4)	2 (4)
	Total	14 (29)	25 (29)	0 (18)	11 (18)
Lower Kuahua	21 June	11 (6)	5 (6)	1 (4)	6 (4)
	25 June	2 (6)	8 (6)	0 (4)	7 (4)
	28 June	0 (6)	2 (6)	0 (4)	0 (4)
	2 July	13 (6)	12 (6)	0 (4)	17 (4)
	5 July	17 (6)	16 (6)	0 (4)	11 (4)
	Total	43 (30)	43 (30)	1 (20)	41 (20)

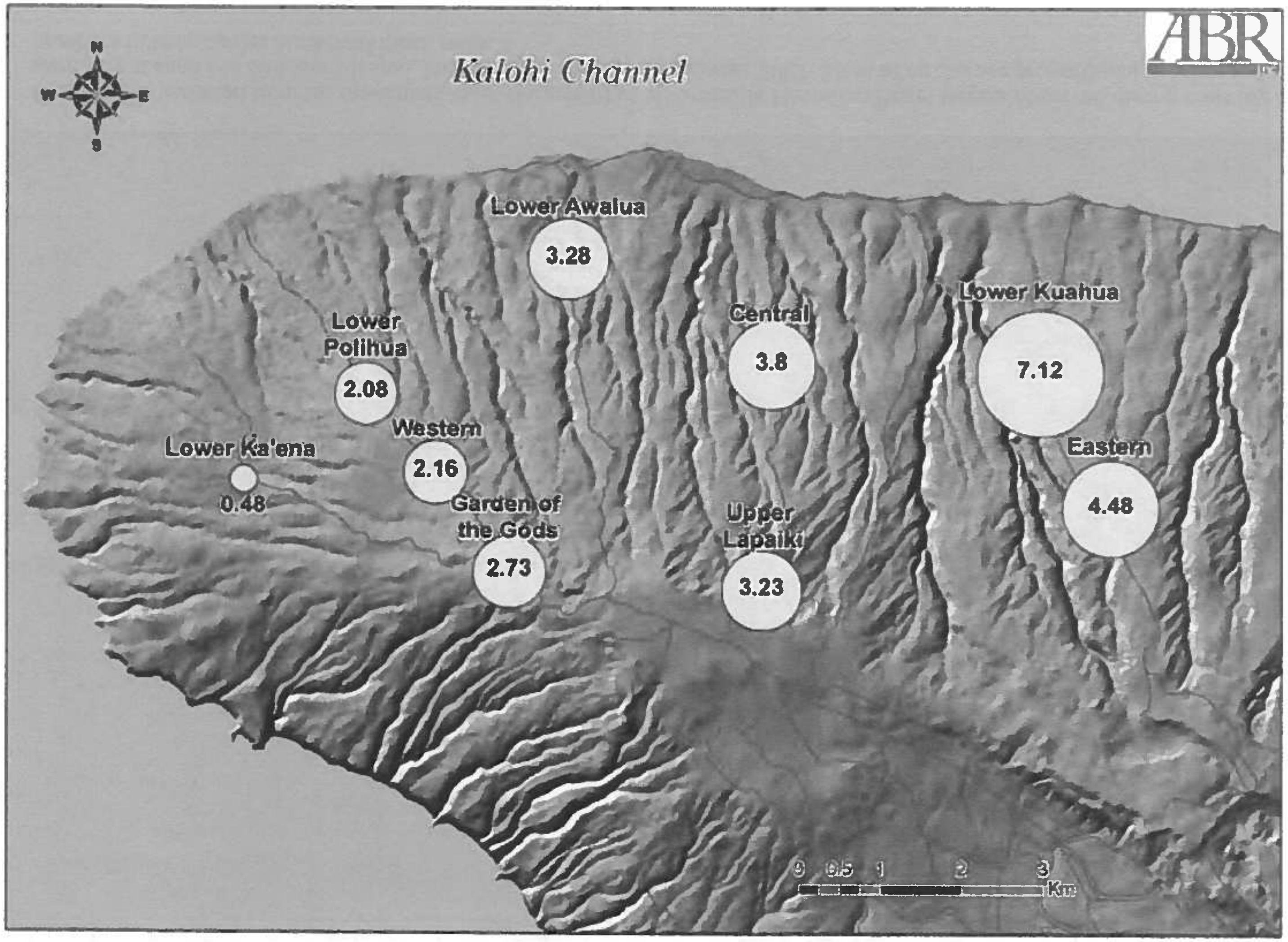

Figure 3. Geographic variation in mean movement rates (targets/h) of all probable Hawaiian Petrel targets observed during evening radar sampling at each site on Lana'i Island, Hawai'i, late spring and summer 2007. Sizes of circles are proportional to mean movement rate; numbers in/near circles are actual mean rates.

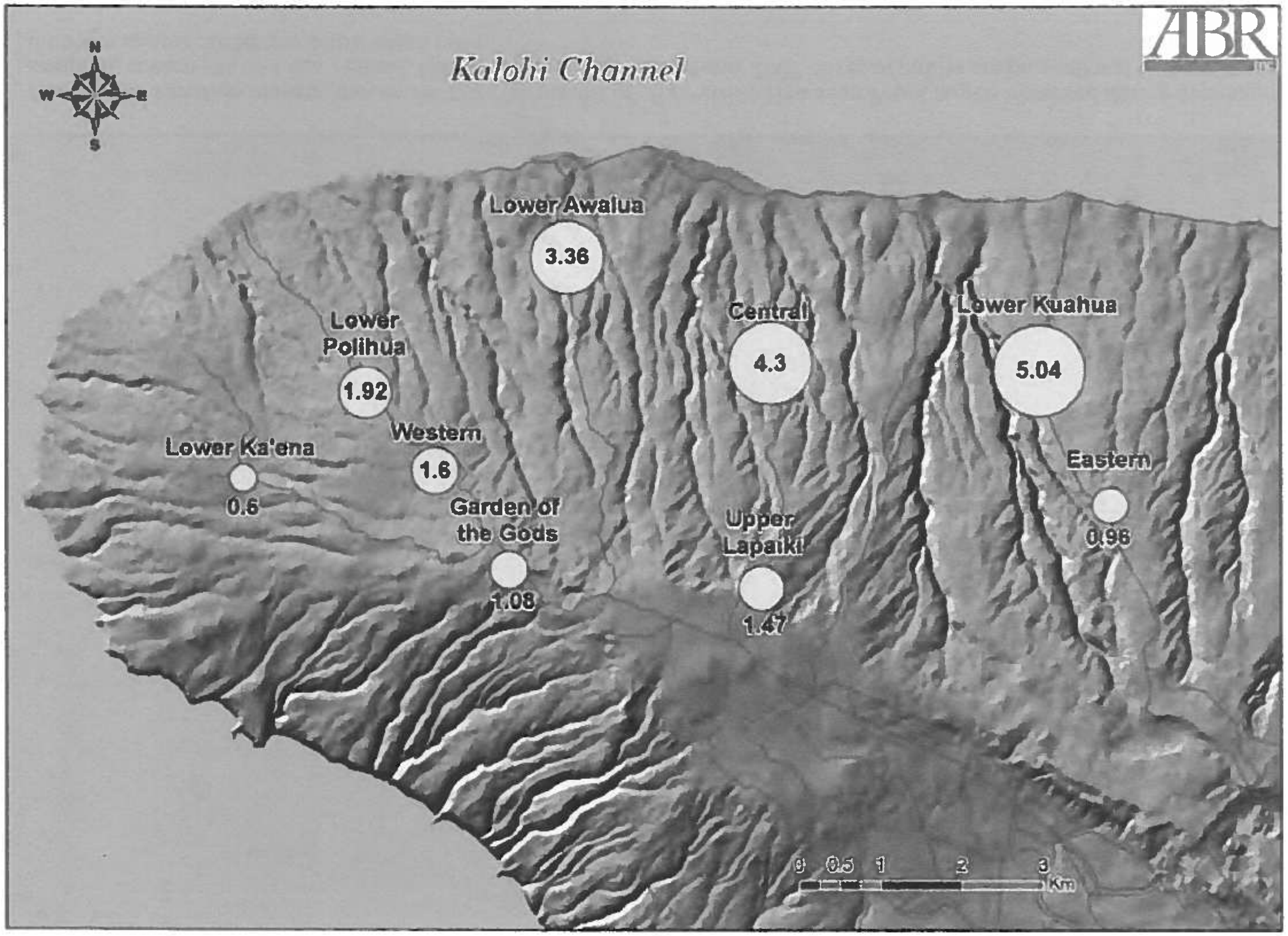

Figure 4. Geographic variation in mean movement rates (targets/h) of all probable Hawaiian Petrel targets observed during morning radar sampling at each site on Lana'i Island, Hawai'i, late spring and summer 2007. Sizes of circles are proportional to mean movement rate; numbers in/near circles are actual mean rates.

Table 6. Mean movement rates and mean counts of probable Hawaiian Petrel targets observed on surveillance radar at Lana'i Island, Hawai'i, late spring and summer 2007, by study site, time of day, and flight direction.

Sampling period/site	Time of day	Movement rate (targets/h)		Number of targets[1]	
		Landward	Seaward	Landward	Seaward
LATE SPRING					
Western	Evening	0.24	1.92	0.72	5.76
	Morning	0.00	1.60	0.00	4.80
Central	Evening	0.66	3.48	1.98	10.44
	Morning	0.00	3.68	0.00	11.04
Eastern	Evening	1.92	2.56	5.76	7.68
	Morning	0.00	0.96	0.00	2.88
SUMMER					
Lower Ka'ena	Evening	0.00	0.48	0.00	1.44
	Morning	0.00	0.60	0.00	1.80
Lower Polihua	Evening	0.48	1.60	1.44	4.80
	Morning	0.00	1.92	0.00	5.76
Garden of Gods	Evening	0.08	2.65	0.24	7.95
	Morning	0.00	1.08	0.00	3.24
Lower Awalua	Evening	0.48	2.80	1.44	8.40
	Morning	0.12	3.24	0.36	9.72
Central	Evening	0.72	2.72	2.16	8.16
	Morning	0.00	4.83	0.00	14.49
Upper Lapaiki	Evening	1.16	2.07	3.48	6.21
	Morning	0.00	1.47	0.00	4.41
Lower Kuahua	Evening	3.56	3.56	10.68	10.68
	Morning	0.12	4.92	0.36	14.76

[1]Number = movement rate * 3 to calculate the number of targets moving during the evening and morning peaks of activity.

observers (Fig. 9). That subset of visual and radar data also had a high proportion of petrels flying toward the colony, with some birds also flying away from the colony.

TIMING OF MOVEMENTS

The timing of landward movement of probable petrel targets was typical of that observed for petrels and shearwaters, with a peak in evening numbers during ~1930–2030 and very little movement in the morning during 0400–0600 (Fig. 10).The timing of the movement of seaward-flying targets however, was very different from the typical pattern, with targets moving at all hours of the night. In addition, movement rates during the final two hours of the evening and throughout the entire morning were high. In fact, seaward rates in the morning were high during even the first morning sampling session (0400–0430), which usually has little movement on other islands (Day and Cooper, unpubl. data).

BEHAVIOR

Most targets observed on radar were flying in a straight-line (directional) pattern, rather than with an erratic or circling behavior. For all sites, times, and sampling periods combined, 88.4% of flights were straight-line directional flights, 11.5% were erratic, and 0.2% were circling.

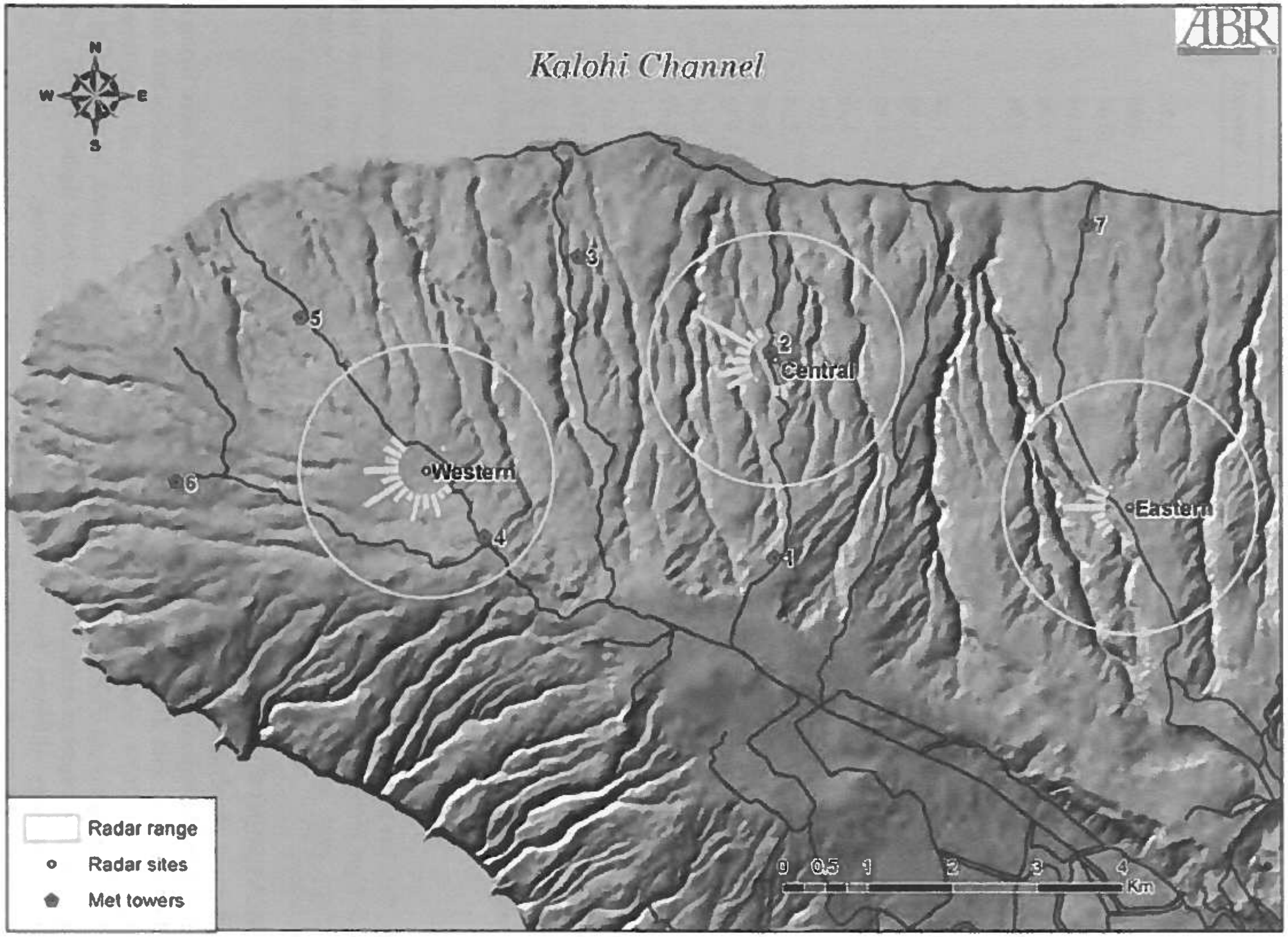

Figure 5. Flight directions of probable Hawaiian Petrel targets observed at each site during evening radar sampling on Lana'i Island, Hawai'i, late spring 2007. Length of spoke is proportional to the number of birds traveling in that direction.

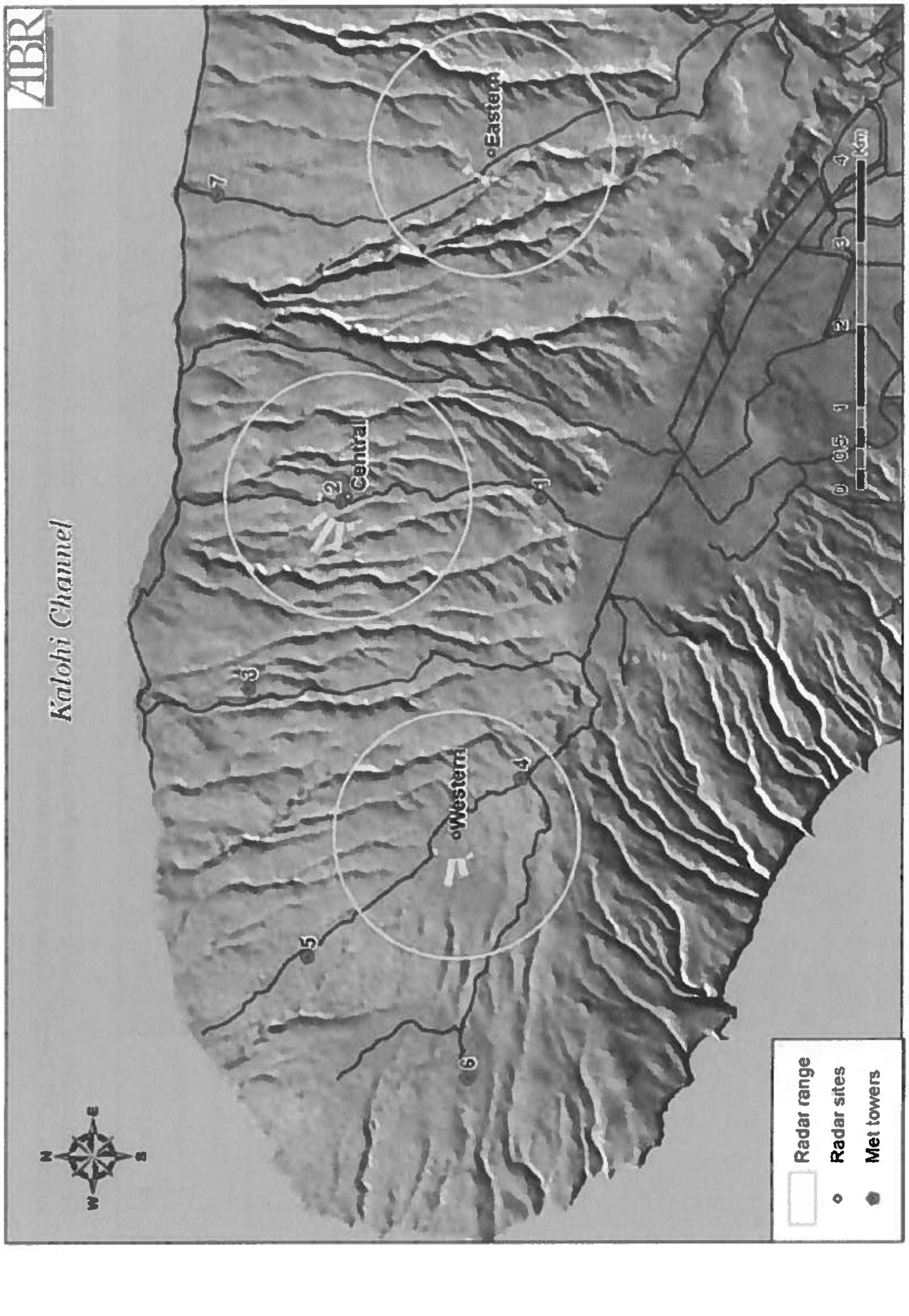

Figure 6. Flight directions of probable Hawaiian Petrel targets observed at each site during morning radar sampling on Lana'i Island, Hawai'i, late spring 2007. Length of spoke is proportional to the number of birds traveling in that direction.

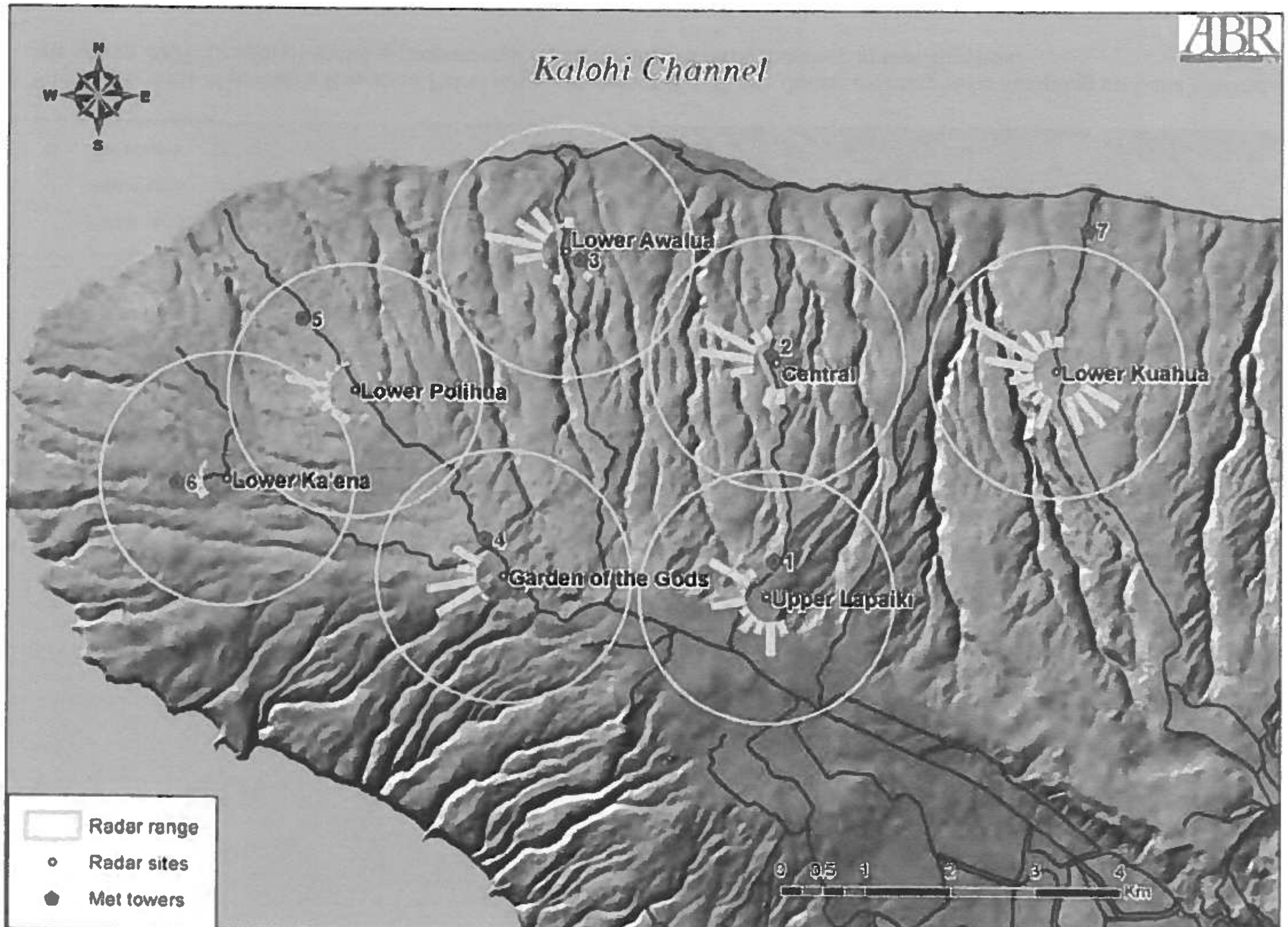

Figure 7. Flight directions of probable Hawaiian Petrel targets observed at each site during evening radar sampling on Lana'i Island, Hawai'i, summer 2007. Length of spoke is proportional to the number of birds traveling in that direction.

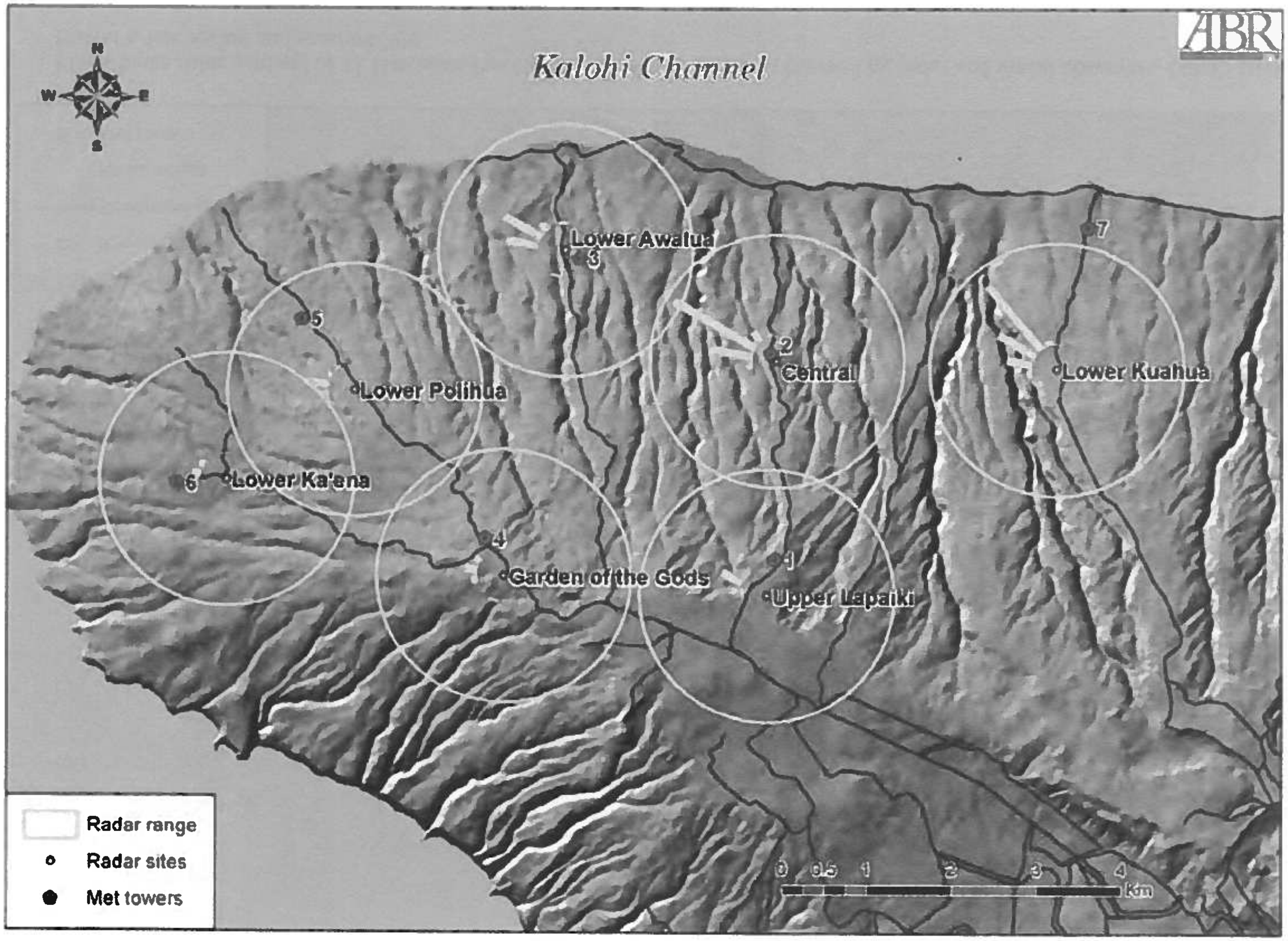

Figure 8. Flight directions of probable Hawaiian Petrel targets observed at each site during morning radar sampling on Lana'i Island, Hawai'i, summer 2007. Length of spoke is proportional to the number of birds traveling in that direction.

