APPENDIX E

Wēkiu Bug Monitoring Plan

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APPENDIX E WĒKIU BUG MONITORING PLAN

Errata Sheet
July 28, 2004

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APPENDIX E WĒKIU BUG MONITORING PLAN
ERRATA

12. Section 3.1 – Introduction (page Effectiveness Monitoring - 1). The following is added after the last paragraph in this section:

NASA and CARA will implement the Wēkiu Bug Monitoring Plan, and restored habitats will be monitored quarterly by a qualified entomologist for 18 months following completion of the proposed habitat restoration to determine if the Wēkiu bug reestablishes in those areas. Monitoring of Wēkiu Bug populations shall continue biannually for no less than five (5) years following completion of the construction of the Outrigger Telescopes, and on an annual basis thereafter for the term of the CDUP. Additionally, efforts will be made to reduce the field study mortality of Wēkiu bugs to less than forty percent (40%). Progress reports on the efforts to reduce the field study mortality rate and monitoring results shall be submitted biannually to the Department of Land and Natural Resources, the Office of Mauna Kea Management, and the Bishop Museum for no less than five (5) years following completion of construction of the Outrigger Telescopes, and on an annual basis thereafter for the term of the CDUP.

13. Section 3.3 – Population Change Module; Question of Interest 3.3.1, Sampling Systems (page Effectiveness Monitoring – 3 - 4),

a. Sampling Intensities, 3.3.1A1 and 3.3.1B1) is changed to read:

3 pitfall traps in each location of restored habitat.

b. Sampling Frequencies, 3.3.1A all and 3.3.1B all) the text within the parentheses is deleted:

14. Section 3.3 – Population Change Module; Reporting: 3.3.1A all and 3.3.1B all) (page Effectiveness Monitoring - 4). The first part of the sentence is changed to read:

Include in all Quarterly, Biannual, and Annual reports,

15. Section 3.3 – Population Change Module; Question of Interest 3.3.2, Reporting System: 3.3.2A all and 3.3.2B all) (page Effectiveness Monitoring - 7). The first part of the sentence is changed to read:

Include in all Quarterly, Biannual, and Annual reports,

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WĒKIU BUG MONITORING PLAN

Prepared for the Outrigger Telescopes Project

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OVERVIEW

1.1 - EXECUTIVE SUMMARY

The Mauna Kea Science Reserve is located on the summit of the tallest mountain in Hawai'i, (13,796 feet). Within the reserve are the world's two largest optical telescopes, constituting the W. M. Keck Observatory (WMKO). Directly adjacent to and below the WMKO is a unique natural environment that supports the Wēkiu bug, a rare insect found only in the extreme habitat of the Mauna Kea summit.

Current plans call for expanding the Keck Observatory by adding four Outrigger telescopes. These new telescopes will enhance the capabilities of telescopes by using a technique known as interferometry.

The National Aeronautics and Space Administration (NASA), through the Jet Propulsion Laboratory (JPL), together with the California Association for Research in Astronomy (CARA) and the University of Hawai'i Institute for Astronomy (IfA), have made a commitment to protect and enhance Wēkiu bug populations and habitat concurrently with construction of the new Outrigger Telescopes. To that end these collaborators have sponsored a Wēkiu Bug Mitigation Report from which they developed the Wēkiu Bug Mitigation Plan. They are also the sponsors of this Wēkiu Bug Monitoring Plan. Monitoring will help to assure all stakeholders that mitigation activities associated with the new construction will be beneficial to this rare insect.

Environmental monitoring is the scientific investigation of the changes in environmental phenomena that happen over time. This Wēkiu Bug Monitoring Plan describes the procedures necessary to implement an investigation of changes in Wēkiu Bug population and habitat adjacent to the WMKO during and after Outrigger Telescope construction.

This Monitoring Plan includes an Overview of Monitoring, (Section 1). Comprehensive discussions of the monitoring Questions of Interest are divided into Compliance and Effectiveness, (Sections 2 and 3). Data management, analysis, and reporting of monitoring findings are discussed in Section 4. A schedule may be found in Section 5. Protocols for data gathering are in Section 6.

