Nā Pua Makani Wind Energy Project

Hawaiian Hoary Bat Deterrent Research Plan

Prepared for:
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Prepared by:

TETRA TECH

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1.0 Introduction

The Nā Pua Makani Wind Project (Project) is owned and operated by Nā Pua Makani Power Partners LLC (NPMPP). The Project operates under a Habitat Conservation Plan (HCP) that was approved by the U.S. Fish and Wildlife Service (USFWS) and Hawaii Board of Land and Natural Resources (BLNR). The BLNR permits activities performed in compliance with the HCP through issuance of an Incidental Take License (ITL), which describes specific requirements and conditions. The corresponding USFWS permit is an Incidental Take Permit (ITP).

Conditions within the ITL and ITP typically align, but in the case of the Project, the ITL identifies Special Condition 8 that requires NPMPP to take additional actions related to the Hawaiian hoary bat (*Lasiurus semotus*) or ʻōpeʻapeʻa to satisfy ITL requirements. The condition reads as follows:

> *In addition to the funding commitments set forth in the HCP, Applicant shall contribute an additional $100,000 toward research on deterring bats as part of its Tier 1 mitigation. The resulting research may also utilize other funding sources. The research project or projects shall be approved by DOFAW and results shall be made publicly available. The research shall be focused on deterrence measures with the goal of reducing the take of ʻōpeʻapeʻa by wind turbines. The research shall be done in compliance with HCP section 6.1.2.1.*

Based on input from the Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) HCP staff, NPMPP contracted Tetra Tech, Inc. (Tetra Tech) to develop a Hawaiian hoary bat deterrent research plan for DOFAW and the Endangered Species Recovery Committee's review and approval. The discussion included consideration of the practicality of implementing the study, potential study designs, the power to detect results, and the BLNR's Decision and Order in the matter of Contested Case No. BLNR-CC-17-001 (BLNR 2018).

This research plan includes sections which address:

- Research plan development and background,
- Research design and methods,
- Measures of success,
- Budget, and
- Schedule.

2.0 Research Plan Development and Background

Several technologies have been investigated for their ability to reduce collision risk for bats. To-date, only ultrasonic acoustic deterrents (UADs) have shown commercial viability and effectiveness in reducing risk to the Hawaiian hoary bat at a commercial wind facility. The installation of UADs has been correlated with a reduction in fatality rates for mainland hoary bats (Weaver et al. 2020). The effectiveness of UADs for mainland hoary bats at Los Vientos Wind Farm in Texas was found to be 78.3 percent (95% confidence interval [CI]: 61.5–95.1%) reduced relative to WTGs without UADs active (Weaver and Castro-Arellano 2019). The effectiveness of UADs for mainland hoary bats at an operating wind farm in Illinois was between approximately 26 percent and 36 percent across three years (90% confidence interval) (Romano et al. 2019). This study also found that while there was varying effectiveness by species, the UADs were most effective for hoary bat. In Pennsylvania, 1.47 times (95% confidence interval [0.39, 3.42] as many mainland hoary bats were killed at wind turbines without UADs (Arnett et al. 2013). The only acoustic deterrent study in Hawaiʻi found that deterrents resulted in a significant decrease in acoustic activity (a reduction from 3,814 calls to 10), and that once the deterrents were decommissioned , acoustic activity returned to pre-installation levels (Hein and Schirmacher [2013] as cited in ESRC and DOFAW 2021).

UADs were first installed at a commercial wind facility in Hawaiʻi by Kawailoa Wind, which performed a proof-of-concept test, installing an NRG Systems (NRG) bat deterrent system on the turbine where most bat fatalities had been observed and monitoring results from July to October 2018 (Tetra Tech 2019). Monitoring included post-construction mortality monitoring with canine search teams, ground-based acoustic detectors, and thermal videography to observe the effects. No bat fatalities were observed during this test, and UADs were deployed at all wind turbines in May and June 2019.