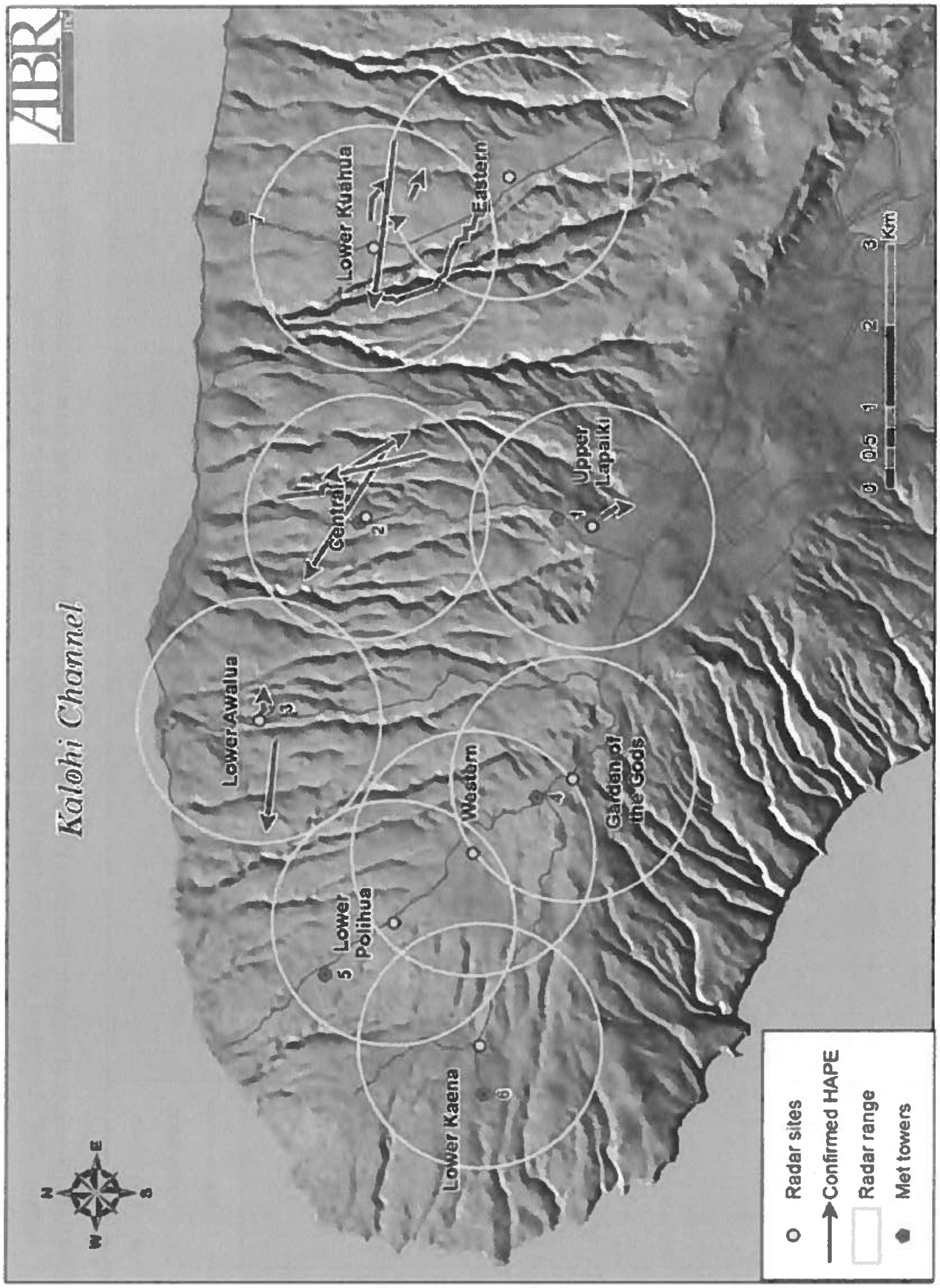

Figure 9. Flight paths (blue arrows) of 11 Hawaiian Petrels that were concurrently observed by radar and visual observers, Lana'i Island, Hawai'i, late spring and summer 2007.

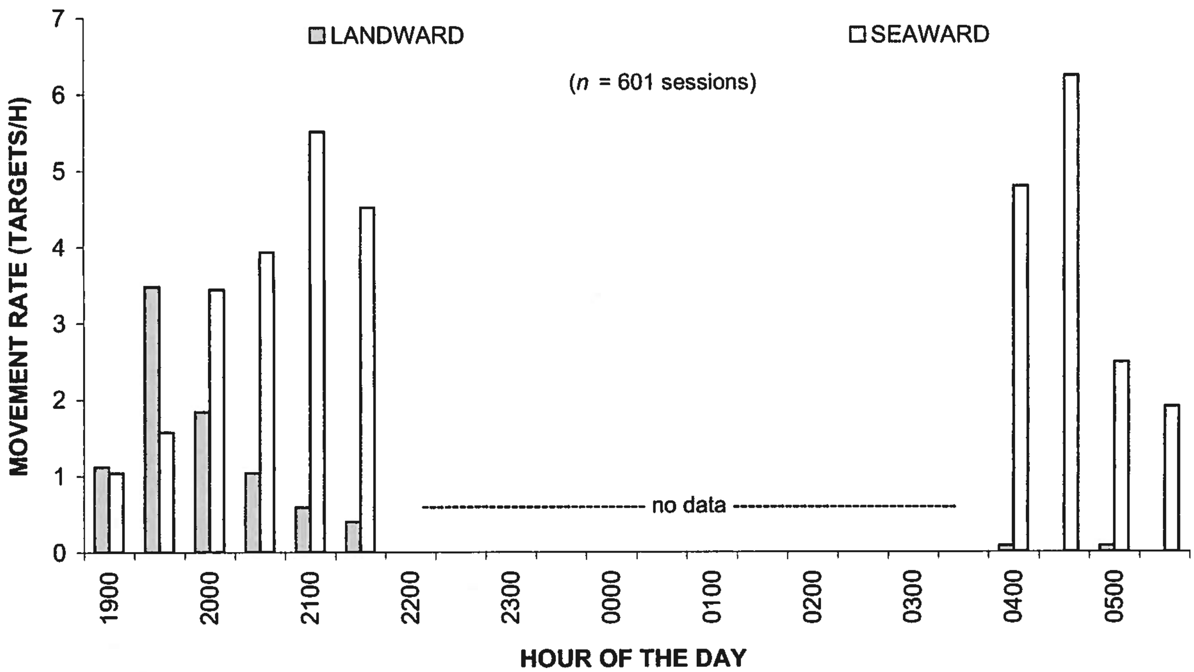

Figure 10. Hourly seaward and landward passage rates of probable Hawaiian Petrel targets observed on radar on Lana'i Island, Hawai'i, during late spring and summer 2007. Note that the number on the X-axis refers to the time that the sampling session began, not the midpoint of the session. The asterisk denotes times that were not sampled.

AUDIO-VISUAL OBSERVATIONS

NUMBERS AND SPECIES-COMPOSITION

We recorded 33 Hawaiian Petrels and 2 unidentified petrels/shearwaters during late spring and summer. Of the 5 birds recorded in late spring, we observed 0 at the Western site, 3 at the Central site, and 2 at the Eastern site (Table 7). In summer, we recorded 30 petrels, with 1 at Lower Ka'ena, 2 at Lower Polihua, 3 at Garden of the Gods, 6 at Lower Awalua, 6 at Central, 2 at Upper Lapaiki, and 10 at Lower Kuahua (Table 8).

In addition to Hawaiian Petrels, we also recorded other species of interest during our late spring and summer surveys. For instance, we saw one Hawaiian Hoary Bat at Garden of the Gods on the evening of 3 July (Tables 9 and 10). No other bats were recorded visually during the study; further, no bats were heard during the opportunistic acoustic monitoring that we did with the bat detector. Other species recorded during the audio-visual sampling included White-tailed Tropicbird (Koa'e Kea; *Phaethon rubricauda*), Greater Frigatebird ('Iwa; *Fregata minor*), Hawaiian Stilt (Ae'o; *Himatopus mexicanus knudseni*), Pacific Golden-Plover (Kolea; *Pluvialis fulva*), Short-eared Owl (Pueo; *Asio flammeus*), and Common Myna.

FLIGHT DIRECTION

We were able to assign flight directions to all Hawaiian Petrels and unidentified petrels/ shearwaters that we recorded visually during late spring and summer. Flight directions of these birds for all data combined showed a pattern of landward flights toward the colony, plus a few seaward flights, in the evening but only seaward flights away from the colony in the morning (Fig. 11). This landward–seaward pattern was similar to that seen on radar during both sampling periods (Figs. 5–8).

FLIGHT ALTITUDE

Visual observations also provided information on flight altitudes of Hawaiian Petrels and

Table 7. Number of Hawaiian Petrels and unidentified petrels/shearwater observed during visual sampling on Lana'i Island, Hawai'i, in late spring 2007, by study site, date, time of day, and flight direction. *n* = number of sampling sessions.

		Evening (1900–2200)		Morning (0400–0530)	
Site	Date	Landward (*n*)	Seaward (*n*)	Landward (*n*)	Seaward (*n*)
Western	26 May	0 (6)	0 (6)	0 (3)	0 (3)
	29 May	0 (6)	0 (6)	0 (3)	0 (3)
	1 June	0 (6)	0 (6)	0 (3)	0 (3)
	4 June	0 (6)	0 (6)	0 (3)	0 (3)
	7 June	0 (6)	0 (6)	0 (3)	0 (3)
	Total	0 (30)	0 (30)	0 (15)	0 (15)
Central	28 May	0 (6)	0 (6)	0 (3)	0 (3)
	31 May	1 (6)	0 (6)	0 (3)	0 (3)
	3 June	0 (6)	0 (6)	0 (3)	0 (3)
	6 June	1 (6)	0 (6)	0 (3)	1 (3)
	9 June	0 (6)	0 (6)	0 (3)	0 (3)
	Total	2 (30)	0 (30)	0 (15)	1 (15)
Eastern	27 May	0 (6)	0 (6)	0 (3)	0 (3)
	30 May	1 (6)	0 (6)	0 (3)	0 (3)
	2 June	0 (6)	0 (6)	0 (3)	0 (3)
	5 June	0 (6)	0 (6)	0 (3)	0 (3)
	8 June	0 (6)	1 (6)	0 (3)	0 (3)
	Total	1 (30)	1 (30)	0 (15)	0 (15)
Total	–	3 (90)	1 (90)	0 (45)	1 (45)

unidentified petrels/shearwaters. Of the 5 petrels seen during the May–June sampling period and the 30 petrels observed during the June–July sampling period, 25 (71.4%) were flying at or below met-tower height (i.e., ≤50 m agl). Flight altitudes varied by flight direction, however: 20 (87.0%) of the 23 landward-flying petrels were flying ≤50 m agl, whereas only 5 (41.7%) of the 12 seaward-bound petrels were flying ≤50 m agl. Further, 33 (94.3%) of the 35 Hawaiian Petrels and unidentified petrels/shearwaters were flying at or below proposed turbine height (i.e., ≤125 m agl). At this high a cutoff altitude, however, flight altitudes did not differ by flight direction: 22 (95.7%) of the 23 landward-bound petrels and 11 (91.7%) of the 12 seaward-bound petrels were flying ≤125 m agl.

The mean (± SE) flight altitude of Hawaiian Petrels and unidentified petrels/shearwaters observed at all sites, times of day, and sampling periods combined was 47 ± 8 m agl (range = 5–200 m agl; *n* = 35 birds). Following the directional pattern seen above, however, the mean flight altitude of Hawaiian Petrels and unidentified petrels/shearwaters flying in a landward direction was 34 ± 9 m agl (range = 5–200 m agl; *n* = 23 birds), whereas the mean altitude of seaward-flying birds was more than 100% higher, at 71 ± 15 m agl (range = 10–175 m agl; *n* = 12 birds).

We recorded only one Hawaiian Hoary Bat during 485 audio-visual sampling sessions (i.e., a rate of 0.005 bats/h). The one bat that we recorded was seen flying towards the northwest over Garden of the Gods at an altitude of ~15 m agl. This bat appeared to be associated with a swarm of insects that had become collected near the ground in the lee of the ridge crest.

Table 8. Number of Hawaiian Petrels and unknown petrel/shearwaters observed during visual sampling on Lana'i Island, Hawai'i, in summer 2007, by study site, date, time of day, and flight direction. *n* = number of sampling sessions.

		Time of day			
		Evening (1900–2200)		Morning (0400–0600)	
Site	Date	Landward (*n*)	Seaward (*n*)	Landward (*n*)	Seaward (*n*)
Lower Ka'ena	22 June	0 (6)	0 (6)	0 (4)	0 (4)
	25 June	0 (6)	0 (6)	0 (4)	0 (4)
	29 June	0 (6)	0 (6)	0 (4)	0 (4)
	2 July	1 (6)	0 (6)	0 (4)	0 (4)
	6 July	0 (6)	0 (6)	0 (4)	0 (4)
	Total	1 (30)	0 (30)	0 (20)	0 (20)
Lower Polihua	24 June	0 (6)	0 (6)	0 (4)	0 (4)
	28 June	0 (6)	0 (6)	0 (4)	1 (4)
	1 July	0 (6)	1 (6)	0 (4)	0 (4)
	5 July	0 (6)	0 (6)	0 (4)	0 (4)
	8 July	0 (6)	0 (6)	0 (4)	0 (4)
	Total	0 (30)	1 (30)	0 (20)	1 (20)
Garden of Gods	23 June	1 (6)	0 (6)	0 (4)	0 (4)
	26 June	0 (6)	0 (6)	0 (4)	0 (4)
	30 June	1 (6)	0 (6)	0 (4)	0 (4)
	3 July	0 (6)	0 (6)	0 (4)	0 (4)
	7 July	0 (6)	0 (6)	1 (4)	0 (4)
	Total	2 (30)	0 (30)	1 (20)	0 (20)
Lower Awalua	23 June	0 (6)	0 (6)	0 (4)	0 (4)
	27 June	0 (6)	0 (6)	0 (4)	0 (4)
	30 June	1 (6)	0 (6)	1 (4)	0 (4)
	4 July	0 (6)	0 (6)	0 (4)	1 (4)
	7 July	2 (6)	0 (6)	0 (4)	1 (4)
	Total	3 (30)	0 (30)	1 (20)	2 (20)
Central	24 June	0 (6)	0 (6)	0 (4)	0 (4)
	27 June	0 (6)	1 (6)	0 (4)	0 (4)
	1 July	1 (6)	0 (6)	0 (4)	0 (4)
	4 July	3 (6)	0 (6)	1 (4)	0 (4)
	8 July	0 (6)	0 (6)	0 (4)	0 (4)
	Total	4 (30)	1 (30)	1 (20)	0 (20)
Upper Lapaiki	22 June	0 (6)	0 (6)	0 (4)	0 (4)
	26 June	0 (6)	0 (6)	0 (4)	0 (4)
	29 June	1 (6)	0 (6)	0 (4)	0 (4)
	3 July	0 (5)	0 (5)	0 (0)	0 (0)
	6 July	0 (6)	0 (6)	0 (4)	1 (4)
	Total	1 (29)	0 (29)	0 (16)	1 (16)
Lower Kuahua	21 June	1 (6)	0 (6)	0 (4)	0 (4)
	25 June	1 (6)	0 (6)	0 (4)	0 (4)
	28 June	0 (6)	0 (6)	0 (4)	0 (4)
	2 July	4 (6)	0 (6)	0 (4)	1 (4)
	5 July	1 (6)	1 (6)	0 (4)	1 (4)
	Total	7 (30)	1 (30)	0 (20)	2 (20)
Total	–	18 (209)	3 (209)	3 (136)	6 (136)

Table 9. Number of Hawaiian Hoary Bats observed during visual sampling on Lana'i Island, Hawai'i, in late spring 2007, by study site, date, and time of day. *n* = number of sampling sessions.

		Time of day	
Site	Date	Evening (1900–2200)	Morning (0400–0600)
Western	26 May	0 (6)	0 (3)
	29 May	0 (6)	0 (3)
	1 June	0 (6)	0 (3)
	4 June	0 (6)	0 (3)
	7 June	0 (6)	0 (3)
	Total	0 (30)	0 (15)
Central	28 May	0 (6)	0 (3)
	31 May	0 (6)	0 (3)
	3 June	0 (6)	0 (3)
	6 June	0 (6)	0 (3)
	9 June	0 (6)	0 (3)
	Total	0 (30)	0 (15)
Eastern	27 May	0 (6)	0 (3)
	30 May	0 (6)	0 (3)
	2 June	0 (6)	0 (3)
	5 June	0 (6)	0 (3)
	8 June	0 (6)	0 (3)
	Total	0 (30)	0 (15)
Total	–	0 (90)	0 (45)

AUDITORY SURVEYS ALONG THE ROAD SYSTEM

During the summer study period, we also conducted auditory surveys along the entire road system within the WRA to investigate the possibility that some petrels were nesting away from the main colony and within the proposed project development area. This concern was raised because of the low flight altitudes of landward-flying Hawaiian Petrels seen during audio-visual surveys (see above); such low altitudes usually are seen near nesting colonies (Cooper and Day, pers. obs.). No petrels were seen or petrel-like calls were heard on any of the 15 nights of sampling that were conducted during summer 2007 (Table 11), suggesting that no petrels were nesting within the WRA.

EXPOSURE INDICES AND FATALITY MODELING

The risk-assessment technique that we have developed involves the use of both radar data and visual data in estimating the fatality of petrels and shearwaters near structures in the Hawaiian Islands (Fig. 2). This modeling technique uses the radar data on movement rates to estimate numbers of birds flying over the area of interest (sampling sites), then expands those estimates for a 270-d year that birds are present on this island (late March through late December; J. Penniman, DOFAW, pers. comm.) and, hence, will be exposed to the proposed met towers and wind turbines. The model then uses information on the physical characteristics of the towers/turbines themselves to estimate horizontal interaction rates, uses visual flight-altitude data to estimate vertical interaction rates, and combines these estimates of interaction rates with the fatality probability to estimate

Table 10. Number of Hawaiian Hoary Bats observed during visual sampling on Lana'i Island, Hawai'i, in summer 2007, by study site, date, and time of day. *n* = number of sampling sessions.

		Time of day	
Site	Date	Evening (1900–2200)	Morning (0400–0600)
Lower Ka'ena	22 June	0 (6)	0 (4)
	25 June	0 (6)	0 (4)
	29 June	0 (6)	0 (4)
	2 July	0 (6)	0 (4)
	6 July	0 (6)	0 (4)
	Total	0 (30)	0 (20)
Lower Polihua	24 June	0 (6)	0 (4)
	28 June	0 (6)	0 (4)
	1 July	0 (6)	0 (4)
	5 July	0 (6)	0 (4)
	8 July	0 (6)	0 (4)
	Total	0 (30)	0 (20)
Garden of Gods	23 June	0 (6)	0 (4)
	26 June	0 (6)	0 (4)
	30 June	0 (6)	0 (4)
	3 July	1 (6)	0 (4)
	7 July	0 (6)	0 (4)
	Total	1 (30)	0 (20)
Lower Awalua	23 June	0 (6)	0 (4)
	27 June	0 (6)	0 (4)
	30 June	0 (6)	0 (4)
	4 July	0 (6)	0 (4)
	7 July	0 (6)	0 (4)
	Total	0 (30)	0 (20)
Central	24 June	0 (6)	0 (4)
	27 June	0 (6)	0 (4)
	1 July	0 (6)	0 (4)
	4 July	0 (6)	0 (4)
	8 July	0 (6)	0 (4)
	Total	0 (30)	0 (20)
Upper Lapaiki	22 June	0 (6)	0 (4)
	26 June	0 (6)	0 (4)
	29 June	0 (6)	0 (4)
	3 July	0 (5)	0 (0)
	6 July	0 (6)	0 (4)
	Total	0 (29)	0 (16)
Lower Kuahua	21 June	0 (6)	0 (4)
	25 June	0 (6)	0 (4)
	28 June	0 (6)	0 (4)
	2 July	0 (6)	0 (4)
	5 July	0 (6)	0 (4)
	Total	0 (30)	0 (20)
Total	–	1 (209)	0 (136)

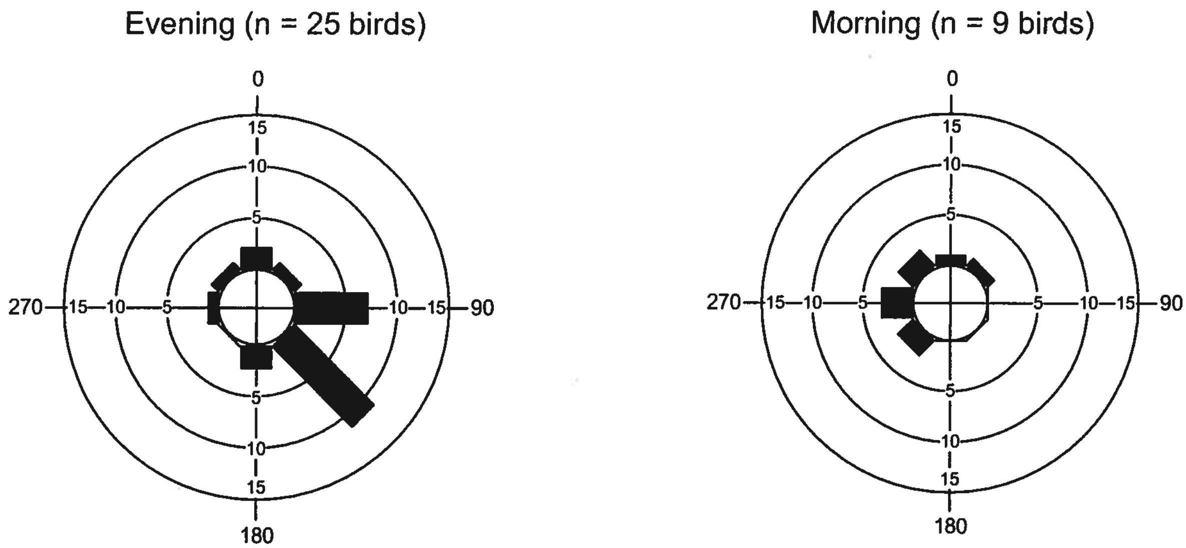

Figure 11. Flight direction of Hawaiian Petrels and unidentified shearwaters/petrels observed during visual sampling on Lana'i Island, Hawai'i, late spring and summer 2007, by time of day. Length of spoke is proportional to the number of birds traveling in that direction.

Table 11. Sampling effort and number of Hawaiian Petrels detected on acoustic surveys during late spring 2007.

Road system	No. sampling points	No. point visits	No. petrel calls
Ka'ena	7	21	0
Polihua	7 [1]	20	0
Road #7	4	8	0
Kanepu'u	6	16	0
Awalua	6	15	0
Lapaiki	8	22	0
Kahua	6	18	0
Kuahua	7	20	0

[1] One of the seven sampling points was dropped after the first visit.

fatality rates under a worst-case scenario of no collision avoidance. Finally, it presents possible levels of fatality based on possible levels of collision avoidance by these birds.

We analyzed the data separately for each of the seven radar sampling sites that we sampled in summer (late June–early July) 2007 (Fig. 1) and constructed fatality estimates for any proposed met towers or wind turbines that will be associated with each site. We tabulated all data from Lana'i on minimal flight altitudes of petrels recorded during the visual sampling and used those data for the vertical-interaction component of our fatality model. Of the 4 petrels seen during the May–June sampling period and the 31 petrels seen during the June–July sampling period, 20 (87.0%) of the 23 landward-flying petrels and 5 (41.7%) of the 12 seaward-flying petrels were flying ≤50 m agl. Further, 22 (95.7%) of the 23 landward-flying petrels and 11 (91.7%) of the 12 seaward-flying petrels were flying ≤125 m agl. We used the midpoints of the landward and seaward percentages (i.e., 64.4% and 93.7% for proposed met towers and wind turbines, respectively) in our fatality models because we assumed that there would be approximately equal numbers of landward and seaward targets passing over a location on any given night.

MOVEMENT RATE

The movement rate is an estimate of the average number of birds passing in the vicinity of the proposed towers/turbines in a day, as indicated by what is seen on the radar screen. It is generated from the radar data by: (1) multiplying the average evening landward and morning seaward movement rates by 3 h to estimate the number of targets moving over the radar site in those first and last 3 h of the night; (2) multiplying the sum of those evening landward counts and morning seaward counts by the quantity (1 + the proportion [12.6%] of targets that move during the rest of the night [= 1.126]) to account for movement during the middle of the night (Tables 6 and 12), following Day and Cooper (1995, unpubl. data); (3) adding the evening seaward counts and morning landward counts to the previous number of targets to get the total number of probable Hawaiian Petrel targets passing within 1.5 km of each site in a night; and (4) multiplying that total number of targets/night by the mean number of petrels/target to generate an estimate of the number of petrels passing in the vicinity of the proposed tower/turbine during an average night (Table 12).

Because we did not have all-night radar data available for Lanai, we used data from all-night sampling sessions on Kaua'i (Day and Cooper 1995) to determine that ~87% of the entire night's movement occurs during the evening and morning landward and seaward peaks, respectively (Day and Cooper, unpubl. data). We believe that all of the radar targets seen during this study were those of Hawaiian Petrels; certainly, all of the targets identified to species were petrels, and all birds definitely identified to species visually were petrels. The estimate of mean flock size for Hawaiian Petrel targets (1.05 ± SE 0.01 birds/target) is calculated from all visual data on this species on Kaua'i, Lana'i, Maui, and Hawai'i combined between 1992 and 2007 (n = 810 observations; Day and Cooper, unpubl. data). We then multiplied this estimate of nightly movement by 270 d (April–December) to generate an estimate of movement over each site during an entire breeding season.

Although we had to base this model of annual fatality on movement rates from the one study period, mean nightly movement rates are known to differ seasonally. For example, because movement rates tend to decrease from summer to fall (Day and Cooper 1995), the use of movement rates from only the summer will tend to overestimate annual interaction and fatality rates, whereas the use of movement rates from only the fall will tend to underestimate annual interaction and fatality rates. At this point, we are unclear exactly what movement rates in spring (April) will be, but State of Hawaii DOFAW personnel believe that that might be the season when the most birds are present at the Lana'ihale colony (J. Penniman, DOFAW, pers. comm.).

Because the resulting estimate of the number of birds/yr is not an integer, we then round it upward to the next whole number to generate an estimate of the average number of birds passing within 1.5 km of the radar site during a year. This rounding technique results in slightly-inflated fatality estimates, but we are being conservative about the fatality of an endangered species.

Table 12. Estimates of mean numbers of probable Hawaiian Petrel targets/night flying over radar-sampling sites on Lana'i Island, Hawai'i, in late spring and summer 2007, by season, radar-sampling site, time of day, and flight direction.

Sampling period/study site	Time of day: Evening (1900–2200) Mean landward movement (targets)	Evening (1900–2200) Mean seaward movement (targets)	Morning (0400–0600) Mean landward movement (targets)	Morning (0400–0600) Mean seaward movement (targets)	Mean nightly movement (targets)[1]
LATE SPRING					
Western	0.72	5.76	0.00	4.80	11.97552
Central	1.98	10.44	0.00	11.04	25.10052
Eastern	5.76	7.68	0.00	2.88	17.40864
Mean	2.82	7.96	0.00	6.24	18.16156
SUMMER					
Lower Ka'ena	0.00	1.44	0.00	1.80	3.46680
Lower Polihua	1.44	4.80	0.00	5.76	12.90720
Garden of Gods	0.24	7.95	0.00	3.24	11.86848
Lower Awalua	1.44	8.40	0.36	9.72	21.32616
Central	2.16	8.16	0.00	14.49	26.90790
Upper Lapaiki	3.24	6.207	0.00	4.41	15.08776
Lower Kuahua	10.68	10.68	0.36	14.76	39.68206
Mean	2.78	6.81	0.10	7.74	18.74948

[1] This value = ((mean landward evening movement + mean seaward morning movement) × 1.126) + mean seaward evening movement + mean landward morning movement.

INTERACTION PROBABILITIES

We have separated the interaction probability into horizontal and vertical components to make its estimation more tractable. The horizontal interaction probability is the probability that a bird seen on radar will pass through or over the airspace occupied by a proposed met tower or proposed turbine located somewhere on the radar screen. This probability is calculated from information on the two-dimensional area (side view) of the proposed tower/turbine and the two-dimensional area sampled by the radar screen to determine the interaction probability. The proposed met-tower system has a central tower with four sets of guy wires attached at five heights; hence, the tower/guy-wire system appears from the side to be an isosceles triangle 50 m high with a base of 67 m and a mean width of 33.5 m (Table 13). The proposed wind turbines have 80-m monopole towers and 45-m-long blades. Two calculations of area were made for turbines because of the huge differences in area of the structure that depended on the orientation when approaching it: a minimal area occupied by each proposed turbine if a bird approaches it from the side (i.e., side profile) and a maximal area occupied by each turbine if a bird approaches it from the front (i.e., front profile, including the rotor-swept area; Table 14). The ensuing ratio of cross-sectional area of the proposed tower/turbine to the cross-sectional area sampled by the radar indicates the probability of interacting with (i.e., flying over or through the airspace occupied by) the proposed tower or turbine. Because the dimensions of the proposed towers/turbines will not differ among sampling periods, estimates of horizontal interaction probabilities will be identical during all sampling periods.

The vertical interaction probability is the probability that a bird seen on radar will be flying at an altitude low enough that it might pass through the airspace occupied by a proposed tower/turbine located somewhere on the radar screen. This probability is calculated from visual data on flight altitudes and from information on the proposed towers' and turbines' heights. Because we do not have sufficient data to determine whether flight altitudes differ seasonally, we assume here that they do not vary; hence, estimates of vertical interaction probabilities will be identical during all seasons.