1.2 - INTRODUCTION

The summit of Mauna Kea, on the Big Island of Hawai'i, is home to the largest observatory complex in the world. The summit is also home to unique plants and animals, including the Wēkiu bug. One of the principle habitats of this rare insect is directly adjacent to and below the Pu'u Hau Oki crater rim site of the W. M. Keck Observatory (WMKO).

This Monitoring Plan was developed to aid in protection and enhancement of the Wēkiu bug population. This Plan is consistent with the goal of good stewardship of the natural environment on the summit of Mauna Kea. The National Aeronautics and Space Administration, through the Jet Propulsion Laboratory, is the sponsor of this Monitoring Plan. The University of Hawai'i, the Institute for Astronomy, and the California Association for Research in Astronomy have provided significant assistance and collaboration.

Outrigger telescopes have been proposed as an addition to the WMKO. As part of that expansion project, three conservation programs have been recommended: mitigation, monitoring, and autecological studies.

Environmental mitigation is the protection and enhancement of natural resources. The Wēkiu Bug Mitigation Report, published under separate cover, recommends a mitigation program that will protect the Wēkiu bug population within Pu'u Hau Oki crater, and restore some of the habitat lost there in the past.

Environmental monitoring is the scientific investigation of the changes in environmental phenomena, attributes and characteristics that happen over time. Ecosystems are dynamic. Habitat conditions change daily, seasonally, and over longer periods of time. Animal and plant populations rise or fall in response to a host of environmental fluctuations. The general purpose of monitoring is to detect, understand, and predict the environmental changes.

JPL, NASA, CARA, and the IfA have made a commitment to do no harm to the Wēkiu bug population during the proposed construction and operation of the Outrigger Telescopes. In order to accomplish this, observatory planners and managers need scientific and reliable information about the Wēkiu bug, about the impacts of management actions to the habitat, and about changes in the population over time. Environmental monitoring is the best way to obtain that information.

This Monitoring Plan proposes methods for investigation of results of actions undertaken in the Mitigation Program, and the subsequent changes in the Wēkiu bug population and habitat. Two types of monitoring are necessary: compliance and effectiveness monitoring. This Plan specifies tasks, budgets, schedules, and methods for both types of monitoring. Compliance monitoring investigates the extent to which contractors, operators, managers, and visitors comply with Wēkiu bug protection guidelines and rules. Effectiveness monitoring investigates the changes in Wēkiu bug habitat and population that happen concurrently and subsequently to construction of the Outrigger telescopes. This includes monitoring of habitat restoration efforts.

The Monitoring Program will provide much of the data needed to protect and enhance natural resources, to modify management actions, to aid in compliance with environmental statutes, and to enhance public education and appreciation of the natural resources at the summit of Mauna Kea.

Monitoring alone, however, will not provide all the desired information about the Wēkiu bug. Additional autecological studies are also recommended. Autecology is the study of the patterns of distribution and abundance of individual species, together with the ecosystem structure and functions that influence distribution and abundance.

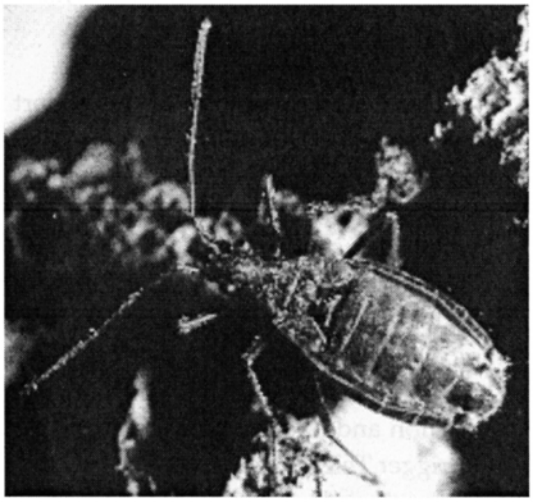


Figure 1 - 1. The Wēkiu bug, *Nysius wekiuicola*, native to the summit area of Mauna Kea. *Photo courtesy W.P. Mull.*

The three conservation programs, mitigation, monitoring, and autecological studies, together will provide the framework for protecting and enhancing the Wēkiu bug habitat and population on Mauna Kea. Lessons learned during the Outrigger Telescopes project will aid conservation efforts elsewhere on the summit, within the greater Mauna Kea Science Reserve, and on other mountaintops in Hawai'i.