The specific effectiveness of UADs on the Hawaiian hoary bat is not known and likely varies by site. Preliminary results from three years of monitoring at the Kawailoa Wind Project on Oʻahu with two observed bat fatalities suggests that there is a 95 percent probability that the Hawaiian hoary bat fatality rate was reduced by 47 percent or more after installation of UADs (Tetra Tech 2022a). This demonstrates that significant reductions in fatality rates using UADs may also be achieved for the Hawaiian hoary bat. However, after 2-years of monitoring at the Auwahi Wind Project, including the observation of 10 bat fatalities, the effectiveness of UADs at the Auwahi Wind Project is likely lower than at the Kawailoa Wind Project (Tetra Tech 2022b). The Kawailoa Wind Project is more comparable to this Project than the Auwahi Wind Project because it is on the same island and is adjacent to steep ridgelines and forests. However, the Kawailoa Wind Project differs from the Project in having higher rates of acoustic bat activity (Tetra Tech 2022a). The Auwahi Wind Project is on a different island with dissimilar terrain (lacks adjacent forest) than this Project and also has higher rates of acoustic activity (Auwahi Wind 2016). Therefore, given the significant reduction in take observed at the more comparable Kawailoa Wind Project, and the fact that the Project is a relatively low risk site based on low acoustic activity and the single observed fatality, the use of UADs is anticipated to reduce Hawaiian hoary bat collision risk at Project wind turbines.

2.1 Purpose

The BLNR Decision and Order specifically identifies in Special Condition 8 a requirement to contribute $100,000 toward research on deterring bats and specifies that the research shall focus on deterrence measures with the goal of reducing bat take by wind turbines. The attachment of Special Condition 8 to the Incidental Take License along with the related Special Condition 7 (a requirement to implement bat deterrent technologies that are proven economical and effective) are explained in Findings of Fact 328 – 329 of the Decision and Order, which explain that the driver of these conditions is to provide additional assurances that the mitigation described in the HCP will fully offset take (BLNR 2018). Further consultation with DOFAW to identify their research priorities helped further refine the purpose of the mitigation projects and clarify the goal of Special Condition 8, reinforcing this view. Specifically, Lauren Taylor described DOFAW's considerations and priorities for this research project in an April 2020 meeting as:

- The research should be directly applicable to the Project.
- Conducting the research on Oʻahu would be preferred.
- DOFAW had concerns about conducting the research on a different wind project
- DOFAW would require that off-island research would need to show direct applicability to the Project.

Based on this input and subsequent follow-up with Paul Radley and Koa Matsuoka, NPMPP and Tetra Tech concluded that the purpose of the research was to better understand how deterrents could be used at the Project to minimize take. Specifically, it is through the relationship of landscape variables (e.g., land use in proximity to turbines, turbine proximity to gulch, turbine proximity to forest edge) to indicators of risk (PCMM results and relative bat acoustic activity rates) that we can understand relative risk to bats from individual Project wind turbines. This will allow us to determine the most practicable locations to install deterrents. This research may also be applied to other projects in Hawaiʻi with similar variables and could help future developers site turbines to reduce risk to bats.

2.2 Agency consultation

This research project was developed in consultation with DOFAW and USFWS through meetings on April 21, 2020, May 3, 2021, and June 8, 2022. A memo describing the phased deployment of the NRG UAD system at the Project was submitted for approval to USFWS and DOFAW on April 15, 2020. The phased deployment memo identified the 4 turbines most likely to have higher bat activity levels due to their position near forest edge and gulch habitats, which have been associated with higher bat use (Tetra Tech 2020). USFWS and DOFAW approved the installation of the NRG UAD system on these 4 turbines prior to the initiation of this research project.

2.3 Project site

The Project consists of eight wind turbines[1] near the town of Kahuku, on the north shore of Oʻahu. The eight wind turbines are located on two separate parcels, four on a privately-owned parcel (TMK (1) 5-6-006:018) and four on a parcel owned by the state Department of Land and Natural Resources (DLNR; TMK (1) 5-6-008:006). Habitats on the two parcels differ, with the turbines on private land occupying mildly-sloped terrain that is interspersed with active small scale mixed-crop agricultural plots. One turbine is located on steeper terrain and is adjacent to gulches and forested habitat. The turbines on the DLNR parcel are positioned along a steep ridgeline and three of the four turbines are adjacent to forested habitat.