EXPOSURE RATE

The exposure rate is calculated as the product of the preceding three variables (annual movement rate, horizontal interaction probability, vertical interaction probability). As such, it is an estimate of the number of birds flying in the vicinity of the proposed tower/turbine (i.e., crossing the radar screen) that could fly in a horizontal location and that could fly at a low enough altitude that they could interact with the tower/turbine. Because movement rates vary among sampling periods, estimates of annual exposure rates also will vary seasonally, as described above; however, in this case, we are estimating annual rates based only based on summer (June–July) data.

FATALITY PROBABILITY

Not all birds possibly interacting with the proposed tower/turbine might be killed by it (e.g., some birds might just brush towers or guy wires with their wingtips and fly away uninjured), necessitating the estimation of the fatality probability. Factors that affect tower fatality probability include whether the tower is a solid monopole or a lattice-type tower, whether the tower is free-standing or guyed, and, if it is a lattice-type tower, the size of the lattice interstices (large free-standing lattice towers will have frameworks with openings several meters wide for birds to pass through safely, whereas towers with small lattices and multiple guy wires effectively are solid objects). Factors that affect wind-turbine fatality probability include the speed and orientation of the bird relative to the rotational speed and orientation (side view or front view) of the turbine blades.

The estimate of fatality probability is derived as the product of (1) the probability of colliding with the proposed tower or its guy wires/the proposed turbine if the bird enters the airspace occupied by either of these structures and (2) the probability of dying if it hits either the tower frame/guy wires or the turbine. The former probability is needed because the above estimates of horizontal interaction probability are calculated as if the proposed tower and its guy wires/turbine are one solid structure, as described above. In the

Table 13. Estimated met tower exposure indices and fatality indices of Hawaiian Petrels (HAPE) at each site on Lana'i Island, Hawai'i, based on radar data collected in late June–early July 2007 and flight-altitude data from Lana'i Island during May–July 2007. Values of particular importance are in boxes.

Variable/parameter	Radar-sampling site (met-tower number)						
	Lower Ka'ena (6)	Lower Polihua (5)	Garden of Gods (4)	Lower Awalua (3)	Central (2)	Upper Lapaiki (1)	Lower Kuahua (7)
MOVEMENT RATE (MVR)							
A) Movement rate (petrel targets/night)	3.46680	12.90720	11.86848	21.32616	26.90790	15.08776	39.68206
B) Mean number of HAPE/target	1.05	1.05	1.05	1.05	1.05	1.05	1.05
C) Daily movement rate (HAPE/day =B*C)	3.64	13.55	12.46	22.39	28.25	15.84	41.67
D) Fatality domain (days/year)	270	270	270	270	270	270	270
E) Annual movement rate (HAPE/year; =C*D, rounded to next whole number)	983	3,660	3,365	6,046	7,629	4,278	11,250
HORIZONTAL INTERACTION PROBABILITY (IPH)							
F) Maximal cross-sectional area of tower and guys (side view = ((33.5m * 50 m)/2)*2 = 1675 m²	1,675.0	1,675.0	1,675.0	1,675.0	1,675.0	1,675.0	1,675.0
G) Cross-sectional sampling area of radar at or below 50 m tower height (= 3000 m * 50 m = 15,000 m²)	150,000.000	150,000.000	150,000.000	150,000.000	150,000.000	150,000.000	150,000.000
H) Horizontal interaction probability (= F/G, rounded to 8 decimal places)	0.01116667	0.01116667	0.01116667	0.01116667	0.01116667	0.01116667	0.01116667
VERTICAL INTERACTION PROBABILITY (IPV)							
I) Vertical interaction probability (proportion petrels flying ≤ tower height; rounded to 8 decimal places)	0.64350000	0.64350000	0.64350000	0.64350000	0.64350000	0.64350000	0.64350000
EXPOSURE RATE (ER; = MVR * IPH * IPV)							
J) Daily exposure rate (HAPE/day = C*H*I, rounded to 8 decimal places)	0.02615714	0.09738531	0.08954813	0.16090668	0.20302111	0.11383771	0.29940263
K) Annual exposure rate (HAPE/year = E*H*I, rounded to 8 decimal places)	7.06359225	26.29984500	24.18004875	43.44504450	54.82008675	30.74063850	80.83968750

Table 13. Continued.

Variable/parameter	Radar-sampling site (met-tower number) Lower Ka'ena (6)	Lower Polihua (5)	Garden of Gods (4)	Lower Awalua (3)	Central (2)	Upper Lapaiki (1)	Lower Kuahua (7)
FATALITY PROBABILITY (MP)							
L) Probability of striking tower or guys if in airspace	1.00	1.00	1.00	1.00	1.00	1.00	1.00
M) Probability of fatality if striking tower or guys	0.95	0.95	0.95	0.95	0.95	0.95	0.95
N) Probability of fatality if an interaction (= L*M, rounded to 5 decimal places)	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
ANNUAL FATALITY RATE (= IR * MP)							
O) Annual fatality rate with 0% exhibiting collision avoidance (HAPE/tower/year = K*N, rounded to 5 decimal places)	6.71041	24.98485	22.97105	41.27279	52.07908	29.20361	76.79770
P) Annual fatality rate with 50% exhibiting collision avoidance (HAPE/tower/year = K*N*0.5)	3.35521	12.49243	11.48553	20.63640	26.03954	14.60181	38.39885
Q) Annual fatality rate with 95% exhibiting collision avoidance (HAPE/tower/year = K*N*0.05)	0.33552	1.24924	1.14855	2.06364	2.60395	1.46018	3.83989
R) Annual fatality rate with 99% exhibiting collision avoidance (HAPE/tower/year = K*N*0.01)	0.06710	0.24985	0.22971	0.41273	0.52079	0.29204	0.76798

Table 14. Estimated turbine exposure indices and fatality indices of Hawaiian Petrels (HAPE) at each site on Lana'i Island, Hawai'i, based on radar data collected in late June–early July 2007 and flight-altitude data from Lana'i Island during May–July 2007. Values of particular importance are in boxes.

Variable/parameter	Radar-sampling site (met-tower number) Lower Ka'ena (6)	Lower Polihua (5)	Garden of Gods (4)	Lower Awalua (3)	Central (2)	Upper Lapaiki (1)	Lower Kuahua (7)
MOVEMENT RATE (MVR)							
A) Movement rate (petrel targets/night)	3.46680	12.90720	11.86848	21.32616	26.90790	15.08776	39.68206
B) Mean number of HAPE/target	1.05	1.05	1.05	1.05	1.05	1.05	1.05
C) Daily movement rate (HAPE/day =B*C)	3.64	13.55	12.46	22.39	28.25	15.84	41.67
D) Fatality domain (days/year)	270	270	270	270	270	270	270
E) Annual movement rate (HAPE/year; =C*D, rounded to next whole number)	983	3,660	3,365	6,046	7,629	4,278	11,250
HORIZONTAL INTERACTION PROBABILITY (IPH)							
F) Turbine height (m)	125	125	125	125	125	125	125
G) Blade radius (m)	45	45	45	45	45	45	45
H) Height below blade (m)	35	35	35	35	35	35	35
I) Front to back width (m)	6	6	6	6	6	6	6
J) Min side profile area (m^2) = (A x D)	750	750	750	750	750	750	750
K) Max front profile area (m^2) = (C x D) + (p x B^2)	6,572	6,572	6,572	6,572	6,572	6,572	6,572
L) Cross-sectional sampling area of radar at or below 50 m tower height (= 3000 m * 50 m = 150,000 m^2)	150,000.000	150,000.000	150,000.000	150,000.000	150,000.000	150,000.000	150,000.000
M) Minimal horizontal interaction probability (= J/L)	0.00500000	0.00500000	0.00500000	0.00500000	0.00500000	0.00500000	0.00500000
N) Maximal horizontal interaction probability (= K/L)	0.04381160	0.04381160	0.04381160	0.04381160	0.04381160	0.04381160	0.04381160
VERTICAL INTERACTION PROBABILITY (IPV)							
O) Vertical interaction probability (proportion petrels flying ≤ turbine height)	0.93700000	0.93700000	0.93700000	0.93700000	0.93700000	0.93700000	0.93700000
EXPOSURE RATE (ER; = MVR * IPH * IPV)							
P) Daily minimal exposure rate (HAPE/day = C*M*O)	0.01705406	0.06349374	0.05838402	0.10490871	0.13236669	0.07422046	0.19520597
Q) Daily maximal exposure rate (HAPE/day = C*N*O)	0.14943310	0.55635250	0.51157947	0.91924371	1.15983927	0.65034345	1.71045721
R) Annual minimal exposure rate (HAPE/year = E*M*O)	4.60535500	17.14710000	15.76502500	28.32551000	35.74186500	20.04243000	52.70625000
S) Annual maximal exposure rate (HAPE/year = E*N*O)	40.35359422	150.2483772	138.1381938	248.1971827	313.1816585	175.61818524	461.8290285

Table 14. Continued.

Variable/parameter	Radar-sampling site (met-tower number)						
	Lower Ka'ena (6)	Lower Polihua (5)	Garden of Gods (4)	Lower Awalua (3)	Central (2)	Upper Lapaiki (1)	Lpwer Kuahua (7)
FATALITY PROBABILITY (MP)							
T) Probability of striking turbine if in airspace on a side approach	1.00	1.00	1.00	1.00	1.00	1.00	1.00
U) Probability of striking turbine if in airspace on frontal approach	0.14	0.14	0.14	0.14	0.14	0.14	0.14
V) Probability of fatality if striking turbine	0.95	0.95	0.95	0.95	0.95	0.95	0.95
W) Probability of fatality if an interaction on side approach (= T*V)	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
X) Probability of fatality if an interaction on frontal approach (= U*V)	0.13585	0.13585	0.13585	0.13585	0.13585	0.13585	0.13585
ANNUAL FATALITY RATE (= IR * MP)							
Minimal annual fatality rate with 0% exhibiting collision avoidance (HAPE/turbine/year = R*W)	1.75003	6.51590	5.99071	10.76369	13.58191	7.61612	20.02838
Maximal annual fatality rate with 0% exhibiting collision avoidance (HAPE/turbine/year = S*X)	2.19281	8.16450	7.50643	13.48703	17.01829	9.54309	25.09579
Minimal annual fatality rate with 50% exhibiting collision avoidance (HAPE/turbine/year = R*W*0.5)	0.87502	3.25795	2.99536	5.38185	6.79096	3.80806	10.01419
Meximal annual fatality rate with 50% exhibiting collision avoidance (HAPE/turbine/year = S*X*0.5)	1.09641	4.08225	3.75322	6.74352	8.50915	4.77155	12.54790
Minimal annual fatality rate with 95% exhibiting collision avoidance (HAPE/turbine/year = R*W*0.05)	0.08750	0.32580	0.29954	0.53818	0.67910	0.38081	1.00142
Maximal annual fatality rate with 95% exhibiting collision avoidance (HAPE/turbine/year = S*X*0.05)	0.10964	0.40823	0.37532	0.67435	0.85091	0.47715	1.25479
Minimal annual fatality rate with 99% exhibiting collision avoidance (HAPE/turbine/year = R*W*0.01)	0.01750	0.06516	0.05991	0.10764	0.13582	0.07616	0.20028
Maximal annual fatality rate with 99% exhibiting collision avoidance (HAPE/turbine/year = S*X*0.01)	0.02193	0.08165	0.07506	0.13487	0.17018	0.09543	0.25096

proposed met-tower design, the tower frame is a solid monopole, and the four sets of guy wires at five 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 without hitting some part of it. Hence, we estimated the probability of hitting the tower or guy wires if the bird enters the airspace at 100%. We consider this probability to be a worst-case scenario for this tower and guy-wire layout, both because of this assumption of hitting some part of the structure and because we assume that there is no behavioral avoidance of the structure by these birds (but see below).

Similarly, a bird approaching a turbine from the side has essentially a 100% probability of getting hit by a blade; in contrast, a bird approaching from the back or front has only a 14.9% probability of hitting a blade. This calculation for the "frontal" bird approach was based on the length of a petrel (43 cm; Simons and Hodges 1998); the average groundspeed of petrels on Lana'i (mean velocity = 48.5 ± 0.4 mi/h; n = 597 probable petrel targets); and the time that it would take a 43-cm-long petrel to travel completely through a 2-m-wide turbine blade spinning at its maximal rotor speed (19 revolutions/min); also see Tucker (1996). Thus, these calculations indicated that 14.9% of the disk of the rotor-swept area would be occupied by a blade sometime during the length of time (i.e., 0.0017 min) that it would take a petrel to fly completely past a rotor blade (i.e., to fly 2.43 m). Again, this probability is a worst-case scenario that assumes no avoidance behavior.

Finally, a bird hitting either the proposed met-tower frame or guy wire or the proposed wind turbine will have a high probability of actually dying unless it just brushes the structure with a wingtip; therefore, we used an estimate of 95% for that parameter. Hence, the overall fatality probability of a bird entering the airspace occupied by a proposed met tower is high and is estimated at 95% (i.e., 1.00 [= probability of colliding with the structure] × 0.95 [= probability of dying if colliding]). The overall fatality probability of a bird entering the airspace occupied by a proposed turbine is estimated at 95% (i.e., 1.00 × 0.95) for a side approach and 14.3% (i.e., 0.149 × 0.95) for a frontal approach. Because these probability estimates do not differ among sampling periods, this estimate of fatality probability will be identical among sampling periods.

FATALITY RATE

The annual fatality rate is calculated as the product of the exposure rate (i.e., the number of birds that might fly in the airspace occupied by the proposed met tower/guy wires or the proposed wind turbine) and the fatality probability (i.e., the probability of collision with a portion of the structure and dying while in the airspace). It is generated as an estimate of the number of birds killed/year as a result of the tower/turbine, based on a 270-d breeding season. Because movement rates vary seasonally (i.e., among sampling periods), fatality rates also will. Again, however, we present annual estimates here based on only on summer data.

The major variables involved in this fatality estimation are presented in Figure 2. The individual steps and estimates involved in these calculations are shown in Table 13 for proposed met towers and Table 14 for proposed wind turbines. Based on data from summer 2007, we estimate annual movement rates of ~983, ~3,660, ~3,365, ~6,046, ~7,629, ~4,278 and ~11,250 Hawaiian Petrels within 1.5 km of the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and Lower Kuahua radar sites, respectively (Tables 13 and 14). Thus, there is a gradation of increasing bird numbers from west to east in the proposed windfarm (also see Figs. 3 and 4). Based on flight-altitude data from Lana'i., we estimate that, on average, 64% of the birds flying through the WRA are flying at altitudes low enough to interact with the proposed met towers (i.e., ≤50 m agl) and that 94% fly at altitudes low enough to interact with the proposed turbines (i.e., ≤125 m agl). Based on these altitudes, the estimated annual movement rates, and the horizontal interaction probability, annual fatality rates at proposed met towers are estimated to be 6.7, 25.0, 23.0, 41.3, 52.1, 29.2, and 76.8 Hawaiian Petrels/tower near the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and

Lower Kuahua radar sites, respectively, assuming that no collision-avoidance behavior occurs (Table 13). Based on these altitudes, the estimated annual movement rates, and the horizontal interaction probabilities, annual fatality rates at proposed wind turbines are estimated to be 1.8–2.2, 6.5–8.2, 6.0–7.5, 10.8–13.5, 13.6–17.0, 7.6–9.5, and 20.0–25.1 Hawaiian Petrels/turbine near the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and Lower Kuahua radar sites, respectively, assuming that no collision-avoidance behavior occurs (Table 14). Fatality rates for proposed wind turbines are presented as ranges because of differential risks associated with side and frontal views of the turbines, as described above.

EFFECTS OF COLLISION AVOIDANCE ON ESTIMATES

We emphasize here that these fatality estimates assume a worst-case scenario in which there is no collision-avoidance behavior by Hawaiian Petrels. Because these birds mostly move during periods of daylight or twilight (Day and Cooper 1995, unpubl. data), however, it is likely that many will be able to see and avoid met towers/guy wires and wind turbines. Similarly, avoidance rates for nocturnally-moving Hawaiian Petrels should be high during periods when the moon is fairly full and visible. Consequently, we have recalculated estimated annual fatality rates for each site and flight-altitude scenario by assuming that 0%, 50%, 95%, or 99% of all Hawaiian Petrels flying near a met tower will see and avoid it. Based on these assumptions about possible collision-avoidance rates, annual fatality rates for proposed met towers are estimated to be 0.1–6.7, 0.3–25.0, 0.2–23.0, 0.4–41.3, 0.5–52.1, 0.3–29.2, and 0.8–76.8 Hawaiian Petrels/tower near the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and Lower Kuahua radar sites, respectively (Table 13). Based on the same set of assumptions about possible avoidance rates, annual fatality rates for proposed wind turbines are estimated to be 0.02–2.2, 0.1–8.2, 0.1–7.5, 0.1–13.5, 0.1–17.0, 0.1–9.5, and 0.2–25.1 Hawaiian Petrels/turbine near the Lower Ka'ena, Lower Polihua, Garden of the Gods, Lower Awalua, Central, Upper Lapaiki, and Lower Kuahua radar sites, respectively (Table 14). We caution again, however, that these assumptions for avoidance rates are not based on empirical data.

DISCUSSION

PETRELS AND SHEARWATERS

SPECIES COMPOSITION

Our visual data suggest that all of the radar targets that we observed with the radar on Lana'i in 2007 were Hawaiian Petrels. Of the 33 tubenoses seen during visual sampling and identified to species, all were identified as Hawaiian Petrels, so we assume that the 2 unidentified petrels/shearwaters also were petrels. Thus, there was no indication from the visual data that Newell's Shearwaters also flew over the area. In addition, other researchers on Lana'i consider Newell's Shearwaters to be extremely rare and are not even convinced that the species nests there (J. Penniman, DOFAW, pers. comm.).

We have suggested previously that Hawaiian Petrels on other islands (Kaua'i, Maui, and Hawai'i) fly into nesting areas earlier in the evening than Newell's Shearwaters do (Cooper and Day 2003; Day et al. 2003a, 2003b). Consequently, we have suggested that radar targets observed after ~30 min past sunset (i.e., at about the point of complete darkness) are predominantly Newell's Shearwaters. Clearly, this is not the case on Lana'i, where there are many Hawaiian Petrels flying into colonies well after the point of complete darkness. On the other hand, our studies from the other islands emphasized coastal sampling, whereas the Lana'i work (this study) and recent research on Maui (Day et al. 2005a, Day and A. Gall, unpubl. data) have occurred inland; in the three latter studies, Hawaiian Petrels were recorded flying primarily after dark, apparently reflecting the time it takes for these birds to fly from the coast to the colonies.

MOVEMENT RATES

Our sampling dates occurred during the incubation period (i.e., the May–June observations) and late-incubation/early chick-rearing period (i.e., the June–July observations) of Hawaiian Petrels (Simons and Hodges 1998; J.

Penniman, DOFAW, pers. comm.). During the summer period, breeding adults, nonbreeding adults, and subadults are visiting the colonies (Simons 1985, Simons and Hodges 1998). The average incubation shift is 16.5 d for Hawaiian Petrels (Simons 1985), so a breeding adult visits the nesting colony every 16–17 d, on average. Further, it is doubtful that all nonbreeding adults and subadults visit the colonies every night. Hence, the mean radar movement rates that we have presented here represent far less than the actual number of birds visiting the colony.

Overall mean movement rates (landward + seaward) on radar recorded on Lana'i tended to be much lower than were rates recorded during radar studies on Kaua'i and East Maui and were slightly lower than rates on West Maui; however, movement rates recorded on Lana'i were similar to rates recorded on Hawai'i (Table 15). Our data from Lana'i also indicate that there are fewer petrels flying over the western portion of the Lana'i WRA than over the central and eastern parts of it. This finding makes sense, given that it is the portion of the WRA that is farthest from the Lana'ihale colony. In fact, mean movement rates in the western portion of the WRA were lower than rates recorded at nearly all other locations that have ever been studied in the Hawaiian Islands (Cooper and Day 2003; Day et al. 2003a, 2003b, Day and Cooper, unpubl. data). Mean overall (i.e., landward + seaward) movement rates near the recently-installed Met Tower 6 in the western end of the study area were ~0.5 targets/h, which is even lower than mean movement rates at the recently-built Kaheawa Wind Park on Maui (1.0–1.2 targets/h; Day and Cooper 1999, Cooper and Day 2004a).

The typical movement pattern for Hawaiian Petrels and Newell's Shearwaters on the way to and from nesting colonies is a pattern of substantial landward movement toward the colonies for ~2 h after sunset, followed by low levels of landward and seaward movement during the middle of the night, followed by a substantial seaward departure from the colonies for 1–2 h prior to sunrise (Day and Cooper 1995, Cooper and Day 2003, Day et al. 2003a). This pattern also fits fairly well with what is known about the timing of vocalizations near the colonies and the timing of nest exchanges (Simons and Hodges 1998). Surprisingly, it appears that the movement pattern on Lana'i may be different from what has been seen on other islands. On Lana'i, the pattern that we observed was that seaward rates always were higher than landward rates, even in the evening; however, seaward rates were as high or higher in the morning than in the evening at most sites, similar to what we have seen on other islands. Seaward rates were as high or higher in the evening than in the morning at only two of seven sites, and those shared similar geographical (farthest inland) and geomorphological (along the east–west ridge) characteristics.

Until more data are collected, we hesitate to speculate extensively on the reasons for the early

Table 15. Mean movement rates (targets/h) of probable Hawaiian Petrel targets observed during radar studies on Lana'i, Kaua'i, East Maui, West Maui, and Hawai'i islands during 2001–2007.

		Movement rate (targets/h)[1]			
Island	Year	Mean	Range	No. sites sampled	Source
Lana'i	2007	2.9	0.5–7.1	9	this study
Kaua'i[2]	2001	118	8–569	13	Day et al. (2003b)
East Maui	2001	53	3.6–134	8	Cooper and Day (2003)
West Maui[2]	2001	8.7	0.4–21	6	Cooper and Day (2003)
Hawai'i[2]	2001–2002	2.5	0–25.8	18	Day et al. (2003a)

[1]All rates are total movement rates (i.e., landward + seaward).
[2]Definitely or probably includes Newell's Shearwaters.

seaward movements over the Lana'i study area, but these movements could be related to differences in landward and seaward flight paths into and out of the Lana'ihale colony. For instance, if most birds flew into the colony from the closest shorelines (as seems to be the case on the other islands; Cooper and Day, unpubl. data) but dispersed seaward in a variety of directions (clearly seen on Lana'i), one would expect a pattern of higher seaward movements like those we saw during both late spring and summer 2007. On the other hand, perhaps landward-flying targets flew inland at rates similar to seaward ones throughout the study area but flew at altitudes lower than seaward-flying ones did, making them less likely to be detected by radar; however, that alternative explanation does not explain the extensive seaward movements that we observed in the evening. Radar observations of birds around the perimeter of the island near the colony and, to some extent, around the rest of the island, could be used to answer these questions and to determine better the movement patterns between the inland colony and marine foraging areas. Such a study also could be used to help determine approximate colony size and to determine the proportion of landward and seaward movements that were from/toward the proposed WRA.

FLIGHT ALTITUDES

The mean flight altitude of Hawaiian Petrels and unidentified petrels/shearwaters recorded at all sites and during all times of day and sampling periods was 47 m agl. Further, the mean landward flight altitude of these birds was much lower (34 m agl) than was the mean seaward flight altitude (71 m agl). Thus, mean flight altitudes (especially landward ones) tend to be much lower than the average seen elsewhere in Hawaii: the mean flight of Hawaiian Petrels on Kaua'i, Maui, and Hawai'i combined is 200 m agl (range = 2–1,000 m agl; n = 696 birds; Day and Cooper, unpubl. data). It is possible that the lower flight altitudes on Lana'i could be related to the moderate, gently-sloping terrain between the coast and the low-elevation colony on Lana'ihale and/or to the low-elevation location of the colony itself: these birds nest at much higher elevations on all other islands, so birds there probably have to fly higher because they have a greater climb to the colonies. Another factor that may cause these lower flight altitudes for birds flying inland is the fact that those birds crossing the WRA are flying primarily into a headwind or a quartering headwind, so perhaps they are flying low because they are trying to get down into the boundary layer to reduce the effects of the headwind.

HAWAIIAN BATS

We recorded only one Hawaiian Hoary Bat during 485 sampling sessions. Thus, our data indicate that bats were present in the proposed WRA but occurred there in very low densities during the study period. Hoary Bats are known to occur on all of the Main Hawaiian Islands, including Lana'i (Baldwin 1950, van Riper and van Riper 1982, Tomich 1986, Fullard 1989, Kepler and Scott 1990, Hawaii Heritage Program 1991, David 2002), so our record is not unexpected. More extensive visual and/or acoustic work could be done to provide better information on the distribution and abundance of bats in the WRA, but our data from this study so far suggest that bat numbers will be low.

EXPOSURE INDICES AND FATALITY MODELING

We estimate that ~8–81 Hawaiian Petrels/yr (i.e., exposure rate) will fly within the space occupied by each proposed met tower in the study area and that 5–462 Hawaiian Petrels/yr will fly within the space occupied by each proposed wind turbine in the study area, based on movement-rate data collected during the late June–early July period. 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 and fatality at windfarms are strongly correlated. For example, Cooper and Day (1998) found no relationship between movement rates and fatality rates of Hawaiian Petrels and Newell's Shearwaters at powerlines on Kaua'i. Other factors (e.g., weather) could be more highly correlated with fatality rates than is bird abundance. To determine which factors are most relevant, studies such as those that collect concurrent data on movement rates, weather, and fatality rates would be needed to begin to determine whether movement rates and/or weather conditions can be used to predict the likelihood of petrel fatalities at these proposed met towers and the proposed windfarm.

In addition to these questions about the unknown relationships among fatality, weather, and abundance, there also are no hard data available on the proportion of petrels and shearwaters that do not collide with towers or turbines because of collision-avoidance behavior (i.e., birds that alter their flight paths and/or flight altitudes to avoid colliding with these structures); however, see Winkelman (1995), Desholm and Kahlert (2005), and Desholm et al. (2006) for studies of avoidance of wind turbines by waterbirds in Europe. Clearly, the detection of met towers/turbines could alter movement rates, flight paths, and/or flight altitudes of these birds, which, in turn, would reduce the likelihood of collision. In addition, there could be differences among species in their ability to avoid obstacles. For example, Cooper and Day (1998) believed that Hawaiian Petrels have flight characteristics that make them more maneuverable at avoiding powerlines than do Newell's Shearwaters, suggesting that this greater maneuverability also might increase their ability at avoiding towers or turbines.

There is evidence that many species of birds do detect and avoid wind turbines in low-light conditions (Dirksen et al. 1998, Winkelman 1995, Desholm and Kahlert 2005, Desholm et al. 2006), but no petrel-specific data on avoidance of met towers or wind turbines is available. 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 paths) 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. 2005b) and in diving ducks approaching offshore windfarms in Europe (Dirksen et al. 1998). Collision-avoidance rates around wind turbines are high for Common Eiders in the daytime (Desholm and Kahlert 2005), gulls (*Larus* spp.) in the daytime (>99%; Painter et al. 1999, cited in Chamberlain et al. 2006), Golden Eagles (*Aquila chrysaetos*) in the daytime (>99%; Madders 2004, cited in Chamberlain et al. 2006), American Kestrels (*Falco sparverius*) in the daytime (87%, Whitfield and Band [in prep.], cited in Chamberlain et al. 2005), and passerines during both the day and night (>99%; Winkelman 1992, cited in Chamberlain et al. 2006). Further, Erickson et al. (2002) suggested that the proportion of nocturnal migrants that detect and avoid turbines must be very high because fatality rates of nocturnal migrants appear "insignificant" relative to nocturnal passage rates of migrating birds. Although Hawaiian Petrels have flight characteristics very different from those of these other species, they are adept at flying through forests near their nests during low-light conditions; hence, it is reasonable to assume that they too have enough visual acuity and maneuverability to help avoid met towers and wind turbines if they see them. Thus, while we agree with others (Chamberlain et al. 2006, Fox et al. 2006) that species-specific and site-specific data are needed in models to estimate fatality rates accurately, we speculate that a high proportion of petrels would detect and avoid large structures under average conditions of weather and visibility. Until petrel-specific data on the relationship between exposure and fatality rates are available, however, we provide a range of assumptions for this variable in our fatality models.

To err on the conservative side, we used a wide range of assumptions about the proportion of petrels and shearwaters that would detect and avoid the proposed met towers (i.e., 0%, 50%, 95%, and 99%) and estimated an annual take of ~7–77 Hawaiian Petrels/tower if 0% of them detect and avoid the met towers; 4–39 if 50% of them detect and avoid the met towers; 1–4 if 95% of them detect and avoid the met towers; and ≤1 if 99% of them detect and avoid the met towers. Obviously, there is a wide range in fatality estimates within each location, but one will be able to refine these estimates only with further research on avoidance behavior at met towers and on the proportion of petrels and shearwaters able to fly close to the met towers without being killed or injured.