1.3 - OBJECTIVES

The general objective of this report is to describe a Monitoring Program that aids in the protection and enhancement of the Wēkiu bug population and habitat adjacent to the W. M. Keck Observatory. The Monitoring Program will investigate the human activities and associated changes that occur to Wēkiu bug population and habitat during construction and operation of the proposed Outrigger Telescopes.

The Monitoring Plan is presented in sections and subsections. In the next subsection, 1.4 - Systematic Monitoring, we discuss the steps necessary to plan and implement monitoring. These steps apply to all the Questions of Interest (QOI's).

In the following two main sections, Section 2 – Compliance Monitoring, and Section 3 – Effectiveness Monitoring, we describe each recommended QOI in detail. The Compliance and Monitoring Sections are organized into modules:

Section 2 - Compliance Monitoring
- 2.1 Introduction
- 2.1 Listing of QOI's
- 2.3 Habitat Restoration Module
- 2.4 Slope Stability Module
- 2.5 Dust Module
- 2.6 Hazardous Materials Module
- 2.7 Trash Module
- 2.8 Alien Arthropods Module

Section 3 - Effectiveness Monitoring
- 3.1 Introduction
- 3.2 Listing of QOI's
- 3.3 Population Change Module
- 3.4 Habitat Module

This organizational structure allows for addition or deletion of component QOI's. As new knowledge is acquired about the Wēkiu bug, some QOI's may be satisfactorily answered and removed from the Program. New knowledge may also lead to new QOI's that can be added. In this way, the Monitoring Program is adaptable to new findings, needs, and conditions.

Discussions of data management, analysis, and reporting may be found in Section 4 - Results. A schedule for the Monitoring Program is given in Section 5 - Schedule and Budget. Protocols for data gathering are in Section 6 – Protocols.

1.4 - SYSTEMATIC MONITORING

Environmental monitoring is the investigation of the changes in environmental phenomena, attributes and characteristics that happen over time.

An investigation concerned only with measuring environmental phenomena, attributes, and characteristics at a single point in time is called an inventory. Monitoring is a series of inventories taken over time, repeated measurements taken in such a way as to be comparable with each other. Systematic monitoring is a monitoring program that follows a specified progression of tasks or steps to maximize the efficiency and utility of the investigation.

The Purposes of Monitoring

The most general purpose of environmental monitoring is to learn about the changes occurring in our natural world. This purpose may be subdivided into three more specific goals: to detect, predict, and understand those changes. Not all monitoring programs have all three of these goals, but all have at least one of them.

Every monitoring program has its own set of unique purposes, as well. These are usually one or more of the following, ranked in general order of increasing complexity and sophistication:

- To detect threshold events, or critical levels, of environmental phenomena, attributes, and characteristics.

- To detect specific changes in the environment.

- To detect hazards and risks to valued ecosystem attributes and functions and/or to the human communities that depend on them.

- To provide historical records of change in environmental phenomena, attributes, and characteristics.

- To detect trends, periodicities, cycles, and/or other patterns in those changes.

- To associate auxiliary phenomena, attributes, and characteristics with trends and patterns of change in key phenomena, attributes, and characteristics.

- To predict future changes in environmental phenomena, attributes, and characteristics.

- To link environmental changes to their causes.

Different monitoring programs may have different sets or combinations of these purposes. Clarity of purpose is important in planning monitoring programs. The more complex and sophisticated goals of establishing associations and cause-and-effect relationships typically require significantly more effort and expense than simple detection of change.

All these purposes of environmental monitoring involve increasing our knowledge and understanding. A closely related purpose of monitoring is to modify management actions. The new knowledge gained through monitoring should be useful in evaluating past environmental treatments and in directing new treatments, management actions, and other human influences. The ultimate goal of environmental management is good stewardship. Monitoring should inform stewardship efforts and help us to protect and enhance the natural world.