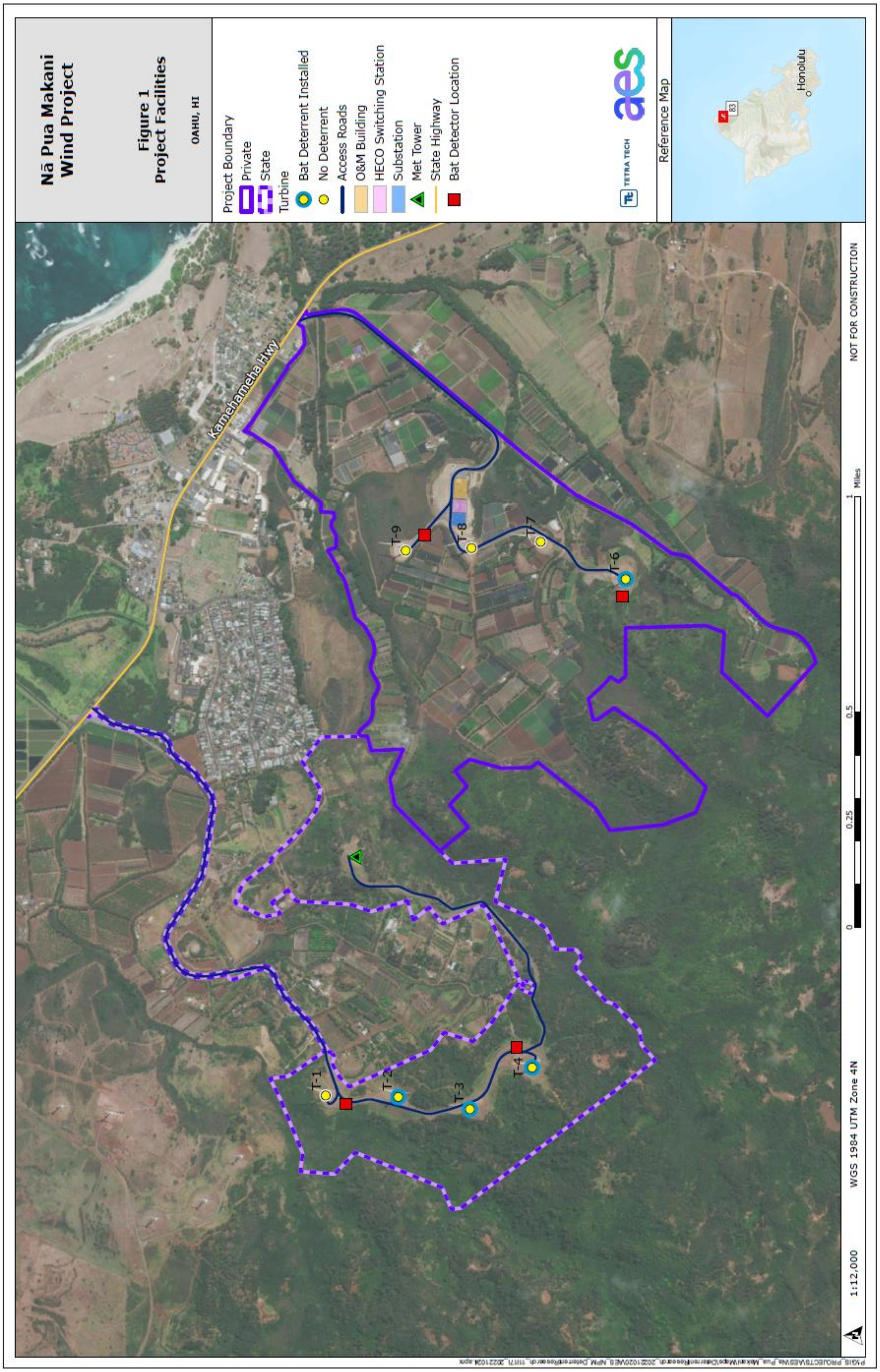
[1] The turbine specifications are 105-meter height, 173-meter maximum blade tip height, 68-meter rotor diameter.

NPMPP collects bat acoustic activity data at ground-based detectors adjacent to four Project turbines (1, 4, 6, and 9; Figure 1). These detectors have a range of approximately 50 meters where land use or slope do not interfere with the bats' acoustic signals. These four turbines were selected to provide representative information across the Project and sample a range of land use (agriculture and undeveloped) and topographical conditions. Overall bat acoustic activity has been very low averaging 2.7 percent of nights with detection in FY 2021, 6.1 percent in FY 2022, and 9.6 percent in FY 2023 (Tetra Tech 2023a); most nights with activity are represented by single detections. Bat acoustic activity is seasonal, with peak activity August – October, and the overall highest peak rate of 23 percent in August 2022 (Tetra Tech 2023a). In contrast, the Kawailoa Wind Project has peak activity rates averaging approximately 30 – 40 percent in May and July – September (Tetra Tech 2022a). At the Kahuku Wind Farm, adjacent to the Project, annual acoustic activity rates average less than 1 percent, and peak activity ratesJuly – September have never exceeded 9 percent (Tetra Tech 2022d). For comparison, both the Kawailoa and Kahuku wind farms currently utilize four acoustic detectors to document bat activity.