Although the actual avoidance rate of wind turbines by petrels is unknown at this time, recent data from the Kaheawa Wind Plant on Maui Island suggests that it is high. After ~1 yr of operation, the recorded (but uncorrected for sampling bias) petrel mortality rate at that 20-turbine windfarm has been 1 Hawaiian Petrel (B. Standley, USFWS, pers.

comm.). Cooper and Day (2004b) modeled seabird fatality for the KWP based on movement rates from radar studies there (Day and Cooper 1999, Cooper and Day 2004a) and estimated that the combined annual fatality of Hawaiian Petrels and Newell's Shearwaters at that site would be ~3–18 birds/yr with a 50% avoidance rate, ~1–2 birds/yr with a 95% avoidance rate, and <1 bird/yr with a 99% avoidance rate. Thus, this data set from 1 yr of operation suggests that the true avoidance rate of petrels around wind turbines is ~95%.

There are several factors that could affect our estimates of exposure and fatality, some in a positive direction and some in a negative direction. One factor that would have increased these estimates was the inclusion of targets that were not petrels or shearwaters. Our visual observations (especially during crepuscular periods, when we could use binoculars) helped to minimize the inclusion of non-target species, but it is possible that some of our radar targets after dark were of other fast-flying species that were active at that time (e.g., Pacific Golden-Plover, Greater Frigatebird).

A second factor that could increase our exposure and fatality estimates was that we collected data during the late incubation period, which is that time when some of the highest counts of the entire breeding season are expected, and then extrapolated those rates across the entire 270-d breeding season. For example, radar counts of petrels and shearwaters on Kaua'i in 1993 were significantly (~3 times) higher in summer (incubation period) than in fall (fledging period; Day and Cooper 1995). The increase in movement rates during incubation and early chick-rearing occurs because of regular visits of breeding birds after hatching and because non-breeders visit the colonies at that time, whereas the fall declines occur because attendance at colonies by non-breeders and failed breeders declines as chick-rearing progresses (Serventy et al. 1971, Warham 1990, Ainley et al. 1997b, Simons and Hodges 1998). We plan to collect data during late fall 2007 to help increase our understanding of this seasonal variation in movement rates on Lana'i Island.

A third factor that would increase our exposure and fatality estimates is that petrels may enter and leave the colony by different routes, as suggested above. Our radar data suggest that petrels are flying inland over the WRA in lower numbers than are petrels flying seaward. Because the risk-assessment modeling assumed that the number flying inland over the WRA balanced the number flying seaward, we took the midpoint between the percentage of inland-flying and seaward-flying petrels that were flying low enough to hit a proposed met tower (87.0% and 41.7%, respectively) or turbine (95.7% and 91.7%, respectively) in the modeling exercise. If, however, more birds were flying seaward than inland because most birds flew inland farther east (out of the WRA), the true vertical interaction probability would be closer to the lower value than to the midpoint. Because we suspect that petrels may be flying into and out of the colony by different routes (see above), our modeling probably overestimates the true fatality rate.

A factor that would decrease our exposure and fatality estimates is if inland-flying targets were missed because they flew low to the ground, within radar shadows. The sites generally were excellent from a radar-sampling perspective, but we know that we missed some targets on radar because of the unusually low flight altitudes of petrels on Lana'i: the mean flight altitude was only 47 ± 8 m agl, or much lower than a mean flight altitude of 200 m agl for all of the other Main Hawaiian Islands combined (Day and Cooper, unpubl. data). For example, ~63% of the 35 birds observed visually in the present study were not detected on radar, suggesting that many were flying too low for the radar to detect them. In contrast, only 9 of the 121 radar targets that passed within 250 m of the visual observer were observed by the visual observer, even though the radar operator alerted the visual observer to the approach of these targets. Thus, the radar and visual techniques are sampling only partially-overlapping subsets of birds, making it problematic to calculate a valid correction factor for the percentage of low-flying targets that the radar might have missed.

A second factor that would decrease our exposure and fatality estimates is if some of the peak morning-movement period occurred before sampling began at 0400. Although our evening and morning sampling periods correspond to the evening and morning peaks of movement for these birds at other islands (Day and Cooper 1995), we noticed on Lana'i that some birds were flying seaward, even in the half-hour before observations began at 0400, suggesting that the peak morning movement out of the colony already had begun before our sampling started. To account in the fatality model for this unexpected-early morning exodus, we expanded our peak morning movement rates to 3 h (i.e., 0300–0600), rather than just to the 2-h sampling window (i.e., 0400–0600) when sampling occurred. Clearly, some all-night radar sampling on Lana'i would help us refine our understanding of the movement patterns of petrels during the middle of the night.

A factor that could affect our exposure and fatality estimates in either direction is interannual variation in counts. For example, counts on Kaua'i were four times lower in fall 1992 than in fall 1993, with the lower counts in 1992 being attributed to the effects of Hurricane Iniki, one of the strongest hurricanes ever to hit the Hawaiian Islands (Day and Cooper 1995). In addition, 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).

A final factor affecting exposure indices involves marking of the proposed met towers and guy wires with white flagging to make them more visible to flying Hawaiian Petrels. This flagging has been found to be effective in reducing collisions of Hawaiian Petrels with ungulate fences near breeding colonies on Hawai'i Island, both because Hawaiian Petrels see flagged structures more easily and because they see them at greater distances, allowing more time for collision avoidance to occur (Swift 2004). Anecdotal information from the petrel colony on Lana'i also suggests that white flagging on ungulate fences there are effective in reducing collisions of petrels with the fence (J. Penniman, DOFAW, pers. comm.). We see no reasons why Hawaiian Petrels' ability to see white-flagged met towers should differ from their ability to see white-flagged fences, so we encourage marking of the towers and guy wires to increase their visibility to these birds and, thus, to increase the birds' anti-collision behavior.

CONCLUSIONS

Although the number of Hawaiian Petrels that might be killed by collision with the proposed met towers and turbines on Lana'i is unknown, we have used our risk-assessment model to approximate their potential fatality rates. The model is affected by all of the input variables; however, the collision-avoidance rate variable has both a very large effect on modeled estimates and also is one of the most poorly understood variables at this time. It will take nocturnal behavioral sampling to understand how these birds will behave around met towers and wind turbines in this proposed windfarm. There is a body of evidence that indicates that a high percentage of birds see and avoid structures (see above), and the limited data from the Maui windfarm suggest that avoidance rates will be high. We suspect that Hawaiian Petrels also have good nocturnal eyesight, given the fact that they must be able to see well to get to and from their burrows. Consequently, we suspect that there will be natural anti-collision behavior as they approach these structures, although the true rate of avoidance is unknown at this time. The fact that many petrels move while there is still light in the sky also will enhance their anti-collision behavior. Finally, we believe that marking the met towers and guy wires to make them more visible to petrels also will increase anti-collision behavior and decrease risk. Hence, we believe that the proportion of petrels that see and avoid the proposed met towers and turbines will be high and will be enhanced by marking but emphasize that, until studies to measure avoidance behavior at marked structures are conducted, that proportion will remain unknown.

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Appendix 4

Lāna'i Spring Avian Report

SPRING AVIAN SURVEY
LĀNA'I RESOURCE AREA
MAUI COUNTY,
HAWAII

PREPARED FOR

CASTLE & COOKE INC.

Prepared by

TETRA TECH EC, INC.

August 2007

Executive Summary

Tetra Tech, EC (TtEC) was contracted by Castle and Cooke to undertake spring avian use surveys for the proposed Lāna'i Wind Resource Area (WRA) in Maui County, Hawaii. Weekly spring surveys were performed at the Lāna'i WRA from April 20 to June 28, 2007. Fixed point count surveys (800 m radius) were conducted at 11 points distributed throughout the WRA.

A total of 15 species, consisting of 299 birds from five taxonomic groups were observed within the Lāna'i WRA. Overall mean use of the WRA was 3.5 birds/20 min. Mean raptor use at the Lāna'i WRA (0.1 birds/20 min; 0.15 birds/30 min when scaled to a 30-minute survey) was the lowest compared to the rates recorded for 14 other wind power sites throughout the continental U.S. A single species of raptor, the short-eared owl, was detected during the 20-minute surveys. The short-eared owl had a mean use of 0.1 birds/20 min and flew through the RSA 9.1% of the time, resulting in an exposure risk of 0.01 birds flying within the RSA/20 min. The short-eared owl has been listed as a bird of conservation concern by the U.S. Fish and Wildlife Services (USFW 2007) and is a state listed endangered species on the island of O'ahu (Hawaii 2007). Short-eared owls primarily flew below the RSA; however, males are known to perform higher altitude aerial displays within the RSA when mating.

Overall non-raptor avian use at Lāna'i WRA is low. Use by non-raptors collectively at the Lāna'i WRA (3.4 birds/20 min; 5.1 birds/30 min when scaled to a 30-min survey) was the lowest when compared to other previously recorded rates from existing wind facilities throughout the continental U.S. The most abundant species of non-raptor within the WRA were the common myna (0.7 birds/20 min; 0.06 exposure risk), sky larks (0.4 birds/20 min; 0.02 exposure risk), house finches (0.1 birds/20 min; 0.02 exposure risk), and white-tailed tropicbird (<0.1birds/20min; 0.01 exposure risk).

No threatened or endangered non-raptor species were observed during the survey; however, dawn-dusk and nocturnal visual and radar surveys conducted by ABR Inc. did detect the presence of the endangered Hawaiian petrel within the WRA (ABR 2007). Due to the lack of Hawaiian petrel observations during this survey, their exposure risks could not be estimated; however this does not indicate that there is no exposure risk to the Hawaiian petrel.

Although much of the WRA is already disturbed, it does provide birds and other wildlife with cover and opportunities for nesting, perching, and foraging. Short-term disturbance associated with construction activities could temporarily displace birds from construction areas and result in the abandonment of nests; long-term noise and disturbance associated with turbine operation may also reduce habitat quality.

Lāna'i Project Area Recommendations

Based on the data available from this survey, it is unlikely that construction of the Lāna'i wind facility will cause detrimental impacts to native bird populations. The following Best Management Practices and recommended studies should provide measures to minimize impacts to birds from the construction and operation of the Lāna'i wind facility. These practices are important not only to reduce the potential for an avian species to be injured or killed by turbines, transmission lines, or other wind farm components but to also protect and enhance habitat for species of concern.

Standard Best Management Practices

- The use of overhead power lines should be minimized. When they are necessary, power poles should be fitted with bird perch guards to minimize bird use. Studies have shown that birds are susceptible to electrocution by power lines (APLIC 2006).
- The use of lights on turbines should be minimized, in accordance with state, federal, and local requirements, when practicable because lights may attract migrating birds to the vicinity of turbines, particularly during certain weather conditions.
- If a raptor nest is discovered during construction it should be mapped, flagged, and designated a 'no disturbance zone' during the construction phase. Active raptor nests may require timing restrictions for construction or operation activities, or alterations to the turbine design plan.
- Habitat loss is typically the leading cause for population declines in a number of species of concern. Bird species are dependent on the native plants for food, cover, and breeding habitat. Degraded vegetative communities or the presence of invasive plant species can reduce the amount of available quality habitat for birds in these areas. In order to decrease the loss of bird habitat therefore:
  - To the greatest extent possible, minimize impacts to native vegetation and riparian areas during design and construction of turbines and associated infrastructure.
  - If native vegetation is disturbed or removed during construction of roads or turbines or during on-going maintenance activities, these areas should be reseeded or planted with native material.
  - Where practical, existing degraded habitat could also be enhanced through the removal and replacement of invasive species with plants native to the site.

Additional studies

- Fall surveys are recommended to determine the level of avian use during fall, because avian use may differ between spring and fall.
- Post-construction monitoring is recommended to quantify mortality impacts to avian species.

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Report prepared by John Crookston and peer reviewed by Laura Nagy and Lynn Sharp.

INTRODUCTION

Castle & Cooke Inc. is proposing to develop a wind energy conversion facility in Lāna'i, Hawaii. The Lāna'i Wind Resource Area (WRA) is located on the northwest corner of Lāna'i island in Maui County, Hawaii (Figure 1). Castle & Cooke Inc. is committed to environmental due diligence at all of its wind energy facilities and therefore contracted Tetra Tech EC (TtEC) to conduct spring avian surveys to quantify local avian use and to identify potential avian impacts associated with the construction and/or operation of the proposed wind facility at the Lāna'i WRA.

Lāna'i is a small volcanic island, approximately 90,000 acres in size. The Lāna'i WRA encompasses approximately 27,204 acres and is located within the Dry Tropical Forest/Tropical Low Shrublands ecoregion in Maui County, Hawaii (National Geographic 2007). Most of the islands endemic habitat has been disturbed by invasive species, widespread cattle grazing, and habitat loss in the form of pineapple plantations (TtEC 2007). The few remaining patches of undisturbed habitat can be found in the northern portion of the island, where the WRA is located. Most of the WRA consists of shrublands growing on windswept hills with steep eroded slopes.

Avian diversity in the Hawaii islands was historically high; however, a combination of habitat destruction and invasion by non-native predators has caused the decline of many endemic avian species (TtEC 2007). There are currently 37 threatened or endangered avian species in Hawaii (Bishop Museum Hawaiian Bird Checklist 2007).

METHODS

Diurnal Fixed-point and Incidental Avian Use Surveys

Avian point count surveys were conducted to evaluate avian use, behavior and species composition at the WRA. Fixed-point surveys, described below, were conducted for 20 minutes at 11 circular plots in the Lāna'i WRA, with incidental observations of other birds made either before or after the official 20 minute point count period or while traveling between survey points. Surveys were conducted during daylight hours under variable weather conditions.

Fixed-point Surveys

Survey dates and locations of survey points were selected to cover a diversity of habitats, and to ensure the best possible viewshed. Surveys were conducted weekly between April 20 and June 28, 2007 (Table 1) at 11 points distributed throughout the WRA (Figure 2). Due to incidental weather and other extenuating circumstances, early setup was delayed at a few of the 11 points, resulting in a total of 85 fixed-point surveys completed during this study.

Data were collected on all birds observed within an 800-meter radius circle centered on the point station. Birds outside the 800-meter radius circle were recorded as incidentals. Surveys at each point lasted for 20 minutes, during which the observer continuously scanned for birds and recorded both visual and auditory observations. Data that were recorded and used in the analysis included species, time, height above ground, distance from observer (horizontal), behavior and flight direction. The order in which stations were surveyed was randomized to account for species variation during the day. Flight heights and distances from the observer were estimated by experienced field ornithologists, who used existing features and topographic maps for reference.

Incidental Observations

Incidental observations were those recorded outside of the official 20-minute survey period. Incidental observations included observations that occurred 1) during travel between points, 2) before or after the official 20-minute survey period, and 3) outside the 800-meter radius circle. These observations were recorded on separate data sheets to provide additional information on avian use of the WRA.

Data Quality Assurance/Quality Control

QA/QC measures were implemented during all stages of data collection, analysis, and report preparation. To ensure legibility and completeness of data sheets, each observer reviewed, and clarified if needed, all data sheets before data entry into a Filemaker™ relational database for data storage and analysis. Prior to analysis, an independent reviewer conducted a 100% quality review of the data entries. Any questions that arose at this time were directed toward and answered by field personnel.

Analysis

Avian Use of the WRA

Avian use of the WRA was derived by calculating the average number of birds observed per 20-minute point count survey. To evaluate the diversity and composition of avian species using the WRA, the number of individuals of each species was summarized. In addition, the number of observations is also presented, where an observation can be either an individual bird or a discrete flock of birds. This information helps evaluate if a high use number is driven by a single event (e.g., flock of birds moving through the rotor swept area).

Flight Behavior

Flight behavior was evaluated by calculating the proportion of flying birds that were observed below, within, or above the turbine rotor swept area (RSA). Turbine type had yet to be established at the time of this survey. As a consequence, a RSA between 35 and 125 meters above the ground was used, representing the largest turbines being considered by Castle & Cooke at the time of the analysis. Birds that were observed flying, but for which there were no flight height data (< 1% of our observations), were excluded from this analysis. A bird was considered to have flown within the RSA if any of its recorded heights overlapped the RSA. That is, if a bird flew at heights that correspond to the RSA at any time during the survey, it was considered to have occurred within the RSA.

Risk Index

To estimate the exposure risk of collision for each species, the following equation was applied:

$$R = A * P_f * P_t$$

where R is the exposure risk, A is the mean number of birds/20 min, P_f is the proportion of all activity observations of species i that were observed flying, and P_t is the proportion of species i that were observed flying within the turbine RSA. R can be interpreted as the average number of birds flying through the RSA during a 20 minute period.

RESULTS

Lāna'i WRA

A total of 5464 acres of the Lāna'i WRA were surveyed during spring point count surveys, covering approximately 20% of the total area of the WRA.

Species Composition

A total of 299 birds, of 15 identified species, were recorded during 85 fixed-point count surveys (Table 2). Because individual birds were not marked, the terms 'abundant' or 'abundance' represent use estimates, and do not indicate absolute density or number of individuals. The most abundant birds were common mynas (20.4% of total birds detected), northern mockingbirds (14.7% of birds detected), sky larks (12.4% of birds detected), and Japanese white-eyes (11.0% of birds detected). Each remaining species comprised 7.4% or less of the total number of birds detected (Table 2).

Avian Use

Overall mean bird use within the Lana' WRA was 3.5 birds/20 min, ranging from 1 to 14 birds per 20-minute point count. Among taxonomic groups, mean use was highest for passerines (3.0 birds/20 min; Table 3) and included common mynas (0.7 birds/20 min), northern mockingbirds (0.5 birds/20 min), sky larks (0.4 birds/20 min), Japanese white-eyes (0.4 birds/20 min), and northern cardinals (0.3 birds/20 min). Mean use for each additional passerine species was ≤ 0.2 birds/20 min.

Game birds had the second highest mean use (0.3 birds/20 min) and included gray francolins (0.2 birds/20 min), wild turkeys (< 0.1 birds/20 min), and ring-necked pheasants (< 0.1 birds/20 min). The only raptor species that was observed during the 20 minute surveys was the short-eared owl, which had a mean use of 0.1 birds/20 min. The remaining taxonomic groups each had an overall mean use of ≤ 0.1 birds/20 min.

Frequency of Occurrence

Passerines were the most commonly detected group. The most common passerines observed were northern mockingbirds (observed in 30.6% of surveys), common mynas (29.4% of surveys), sky larks (23.5 of surveys), northern cardinals (22.4% of surveys), and Japanese bush-warblers (17.6% of surveys). All other species from the varying taxonomic groups were detected in ≤ 12.9% of surveys.

Flight Height and Exposure Risk

During spring avian use surveys, behavioral data were collected for 99.3% of all birds observed during point count surveys. Of these birds, 67.2% were observed flying (data on flight height and direction were available for 99.5% of birds in flight). For raptors with flight height data, 90.9% flew below the RSA and 9.1% flew within the RSA. For non-raptors with flight height data, 94.7% flew below and 5.3% flew within the RSA (Table 4).

Exposure risk was determined by multiplying mean use, by the proportion of birds observed flying, and the proportion of birds that occurred within the anticipated RSA. Common mynas had the greatest exposure risk (0.06 birds flying within the RSA/20 min), followed by sky larks (0.02), house finches (0.02), white-tailed tropicbirds (0.01), and short-eared owls (0.01). All remaining species had exposure risk of < 0.01 (Table 5). Although the exposure index provides a relative ranking as to what species may be most at risk, an index value of zero indicates low, rather than no risk associated with the construction and operation of wind turbines at the Lāna'i WRA.

Flight Direction

No trend in flight direction was seen. These flight patterns primarily represent Lāna'i residents; therefore, this survey captured local movements in the form of short flights within the WRA.

Species Distribution

Most bird observations occurred at survey points one, four, nine, ten, and eleven (Table 7). The majority of common mynas (20 out of 51 birds) were seen at point 9. Northern cardinals were seen throughout the WRA.

Incidental Surveys

Three species were documented as incidentals during the spring surveys that were not seen during the point count surveys (Table 8). These additional species include chukars, house sparrows, and a single barn owl.

DISCUSSION AND RECOMMENDATIONS:

Raptor Use and Exposure Risk

Raptor use at the Lāna'i WRA is low (0.1 birds/20 min; 0.15 birds/30 min when scaled to a 30 minute survey), ranking the lowest out of 14 WRAs when compared to rates observed at existing wind facilities within the continental U.S. (Table 9). Because studies of avian use do not share identical methodologies (e.g., length of survey period or location) comparisons should only be used to provide useful generalities.

A single species of raptor, the short-eared owl, was detected during the 20 minute surveys. The short-eared owl had a mean use of 0.1 birds/20 min and flew through the RSA 9.1% of the time, resulting in an exposure risk of 0.01 birds flying within the

RSA/20 min. The short-eared owl has been listed as a bird of conservation concern by the U.S. Fish and Wildlife Services (USFW 2007) and is a state listed endangered species on the island of O'ahu (Hawaii 2007). Its current population size on the island of Lana'i is unknown. Populations of this ground-nesting species have been declining throughout the U.S. due to a loss of suitable nesting habitat (Melvin et al. 1989). Short-eared owls primarily flew below the RSA during the 20-minute survey (90.9% of the time); however, males are known to perform higher altitude aerial displays during the mating season. These displays occur at an altitude range of 30 to 150 meters (Carson 1962), which is within the RSA. Their mating season extends from mid-February to June with its peak in April (Holt 1992).

Non-raptor Use and Exposure Risk

Overall non-raptor avian use at Lāna'i WRA is low. Use by non-raptors collectively at the Lāna'i WRA (3.4 birds/20 min; 5.1 birds/30 min when scaled to a 30 min survey) was the lowest when compared to other previously recorded rates from existing wind facilities throughout the continental U.S. (Table 9). Exposure risks were low at the WRA due to low mean use and the majority of individuals flying below the RSA. The most abundant species of non-raptor within the WRA was the common myna, which had a mean use of 0.7 birds/20 min and an exposure risk of 0.06. The common myna is not a native Hawaiian species, and was first introduced to the islands as a bio-control method for cutworms (Caum 1933). It has since become one of the most common species within the pacific islands. Due to its low exposure risk and large population size, potential impacts are unlikely to negatively impact the common myna's population.

Other non-raptor species detected during the survey include sky larks (0.4 birds/20 min; 0.02 exposure risk), and house finches (0.1 birds/20 min; 0.02 exposure risk), neither of which are endemic to Hawaii (Grinnell 1911; Scott et al. 1986) and both of which have low exposure risks. Only two native Hawaiian non-raptor species were detected during this survey: the white-tailed tropicbird (< 0.1 birds/20 min), and the great frigatebird (< 0.1 birds/20 min), both of which had an exposure risk of < 0.01, indicating that they are not likely to be at risk for colliding with turbines. All additional non-raptor species had an exposure risk of < 0.01.

No threatened or endangered non-raptor species were observed during this survey; however, a nocturnal visual and radar survey conducted by ABR Inc. did detect the presence of the endangered Hawaiian petrel within the WRA (ABR 2007). The reason for the lack of Hawaiian petrel observations within this current survey may be due to this species' propensity to travel at dawn, dusk, and night, while this point count survey was conducted during daylight hours. Due to the lack of Hawaiian petrel observations, their exposure risks could not be estimated at this time; however this does not indicate that there is no exposure risk to the Hawaiian petrel. In fact, although the 2007 sonar survey was unable to determine a fixed exposure risk for the Hawaiian petrel, it did indicate that they may be at risk of turbine collisions within the Lāna'i WRA (ABR 2007).

Potential Impacts to Avian Species

The impacts to avian species that could result from the construction and operation of the Lāna'i WRA are direct morality and injury from collisions with turbines or guy wires, permanent or temporary habitat loss, and displacement of birds from habitats near turbines. Although much of the WRA is already disturbed, it does provide birds and other wildlife with cover and opportunities for nesting, perching, and foraging. Short-term disturbance associated with construction activities could temporarily displace birds from areas; long-term noise and disturbance associated with turbine operation may also reduce habitat quality in the WRA. Much of the WRA is highly disturbed and mitigation of impacts through native habitat restoration and enhancement may offset impacts.

Songbird displacement associated with wind power development has been documented at other wind plants. This displacement has been attributed to the direct loss of habitat or reduced habitat quality within 50 meters of a turbine pad (WEST and NWC 2004). For example, at the Buffalo Ridge WRA, densities of male songbirds were significantly lower in Conservation Reserve Program (CRP) grasslands containing turbines than in CRP grasslands without turbines, which has been attributed to avoidance of turbine noise and maintenance activities, and reduced habitat quality due to the presence of access roads and large gravel pads surrounding the turbines (Leddy et al. 1999). Likewise, at the Buffalo Ridge site in Wyoming, the abundance of shorebirds, waterbirds, upland game birds, woodpeckers, and several groups of passerines was found to be lower in areas with turbines than without (Johnson et al. 2000a). However, data from Johnson et al. (2000a) suggest that the extent of reduced use is primarily limited to those areas within 100 meters of turbines.

Lāna'i Project Area Recommendations

Based on the data available from this survey, it is unlikely that construction of the Lāna'i wind facility will cause detrimental impacts to native bird populations within the WRA. The following Best Management Practices and recommended studies will provide measures to minimize impacts to birds from the construction and operation of the Lāna'i wind facility.

Best Management Practices

Several best management practices can be implemented at wind farm facilities in order to avoid and minimize potential impacts to avian species and habitat (Kerlinger 2004). These practices are important not only to reduce the potential for an avian species to be injured or killed but to also protect and enhance habitat for species of concern.

Standard Best Management Practices

- The use of overhead power lines should be minimized. When they are necessary, power poles should be fitted with bird perch guards to minimize bird use. Studies have shown that birds are susceptible to electrocution by power lines (APLIC 2006).
- The use of lights on turbines should be minimized, in accordance with state, federal, and local requirements, when practicable because lights may attract

migrating birds to the vicinity of turbines, particularly during certain weather conditions.

- If a raptor nest is discovered during construction it should be mapped, flagged, and designated a 'no disturbance zone' during the construction phase. Active raptor nests may require timing restrictions for construction or operation activities, or alterations to the turbine design plan.
- Habitat loss is typically the leading cause for population declines in a number of species of concern. Bird species are dependent on the native plants for food, cover, and breeding habitat. Degraded vegetative communities or the presence of invasive plant species can reduce the amount of available quality habitat for birds in these areas. In order to decrease the loss of bird habitat therefore:
  - To the greatest extent possible, minimize impacts to native vegetation and riparian areas during design and construction of turbines and associated infrastructure.
  - If native vegetation is disturbed or removed during construction of roads or turbines or during on-going maintenance activities, these areas should be reseeded or planted with native material.
  - Where practical, existing degraded habitat could also be enhanced through the removal and replacement of invasive species with plants native to the site.

Additional studies

- Pre-construction fall surveys are recommended to determine the level of avian use during fall, because avian use differs between spring and fall.
- Post-construction monitoring is recommended to quantify mortality impacts to avian species.

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TABLES

Table 1. **Lanai 2007 spring point count survey dates.**

Date
April 20
April 27
May 3
May 4
May 8
May 17
May 23
May 24
May 30
May 31
June 21
June 22
June 28

Table 2. Avian species observed during spring point count surveys at the Lanai Wind Resource Area. 2007

Species	Number of Birds	Number of Observations	Mean Use # birds/ 20 min.	Frequency % of surveys detected	Percent Composition
common myna	61	44	0.7	29.4	20.4%
northern mockingbird	44	42	0.5	30.6	14.7%
sky lark	37	33	0.4	23.5	12.4%
Japanese white-eye	33	25	0.4	17.6	11.0%
northern cardinal	22	21	0.3	22.4	7.4%
unidentified passerine	17	11	0.2	12.9	5.7%
Japanese bush-warbler	17	17	0.2	9.4	5.7%
gray francolin	15	14	0.2	10.6	5.0%
house finch	12	9	0.1	9.4	4.0%
short-eared owl	11	11	0.1	10.6	3.7%
zebra dove	8	7	0.1	7.1	2.7%
Indian silverbill	8	4	0.1	4.7	2.7%
wild turkey	4	1	0.0	1.2	1.3%
ring-necked pheasant	4	4	0.0	4.7	1.3%
white-tailed tropicbird	2	2	0.0	2.4	0.7%
unknown bird	2	2	0.0	2.4	0.7%
unidentified sparrow	1	1	0.0	1.2	0.3%
great frigatebird	1	1	0.0	1.2	0.3%
Grand Total	**299**	**249**	**3.5**		

Table 3. Avian species, by taxonomic group, observed during spring point count surveys at the Lanai Wind Resource Area, 2007.