The Systematic Approach

We have identified the following seven-step process for planning of environmental monitoring:

1. Prepare clear statements of the important Questions of Interest (QOI's).

2. Design the sampling systems.

3. Develop sampling protocols for data collection.

4. Prepare the data management systems.

5. Plan the analysis and interpretation systems.

6. Develop a reporting system.

7. Develop a monitoring sustainability plan.

Each of these seven steps must be undertaken and completed to develop a successful monitoring program. The steps must be undertaken in a comprehensive manner. Planning decisions made in any one stage affect decisions at all the other stages.

Each QOI, (described in the Compliance Monitoring and Effectiveness Monitoring sections of this Plan), has been quantified, prioritized, and evaluated in accord with the seven planning steps.

1. Prepare clear statements of the QOI's.

The first step in developing this Monitoring Plan required clearly defining the QOI's. Key questions are those with answers that can be efficiently estimated and that yield the information necessary for management decision-making. The Monitoring Program depends upon identification of the important issues and concerns, and reducing general problems to questions of specific, measurable factors. Much future effort will be spent investigating the QOI's. Among those will be compliance checks to ensure that mitigation guidelines are followed. The QOI's also include measurement of Wēkiu bug population changes and changes in habitat characteristics, to be examined for relationships to natural phenomena (weather/climate) and human activities at the summit.

2. Design the sampling systems.

The second step in developing this Monitoring Plan was designing the sampling systems. Proposed questions of interest were prioritized, based on the projected costs of collecting the data and the projected value of the knowledge to be gained. Expertise in statistics, biometrics, and cost / benefit analysis was required for sampling system design. Some of the design techniques that were applied are power analysis, cost allocation analysis, sampling structure determinations, sample size determinations, scale evaluations, randomization, replication, blocking, and covariate determinations. Schedules of sampling efforts were also developed. Monitoring is the investigation of change over time, so planning the frequency and timing of sampling was an essential element in the sampling system design.

3. Develop sampling protocols for data collection.

The third step in developing this Monitoring Plan was creating the data collection systems. Sampling protocols are necessary to standardize data collection. Data gathered in the future must be comparable to data gathered today to statistically detect significant environmental changes. The protocols include specific methods to be used for each QOI, descriptions of the tools necessary for data collection, and randomization schemes for determining trap placement or measurement device location. Some of these protocols have been field-tested to assure feasibility and efficiency. Nondestructive sampling techniques have been recommended.

4. Prepare the data management systems.

The fourth step in developing this Monitoring Plan was the preparation of a data management plan. The data collected in each sampling exercise will be checked for errors and corrected. Data sets will be entered into a database for easy access and retrieval. Monitoring requires comparisons of attributes over lengthy periods of time. The database must be properly archived to be retrievable many years in the future.

It is important to recognize that data sets are expensive to obtain, and hence have significant monetary value. Not only will the archived data contribute information for future management decisions in the vicinity of Pu'u Hau Oki, they will also provide information potentially useful for natural resource management elsewhere on the Mauna Kea summit and on other mountaintops in Hawai'i.

5. Plan the analysis and interpretation systems.

The fifth step in developing this Monitoring Plan was the development of an analysis and interpretation plan. Statistical analysis and scientific interpretation are necessary to produce logical inferences and new knowledge from monitoring data. Techniques of exploratory data analysis (EDA), graphics, statistical distribution tests, data transformations, and modeling are described in this Plan.

Much of the information gained through monitoring will be evaluated by means of mathematical models. Such models include time trend analysis, survival analysis, growth and mortality models, and population change models. The appropriate model forms are specified for each QOI. These include the environmental parameters to be estimated, inferential strength measures appropriate to each QOI, and methods of biological interpretation.

6. Develop a reporting system.

The sixth step in developing this Monitoring Plan was the development of a plan for reporting the results. The new knowledge acquired through monitoring will be communicated to responsible parties and agencies, including JPL, NASA, CARA, the IfA, and other groups. Charts, tables, and maps may be the immediate products of analysis, but they will not stand alone. Associated reports will be clearly written, with consideration of the intended audience and the appropriate application of the findings. The reports will clearly explain the results of data analysis and the implications to natural resource management. Monitoring

reports will be produced according to the schedules specified for each QOI.