2.4 Technology

Based on available information UADs appear to be the most effective and commercially viable deterrent technology for the Project at this time. The NRG system proven effective at the Kawailoa Wind Project is comprised of 5 deterrent units (DU) distributed around the nacelle and directed to provide overlapping coverage around the full 360-degree rotation of the turbine blades. This overlapping coverage provides redundancy, allowing for continued functionality of the bat deterrent system even if a DU fails. These DUs and each turbine's deterrent unit controller (DUC) work together to use ultrasound to discourage bats from entering the turbine's rotor swept area.

During Project construction, NPMPP consulted with NRG to determine if the NRG bat deterrent system could be installed with the Project's Vestas V136 turbines. NRG reported that their system could be installed on these turbines and that a UAD system installation for the Project would be comprised of 6 DUs and one DUC installed at each turbine where this minimization measure was to be implemented.


Nā Pua Makani
Wind Project
Figure 1
Project Facilities
OAHU, HI
Project Boundary
Private
State
Turbine
Bat Deterrent Installed
No Deterrent
Access Roads
O&M Building
HECO Switching Station
Substation
Met Tower
State Highway
Bat Detector Location
TETRA TECH
aes
Reference Map
Honolulu
83
Kamehameha Hwy
T-1
T-2
T-3
T-4
T-6
T-7
T-8
T-9
NOT FOR CONSTRUCTION
0
0.25
0.5
1
Miles
WGS 1984 UTM Zone 4N
1:12,000

2.5 Alternative approaches

In addition to the proposed research plan (Section 3.0), NPMPP and Tetra Tech considered two alternative research options to meet the conditions identified in the ITL. NPMPP could test the efficacy of an alternative deterrent system or could strive to help refine the deployment approach for a UAD system to the Hawaiian hoary bat.

The Endangered Species Recovery Committee and DOFAW published a draft guidance document which summarizes the current status of bat deterrence technology (ESRC and DOFAW 2021). Among the options presented in this summary, ultraviolet light has shown some initial promise and would have the potential to be implemented at an existing wind project, both key considerations for an action designed to reduce risk to Hawaiian hoary bats at the existing Project.

Gorresen et al. (2015) demonstrated that dim ultraviolet light could have a deterrent effect on the Hawaiian hoary bat. However, the conclusions were weaker than those for UAD technology and testing of the technology is in its infancy with limited results and no significant measure of effect on bats, birds, or insects (Cryan et al. 2021). Besides the technology being less advanced and ready for commercial deployment, testing at a site that would provide information directly to the Project would be challenging. To push such a technology forward would require extensive testing at commercial wind farms where bat encounters are common to measure potential benefits as adjustments are made to the deterrent equipment. The low levels of bat activity at the Project would make such a study unproductive. Therefore, based on consultation with DOFAW and internal investigation, this did not appear likely to further the purpose of the research condition imposed by the BLNR.

Refining the implementation of the existing NRG bat UAD system in Hawaiʻi is not likely to be feasible at the Project alone. Fatality events have been shown to be rare, and acoustic activity in the vicinity of the turbines is low and highly seasonal, suggesting that the testing of the efficacy of adjustments are likely to require years of data collection.

3.0 Research Design and Methods

3.1 Overview

Tetra Tech identified one feasible option to advance deterrent technology in a way that can help NPMPP and regulatory agencies understand if and how to implement the technology to reduce risk to the Hawaiian hoary bat at the Project. Based on Tetra Tech's review, NPMPP and Tetra Tech decided a study at the Project to test for differences in bat activity and bat fatalities among turbines, including an analysis of potentially explanatory factors, would be the most productive approach to the research project.

The Project is uniquely situated on land with varied topography, bat activity patterns, proximity to edge habitat, and land use. These varied conditions in combination with the installation of UADs across the range of these conditions creates an experimental environment that should, over time, help elucidate patterns of bat activity and risk at the Project. The goal of this research is to directly inform decision-making on whether expansion of the UAD installation is warranted as well as contribute to the body of knowledge about the Hawaiian hoary bat. To the extent that this research helps refine an understanding of bat risk and bat activity relative to local environmental variables and bat activity patterns, the results may also be leveraged by other commercial wind projects and regulators in Hawaiʻi to assist in planning or making recommendations on appropriate minimization measures. Consistent with commitments in the HCP referenced in the ITL special condition, research results will be made publicly available.