Taxonomic Group Species	Number of Birds	Number of Observations	Mean Use # birds/ 20 min	Frequency % of surveys detected	Percent Composition
Passerine					
common myna	61	44	0.7	29.4	20.4%
northern mockingbird	44	42	0.5	30.6	14.7%
sky lark	37	33	0.4	23.5	12.4%
Japanese white-eye	33	25	0.4	17.6	11.0%
northern cardinal	22	21	0.3	22.4	7.4%
unidentified passerine	17	11	0.2	12.9	5.7%
Japanese bush-warbler	17	17	0.2	9.4	5.7%
house finch	12	9	0.1	9.4	4.0%
Indian silverbill	8	4	0.1	4.7	2.7%
unknown bird	2	2	0.0	2.4	0.7%
unidentified sparrow	1	1	0.0	1.2	0.3%
Group Total	**254**	**209**	**3.0**		**84.9%**
Raptor					
short-eared owl	11	11	0.1	10.6	3.7%
Group Total	**11**	**11**	**0.1**		**3.7%**
Gamebird					
gray francolin	15	14	0.2	10.6	5.0%
wild turkey	4	1	0.0	1.2	1.3%
ring-necked pheasant	4	4	0.0	4.7	1.3%
Group Total	**23**	**19**	**0.3**		**7.7%**
Pigeons/Doves					
zebra dove	8	7	0.1	7.1	2.7%
Group Total	**8**	**7**	**0.1**		**2.7%**
Waterbird					
white-tailed tropicbird	2	2	0.0	2.4	0.7%
great frigatebird	1	1	0.0	1.2	0.3%
Group Total	**3**	**3**	**0.0**		**1.0%**
Grand Total	**299**	**249**			

Table 4. Summary of avian flight heights (includes flying birds only) in relation to the turbine rotor swept area (RSA) during spring point count surveys at the Lanai Wind Resource Area, 2007.

	Observations		Individuals	
	Number	**Percentage**	**Number**	**Percentage**
Non-raptors				
Below RSA (<35m)	136	94.4%	179	94.7%
Within RSA (between 35m and 125m)	8	5.6%	10	5.3%
Raptors				
Below RSA (<35m)	10	90.9%	10	90.9%
Within RSA (between 35m and 125m)	1	9.1%	1	9.1%

Table 5. Avian flight height characteristics in relation to the turbine rotor swept area (RSA) for species at risk of collision at the Lanai Wind Resource Area, during spring 2007. Exposure risk=proportion of birds flying × proportion flying within the RSA × mean use.

Species	Exposure Risk*	Mean Use # birds/20 min	Percent Flying	Percent Below RSA	Percent Within RSA	Percent Above RSA
common myna	0.06	0.7	100.0	91.8	8.2	0.0
sky lark	0.02	0.4	64.9	91.7	8.3	0.0
house finch	0.02	0.1	91.7	81.8	18.2	0.0
white-tailed tropicbird	0.01	0.0	100.0	50.0	50.0	0.0
short-eared owl	0.01	0.1	100.0	90.9	9.1	0.0
zebra dove	0.00	0.1	100.0	100.0	0.0	0.0
wild turkey	0.00	0.0	0.0	0.0	0.0	0.0
unidentified sparrow	0.00	0.0	0.0	0.0	0.0	0.0
unidentified passerine	0.00	0.2	94.1	100.0	0.0	0.0
unknown bird	0.00	0.0	100.0	100.0	0.0	0.0
ring-necked pheasant	0.00	0.0	25.0	100.0	0.0	0.0
northern mockingbird	0.00	0.5	61.4	100.0	0.0	0.0
northern cardinal	0.00	0.3	18.2	100.0	0.0	0.0
Japanese white-eye	0.00	0.4	72.7	100.0	0.0	0.0
Japanese bush-warbler	0.00	0.2	0.0	0.0	0.0	0.0
indian silverbill	0.00	0.1	87.5	100.0	0.0	0.0
gray francolin	0.00	0.2	20.0	100.0	0.0	0.0
great frigatebird	0.00	0.0	0.0	0.0	0.0	0.0

Table 6. Flight directions of birds observed during spring point count surveys at the Lanai Wind Resource Area, 2007.

Species	Number Flying	Number of Observations	Percentage of Flights in Various Flight Directions								
			N	NE	E	SE	S	SW	W	NW	Variable
common myna	61	44	24.6	14.8	23.0	0.0	21.3	4.9	11.5	0.0	0.0
northern mockingbird	27	25	18.5	11.1	11.1	14.8	25.9	3.7	3.7	11.1	0.0
sky lark	24	21	13.6	18.2	31.8	9.1	13.6	0.0	9.1	4.5	0.0
Japanese white-eye	24	17	29.2	8.3	20.8	0.0	29.2	0.0	12.5	0.0	0.0
unidentified passerine	16	10	6.3	0.0	6.3	0.0	25.0	0.0	62.5	0.0	0.0
short-eared owl	11	11	36.4	9.1	27.3	0.0	9.1	9.1	0.0	0.0	0.0
house finch	11	8	18.2	9.1	18.2	0.0	27.3	0.0	18.2	9.1	0.0
zebra dove	8	7	12.5	25.0	25.0	0.0	0.0	0.0	12.5	25.0	0.0
Indian silverbill	7	3	28.6	0.0	0.0	0.0	0.0	28.6	42.9	0.0	0.0
northern cardinal	4	3	25.0	0.0	25.0	0.0	0.0	0.0	50.0	0.0	0.0
gray francolin	3	2	0.0	0.0	0.0	0.0	0.0	0.0	66.7	33.3	0.0
white-tailed tropicbird	2	2	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0
unknown bird	2	2	0.0	0.0	50.0	0.0	50.0	0.0	0.0	0.0	0.0
ring-necked pheasant	1	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Grand Total	**201**	**156**	**20.9**	**10.9**	**19.4**	**4.0**	**19.4**	**3.5**	**16.4**	**4.0**	**0.0**

Table 7. Avian species observed by point during spring 2007 point count surveys at Lanai Wind Resource Area.

Species	Number of Indiv.	Number of Obs.	Points										
			1	2	3	4	5	6	7	8	9	10	11
common myna	61	44	7	0	2	0	1	0	7	5	20	6	13
northern mockingbird	44	42	2	4	1	1	1	3	2	13	2	14	1
sky lark	37	33	0	11	4	6	0	0	2	6	3	3	2
Japanese white-eye	33	25	0	0	1	1	0	0	2	0	8	3	18
northern cardinal	22	21	5	2	1	1	0	2	3	0	3	3	2
unidentified passerine	17	11	1	0	1	3	0	0	1	0	2	2	7
Japanese bush-warbler	17	17	0	0	0	6	0	0	4	0	0	0	7
gray francolin	15	14	7	0	0	1	2	1	1	0	2	1	0
house finch	12	9	0	0	2	8	0	0	1	0	0	0	1
short-eared owl	11	11	0	0	0	0	1	2	3	0	2	0	3
zebra dove	8	7	3	0	0	0	1	0	0	2	1	1	0
Indian silverbill	8	4	7	1	0	0	0	0	0	0	0	0	0
wild turkey	4	1	0	0	0	4	0	0	0	0	0	0	0
ring-necked pheasant	4	4	0	0	0	1	0	0	1	0	1	0	1
white-tailed tropicbird	2	2	1	0	0	0	0	1	0	0	0	0	0
unknown bird	2	2	1	1	0	0	0	0	0	0	0	0	0
unidentified sparrow	1	1	0	0	0	1	0	0	0	0	0	0	0
great frigatebird	1	1	0	0	0	1	0	0	0	0	0	0	0
Grand Total	**299**	**249**	**34**	**19**	**12**	**34**	**6**	**9**	**27**	**26**	**44**	**33**	**55**

Table 8. Incidental observations of birds during spring point counts at the Lanai Wind Resource Area, 2007.

Species	Number of individuals
barn owl	1
chukar	7
common myna	10
gray francolin	35
house sparrow	5
Indian silverbill	6
Japanese white-eye	2
northern cardinal	2
northern mockingbird	4
ring-necked pheasant	6
short-eared owl	11
sky lark	7
wild turkey	20
white-tailed tropicbird	4
zebra dove	21
Grand Total	141

Table 9. Comparison of mean use at the Lana'i Wind Resource Area to existing WRA (estimates standardized to birds/30-min survey).

Project site	Mean Use (fall surveys unless otherwise indicated) Raptors	Mean Use (fall surveys unless otherwise indicated) Other Birds	Estimate Basis	Reference
Montezuma Hills, CA	6.72 (annual average)	474 (mostly unidentified blackbirds)	1.5* use/20 min	Kerlinger et al. (2005)
Altamont Pass WEC, CA	3.20 (annual average)	N/A	1.5*use/20 min	Orloff and Flannery (1992)
Cotterel Mountain, ID	2.54	14.29	1.5*use/20 min	BLM (2005)
Klickitat County PEIS study area, WA	1.43	23.01	1.5*Use/20 min	Johnson et al. (2006)
Windy Point, WA	1.19	25.75	1.5*Use/20 min	Johnson et al. (2006)
Buffalo Ridge WEC, MN	0.96-1.26 (various areas)	N/A	1.5*use/20 min	Erickson et al. (2002)
Stateline Wind Project, OR-WA	0.88	10.64	1.5*use/20 min	West, Inc. (2004)
Foote Creek WEC, WY	0.73	N/A	0.75*use/40 min	Johnson et al. (2000b)
Klondike, OR	0.70	N/A	1.5*use/20 min	Erickson et al. (2002)
Wild Horse, WA	0.68(fall-summer)	8.63	Use/30 min	Erickson et al. (2003)
Condon, OR	0.52	7.14	1.5*use/20 min	URS Corporation et al. (2001)
Biglow Canyon, OR project site and reference area	0.47 0.54	15.18 10.09	Use/30 min	WEST, Inc. (2005)
Maiden, WA	0.44	6.83	Use/30 min	Young et al. (2002)
Lāna'i, HI	**0.15**	**5.1**	**1.5*use/20 min**	**This Study**

FIGURES

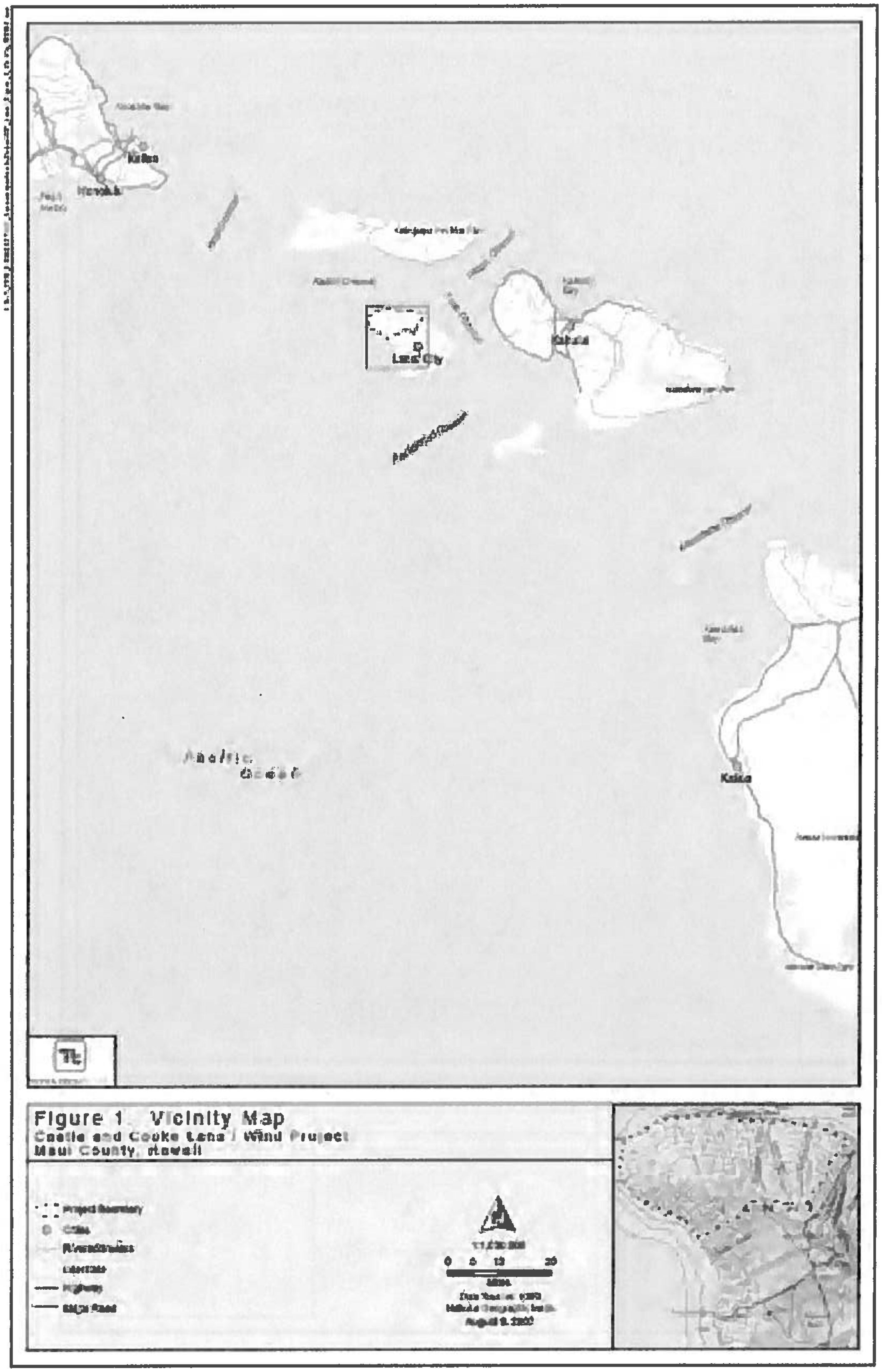

Figure 1. Vicinity Map
Castle and Cooke Lana'i Wind Project
Maui County, Hawaii

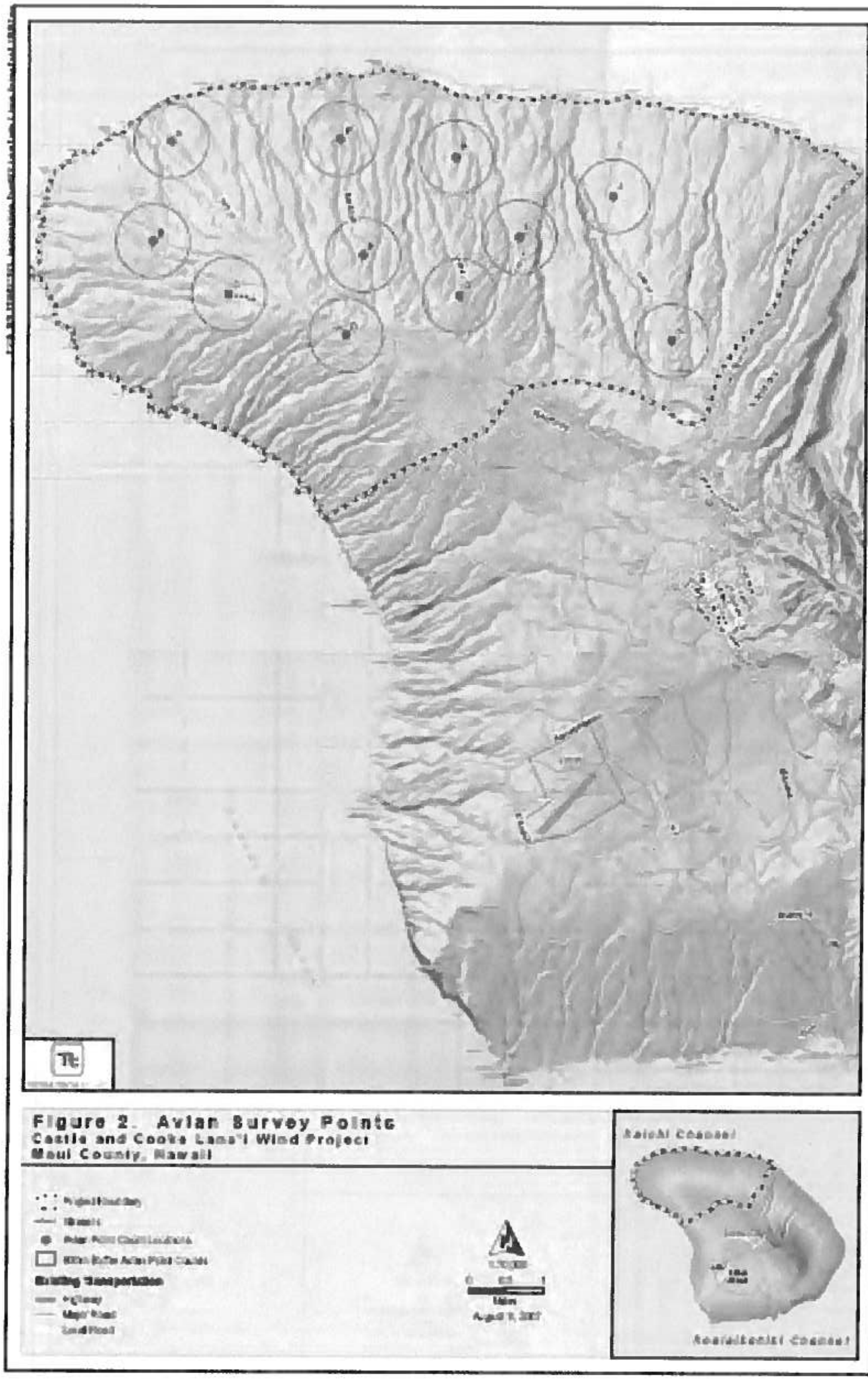

Figure 2. Avian Survey Points
Castle and Cooke Lana'i Wind Project
Maui County, Hawaii

Appendix 5

Met Tower Botanical Survey

Botanical surveys at seven meteorological tower sites on northern Lāna'i, Hawai'i[1]

December 13, 2007 *AECOS* No. 1162

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Summary

The results of two days of surveys at seven meteorological sites (one developed, six proposed) from November 26 through 28, 2007 revealed a mix of introduced and native plant species in essentially grassland to low-growing shrubland communities on the northern part of the Island of Lāna'i. A list of the species present with an estimate of the relative abundance of species at each site was developed. The surveys extended outward to or slightly beyond a radius of 100 meters from a pre-established center-point for each site in order to provide flexibility in the erection of the meteorological towers. No plant species listed as federally threatened or endangered was observed in any of the survey areas.

Introduction

This report presents the results of botanical surveys at seven specific sites located on the northern part of the Island of Lāna'i, Maui County, Hawai`i (Figure 1). The sites are to be used for erection of meteorological (met) towers to provide information on wind conditions across the undeveloped part of the Island for the proposed Lāna'i Wind Energy Project (Project). The purpose of these initial botanical surveys is to assure the planning and engineering teams of the project proponent, Castle & Cooke Resorts, Hawaii, that tower erection can proceed without concern for the presence of federally listed plant species.

[1] Report prepared for TetraTech EC Inc., Honolulu to become part of the public record for the Lanai Wind Energy Facility.
[2] Botany Department, B. P. Bishop Museum.

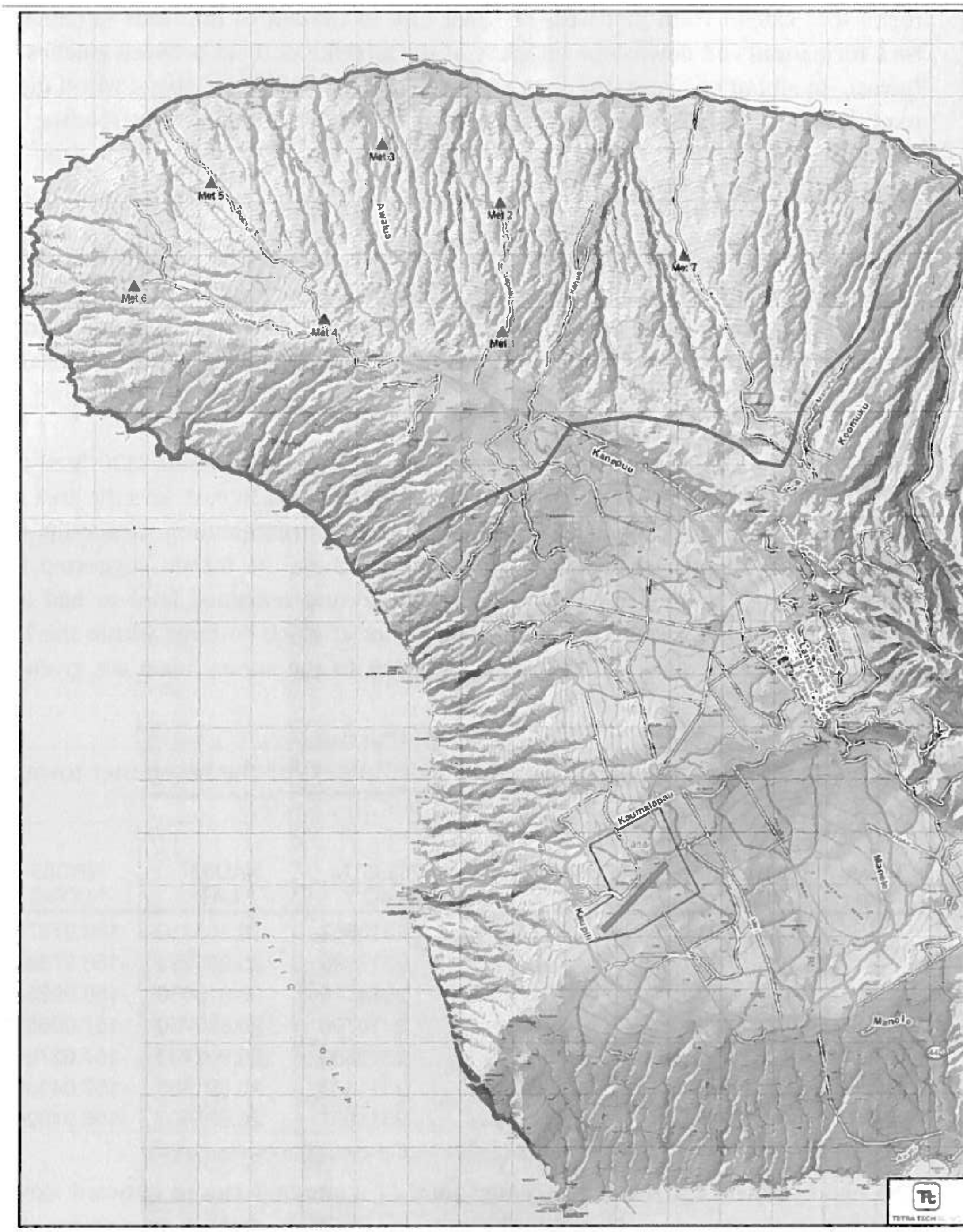

Figure 1. Northern Lāna'i showing locations of the seven met tower sites. Project area boundary shown as blue line; orange lines are roads (most paved).

All of the seven sites surveyed are accessible over the network of 4-wheel drive roads that extend from just west of Lanai City to Garden of the Gods (a badland rock formation) and downslope on many of the interfluves (land between gulches or fluves). In all but one case, the sites are located directly adjacent to a 4-wheel drive road. At Site 3, a shallow gulch separates the center of the site from the roadway.

Survey Methods

The primary purpose of this set of surveys is to establish that no federally listed endangered, threatened, or proposed-for-listing plants are growing at or near seven proposed met tower sites. Federal and State of Hawai'i listed species status follows species identified in the following documents: DLNR (1998); Federal Register (2005), USFWS (2005, 2006)[3].

Survey boundaries were established to be a minimum of 100 meters (330 feet) out from a center point previously selected as the best position in each specific area for the erection of a tower to hold the meteorological instrumentation. Generally, the boundary was slightly exceeded in any direction where the terrain suggested the met tower could be moved (that is, where the ground remained level or had low slope). Surveys were terminated at steep slopes or at gulch bottoms within the 100 meter radius. Met tower center points provided to the survey team are given in Table 1.

Table 1. UTM and longitude/latitude coordinates for the seven met tower sites surveyed November 26-28, 2007.

Tower Site	Elevation (ft)	NAD83 UTM Zone 4Q X	NAD83 UTM Zone 4Q Y	NAD83 ° LAT	NAD83 ° LONG
1	1563	710784	2310552	20.883216	-156.973733
2	682	710737	2312995	20.905283	-156.973883
3	370	708471	2314115	20.915650	-156.995533
4	1459	707369	2310790	20.885750	-157.006516
5	492	705205	2313386	20.909433	-157.027000
6	565	703734	2311433	20.891966	-157.041366
7	928	714255	2311957	20.895502	-156.940208

The two botanists started at the center point of a site and moved outward slowly together to develop a species list of the dominant and common species present. Each botanist then separately covered on foot approximately two-thirds of a met tower survey area in wandering transects, using hand-held GPS units to establish that coverage was complete and roughly within bounds. This approach provided an

[3] State statutes link the threatened and endangered plant species for the State of Hawai'i to the federal list of threatened and endangered species.

efficient use of each botanists' time while insuring some overlap in area actually surveyed by each.

A typical record of the survey track from one of the botanist's GPS unit is shown as Figure 2. Coverage during a wandering transect varied with the terrain and the vegetation type. In areas of low topography with sparse or low-growing grass, this distance might be 20 meters; in areas of greater topography or taller shrub growth, this distance would be reduced to 5 or 10 meters. In badland areas it was possible to inspect the few plants standing out on the barren ground and concentrate on the margins supporting plant growth.

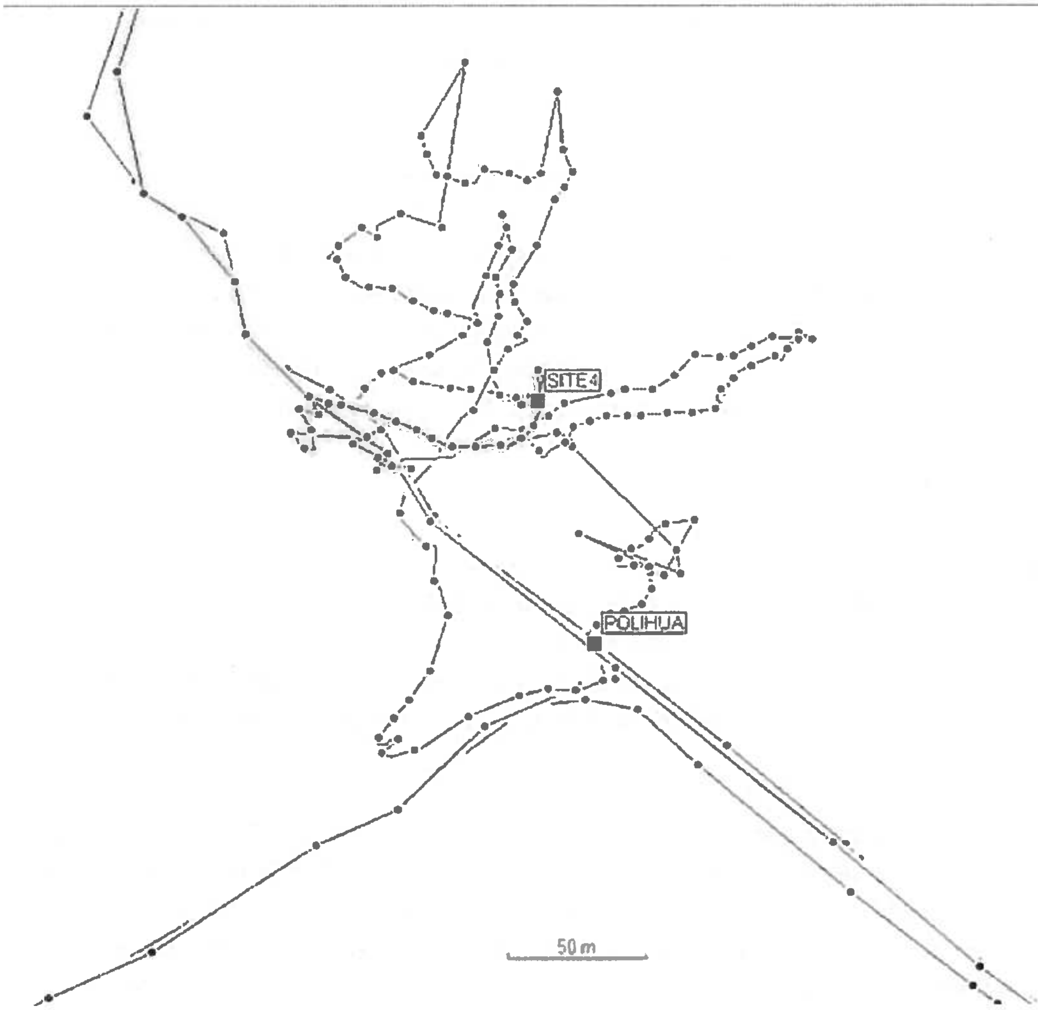

Figure 2. Example of GPS recorded track produced by one of the botanists surveying Site 5 on November 27. Track in yellow represents a November 26 reconnaissance visit. The track of the vehicle along roads was also recorded.