7. Develop a monitoring sustainability plan.

The seventh step in developing this Monitoring Plan is consideration of monitoring sustainability. Institutional commitment from stakeholders must be developed to secure annual budgetary planning for future monitoring efforts. Monitoring happens in the context of time. Environmental changes, and trends in those changes, are often detected only after several years of data collection. The individuals, groups and agencies concerned with management of the Mauna Kea summit must consider the Monitoring Program to be a permanent fixture in future budgets. Involving other stakeholders, such as the Hawai'i Department of Land and Natural Resources, the US Fish and Wildlife Service, native Hawaiian groups, environmental groups, and concerned citizens will help to build community commitment to the program.

Figure 1 - 2. Mauna Kea summit in winter. *Photo by D.A. Swanson, courtesy US Geological Survey.*

COMPLIANCE MONITORING

2.1 - INTRODUCTION

Compliance monitoring studies the extent to which contractors, operators, managers, and visitors comply with Wēkiu bug protection guidelines and rules. This Compliance Monitoring section is based on the twenty Recommendations made in the Wēkiu Bug Mitigation Report (under separate cover). CARA developed the Wēkiu Bug Mitigation Report based on this report and the Recommendations contained therein. Monitoring for compliance with guidelines will give the operators, oversight agencies, and the public the information necessary to ensure that natural resources are protected during the Outrigger Telescopes project.

This Compliance Monitoring Section is organized into eight modules:

2.1 Introduction
2.1 Listing of QOI's
2.3 Habitat Restoration Module
2.4 Slope Stability Module
2.5 Dust Module
2.6 Hazardous Materials Module
2.7 Trash Module
2.8 Alien Arthropods Module

More Questions of Interest (QOI's) may be added, or some deleted, if and when desired. The Monitoring Program is thus adaptable to new conditions and findings.

Each Module contains a comprehensive discussion of each of the associated QOI's, including justification, monitoring goals, sampling systems, sampling protocols, analysis and interpretation, and reporting.

Subsections on data analysis, data management and reports may be found in Section 4 – Results. Reports called for in this Monitoring Plan include Quarterly Reports during construction, a synthesis report upon Construction Completion, and a Post-Construction Report one year following completion. Special reports for some QOI's are also planned. The more complex sampling protocols may be found in Section 6 - Protocols.

Many of the QOI's include the general question of "when". It should be noted that, for the purposes of this Monitoring Program, initial conditions are those that will be found when the first inventories are performed, not the conditions estimated or hypothesized to have existed prior to this project.

2.2 - LISTING OF THE COMPLIANCE MONITORING QUESTIONS OF INTEREST

2.3 - Habitat Restoration Module

2.3.1 What type of habitat restoration has occurred, (final designs, installation procedures followed), where has habitat been restored, (location, dimension), and when, (dates, progress)?

2.4 - Slope Stability Module

2.4.1 What kind of temporary and permanent barriers have been installed to prevent disturbance to Wēkiu bug habitat in Pu‘u Hau Oki crater, (final designs, installation procedures followed), where have they been installed (location, dimension), and when were they installed (dates, progress)?

2.4.2 Where, when, and in what quantities has cinder been accidentally side-cast into Wēkiu bug habitat in Pu‘u Hau Oki crater?

2.4.3. Where, when, and in what quantities has snow or ice (accumulated by plowing) been side-cast into Wēkiu bug habitat in Pu‘u Hau Oki crater?

2.4.4 Where, when, what kind, and how many educational signs, (placed to discourage pedestrian traffic in Wēkiu bug habitat in Pu‘u Hau Oki crater), have been installed?

2.5 - Dust Module

2.5.1 Where, when, and in what quantities has water been applied to excavation sites and cinder stockpiles created by earthmoving activities?

2.5.2 Where and when have dust-generating activities been suspended, (to prevent dust from being blown into Wēkiu bug habitat in Pu‘u Hau Oki crater)?

2.5.3 Where and when have excavated materials and cinder stockpiles been covered, (to prevent dust from being blown into Wēkiu bug habitat in Pu‘u Hau Oki crater)?