3.2 Materials and Methods

Detectors – Hawaiian hoary bat activity at each of the Project's eight turbines will be monitored year-round using Song Meter SM4BAT-FS ultrasonic acoustic detector equipped with high frequency microphones (SMM-U2; Wildlife Acoustics, Inc., Maynard, Massachusetts), elevated 3 meters above the ground on poles and powered by 12 v/36 amp-h batteries connected to 10 w/12 v Solar Panels (ACOPOWER, Walnut California). All units will record nightly activity beginning 1 hour before sunset and end 1 hour after sunrise for at least five years or until project completion (See Section 4.0, *Project Completion*). Acoustic recordings with associated dates and times will be stored on SDXC class 10 memory cards (Western Digital, San Jose, California) in the SM4BAT-FS units. Ultrasonic acoustic detectors with a range of 50 meters are currently deployed between 61 and 91 meters from turbines 1, 4, 6, and 9 (Figure 1) as follows:

- Turbine 1- Detector is approximately 82 meters south of the turbine.
- Turbine 4- Detector is approximately 86 meters northeast of the turbine.
- Turbine 6- Detector is approximately 61 meters west of the turbine.
- Turbine 9- Detector is approximately 91 meters southeast of the turbine.

Upon approval of this research plan, an additional four acoustic detectors, which will be the same models as the ones currently installed, will be deployed at the four remaining turbines.

UAD – Four turbines are currently fitted with NRG bat UAD system (Figure 1). Each DU generates six nominal frequencies (20 kHz, 26 kHz, 32 kHz, 38 kHz, 44 kHz, and 50 kHz). NRG continues to work to refine their understanding of the sound pressure levels that are effective at deterring bats.

Fatality monitoring – The Post-construction mortality monitoring program is designed and implemented to maximize to the extent practicable the probability of detecting downed wildlife, including the Hawaiian hoary bat. Briefly, this program includes carcass searches conducted weekly throughout the year at all turbines. Searches are performed by highly trained canine search teams, covering the entire searchable portion of each search area (including areas with maintained vegetation in the vicinity of the turbines, and active agricultural areas where regular searching is feasible and safe for the canine search teams). Search teams are tested for their ability to detect carcasses, and carcasses are placed to test for the length of time that carcasses remain available to be found. Search areas used in the analysis cover approximately 70 percent of the potential carcass distribution for bats, with the remaining 30 percent being unsearchable due to safety concerns (e.g., steep terrain, the presence of aggressive dogs) or other limitations (e.g., to avoid damage to sensitive agricultural crops). Further details on the described methods for Fatality monitoring at the project are available in the Project's Post-construction Mortality Monitoring (PCMM) Implementation Plan (Tetra Tech 2023b).

Environmental Variables – To better understand how landscape features may contribute to fatality risks of bats at the Project, several habitat features will be assessed and included as variables in models predicting bat fatalities at the Project. Habitat features will include habitat type (e.g., Agriculture and Non-agricultural), distance to forest edge, and distance to gulch. Habitat features will be assessed using the most current areal imaging available and conducted using ArcGIS v10.7.0.10450 (ESRI, Redlands, California) or Google Earth Pro v7.3.3.7786 (Google, Mountain View, California).

3.3 Analysis Approach

3.3.1 Hawaiian hoary bat acoustic data

Acoustic recordings will be processed in Kaleidoscope PRO version 5.1.9 (Wildlife Acoustics, Inc., Maynard, Massachusetts) using the Bats of North America 5.1.0 AutoID classifier for Hawaiʻi. All recorded files will be verified manually by a single expert to remove all false-positive/negative identification error from the data set prior to analysis. A minimum threshold of two pulses within a single recording file will be used to confirm a positive detection. The proportion of detections per detector night will be used as a metric to quantify bat activity at the Project. A detector night is defined as any night in which the acoustic detector remained active for more than 50 percent of the anticipated recording duration. Given the low rates of bat acoustic activity patterns observed, the proportion of detections per detector night is likely to provide the most observation-rich data set through which to look at bat activity. However, collected data will include the number of feeding buzzes, number of passes, and foraging duration as well, to allow for more detailed characterization of bat behavior within the Project area. This additional behavioral data may also help elucidate patterns that are not distinguishable from the gross measure of bat acoustic activity, proportion of detections per detector night.