Upon completion of the surveys, the positional information gathered from each site was plotted on a topographic map. This included the central point and a series of waypoints recorded by one GPS unit, and a comparison of the track recorded by the other unit. This approach insured that the resulting smoothed polygon connecting the waypoints incorporated all the area shown by the second GPS unit (which had the capability of recording the actual track as a series of time interval set waypoints). The mapped individual survey areas are presented herein as Figures 3 through 9. Elevation contours on these maps are in meters.

Most plants were easily identified in the field. In a few cases, photographs were taken and specimens collected for closer examination in the laboratory. In one case a mounted voucher specimen of *Mollugo cerviana*, representing a new record for the Island of Lāna'i was created for deposit in the herbarium of the B. P. Bishop Museum.

With respect to conditions at the time of the survey, rainy weather was experienced throughout the morning of November 27, which slowed the work on that date. However, the wet season on Lāna'i was well underway and the vegetation was green and flushed with growth. Some annuals were observed only as seedlings, and thus their abundance could not be estimated in any meaningful way. Seedlings of some shrubs, such as 'ilima (*Sida fallax*) and 'uhaloa (*Waltheria indica*), were very abundant and the abundance estimates for these plants are for adults only.

Results

Lāna'i has a number of areas where rare native plants are found, and these are scattered widely over the island, although most federally listed species occur in the uplands east of Lāna'i City and in the dry forest preserve to the north of town. Because of the large population of Axis deer or chital (*Axis axis*) on the island, several areas supporting native plants are fenced to exclude herbivory on the rare native plants.

Some 37 federally listed plants are known from the island, including 7 that are endemic to (known only from) Lāna'i. The remaining 30 species are also found on other islands in the Hawaiian archipelago (Federal Register, 2002). Critical Habitat has been proposed totaling 4,800 acres (1942 hectares) for some 18 endangered plant species on Lāna'i. However, presently, a total of 789 acres (320 hectares) has been designated. With one exception, units are all located on the southern half of the Island. The exception is Unit 1 (373 acres or 151 hectares) located between elevations of 590 and 950 feet (180 and 290 meters) upslope of Pōhakuloa Point on the north side of Lāna'i (Federal Register, 2003). Unit 1 is designated Critical Habitat for *Tetramolopium remyi*, a short-lived perennial in the Family Asteraceae. This species once occupied the designated Unit 1 area but was considered extirpated at the time of the final ruling, with the possibility that there remained a seed bank of *T. remyi* in the area.

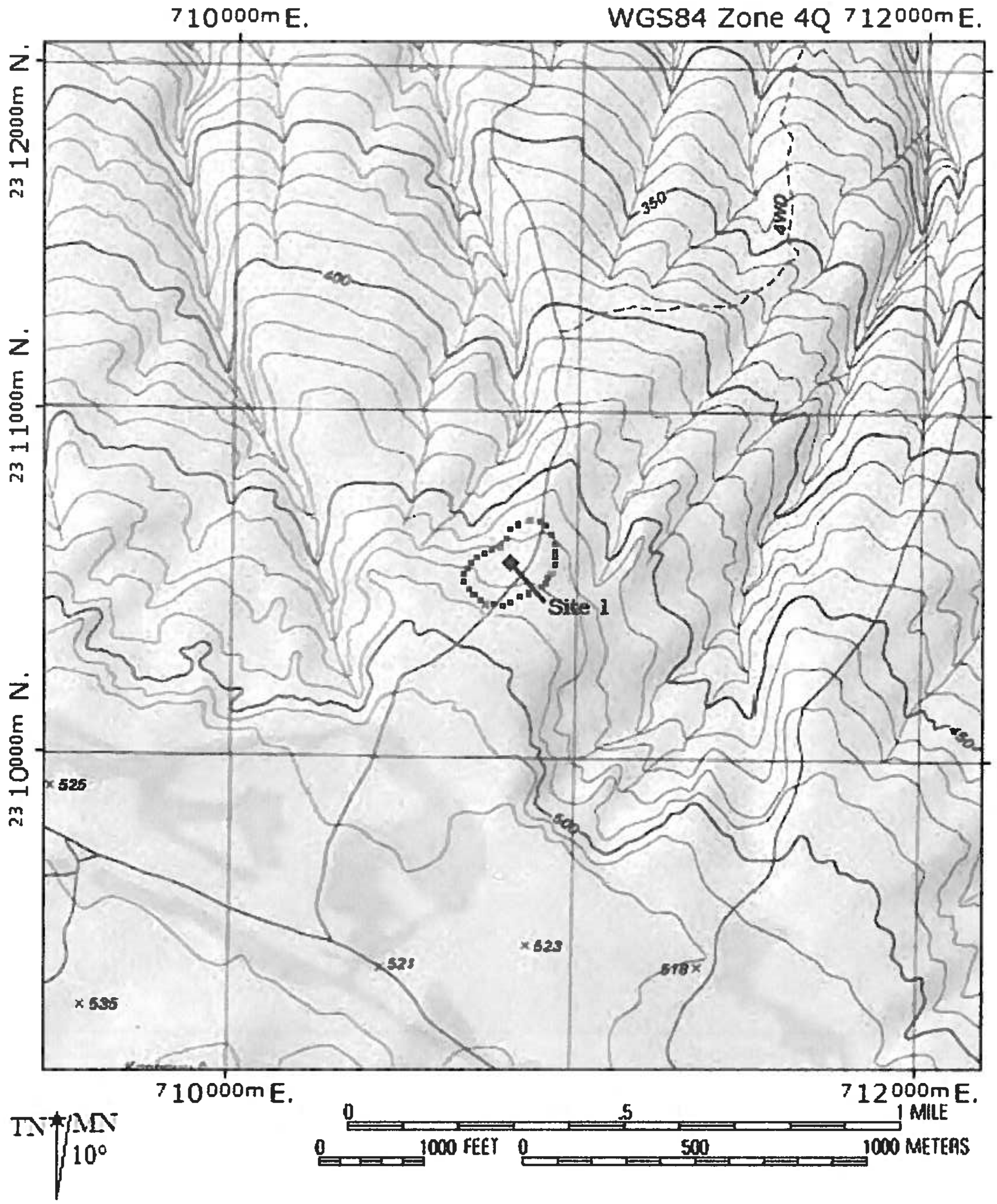

Figure 3. Location and survey area boundary for Site 1, surveyed on November 27, 2007 (GPS recorded waypoints shown in red).

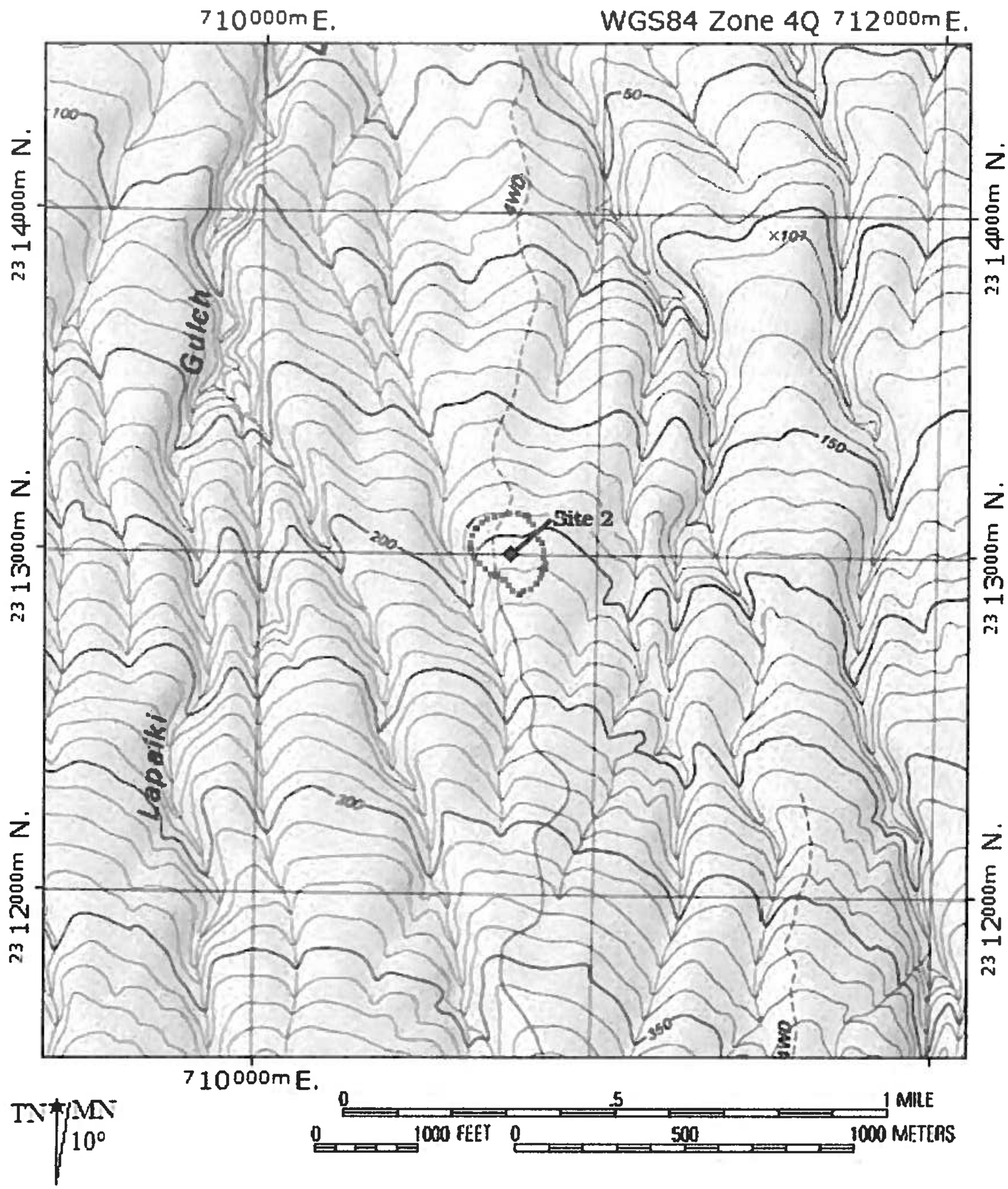

Figure 4. Location and survey area boundary for Site 2, surveyed on November 27, 2007 (GPS recorded waypoints shown in red).

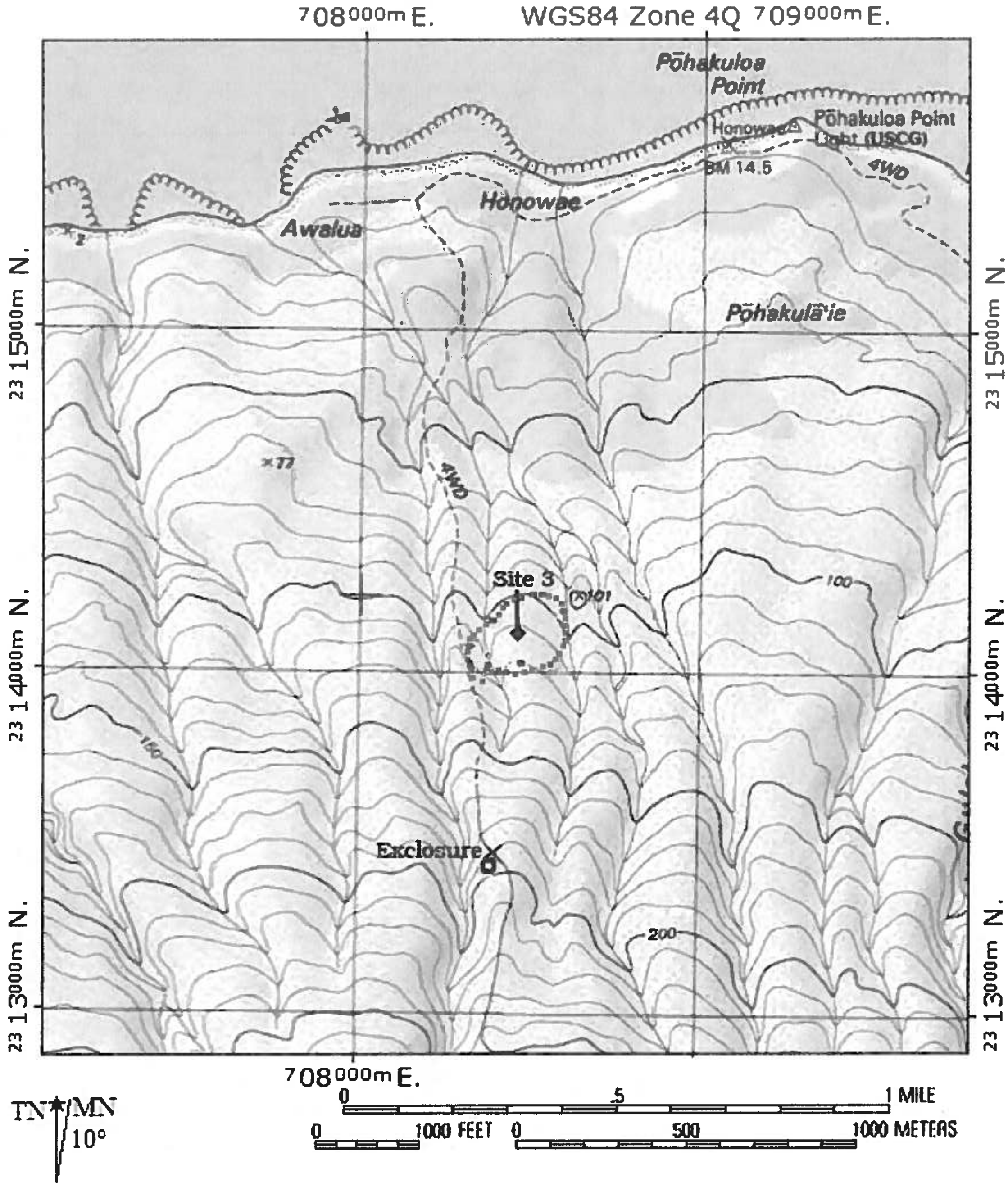

Figure 5. Location and survey area boundary for Site 3, surveyed on November 28, 2007 (GPS recorded waypoints shown in red).

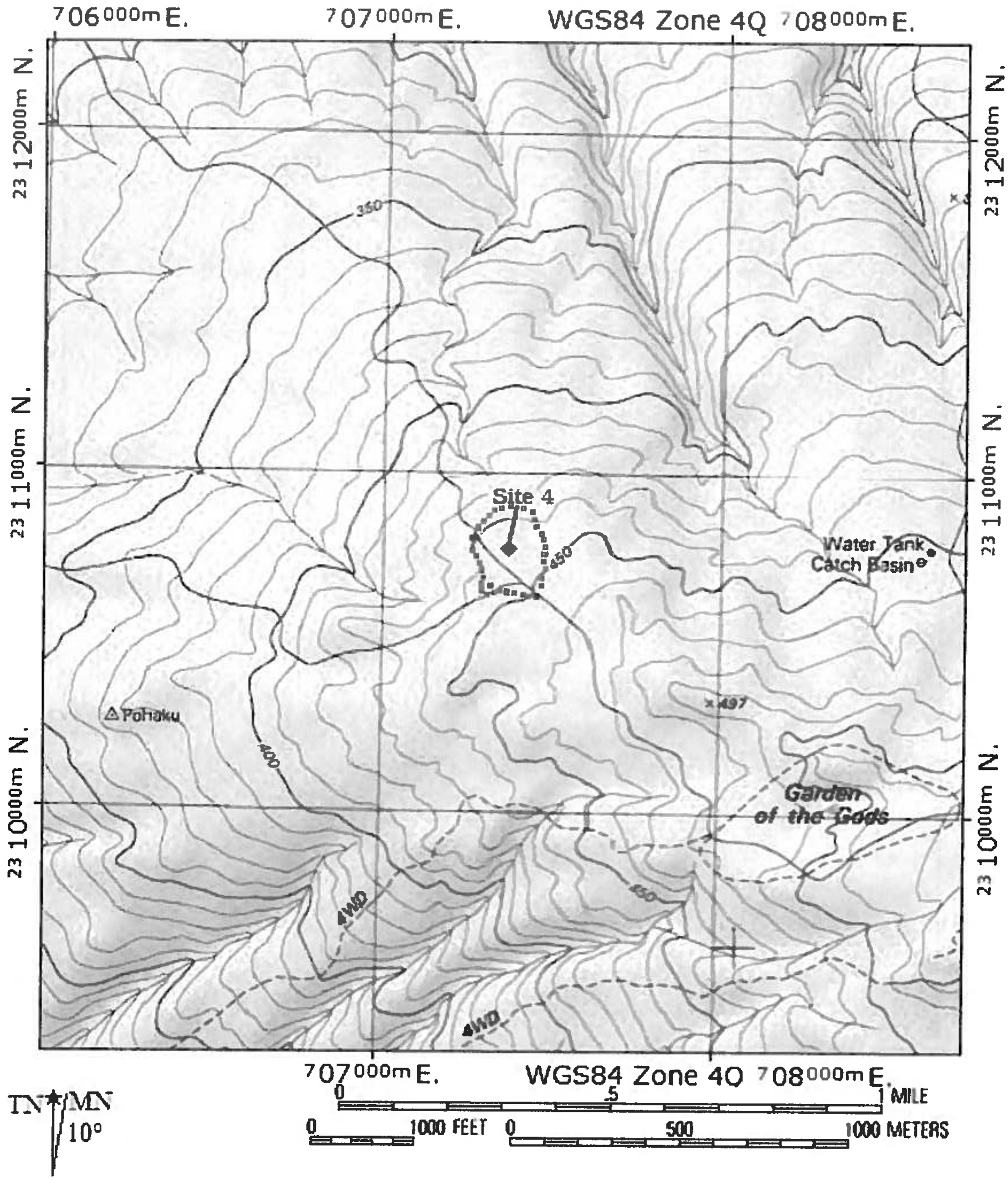

Figure 6. Location and survey area boundary for Site 4, surveyed on November 27, 2007 (GPS recorded waypoints shown in red).

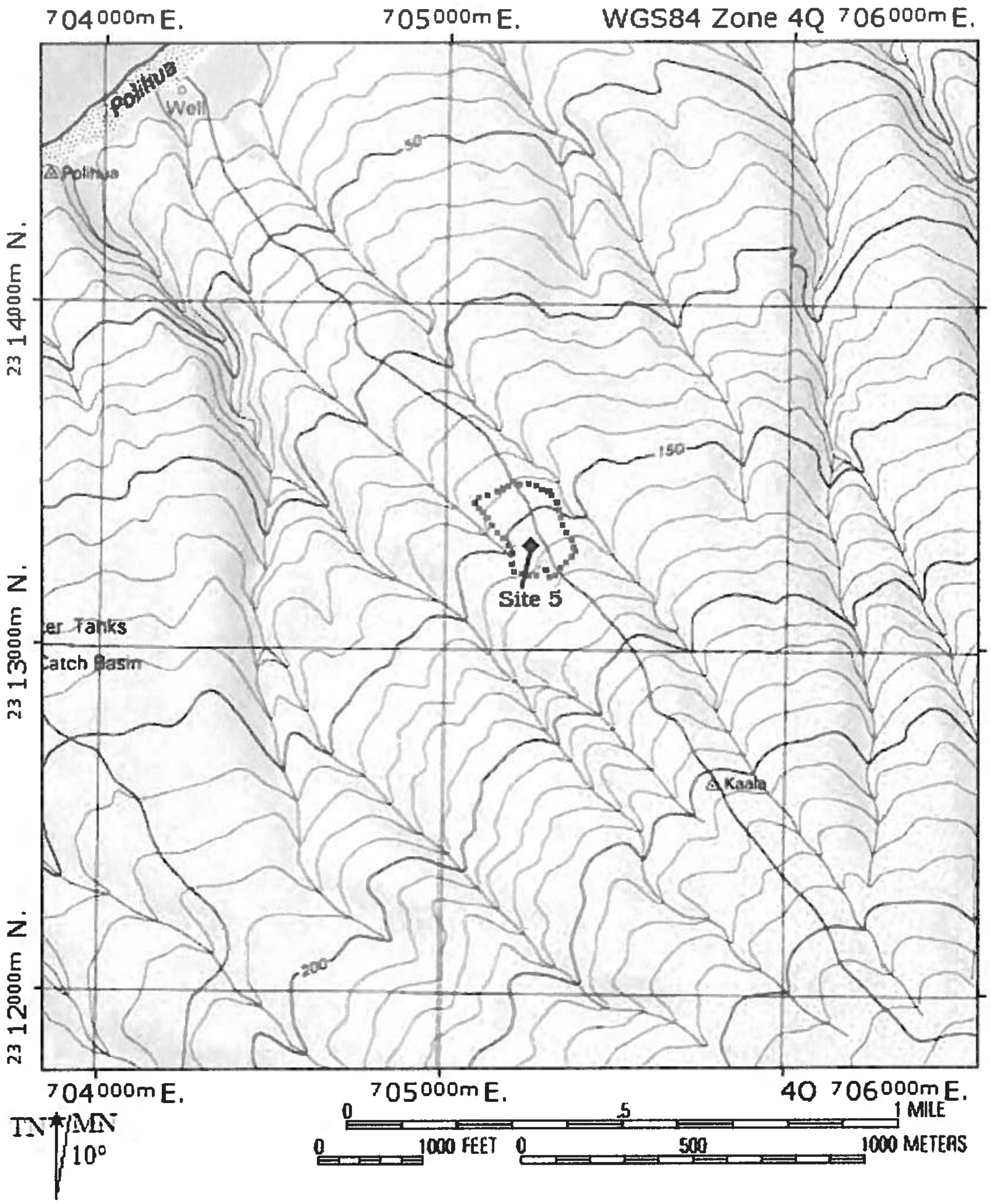

Figure 7. Location and survey area boundary for Site 5, surveyed on November 27, 2007 (GPS recorded waypoints shown in red).

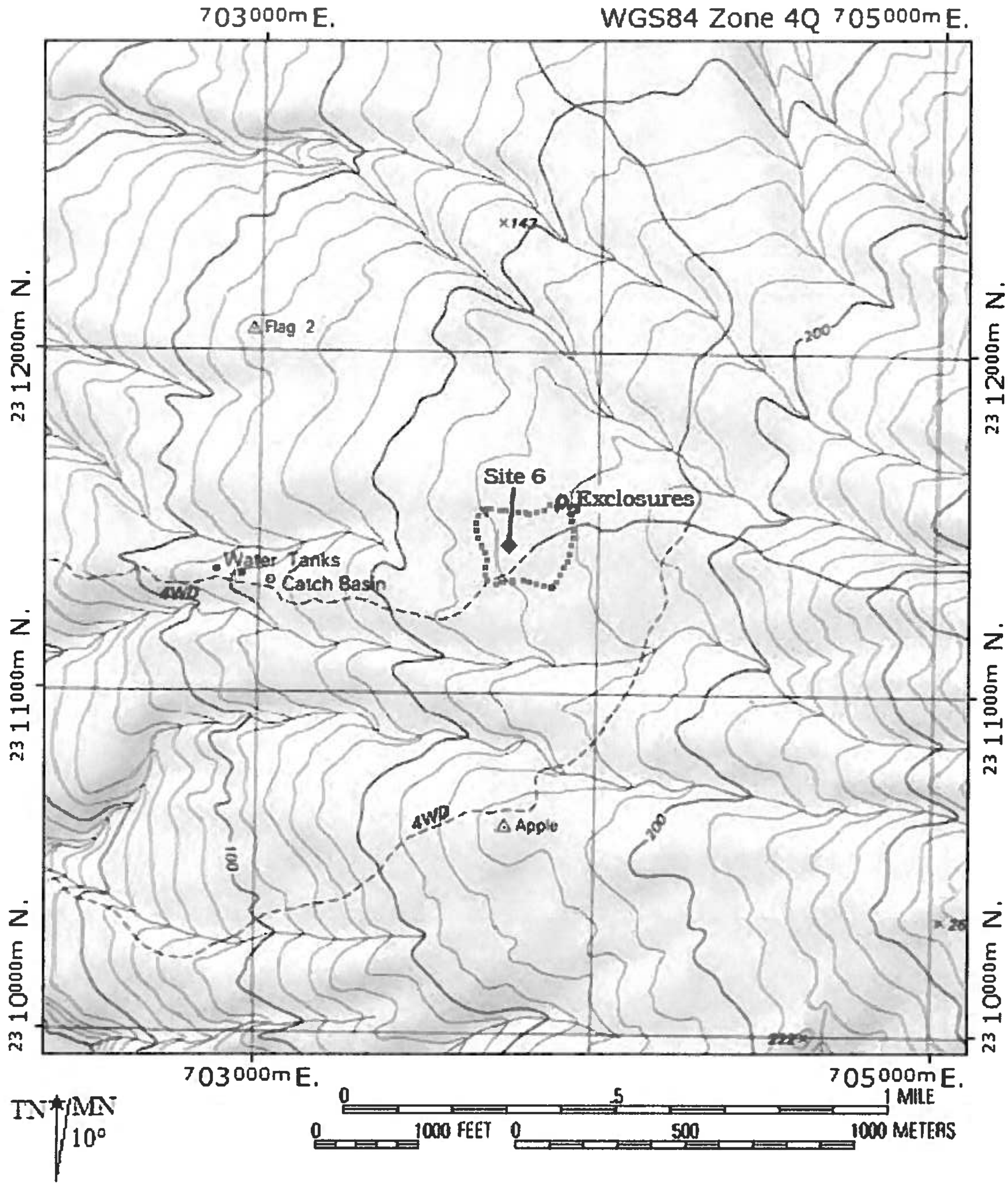

Figure 8. Location and survey area boundary for Site 6, surveyed on November 27, 2007 (GPS recorded waypoints shown in red).

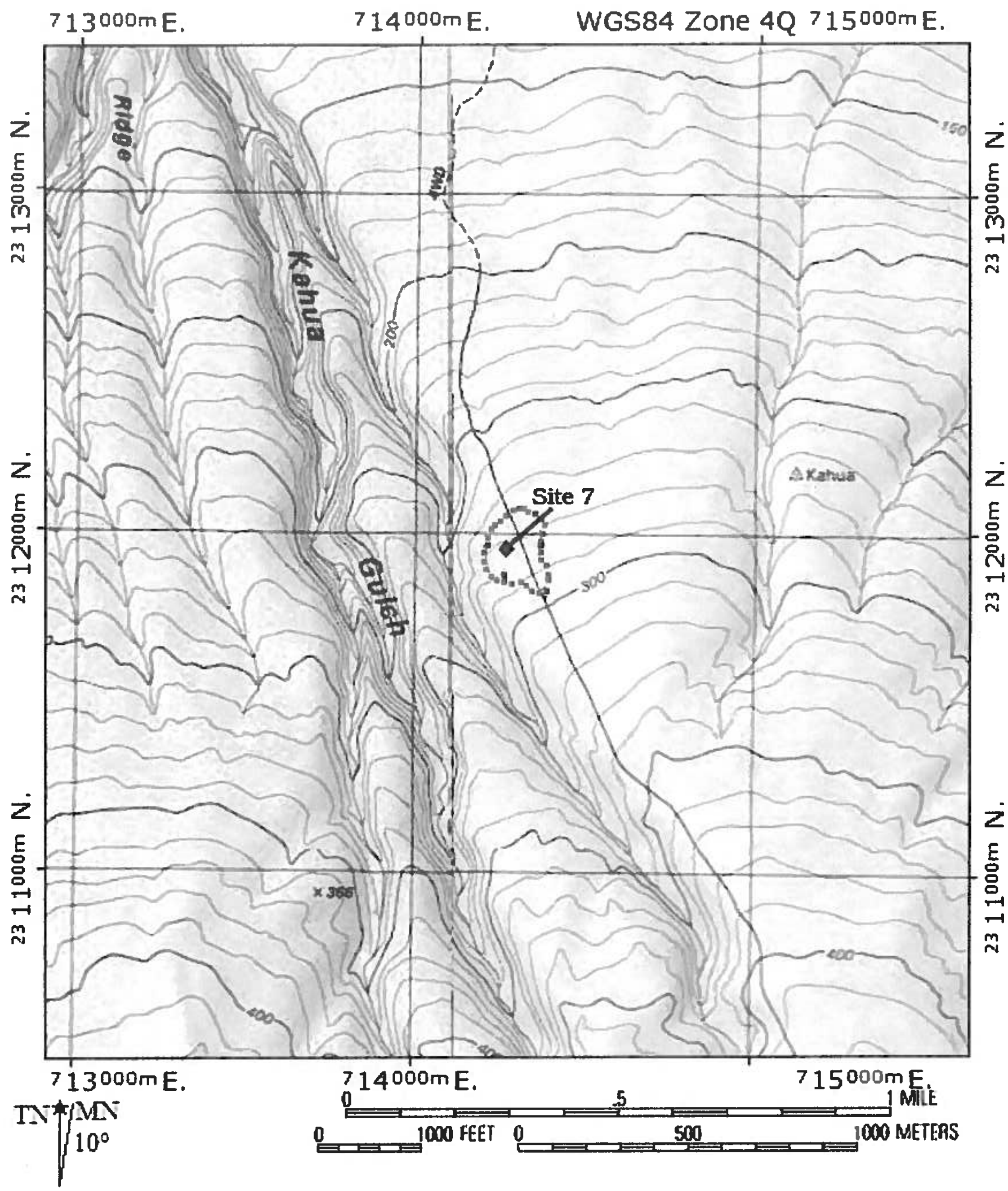

Figure 9. Location and survey area boundary for Site 7, surveyed on November 28, 2007 (GPS recorded waypoints shown in red).