2.5.4 Where, when, and in what quantities have soil-binding compounds been used?

2.6 - Hazardous Materials Module

2.6.1 Where, when, and in what quantities have chemicals been used for washing observatory mirrors? Have all regulatory guidelines been followed, including the proper disposal of associated compounds, tools, and containers?

2.6.2 Where, when, and in what quantities have contractors used paints, thinners, and solvents on-site? Have all regulatory guidelines been followed, including the proper disposal of associated compounds, tools, and containers?

2.6.3 Where, when, and in what quantities have spills of hazardous materials occurred? In the case of spills, have all regulatory guidelines for spill cleanup been followed?

2.7 - Trash Module

2.7.1 Where and when have roll-off trash containers been tightly covered, (or uncovered)?

2.7.2 Where and when have construction materials stored at the site been covered with tarps, or anchored in place to prevent movement by wind (or left uncovered and/or unsecured)?

2.7.3 What kind of outdoor trash receptacles have been installed to prevent trash from being blown into Wēkiu bug habitat in Pu‘u Hau Oki crater, where have they been installed, and when were they installed?

2.7.4 Where, when, what kind, and in what quantities have construction materials and other trash been blown into Wēkiu bug habitat in Pu‘u Hau Oki crater? Where, when, and what methods have been used to collect construction materials and other trash blown into Wēkiu bug habitat in Pu‘u Hau Oki crater?

2.8 - Alien Arthropod Module

2.8.1 Where and when have ants been detected at storage yards and staging areas, and what eradication actions have been taken?

2.8.2 Where and when have alien arthropods, or soil, dirt, or vegetation capable of harboring alien arthropods, been found on earth-moving equipment? When has earth-moving equipment been pressured-washed (to remove alien arthropods) before being moved to the construction site?

2.8.3 Where and when have large trucks, tractors, other vehicles, and construction materials been inspected before being transported to the summit? Have any alien arthropods been found in those inspections? Where, when, and what actions have been taken to eradicate any alien arthropods found in those inspections?

2.8.4 Where and when have shipping crates and boxes been inspected for spider webs, egg masses, and other signs of alien arthropods before being transported to the summit? Have any alien arthropods been found in those inspections? Where, when, and what actions have been taken to eradicate any alien arthropods found in those inspections?

2.8.5 Where, when, and in what quantities have alien arthropods been found at the WKMO observatory site? Where, when, and what actions have been taken to eradicate any alien arthropods found in those inspections?

2.3 - Habitat Restoration Module

Question of Interest 2.3.1

What type of habitat restoration has occurred, (final designs, installation procedures followed), where has habitat been restored, (location, dimension), and when, (dates, progress)?

Justification:

Habitat restoration areas will provide new habitat for Wēkiu bugs in areas damaged or disturbed by new or prior observatory construction activities, (see Recommendations IV-1 and IV-2 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To provide an historical record of Wēkiu Bug habitat restoration activities. See also Effectiveness Monitoring, Habitat, and Population.

Sampling System:

Sampling Measurements

2.3.1A) Professional review of plans prior to installation of the restored habitat. Engineers and entomologists will review proposed locations, designs, and construction procedures to insure that the restoration will have a high likelihood of recreating and restoring favorable Wēkiu bug habitat.

2.3.1B) Measurements during construction of restored areas.

1) Size distribution of screened and washed cinder used.
2) Locations, including spatial extent of site preparation and installation activities, as well as final size of restored areas.

2.3.1C) Measurements following construction of the restored areas.

1) Depths of installed screened and washed cinder.
2) Porosity of installed screened and washed cinder. Note: porosity is the percentage, by volume, of voids divided by the total volume of materials installed.

Sampling Intensities

2.3.1A) 100% review

2.3.1B1) Prior to installation count the number of rocks or rock fragments by diameter class (screen size) from a random sample of the screened and washed cinder to be used for habitat restoration. One twentieth of one percent (0.05%) of the material will be measured, (1 cubic foot measured per 2,000 cubic feet of screened and washed cinder). If screening and washing procedures are altered during construction, additional measurements should be made. Sampling target: 10 samples, 0.5 cu. ft. each.