Hawaiian hoary bat acoustic monitoring results and 95 percent confidence intervals will be developed for each of the grouped UAD and control turbines, as well as for each individual turbine within the UAD and control groups. Based on data from the first two years of acoustic monitoring, although bat acoustic activity rates at the Project are low, there may be sufficient data to differentiate among turbines with higher and lower bat acoustic activity.

3.3.2 Fatality data

Data collected from fatality monitoring efforts will be analyzed to model annual fatality estimates (λ) and 95 percent confidence intervals for each of the grouped UAD and control sites as well as for each individual turbine within the UAD and control groups using Evidence of Absence v2.0 (EoA; Dalthorp at al. 2017).

Given results from the first two years of Project operations, fatalities are likely to be few and estimated fatality rates are not likely to show significant differences due to the rarity of events.

Both incidental and observations of fatalities during searches within the searched areas will be included in EoA analyses. Incidental fatality observations of Hawaiian hoary bats that occur outside of searched areas will not be incorporated into the EoA analysis, but will be considered to have been part of the unobserved direct take as calculated by the difference between the EoA estimate of take and the number of fatalities observed within the searched areas.

Publicly available post-construction mortality monitoring or other data from the nearby Kawailoa Wind Project and Kahuku Wind Project may allow for a parameterization of the fatality model at the Project using observed fatality risk from these two projects with more operational history.

3.3.3 Statistical analysis

All statistical tests will be two-tailed, employed an α value of 0.05, and will be conducted using R statistical software v4.05 (R Core Team 2017). UAD and control group fatality estimates will be tested for differences. Generalized linear models (GLMM) will be constructed with the 'stats' package to assess how bat activity (detection rates, feeding buzzes, number of passes, and foraging duration) and environmental variables (habitat type, distance to forest edge, and distance to gulch) effect fatality estimates at UAD and control sites (Thompson et al. 2017, MacGregor and Lemaître 2020, Moustakas et al. 2023). The general model can be framed as:

$$\lambda \sim habitat+distance\ to\ forest+bat\ activity+(ID\backslash random)$$

To the extent practicable, NPMPP will explore how publicly available post-construction mortality monitoring data, bat activity data, and environmental variables at the Kawailoa and Kahuku wind projects may be used to parameterize the fatality model. However, there are likely to be significant challenges to developing a dataset that informs risk from these two projects:

- The lack of agricultural crops in the vicinity of the Kawailoa and Kahuku wind projects,
- Potential challenges in the comparability and availability of bat acoustic data among the three projects, and
- The similarity of landscape features within the Kawailoa and Kahuku wind projects

These conditions likely limit the feasibility of characterizing individual turbines with full sets of data and the scale of differences in variable values among turbines. These constraints will likely limit NPMPP's ability to discern patterns associated with the bat activity and environmental variables identified.

3.4 Expected Outcomes

NPMPP expects results from this research project to achieve the following:

- Improve understanding of how various environmental and bat activity variables affect risk to bats at the Project
- Inform decisions regarding the installation of the UAD system on additional turbines at the Project

- Add to the body of knowledge regarding the potential benefits and effectiveness of UAD systems in Hawaiʻi.

4.0 Project Completion

The research will be considered to have been successfully completed upon fulfillment of the criteria under either Option 1 or Option 2:

- Successful implementation Option 1:
    - NPMPP has satisfied DOFAW and USFWS that UADs are not increasing risk to bats at the Project and DOFAW and USFWS have authorized NPMPP to install a UAD system on all Project turbines; and
    - NPMPP has installed the UAD system on all Project turbines and confirmed they are all working as intended.
- Successful implementation Option 2:
    - NPMPP has analyzed data during the five-year study period, and power analyses suggest there is insufficient variability in monitored parameters to anticipate statistically significant explanatory results over the remainder of the ITP and ITL term.
    - NPMPP will consult with DOFAW and USFWS to determine whether it is appropriate to remove the deterrents from the Project turbines or otherwise alter the deterrent program.
- Continued commitments under options 1 or 2:
    - NPMPP will annually explore the results of the research to assess if turbines with installed UADs have unexplained significant differences in take in comparison to control turbines.
    - Should results suggest statistically significant differences in take have occurred or are occurring, NPMPP will report this finding and consult with USFWS and DOFAW, as appropriate.