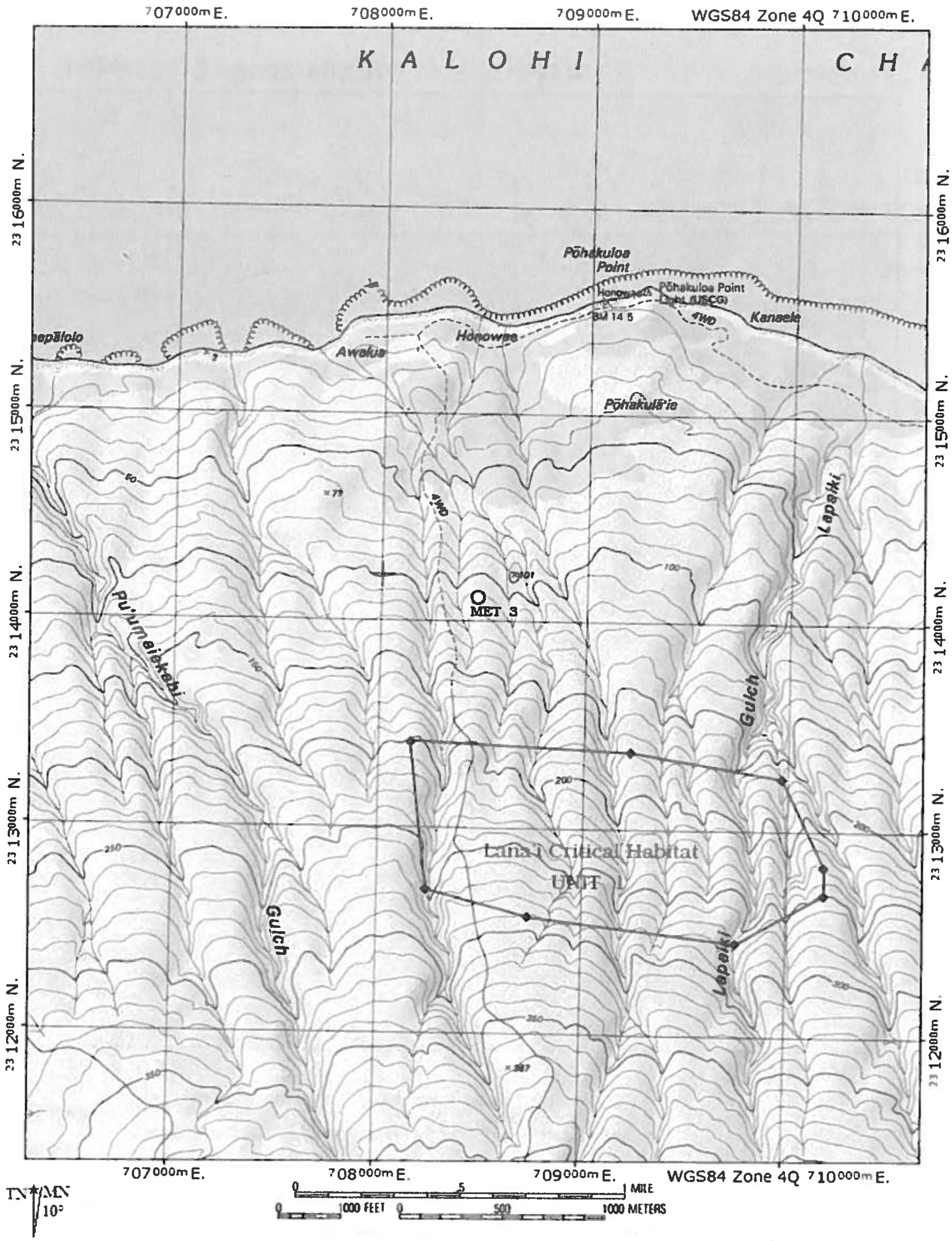

Figure 10. USFWS designated Critical Habitat Unit 1 on Lāna'i shown in relation to met tower Site 3 (MET 3), the nearest met tower site of the seven proposed.

None of the met tower survey areas is located within a designated Critical Habitat. Met tower Site 3, at 370 feet (113 meters) elevation is located approximately 4000 feet (1200 meters) down slope of Unit 1 (Figure 10). Note that the roadway passing through Unit 1 is specifically exempted from the critical habitat (Federal Register, 2003, §17.96).

General Vegetation Descriptions

A future phase of the botanical efforts to be undertaken on Lāna'i for the proposed Project will involve mapping of vegetation types within the Project boundary. However, it is valuable to point out here the general vegetation at each of the met tower sites. This vegetation varies from badlands (that is, areas of severe erosion lacking or with extremely sparse plant growth; Figure 11) to grasslands to scrub lands (areas dominated by low or scrubby bushes; Figure 12).

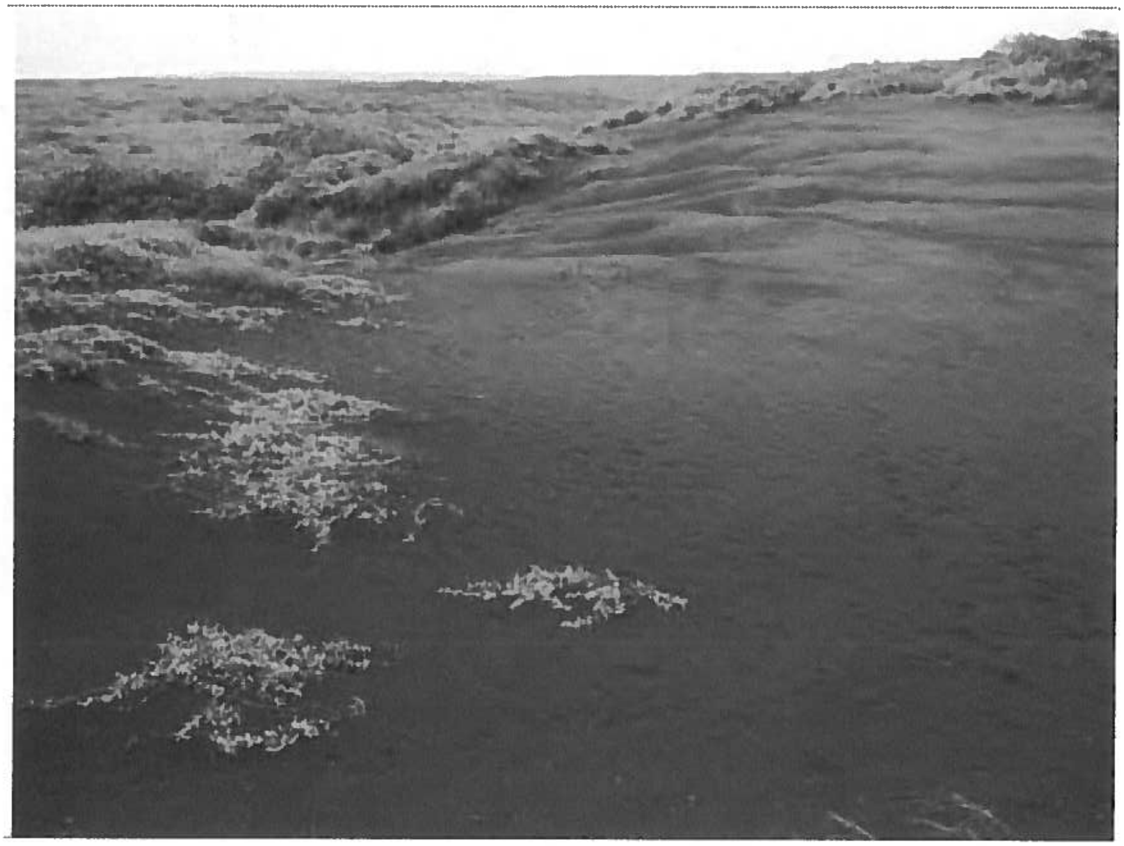

Figure 11. Margin of a badlands area showing invasion by *'ilima.*

Met tower Site 1 (Figure 3) is in a badlands area. Vegetated land beyond the severely eroded ground covering most of the area is grassland where Angleton grass (*Dichanthium aristatum*) predominates. Very scattered shrub growth consists of 'a'ali'i (*Dodonaea viscosa*), lantana (*Lantana camara*), and 'uhaloa.

Met tower Site 2 is located further down the interfluve from Site 1 (Figure 4). In this area, the grassland is dominated by Angleton grass and pili grass (*Heteropogon contortus*), with 'a'ali'i common as a low shrub. Another grass, Natal redtop (*Melinus repens*) is prominent. Other plants regularly encountered are 'ilima (*Sida fallax*), 'uhaloa, lantana, and partridge pea (*Chamaecrista nictitans*). A native shrub, *Lipochaeta heterophylla*, is present in this area, as is an endemic vine, *Ipomoea tuboides.*

Figure 12. Heavily grazed grassland and low-growing shrubs ('aàli'i) at Site 7.

Met tower Site 3 is located well downslope near the coast (at 370 feet or 113 meters) on the road to Awalua (Figure 5). Areas of dense Guinea grass (*Urochloa maxima*) and Christmas berry (*Schinus terebinthefolius*) growth occur along the road further upslope, but the grassland at Site 3 is very open and dominated by a mix of pitted beardgrass (*Bothriochloa pertusa*) and native pili grass. A gulch between the site and the road contains kiawe (*Prosopis pallida*) and indigenous *Abutilon incanum*. A distance of some 0,75 mile (1.2 kilometers) up the road from Site 3 is a small fenced exclosure. This exclosure is located along the northern edge of Critical Habitat Unit 1 (Federal Register, 2003; see Figure 10). The only native plant species seen within the exclosure was a *Bidens* (possibly a hybrid). This plant was, however, more abundant immediately outside the exclosure than inside it. The fence may have been erected to prevent herbivory on germinating of *Tetromolopium remyi* seeds potentially in the soil.

Met tower Site 4 (Figure 6) is located on the central ridge beyond (west of) the Garden of the Gods. A part of the site is badlands. This site is mostly grassland of Angleton grass, but includes significant areas of Guinea grass and shrubland. The shrubland is exclusively low growing ʻaʻaliʻi mixed with Angleton grass in the center of the site, but other areas are a mix of lantana, Guinea grass, and koa haole (*Leucaena leucocephala*). The plants here display greater stature than the grasses and shrubs seen at other sites.

Met tower Site 5 is located off the road to Polihua Beach, at about 490 ft (150 m) in elevation (Figure 7). This area is very open grassland of mostly pili grass and pitted beardgrass. A shallow gulch with kiawe trees lies off to the west. The most common shrubs in this area are klu (*Acacia farnesiana*) and ʻuhaloa.

Met tower Site 6 (Figure 8) already has a met tower erected and is being used to survey interactions between the tower, guy wires, and birds. Although much of the site is fairly open, this site is best described as a koa haole shrubland. Klu is common. The dominant grass is pitted beardgrass, with a few areas dominated by pili grass. Two fenced exclosures are located just outside the survey area, approximately 650 feet (200 meters) from the erected tower. Only one of the exclosures appeared to contain an unusual plant, a single specimen of the endangered *Hibiscus brackenridgei*. The fenced exclosures will not be disturbed by Project activities to ensure no impacts on this specimen.

Met tower Site 7 is located on the interfluves east of Kahua Gulch, furthest east of the proposed met tower sites, and is reached by a 4-wheel drive road off State Route 44 (Figure 9). The grass here appeared either severely cropped or lagging behind the grasses observed at the other sites in reaching maturity (Fig. 11). Both pili and pitted beardgrass are present, and the latter is presumed to be the dominant species over much of the site. However, this site included upslope of the central point, a dense scrub growth of native ʻaʻaliʻi, unusual among all the locations surveyed in the density and monotypic nature of the growth. Another native shrub, *Lipochaeta heterophylla*, and the native vine, *Ipomoea tuboides*, are present in this area, although less abundant than at Site 2.

Flora

A plant checklist (Table 2) was compiled from the observations made on the wandering transects conducted over each of the seven sites. Entries in Table 2 are arranged alphabetically under family names. Included are the scientific name, the common name, and status (whether native or introduced) of each species. The nomenclature of the flowering plants follows that of Wagner, Herbst, and Sohmer

(1999) for both the native and naturalized plants. Names for ferns (only one species was recorded) follow Palmer (2003).

A total of 54 species of flowering plants (and one fern) are listed for all seven met tower sites combined. Of the 55 plant species identified, 13 are regarded as native to the Hawaiian Islands (either indigenous or endemic), or 23.6% of the species. This proportion of natives (nearly one-quarter of the species present) is high compared with most disturbed areas in the Hawaiian Islands. On O'ahu, lowland and middle elevation sites seldom exceed 12% native species (and are typically under 3%) and the number of natives is typically low. On northern Lāna'i, the natives at most of the met tower sites remain significant in their abundance.

The native endemics include the fern (*Doryopteris decipiens*), a fairly widespread species in the islands. Less common are the shrub, *Lipochaeta heterophylla*, and the vine, *Ipomoea tuboides*.

Discussion

None of the plants observed at or surrounding (within 100 meters) the seven met tower sites are federally listed, are particularly rare on Lāna'i, or would require special care to be taken in planning or erecting the met towers. While the native endemics found at a few of the sites are not afforded special protection, minimal anticipated disturbance erecting the met towers should provide ample protection for these somewhat rare representatives of a once more flourishing native community.

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Table 2. Listing of plant species observed at seven meteorological sites on Lānaʻi on November 26-28, 2007.

FAMILY *Species Name*	COMMON NAME	STATUS	TOWER SITE No. 1	2	3	4	5	6	7	Notes
	FERNS & FERN ALLIES									
PTERIDACEAE										
Doryopteris decipiens (Hook.) J. Sm.		**end**	--	--	U	--	U	--	--	
	FLOWERING PLANTS DICOTYLEDONES									
ANACARDIACEAE										
Schinus terebinthifolius Raddi	Christmas berry	nat	O	--	--	R	--	--	--	
ASTERACEAE										
Acanthospermum australe (Loefl.) Kuntze	Paraguay burr	nat	--	--	--	R	--	--	--	
Ageratum cf. *conyzoides* L.	---	nat	--	--	--	--	--	R	--	(4)
Bidens sp.		nat	--	--	R	--	--	--	--	(4)
Conyza bonariensis (L.) Cronquist	hairy horseweed	nat	R	--	--	--	--	--	--	
Cirsium vulgare (Savi) Ten.	bull thistle	nat	R	--	--	--	--	--	--	(4)
Emilia fosbergii Nicolson	Flora's paintbrush	nat	(1)	(1)	(1)	U	(1)	(1)	(1)	(2)
Heterotheca grandiflora Nutt.	telegraph weed	nat	R	--	--	--	--	--	--	(4)
Hypochoeris radicata L.	hairy cat's ear	nat	--	--	R	--	--	--	--	(4)
Lipochaeta heterophylla A.Gray	---	**end**	--	O1	--	--	--	--	U1	
Pluchea carolinensis (Jacq.) G.Don	sourbush	nat	--	--	--	--	R	--	--	(4)
Sonchus oleraceus L.	sow thistle	nat	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(4)
CONVOLVULACEAE										
Convolvulus arvensis L.	field bindweed	nat	--	--	--	--	R	--	--	(3)
Ipomoea cairica (L.) Sweet	*koali ʻai*	**ind?**	--	--	--	R	--	--	--	(4)
Ipomoea tuboides Degener & Ooststr.	*hunakai*	**end**	--	U	--	--	--	--	R	(4)
CUSCUTACEAE										
Cuscuta cf. *sandwichiana* Choisy	*kaunaʻoa*	**end**	--	--	--	--	--	--	R	
FABACEAE										
Acacia farnesiana (L.) Willd.	*klu*	nat	--	O	O	--	C	C	--	
Chamaecrista nictitans (L.) Moench	partridge pea	nat	O2	(1)	U	O	O	R	U	(1)
Desmodium incanum DC	Spanish clover	nat	--	--	--	R	--	--	--	

Table 2 (continued).

FAMILY *Species Name*	COMMON NAME	STATUS	TOWER SITE No. 1	 2	 3	 4	 5	 6	 7	Notes
FABACEAE (continued)										
Desmodium sandwicense E. Mey.	Spanish clover	nat	--	--	--	R	--	--	--	
Desmodium triflorum (L.) DC	---	nat	--	--	--	R	--	--	--	
Indigofera suffruticosa Mill.	indigo	nat	R	--	--	--	--	--	--	
Leucaena leucocephala (Lam.) de Wit	*koa haole*	nat	U	U	--	O	--	AA	R	
Macroptilium lathyroides (L.) Urb.	cow pea	nat	--	--	(1)	R	(1)	R	--	
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	*kiawe*	nat	--	O	O2	--	O2	O	--	
MALVACEAE										
Abutilon incanum (Link) Sweet	hoary abutilon	**ind?**	--	--	U	--	R	U	--	
Malva parviflora L.	cheeseweed	nat	--	--	--	--	--	R1	--	
Malvastrum coromandelianum (L.) Garcke	false mallow	nat	--	--	R	--	--	--	--	
Sida fallax Walp.	*'ilima*	**ind**	O	C	O	U	C	O	A	
MENISPERMACEAE										
Cocculus orbiculatus (L.) DC.	*huehue*	**ind**	R	--	--	R	--	--	--	
MOLLUGINACEAE										
Mollugo cerviana (L.) Ser.	threadstem carpetweed	nat.	--	--	--	--	--	R	--	(3)
MYOPORACEAE										
Myoporum sandwicense A.Gray	*naio*	**ind**	R	--	--	--	--	--	R	
OXALIDACEAE										
Oxalis corniculata L.	*'ihi'ai*, yellow wood sorrel	**ind?**	R	--	--	R	--	--	--	
PASSIFLORACEAE										
Passiflora suberosa L.	*huehue haole*	nat	R	--	--	--	--	--	--	(4)
PLANTAGINACEAE										
Plantago lanceolata L.	narrow-leaved plantain	nat	O2	--	--	O	--	--	(1)	
PORTULACACEAE										
Portulaca oleracea L.	pig weed	nat	--	--	--	--	--	R	--	(4)
SAPINDACEAE										
Dodonaea viscosa Jacq.	*'a'ali'i*	**ind**	AA	A	--	A	--	--	AA	
SOLANACEAE										
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	nat	R	--	--	R	--	--	--	

Table 2 (continued).

FAMILY / Species Name	COMMON NAME	STATUS	TOWER SITE No. 1	2	3	4	5	6	7	Notes
STERCULIACEAE										
Waltheria indica L.	*'uhaloa*	**ind?**	A	C	O	U	C	O	C	(2)
VERBENACEAE										
Lantana camara L.	lantana	nat	C	O	O	O	O2	O	O	(2)
Stachytarpheta jamaicensis (L.) Vahl	Jamaican vervain	nat	U2	--	--	U	R	R1	O	
	FLOWERING PLANTS MONOCOTYLEDONES									
POACEAE										
Bothriochloa pertusa (L.) A.Camus	pitted beardgrass	nat	--	A	AA	--	A	AA	(3)	
Cenchrus ciliaris L.	buffelgrass	nat.	--	--	O	--	U3	R1	--	
Cynodon dactylon (L.) Pers.	Bermuda grass	nat	O3	--	--	U2				
Dichanthium aristatum (Poir.) C.E.Hubb.	Angleton grass	nat	AA	AA	--	AA	--	--	U2	
Digitaria insularis (L.) Mez ex Ekman	sourgrass	nat	U3	--	R	R1	--	--	--	
Heteropogon contortus (L.) P.Beauv. ex Roem. & Schult.	*pili*	**ind?**	--	AA	A	--	AA	O	O2	
Melinis minutiflora P.Beauv.	molasses grass	nat	U1	--	--	R	--	--	--	
Melinis repens (Willd.) Zizka	Natal redtop	nat	R	C	U	U	R1	--	R	
Paspalum dilatatum Poir.	Dallis grass	nat	R2	--	--	R	--	--	--	
Sporobolis cf. *africans*	African dropseed	nat	R	--	--	--	--	--	--	
Setaria gracilis Kunth	yellow foxtail	nat	R	--	--	--	--	--	--	
Urochloa maxima (Jacq.) R. Webster	Guinea grass	nat	R	--	--	O3	R	--	U	
Indet no. 1 "vernal"	---	nat	--	O	U	--	U	--	--	

Status = distributional status
- **End.** = endemic; native to Hawaii and found naturally nowhere else.
- **Ind.** = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
- **Ind?** = Possibly indigenous or an early Polynesian introduction.
- Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.

Abundance = occurrence ratings for plants:
- R - Rare - only one or two plants seen.
- U - Uncommon - several to a dozen plants observed.

Table 2 (continued).

O - Occasional - More than a dozen plants seen, but encountered infrequently.
C - Common - considered an important part of the vegetation and encountered regularly.
A - Abundant - found in large numbers; may be locally dominant.
AA - Abundant - abundant and dominant; a vegetation defining species for the survey site.
Numbers (1-3) after an abundance rating for a species indicate modifications for localized abundance increases as per the following examples:

R1 – species encountered perhaps once, but several plants seen together.
O2 – a species encountered only occasionally, but seen in clusters of several to many specimens.
U3 – plant uncommon in its distribution, but very numerous where encountered.

Notes:

(1) Present only as numerous seedlings.
(2) Also present as numerous seedlings.
(3) Not previously recorded from the island of Lāna'i.
(4) Observed, but without flower or fruit and ID therefore tentative.

Appendix 6

Post-Construction Monitoring Protocol

POST-CONSTRUCTION MONITORING PROTOCOL FOR THE LĀNA'I METEOROLOGICAL TOWERS PROJECT, LĀNA'I, HAWAII

PREPARED FOR

Castle & Cooke Resorts, LLC

PREPARED BY

TETRA TECH EC, INC.

August 2008

POST-CONSTRUCTION FATALITY MONITORING PROTOCOL FOR THE LĀNA'I METEOROLOGICAL TOWER PROJECT, LĀNA'I, HAWAII

On August 8, 2007, the State of Hawaii's Department of Land and Natural Resources (DLNR) issued Castle & Cooke Resorts, LLC (Castle &Cooke) Conservation District Use Permit (CDUP) LA-3419 to conditionally approve the installation of one temporary meteorological (met) tower at site number 6 and preliminarily approve installation of the remaining six met towers on the Island of Lāna'i, Maui County, Hawai'i. Met tower 6 was erected on August 28, 2007. The six additional towers were approved for installation by DLNR on December 10, 2007. Six of the seven towers were installed by February 8, 2008 and the seventh tower has not yet been installed. The towers will remain in operation through March 1, 2010. These towers will collect data on wind speeds and patterns throughout the northern portion of the island. This data, in turn, will be used to determine the feasibility of a commercially viable wind energy facility. Castle & Cooke is committed to developing renewable energy on the Island of Lāna'i while preserving the unique environmental, cultural, and historic resources found on the island.

Four federally and state endangered or threatened species have the potential to occur or are known to occur on Lāna'i within the vicinity of the wind resource area (WRA). Castle & Cooke is in the process of conducting a comprehensive radar study to determine the presence of endangered Hawaiian Petrels, Hawaiian hoary bats, Hawaiian stilts, and threatened Newell's shearwaters near proposed met tower locations and throughout the larger WRA. The Hawaiian petrel is known to nest on the island and has been observed within the WRA. The presence of the Hawaiian hoary bat and Newell's shearwater has been documented on Lāna'i but their breeding status on the island is not known. Hawaiian stilts occur at the wastewater treatment plant, and one stilt was observed flying over the WRA during the summer 2007 radar surveys.

A post-construction monitoring protocol was developed to assess potential impacts to these species as a result of met tower operation. The primary objective of the monitoring protocol is to determine whether any of the four federally and state listed species are impacted as a result of collision with one or more of the met towers and to ensure compliance with the provisions and limitations of the Habitat Conservation Plan (HCP) for the Construction and Operation of the Lāna'i Meteorological Towers and the Incidental Take Permit/Incidental Take License (ITP/ITL) to be issued by the U.S. Fish and Wildlife Service (USFWS) and DLNR, respectively. Monitoring will also document impacts to other non-listed species. The monitoring program will identify bird and/or bat fatalities within the study area by using systematically conducted, standardized carcass searches, carcass removal (scavenging) trials, and searcher efficiency trials. Although direct take of bats by met towers will be assessed through carcass searches, this monitoring protocol is designed primarily to detect seabird take.

The protocol described below outlines a minimum number of surveys and trials and provides an adaptive management approach to monitoring the met towers. The methods and timing of measures can be modified over time to increase the effectiveness and efficiency of the program, as needed. However, any recommended changes to the minimum number of surveys and/or trials from the baseline provided in this protocol would require review and approval by USFWS and DLNR/Division of Forestry and Wildlife (DOFAW). The protocol includes 1) standardized carcass searches to monitor potential injuries or fatalities, 2) carcass scavenging trials to assess seasonal, site-specific carcass removal rates by scavengers, and 3) searcher efficiency trials to assess observer efficiency in finding carcasses. If any of these listed species are documented to be killed as a result of collision with a met tower, the observed direct take will be evaluated and adjusted accordingly based on searcher efficiency trials to ensure compliance with the authorized HCP and ITP.

1.0 STANDARDIZED CARCASS SEARCHES

Carcass searches will be conducted to estimate the number of avian and bat fatalities attributable to the met towers. An estimate of the total number of carcasses will be made by adjusting for removal bias (affected by scavenging) and searcher efficiency bias (affected by detection) (see Sections 2.0 and 3.0). The methods, timing, and duration of the carcass searches are described below.

1.1 Methods

Personnel trained in proper search techniques ("the searchers") will conduct carcass searches at each of the met tower locations. Boundaries of square plots will be delineated along each met tower to be searched. A strip transect design is appropriate for this study, providing almost 100 percent coverage of the search area. Each search plot will be split into four quadrants, with each searched sequentially. This facilitates the searchers ability to stay on transect lines and maximize searching efficiency (Gritski pers. comm. 2006).

When conducted for wind turbines, typically, plot size extends outward from the base of a wind turbine a minimum distance equal to the turbine height. However, other research in the 1990s through the early 2000s has shown that most birds and bats killed in collisions with wind turbines remain within 63 meters (207 feet) of the turbine (Orloff and Flannery 1992, Higgins et al. 1996 (as cited in Young et al. 2003), Johnson et al. 2002). Young et al. 2003 conducted carcass searches for met towers approximately 38 meters (125 feet) in height at the Foote Creek Rim Wind Plant within 63 m (207 feet) of each tower. Casualties were documented at this project between 3 meters to 50 meters from the met towers with an average distance of 23 meters.

Met towers to be erected on Lāna'i are 50 meters (165 ft) tall with a guy wire radius of 30.5 to 33.5 meters (100 to 110 feet). Based on the results from previous wind power research, all areas within 63 meters from each met tower at Lāna'i will be searched. If the results from the initial carcass surveys show that the plot size is too large or small, the area will be adjusted accordingly pending approval by USFWS and DLNR/DOFAW. Geographic Positioning System (GPS) locations of the search plot corners will be included in initial data collection. Transects will be set at approximately 6 meters (19.7 feet) apart, depending on the habitat type, and the searcher will walk along each transect searching both sides out to 3 meters (10 feet) for fatalities. Search area and speed may be adjusted by habitat type, after evaluation of the first searcher efficiency trial, if needed. In addition, monitoring plots will be marked in such a way that searchers can easily walk the transects so they can concentrate on searching for carcasses. Materials used to identify the search area may include but are not limited to flagging, stakes or other visible item.