2.3.1B2) After installation locate perimeter points every 20 feet around the restored areas. Locations should be accurate to ± 2 feet relative to fixed reference points, such as existing building corners or survey monuments. Sampling target: 15-20 located perimeter points, suitable for mapping the areas.

2.3.1C1) Measure depth of installed cinder ± 1 inch on a randomly located 20'x20' grid, (one measurement per 400 square feet of installed habitat mitigation structures or restored areas). Sampling target: 10 cinder depth measurements.

2.3.1C2) Measure porosity of installed screened and washed cinder. One twentieth of one percent (0.05%) of the installed material will be measured, (1 cubic foot measured per 2,000 cubic feet of screened and washed cinder). Sampling target: 10 samples, 1 cu. ft. each.

Sampling Frequencies

2.3.1A) Once, prior to restored habitat installation.

2.3.1B all) Once, during restored habitat installation. If procedures or locations are altered during installation, or repeated in new locations, measurements B1, B2, and B3 may need to be repeated.

2.3.1C all) Once, immediately after installation. If procedures or locations are altered during installation, or repeated in new locations, measurements C1, and C2 may need to be repeated.

Sampling Protocol: See Protocols, Habitat

Data Management: See Results, Data Management

Analysis and Interpretation:

2.3.1B1) Histogram

2.3.1B2) Map (GIS)

2.3.1C1) Mean, range, variation. Map point measurements (GIS)

2.3.1C2) Mean, range, variation. Map point measurements (GIS)

Reporting:

2.3.1A) Written review of habitat restoration plans, delivery prior to initiating installation.

2.3.1B all) Written report, within two months after installation.

2.3.1C all) Written report, within two months after installation. Include in Post Construction Report.

2.4 - SLOPE STABILITY MODULE

Question of Interest 2.4.1

What kind of temporary and permanent barriers have been installed to prevent disturbance to Wēkiu bug habitat in Pu'u Hau Oki crater, (final designs, installation procedures followed), where have they been installed (location, dimension), and when were they installed (dates, progress)?

Justification:

Temporary and permanent barriers constructed along the slope break prior to construction will prevent excavated cinder, construction materials, and trash from falling or blowing into Pu'u Hau Oki crater, (see Recommendation IV-3 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To provide an historical record of Wēkiu bug habitat protection activities. See also Effectiveness Monitoring, Habitat Structure Module.

Sampling System:

Sampling Measurements

2.4.1A) Measurements during construction and use of temporary barriers.
- **1)** Sizes, shapes, colors, and face textures of any barriers used.
- **2)** Locations of any barriers used.

2.4.1B) Measurements after installation of permanent barriers.
- **1)** Sizes, shapes, colors, and face textures of any barriers used.
- **2)** Locations of any barriers used.

Sampling Intensities

2.4.1A1 & 2.4.1B1) Describe each type of barrier used.

2.4.1A2 & 2.4.1B2) Locate points every 20 feet along the barriers. Locations should be accurate to ± 1 foot relative to fixed reference points, such as existing building corners or survey monuments. Sampling target: 20 located barrier points, suitable for mapping the barriers.

Sampling Frequencies

2.4.1 all) Once for each type of barrier. In addition, compliance visual inspections at random intervals, averaging once per month.

Sampling Protocol:

2.4.1A2 & 2.4.1B2) **Tools:** 100′ tape measure, compass, clinometer
Procedures: measure distance, azimuth, and slope from fixed reference points to points every 20′ along the temporary and permanent barriers.

Data Management: See Results, Data Management

Analysis and Interpretation:

2.4.1A1 & 2.4.1B1) Description

2.4.1A2 & 2.4.1B2) Map (GIS)

Reporting:

2.4.1A1& 2.4.1A2) For temporary barriers, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

2.4.1B1 & 2.4.1B2) For permanent barriers, a written report, within two months after installation. Include in Post Construction Report.

Question of Interest 2.4.2

Where, when, and in what quantities has cinder been accidentally side-cast into Wēkiu bug habitat in Pu'u Hau Oki crater?

Justification:

Excavated cinder, side cast into Wēkiu bug habitat, could alter slope stability and habitat structure. (see Recommendation IV-3 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To detect hazards and risks to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities. See also Effectiveness Monitoring, Habitat Structure Module.