5.0 Budget

The budget for the deterrent study described in this document is provided in Table 1. The four UADs were installed prior to initiation of the Project, however UAD maintenance and replacement is necessary regularly throughout each year of operation. Therefore, the costs to maintain the UADs during the life of this Project is counted towards the budget. Annual UAD maintenance and replacements includes the costs to replace the DUs and DUCs, and the cost of personnel to maintain and monitor the bat deterrent system during the 5-year Project. Costs are based on the frequency of DU and DUC replacement during operation of the system (2019 – 2023) and the current cost of replacement parts.

Table 1. Deterrent Study Budget

Category	Quantity	Unit/Annual Cost	Total Cost
Monitoring Equipment			
Bat acoustic monitors[1]	4 units	$1,700	$6,800
Deterrent Equipment Maintenance and Replacement			
UAD system	5 years[2]	$32,500	$162,500
Staff time	5 years[2]	$5,000	$25,000
Analysis and Reporting			
Supplemental bat acoustic data analysis	5 years[2]	$4,800	$24,000
Supplemental statistical analysis	5 years[2]	$2,000	$10,000
Supplemental reporting	5 years[2]	$3,600	$18,000
Total			**$246,300**

1. Microphones replaced annually.
2. Annual costs; assumed 5 years of study.

6.0 Schedule

Table 2 provides an implementation schedule for the deterrent research plan.

Table 2. Deterrent Study Schedule

<table>
<tr><th>Study Year</th><th>Actions</th><th>Reporting</th></tr>
<tr><td>Year 1</td><td>• Purchase and install bat acoustic monitors for four turbines without monitors
• Continuous PCMM and acoustic monitoring throughout the year (PCMM is required separately under the HCP)
• Develop datasets with publicly available fatality monitoring, publicly bat acoustic monitoring data, and environmental variables for the Kahuku and Kawailoa wind projects to parameterize risk model
• Perform statistical analyses as outlined in Section 3.3
• In consultation with USFWS and DOFAW, consider installation of UAD systems on turbines without deterrents, as warranted</td><td rowspan="5">Prepare a separate report summarizing results. Report will be included as an appendix to the HCP annual report.</td></tr>
<tr><td>Year 2</td><td>• Continuous PCMM and acoustic monitoring throughout the year (PCMM is required separately under the HCP)
• Perform statistical analyses as outlined in Section 3.3
• In consultation with USFWS and DOFAW, consider installation of UAD systems on turbines without deterrents, as warranted</td></tr>
<tr><td>Year 3</td><td>• Continuous PCMM and acoustic monitoring throughout the year (PCMM is required separately under the HCP)
• Perform statistical analyses as outlined in Section 3.3
• In consultation with USFWS and DOFAW, consider installation of UAD systems on turbines without deterrents, as warranted</td></tr>
<tr><td>Year 4</td><td>• Continuous PCMM and acoustic monitoring throughout the year (PCMM is required separately under the HCP)
• Perform statistical analyses as outlined in Section 3.3
• In consultation with USFWS and DOFAW, consider installation of UAD systems on turbines without deterrents, as warranted</td></tr>
<tr><td>Year 5</td><td>• Continuous PCMM and acoustic monitoring throughout the year (PCMM is required separately under the HCP)
• Perform statistical analyses as outlined in Section 3.3
• In consultation with USFWS and DOFAW, consider installation of UAD systems on turbines without deterrents, as warranted</td></tr>
</table>

7.0 References

Arnett E.B., C.D. Hein, M.R. Schirmacher, M.M.P. Huso, and J.M. Szewczak. 2013. Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. PLOS ONE 8(9): 10.1371/annotation/a81f59cb-0f82-4c84-a743-895acb4b2794. https://doi.org/10.1371/annotation/a81f59cb-0f82-4c84-a743-895acb4b2794

Auwahi Wind (Auwahi Wind Energy, LLC). 2016. Auwahi Wind Farm Habitat Conservation Plan FY 2016 Annual Report. https://dlnr.hawaii.gov/wildlife/files/2013/10/Auwahi-HCP-Annual-Report-FY16_083116_complete.pdf

BLNR (Board of Land and Natural Resources—State of Hawai‘i). 2018. Case No. BLNR-CC-17-001. Findings of Fact, Conclusions of Law, and Decision and Order.