If carcasses of a listed species are found, searchers will follow the Downed Wildlife Protocol (**Attachment 1**), and carcasses will be left in place and moved only if directed by DOFAW or USFWS. If directed to move the carcasses, searchers will deliver carcasses to Service Law Enforcement who will send them to a forensics lab for future reference and necropsy. The original USFWS Special Purpose Permit was issued on September 21, 2007, and the Protected Wildlife Permit on DOFAW February 2008.

All carcasses (avian and bat) found during the standardized carcass searches will be recorded and identified by a unique number. A copy of the data sheet for each carcass will be kept with the carcass at all times. For each carcass found, searchers will record species, sex and age when possible, date and time collected, location, condition and any comments that may indicate cause of death (**Attachment 2**). Searchers will record the condition of each carcass found, using the following condition categories:

- Intact – a carcass that is completely intact, is not badly decomposed and shows no sign of being fed upon by a predator or scavenger
- Scavenged – an entire carcass that shows signs of being fed upon by a predator or scavenger, or portions of a carcass in one location (e.g., wings, skeletal remains, legs, pieces of skin, etc.)
- Feather Spot – 10 or more feathers at one location indicating predation or scavenging or 2 or more primary feathers

Searchers will photograph each carcass as found and establish GPS points. A detailed map of the search area can then be created showing the location of the met towers and associated facilities, the study area, and any carcasses located.

The searchers may discover carcasses incidental to formal carcass searches (e.g., predation or while driving within the project area). For each incidentally discovered carcass, the searcher will identify, photograph, and record data for the carcass as would be done for carcasses found during formal scheduled searches.

Any injured native birds found on the facility site will be carefully captured by a trained project biologist or technician and transported to a local wildlife rehabilitator. All project staff and consultants will be trained on how to handle any downed wildlife or carcasses found anywhere within the project area. Furthermore, a Downed Wildlife Incident Report (**Attachment 3**) will be completed for any injured animal or fatality.

1.2 Important Considerations

Important factors to consider in developing the monitoring plan include target species size and the type of vegetative cover being surveyed. The Hawaiian petrel and Newell shearwater are relatively large birds with wingspans over 30 inches. Hawaiian stilts are slender birds approximately 16 inches in length. Downed individuals should be detectable compared to smaller bird species and most bats. The Hawaiian hoary bat is much smaller (10.5 – 13.5 inches), with darker coloring, so it will make individuals much more difficult to detect using visual searches (USFWS, 1998). Some of the met tower sites are densely vegetated with shrub/scrub habitat while other areas are open grasslands or are barren of vegetation. However, vegetation maintenance should provide a more consistent vegetation type between towers.

2.0 CARCASS SCAVENGING TRIALS

"Carcass scavenging or removal" is the disappearance of a carcass from the search area due to scavenging. This may serve as a potential source of bias associated with fatality rate estimation. Scavengers may preclude detection of carcasses or make it problematic to identify remains and determine cause of death. Thus, seasonal differences in scavenging rates (i.e., changes in scavenger population density) and possible differences in the size of animal being scavenged are typically taken into account when estimating fatality. Additionally, the timing of fatality searches must be conducted at a frequency that minimizes loss due to scavenging.

The objective of the carcass scavenging trials is to document the length of time avian carcasses remain in the search area and subsequently determine the frequency of carcass searches within the search plots. Carcass scavenging trials will be conducted during each season in the vicinity of the search plots. Carcass scavenging rates will be used to adjust carcass surveys for removal bias. Removal rates will be determined for each season.

Carcasses used in the trials may include representatives of the seabirds if legally available and permitted by USFWS and DOFAW; bat carcasses will not be available for scavenging trials. Castle & Cooke will coordinate with DOFAW and USFWS to follow appropriate protocols in using carcasses during carcass scavenging trials. Carcasses of non-native passerines, commercially available game bird chicks or legally obtained native birds may be used to simulate bats if another appropriate alternative is not designated. Carcasses of legally obtained wedge-tailed shearwaters, commercially available adult game birds, or cryptically colored chickens will be used to simulate seabirds.

To avoid confusion with met tower-related fatalities, planted carcasses will not be placed in fatality monitoring search plots. Planted carcasses will be placed in the vicinity of met towers but not so near as to attract scavengers to the search plots. The planted carcasses will be located randomly within the carcass scavenging trial plots.

Carcasses will be placed in a variety of postures to simulate a range of natural conditions. For example, birds will be: 1) placed in an exposed posture (e.g., thrown over the shoulder), 2) hidden to simulate a crippled bird (e.g., placed beneath a shrub or tuft of grass) and, 3) partially hidden. Trial carcasses will be marked discreetly for recognition by searchers and other personnel. Trial carcasses will be left at the location until the end of the carcass scavenging trial.

Carcasses will be checked as follows, although actual intervals may vary. Carcasses will be checked for a period of 28 days to determine removal rates; however, total number of searcher days will be adjusted according to observed scavenging rates. Carcasses will be checked approximately every day for the first seven days, and then on day 10, day 14, day 21, and day 28. This schedule may vary depending on the initial removal rate observed, weather, and coordination with the other survey work. At the end of the 28-day period, any remaining trial carcasses and scattered feathers will be removed.

Each trial will use as many bird carcasses as are available; the target is 10-20 carcasses. The number and distribution of carcasses will be determined on a per site/habitat basis; carcasses will be placed near each operating met tower to account for potential local differences in scavenger populations.

3.0 SEARCHER EFFICIENCY TRIALS

The objective of searcher efficiency trials is to estimate the percentage of bird fatalities that searchers are able to find. Searcher efficiency will be estimated by habitat type and season. Estimates of searcher efficiency will be used to adjust carcass counts for detection bias. Searcher efficiency trials will be conducted on the fatality monitoring search plots in all habitat types.

Searcher efficiency trials will be conducted in each season as defined above, during the period in which the fatality monitoring occurs. Trials will be spread throughout the year to incorporate the effects of environmental variables such as weather and scavenger populations. Key elements of these trials include:

- At least three trials will be conducted in each season.
- Each trial will use a variable number of carcasses so that the searcher will not know the total number of trial carcasses being used in any trial.
- For each trial, birds will be used according to their availability. A suitable substitute will be used for bats but SEEF will not be applied to adjusted take because it is highly unlikely that an incidental take of a bat would occur.
- Wedge-tailed shearwater will be the primary species used for searcher efficiency trials if available. It is anticipated that 2 to 5 carcasses will be used per trial.
- Personnel conducting searches will not know in advance when trials are conducted; nor will they know the location of the trial carcasses.
- Carcasses will be placed in a variety of postures to simulate a range of conditions. For example, birds will be: 1) placed in an exposed posture (thrown over the shoulder), 2) hidden to simulate a crippled bird and 3) partially hidden.
- Each non-domestic carcass will be discreetly marked and located with GPS at the planted site so that it can be identified as an efficiency trial carcass after it is found.
- The number and location of the efficiency trial carcasses found during the carcass search will be recorded.

If new searchers are brought into the search team, additional detection trials will be conducted to ensure that detection rates incorporate searcher differences.

4.0 SAMPLING INTENSITY AND DURATION

The first carcass scavenging trial will be conducted in March 2008 prior to the start of met tower carcass surveys (beginning March 1, 2008) to establish an appropriate survey schedule for the spring 2008 season. This will be very useful in increasing the efficiency of the study since scavenging rate detections will determine the appropriate search frequency. If scavenging is high, search frequency needs to be high (see Arnett 2005).

Carcass searches will begin approximately on March 15, the approximate date that the seabirds return to the colony. Our initial assumption is that scavenging will be low based on the low bird use in the WRA and the low diversity of potential scavengers. However, based on DOFAW and USFWS recommendations, carcass searches will be conducted approximately two times per week or no longer than 3 days apart during the initial scavenging trial. Once data from the initial scavenging trial has been evaluated, the frequency of carcass searches will adjusted accordingly for effectiveness and efficiency for the remainder of the spring 2008 survey season, as approved by DOFAW and USFWS. Similarly, carcass search frequency in subsequent seasons will be determined by scavenging trials conducted at the beginning of each season. Carcass searches will be conducted from March 15 to approximately December 15 (or earlier in December if the petrels have been verified by DOFAW to have left the island), during the two year period in which the temporary met towers are operational. DOFAW and USFWS stated carcass searches are not required between approximately December 15 and March 15, when the seabirds are not on the island. Additional surveys may be conducted after climatic conditions/events, such as storm events, fog, or moonless nights, as these events could increase the likelihood of collisions with met towers. Seasons will be defined as: Spring (March 15 – June 15), Summer (June 16-September 15), and Fall (September 16-December 15 or when DOFAW has verified seabirds have left the colony). The exact day a new trial or surveys may begin or end may vary a few days depending on when the seabirds arrive or leave the colony, site conditions, carcass availability, etc. DOFAW and USFWS will provide Castle & Cooke and/or its consultants sufficient notice prior to conducting a site visit to enable appropriate project staff to participate. Agency staff may also conduct compliance monitoring without prior notice.

Personnel will conduct carcass scavenging trials within each of the seasons defined above during the years in which fatality monitoring occurs. The winter season beginning and ending dates may vary based on when DOFAW biologists confirm seabirds have left or returned to the colony. Trials will be spread throughout the year to incorporate the effects of environmental variables such as weather and scavenger densities.

Changed circumstances such as hurricanes, major storms, fire, and other such events may affect the timing of the surveys. If the met towers are not accessible as a result of storm events or road conditions, and/or staff safety is questionable, the surveys will continue as soon as is safely possible. Castle & Cooke will coordinate with DOFAW and USFWS on such changed circumstances as soon as possible.

5.0 ANALYTICAL METHODS FOR FATALITY ESTIMATES

Estimates of avian fatalities during the life of the met towers are based on the following:

(1) The number of carcasses located during standardized searches for which the cause of death is attributed to the met towers; carcasses found within survey plots are assumed to be the result of the met tower unless other obvious indicators exist.

(2) Carcass scavenging rates expressed as the estimated average time a carcass is expected to remain in the study area and be available for detection by the searchers during the entire survey period.

(3) Searcher efficiency expressed as the proportion of planted carcasses found by searchers.

The following sections describe how the avian fatalities will be quantified.

5.1 Fatality calculations

The estimate of total fatalities is based on the number of fatalities found within the met tower survey plots, confirmed to be attributed to the met tower, and adjusted for the probability that the observer found the carcass and the time that the caresses remained to be found (i.e., was not scavenged). Calculations are based on Young et al. (2003) and are presented below.

5.1.1 Number of carcasses

The average number of carcasses per search period is calculated using:

$$\bar{c} = \frac{\sum_{i=1}^{k} c_i}{k}$$

where c_i is the number of carcasses found at met tower i, and k is the number of met towers searched.

Total number of carcasses found is calculated by:

$$C = k * \bar{c}$$

5.1.2 Searcher Efficiency

Searcher efficiency (p) is calculated as the proportion of the carcasses found by observers divided by the total number of carcasses available to find.

5.1.3 Scavenging rate

The average number of days that a carcass remained on site is calculated using:

$$\bar{t} = \frac{\sum_{i=1}^{k} t_i}{k}$$

where t_i is the number of days each carcass remained on the study area and k is the number of carcasses evaluated.

5.1.4 Mortality estimate

The estimated total number of fatalities is calculated by

$$m = \frac{N * I * C}{k * \bar{t} * p}$$

where N is the total number of met towers, I is the time between searches (days), C is that total number of carcasses during the study period, k is the number of met towers searched, $\bar{t}$ is the mean length of time a carcass remained on the plot, and p is the searcher efficiency.

6.0 RESULTS

Fatality rates will be calculated on a per met tower basis and for the project as a whole. Each season's percent searcher efficiency will be applied to the observed direct take (carcasses found, if any, during searches) to quantify adjusted take (direct and unobserved direct take combined). Variance will not be calculated pursuant to USFWS recommendation. Adjusted take will be compared to the tiered take limits authorized in the HCP. If a Hawaiian petrel, Newell's shearwater, hoary bat, or Hawaiian stilt is documented to be killed as a result of collision with a met tower, the take will be evaluated to ensure compliance with the provisions of the authorized HCP and ITP/ITL.

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Attachment 1
Lāna'i Downed Wildlife Protocol

LANA'I DOWNED WILDLIFE PROTOCOL *

Downed birds (any seabirds, and or Hawaiian short-eared owl) considered here may be dead or injured at discovery. Hawaiian Bats may also be found and need attention. All need immediate attention by the discoverer.

A ***prioritized*** Contact List of Division of Forestry & Wildlife (DOFAW) Staff follows, prioritized from first to last to contact. It is essential for you to actually speak with a person and not to rely on voicemail as "a contact"; however you may leave a message and then contact the next person in the listing.

DEAD BIRD OR HAWAIIAN BAT:

- Leave in place, DOFAW will do site and circumstantial assessment, make photographs, and measurements before securing and removing bird or bat.

- Contact DOFAW staff about find; Call list, for DOFAW staff, in order for calling:
    1. Fern Duvall 808-264-0922
    2. Jay Penniman 808-280-4114
    3. Christine Costales 808-559-0436
    4. Derwin Kwon 808-357-5090
    5. Mike Coelho (DOCARE) 808-565-7916

FAILSAFE if no one is contacted – call Maui Police Dispatch 808-244-6400 and request that they contact **"Wildlife"**

INJURED BIRD OR HAWAIIAN BAT:

Equipment necessary to have available for response:

- Pet carriers (medium) – 2 available at minimum
- Cardboard small animal (rat/rabbit/hamster) carriers – 2 minimum
- Pieces of artificial turf/outdoor carpeting to place on floors of pet carriers
- Non-tippable shallow dog water-bowls for water; water
- Gloves
- Tent stakes (6)

Procedure

1. Gently pick up and place bird into carrier equipped with turf/carpet (place bat first into cardboard small animal carrier, and this into the pet carrier) Place only 1 bird or bat in a carrier.
2. Mark exact spot of find(s) with tent stake(s)
3. Call DOFAW Contact List - as above
4. Move or transport bird/bat from site subsequent to notification of DOFAW staff and after DOFAW instructions
5. DO NOT feed birds, provide water in bowl. No food or water for Hawaiian bats.

*Protocol provided by DOFAW August 24, 2007

Attachment 2
Lāna'i Avian Fatality Survey Form

Lana'i Downed Wildlife Survey

Location: ____________________ **Observer:** ______________________________ **Date:** ____________
Start Time: ______________________________ **End Time:** ____________

Environmental Conditions:

Cloud Cover:____ (0=about 25%, 1=26-50%, 2=51-75%, 3=76-100%) **Temperature:**______
Precipitation:___Rain____ Fog___Other___ (0=None, **L**=light, **M**=Moderate, **H**=Heavy, Other= Hail, Snow)
Wind:_____ 0=<1 mph, 1=1-3 mph (leaves barely move), 2=3-7 mph (leaves rustle, small twigs move),
3=8-12 mph (sm. Twigs move), 4=13-18 mph (sm. Branches move) 5=12-24 mph (lg. Branches move trees sway)
Vegetation: Ave. ht. ______(cm); **Ave. vigor** _____ (**G**= Green, **M** = Mixed, **B** = Brown);
Cover ______% (% ground obscured by plant cover), record details in comments

Tower No.	Species	Sex	Age	Remains	Dir. From Tower	Dist. From Tower	UTM N	UTM E	Approx. Carcass Age	Photo nmbrs	Vegetation Type	Comments

Species: 4-letter code
Sex: sex of animal if known (**M** = Male, **F** = Female); **Age: A** = Adult, **S** = Subadult, **J** = Juvenile
Remains: E=Entire body, **W**=Wing, **F**=Feathers/Fur, **S**=feather spot (10 or more, or 3 primaries),**B**=Bones, **O**=Other (add to Comments)
Dir. From Tower: Compass direction of carcass from Tower base
Dist. From Tower: Distance (meters) of carcass from Tower
Carcass age: Approximate age in days of carcass remains
Comments: Print notes as needed

Attachment 3
Lana'i Downed Wildlife Incident Report

Downed Wildlife Incident Report

Location	
Date and Time Identified	
Species	
Probably Cause of Injury/Death	
Action Taken	
Other Comments	
Name of Observer	

Appendix 7
Mitigation Program
Scope of Work

MITIGATION PLAN SCOPE OF WORK TO BE COMPLETED BY DIVISION OF FORESTRY AND WILDLIFE

Lāna'i Meteorological Towers Project

1.0 INTRODUCTION

Castle & Cooke Resorts, LLC (Castle & Cooke) is conducting meteorological data collection throughout the northern portion of Lāna'i to determine whether the existing wind resource would support the development of a commercial-scale wind energy facility. Biological surveys conducted to date have determined the presence of Hawaiian petrel (*Pterodroma sandwichensis*), Hawaiian hoary bat (*Lasiurus cinereus semotu*), and Hawaiian stilt (*Himantopus mexicanus knudseni*); Newell's shearwaters (*Puffinus newelli*) have not been detected within the proposed project area. As a result, the Division of Forestry and Wildlife (DOFAW) and the United States Fish and Wildlife Service (USFWS) have requested that Castle & Cooke prepare a Habitat Conservation Plan (HCP) and acquire an incidental take license/permit (ITL/ITP) to allow for the potential incidental take of these four federally listed threatened and/or endangered species.

Coordination with DOFAW and USFWS during HCP development determined that a combination of habitat restoration and predator control would likely result in a net benefit for these species. In 2006, DOFAW rediscovered a colony of Hawaiian petrels at the Lāna'ihale. As mitigation for the potential incidental take of the Hawaiian petrel, the Newell's shearwater, and the Hawaiian hoary bat, DOFAW and USFWS recommended restoring disturbed habitat within the petrel colony as well as augmenting DOFAW's existing cat trapping program within the Lāna'ihale. A second tier of mitigation was developed for petrels if Tier 1 take limits are reached, and would include restoration of a larger area. As mitigation for the potential take of Hawaiian stilts, DOFAW and USFWS recommended initiating a cat trapping program in the vicinity of the Lāna'i wastewater treatment facility, the area where Hawaiian stilts are known to be breeding residents. Castle & Cooke is providing the funds to DOFAW to implement the habitat restoration and predator control program. DOFAW is responsible for the design, implementation, and monitoring of this scope of work.

This scope of work outlines the steps that will be taken to restore three acres (additional three acres for Tier 2) of habitat on Lāna'ihale and augment DOFAW's current predator control program on Lāna'i.

2.0 LĀNA'IHALE HABITAT RESTORATION

At Lāna'ihale, much of the potential nesting habitat for Hawaiian petrels and Newell's shearwaters has been degraded by the introduction of ungulates and subsequent establishment of invasive species such as strawberry guava (*Psidium cattleianum*). DOFAW has identified two, three-acre parcels within the Lāna'ihale that offer the opportunity for habitat restoration (see Figure 1). DOFAW selected the two, three-acre parcels based on the following:

- Reliable records of former petrel nesting behavior (Jeffrey, pers. comm.)
- Accessibility
- Uluhe present in isolated patches
- Provide a migration corridor between two gulches with known petrel nesting

As part of the Tier 1 mitigation, DOFAW will restore, at a minimum, one of the three-acre parcels. At its discretion, DOFAW has the option to reallocate the authorized Tier 1 funding to restore the second three-acre parcel.

2.1 Phase I – Site Assessment

Maui Invasive Species Committee (MISC) and DOFAW staff conducted a detailed site assessment of the habitat restoration area to identify any known native and listed plant and animal species as well as cultural resources. Project staff and cooperators on the site will also be trained to recognize and protect native snails and ʻuaʻu burrows and sign (feathers, odor, droppings) which indicate the possible presence of burrows on Lana'ihale. Any native plants, snails or petrel burrows will be mapped and protected throughout restoration and maintenance activities. In the event that burrows are located, they will be mapped and included with existing project burrows which are followed for reproductive success and other ongoing studies. Treatment of the site will require very thorough observation of the entire restoration area to give a high confidence level that all existing burrows will be known. Quantifying recruitment into the site will then be possible with regular searches for new burrows.

DOFAW will map and flag the areas in which vegetation removal will occur. The site will be divided into 12, approximate one-quarter acre management units. Random plots will be established to describe the site. Species composition, size class, canopy closure, slope and aspect will all be recorded. Plots will be permanently marked for evaluation at future dates.

2.2 Phase II – Site Clearing

DOFAW staff recognized strawberry guava (*Psidium cattleianum*) as a serious threat to the Lānaʻihale watershed and the petrel in early 2006. Strawberry guava is widely distributed in the Lānaʻi forest. In areas, it forms mono-typic stands, eliminating, among other species, uluhe fern (*Dicranopteris linearis* and *Diplopterygium pinnatum*) habitat. Uluhe fern is the dominant component of Hawaiian petrel habitat on Lānaʻi. DOFAW has consulted with the MISC, Haleakala National Park, National Tropical Botanical Gardens and others with experience in guava control.

DOFAW has contracted MISC to conduct the initial phase of vegetation removal within the restoration parcel(s). MISC will conduct much of the vegetation removal during the winter and early spring prior to the petrels return to the colony. However, clearing activities will continue throughout the summer and fall according to specific guidelines. Restoration activities will be conducted so as to minimize any disturbance to the petrel colony during the breeding season and potentially to Hawaiian hoary bats if indeed bats breed on Lānaʻi. Clearing activities will not occur in the vicinity of active petrel burrows during the breeding season. The sensitive period for bats is July 1 through September 30. During that time period, five consecutive days of negative bat detections must occur for DOFAW to be able to cut trees greater than 3 meters in height.

Vegetation removal will focus on stems greater than 1 cm. Trees will be cut with chain saws, and cut stumps will be immediately treated with herbicide. All cut material will be chipped, and chips will be distributed on and adjacent to the site in a manner which will minimize the area impacted. Stems larger than 6 inches will be offered to Castle & Cooke for their use or used on site for erosion control if such need is identified. Material of this size having no other use will be placed in such a way that it is naturally recycled into the forest soil.

DOFAW will implement erosion control measures during this initial phase of vegetation removal and on-going maintenance if needed. Erosion control would include the use of appropriate Best Management Practices so as to prevent erosion during storm events on the steep slopes.

The one non-native tree species which will not be removed is the Cook pine (*Araucaria columnaris*). Cook pine has been identified as a significant collector of moisture from clouds and fog. Therefore, it is being utilized to attempt to increase the recharge of the Lāna'ihale aquifer. One of the reasons that Cook pine is a desirable species for this use is the assumption that it will not form a closed canopy forest, pushing the wind blown cloud and fog above ground level. If this assumption holds it should mean that Cook pine can be a component in an otherwise native Lāna'i forest. The native forest is and was a low stature forest with dense understory (uluhe, etc.). Cook pines would be scattered throughout, at distances which still allow the aerial mating behavior of the petrel to occur without presenting collision hazard.

2.3 Phase III – Site Management

DOFAW staff will monitor and maintain the restoration parcel(s) for the 2-year duration of the meteorological towers project. All stems remaining after the initial clearing will be cut and treated with herbicide. Site specific techniques i.e.: percent triclopyr, triclopyr amine or triclopyr ester, for control will be finalized before control work commences. Staff understands that control techniques will be adaptable, dependant upon conditions and situations found on site.

The majority of stems will be less than 1 cm diameter. Cutting will involve chain saws and hand cutters. Attention and care will be paid to all native plants on the site. Rats (*Rattus* sp.) eat seeds of many native plant species. Project staff will collect ripe seed from native plants, both on the site and across Lāna'ihale as they carry out their other duties. These seeds will be given to the Castle & Cooke plant nursery for propagation. When plants have reached planting age, they will be planted within the restoration parcel(s). If, during the course of the two-year period, seed or appropriate plants become available from other sources, they will be utilized to aid in the re-vegetation of the restoration parcel(s) if needed.

Re-vegetation will utilize Lāna'i seed and plant stock. Work will be carried out and recorded by management unit. Cutting and treating all the small diameter stems will be an extremely long and demanding task. However, it is a crucial element of the attempt to eradicate strawberry guava in particular. Seed collection needs to happen from the start of the work and continue throughout. This and attention to enhancing the area for existing plants will be accelerated when the small diameter stems are removed. Project staff will have to be constantly vigilant to control re-sprouting of remaining root stock. The seed bank in the area is unknown but certainly exists and new growth must also be identified and controlled. There has been little success in propagating uluhe fern in Hawai'i (Romanchak et al. 2005). However, there have been some techniques learned and with these and input from botanists familiar with the plant, staff will attempt to increase the rate of uluhe re-colonization with in the site.

2.4 Phase IV – Monitoring

DOFAW will conduct regular (semi-annual) monitoring surveys within the restoration area throughout the 2-year period and for a period of up to 8 years thereafter or until nesting and/or fledging success of petrels has been documented, whichever comes first (if take of petrels occurs as a result of collision with one or more of the met towers). Plots established during the site assessment will be surveyed throughout the monitoring period. Data collected at each plot will include at a minimum percent cover and dominance of plant species within each plot and wildlife species observations including sign of petrels or burrows. Each plant or animal species will be identified as native, federally or state-protected, or invasive. Management recommendations will be identified after each monitoring event and described in the annual summary reports provided to Castle & Cooke.

3.0 PREDATOR CONTROL

Predation of young and adults is considered one of the primary threats to all four species. Feral cats, barn owls, and rats represent the predators known to occur on Lāna'i that may kill adult or young Hawaiian petrels, Newell's shearwaters, and Hawaiian stilts. An active feral cat population has been documented in the vicinity of the petrel colony and the wastewater treatment plant. DOFAW has established traps in some locations around the colony and does not currently have the staff to conduct regular trapping at the treatment plant. Twenty percent of cats trapped at the petrel colony to date contained seabird remains in their stomachs which suggests cats are a source of mortality. Increasing the trapping efforts for cats at the Lāna'ihale, as well as establishing a regular program at the wastewater treatment plant, would logically have the potential to decrease the number of adult and juvenile birds killed and have a net positive effect on these populations.

3.1 Lāna'ihale Predator Control

As part of the Tier 1 mitigation plan for the met towers, DOFAW will augment their existing predator-control within the petrel colony by adding 20 additional cat traps throughout the Lāna'ihale for a two-year period beginning March 1, 2008; locations will be determined by DOFAW. Traps will be placed in previously disturbed areas; creating new trails through the colony would only provide increased access for the cats to the birds and burrows. The stomach content of cats trapped will be examined to verify the presence of remains of the covered species. Cat tissue will also be analyzed for stable isotopes of carbon and nitrogen to identify prey consumed.

If Tier 2 mitigation is required, an additional 15 traps will be set within the Lāna'ihale for the duration of the meteorological towers project, or March 1, 2010.

3.2 Wastewater Treatment Plan Predator Control

DOFAW will conduct cat trapping within the vicinity of the wastewater treatment facility to mitigate for potential take of Hawaiian stilts. Twelve cat traps will be placed at locations surrounding the wastewater treatment plant; locations will be determined by DOFAW. Cat trapping at the wastewater treatment facility will begin sometime after March 1, 2008 and continue through March 1, 2010.

4.0 MONITORING

DOFAW will provide Castle & Cooke with status reports after each semi-annual monitoring event that will be expanded upon for annual reports to be completed throughout the 2-year project period. DOFAW's annual report for the mitigation program must be submitted to Castle & Cooke by August 15 of each year. Castle & Cooke will then provide DLNR with annual reports for the HCP and mitigation program on August 31, 2008 and August 31, 2009 and will provide a final report 30 days after completion of the project (March 1, 2010). DOFAW will continue monitoring and maintaining the restoration area after the 2-year project period pursuant to the conditions outlined in the Memorandum of Agreement between DOFAW and Castle & Cooke.

5.0 REFERENCES

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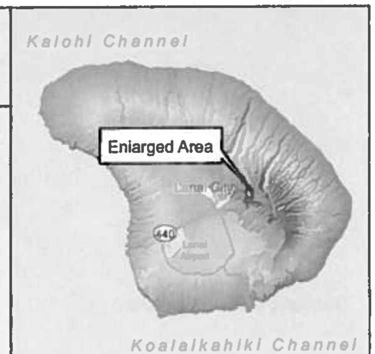
Figure 1. Lāna'i Hale Restoration Area
Castle and Cooke Lāna'i Meteorological Towers Project
Maui County, Hawaii



Restoration Areas

- Tier 1: 3 acres
- Tier 2: 3 acres
- Restoration Area Turning Points
- Local Road

Note: Restoration area turning points are presented as X,Y coordinate pairs in NAD83, UTM Zone 4 North

N

1:2,000

0 25 50 100

Meters

February 13, 2008