Cryan, P.M., P.M. Gorresen, B.R. Straw, S. Thao, and E. DeGeorge. 2021. Influencing activity of bats by dimly lighting wind turbine surfaces with ultraviolet light. Animals 2022, 12, 9. https://doi.org/10.3390/ani12010009

Dalthorp, D., M. Huso, and D. Dail. 2017. Evidence of Absence (v2.0) Users Guide: U.S. Geological Survey Data Series 1055 109 p., https://pubs.usgs.gov/ds/1055/ds1055.pdf

ESRC (Endangered Species Recovery Committee) and DOFAW (State of Hawai‘i Department of Land and Natural Resources Division of Forestry and Wildlife). 2021. Hawaiian Hoary Bat Guidance for Renewable Wind Energy Proponents. https://dlnr.hawaii.gov/wildlife/files/2021/01/Draft-Hawaiian-Hoary-Bat-Guidance-Document_011321.pdf

Hein, C.D. and M.R. Schirmacher. 2013. Preliminary field test of an ultrasonic acoustic deterrent device with the potential of reducing Hawaiian hoary bat (*Lasiurus cinereus semotus*) fatality at wind energy facilities. Unpublished report submitted to First Wind, Portland, ME by Bat Conservation International, Austin, TX.

MacGregor, K.A. and J. Lemaître. 2020. The management utility of large-scale environmental drivers of bat mortality at wind energy facilities: The effects of facility size, elevation and geographic location. Global Ecology and Conservation, Volume 21. https://doi.org/10.1016/j.gecco.2019.e00871

Moustakas, A., P. Georgiakakis, E. Kret, and E. Kapsalis. 2023. Wind turbine power and land cover effects on cumulative bat deaths. Science of the Total Environment. Volume 892. https://doi.org/10.1016/j.scitotenv.2023.164536

R Core Team. 2017. R: A Language and Environment for Statistical Computing. https://www.R-project.org/

Romano, B.W., J.R, Skalski, R.L. Townsend, K.W. Kinzie, and K.D. Coppinger. 2019. Evaluation of an acoustic deterrent to reduce bat mortalities at an Illinois wind farm. Wildlife Society Bulletin. Volume 43, Issue 4. Pages 608-618. **https://doi.org/10.1002/wsb.1025**

Tetra Tech (Tetra Tech, Inc.). 2019. Kawailoa Wind Project Habitat Conservation Plan FY 2019 Annual Report. Prepared for Kawailoa Wind, LLC. https://dlnr.hawaii.gov/wildlife/files/2020/01/Kawailoa-HCP-FY-2019-Annual-Report-Final-1.pdf.

Tetra Tech. 2020. Nā Pua Makani Wind Energy Project bat acoustic deterrent installation and research plan options. Prepared April 2020.

Tetra Tech. 2022a. Kawailoa Wind Project Habitat Conservation Plan FY 2022 Annual Report. Prepared for Kawailoa Wind, LLC. https://dlnr.hawaii.gov/wildlife/files/2022/12/Kawailoa-HCP-FY2022-Annual-Report_22DEC2022_final.pdf

Tetra Tech. 2022b. Auwahi Wind Farm Habitat Conservation Plan FY 2021 Annual Report. Prepared for Auwahi Wind Energy, LLC. https://dlnr.hawaii.gov/wildlife/files/2022/12/RevisedDraft-Auwahi-Wind-FY2022-HCP-annual-report-_compiled.pdf

Tetra Tech. 2022c. Kahuku Wind Power Habitat Conservation Plan FY 2022 Annual Report. https://dlnr.hawaii.gov/wildlife/files/2022/12/Kahuku-Wind-FY-2022-Annual-HCP-Report-FINAL.pdf

Tetra Tech. 2023a. Nā Pua Makani Wind Energy Project Habitat Conservation Plan FY 2023 Annual Report. In Prep. Prepared for Nā Pua Makani Power Partners.

Tetra Tech. 2023b. Nā Pua Makani Wind Project post-construction mortality monitoring implementation plan. Revision submitted September 2023.

Thompson M, J.A. Beston, M. Etterson, J.E. Diffendorfer, and S.R. Loss. 2017. Factors associated with bat mortality at wind energy facilities in the United States. Biol Conserv. 2017;215:241-245. doi: 10.1016/j.biocon.2017.09.014. PMID: 31048934; PMCID: PMC6490962.

Weaver, S. and I. Castro-Arellano. 2019. Studying behavior and testing strategies to reduce impact of wind energy on bats in Texas. Final Performance Report. Prepared for the State Wildlife Grant Program, Texas.

Weaver, S., C. Hein, T. Simpson, J. Evans, and I. Castro-Arellano. 2020. Ultrasonic acoustic deterrents significantly reduce bat fatalities at wind turbines. Global Ecology and Conservation 24 (2020) e01099.