Sampling System:

Sampling Measurements

2.4.2A) Measure, during construction, the change in cinder surface position down slope of the construction areas adjacent to Pu'u Hau Oki crater.

Sampling Intensities

2.4.2A) Measurement points every 20 feet horizontally (on the contour) 10 feet (slope distance) down slope of construction areas for Outrigger Telescopes 1 and 2 (on the Pu'u Hau Oki crater side). Sampling target: 15-20 located measurement points.

Sampling Frequencies

2.4.2A) Once per month during construction, and again one year following completion of construction activities. Sampling target: 18-21 dates.

Sampling Protocol:

2.4.2A) Tools: Prepare measuring rods, using 6-foot-long rebar or metal fence posts, by painting white with red or black marks at one inch increments from top.

Procedures: Locate and mark with survey stakes the boundaries of construction areas. Drive measuring rods securely into the slope every 20 feet on the contour, 10 feet slope distance below edge of construction areas for Outrigger Telescopes 1 & 2 (on the Pu'u Hau Oki crater side). Repair and restore (by raking) the slope surface around each measuring rod. Record the vertical distance (length in inches) from the surface to the top of each measuring rod. Subsequent measurements should be made using binoculars to view the rods from upslope positions (to minimize any further habitat disturbance). Repeat these measurements once per month. If significant amounts of side cast cinder are detected, estimate the slope distance (in feet, down slope of each measuring rod, that side cast cinder is visually evident.

Data Management: See Results, Data Management

Analysis and Interpretation Systems:

2.4.2A) If the measuring rods are driven securely, they should not move up or down. If significant amounts of cinder are side cast from construction activities, changes in the vertical distances from the surface to the top of each rod will be detected. Trigonometric calculations, using the estimated down slope coverage of side cast cinder, will yield volume estimates of the amount of cinder side cast into Wēkiu bug habitat in Pu'u Hau Oki crater. Repeating the measurements every two weeks will provide an ongoing assessment of side cast cinder.

Reporting System:

2.4.2A) If side cast cinder is detected, it should be reported immediately. Otherwise, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.4.3

Where, when, and in what quantities has snow or ice (accumulated by plowing) been side-cast into Wēkiu bug habitat in Pu'u Hau Oki crater?

Justification:

Large quantities of accumulated snow (ice boulders), side cast into Wēkiu bug habitat, could alter slope stability and habitat structure, (see Recommendation IV-3 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To detect hazards and risks to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities. See also Effectiveness Monitoring, Habitat Structure Module.

Sampling System:

Sampling Measurements

2.4.3A) Measure snow accumulations, should they occur, along the upper edge of Pu'u Hau Oki crater.

Sampling Intensities

2.4.3A) Measurement points every 40 feet horizontally along the upper edge of Pu'u Hau Oki crater. Sampling target: 10 located measurement points.

Sampling Frequencies

2.4.3A) Once per month, during periods when snow accumulates (from plowing or other snow removal methods). It is possible that deep snow may not occur during the Outrigger Telescope project.

Sampling Protocol:

2.4.3A) Tools: 100′ tape measure, shovel

Procedures: Measure width, breadth, and length of snow accumulations at points every 40′ along the upper edge of Puʻu Hau Oki crater.

Data Management: See Results. Data Management

Analysis and Interpretation Systems:

2.4.3A) Time series, volume of accumulated snow at dates.

Reporting System:

2.4.3A) If conditions are found that constitute a hazard to Wēkiu bug habitat in Puʻu Hau Oki crater, it should be reported immediately. Otherwise, include in Quarterly Reports, Construction Completion Report within two months after the completion of construction activities, and in the Post-Construction Report.

Question of Interest 2.4.4

Where, when, what kind, and how many educational signs, (placed to discourage pedestrian traffic in Wēkiu bug habitat in Pu'u Hau Oki crater), have been installed?

Justification:

Educational signs will help prevent unintentional disturbance of Wēkiu bug habitat by workers and visitors, (see Recommendation IV-4 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To provide an historical record of Wēkiu bug habitat protection activities. See also Effectiveness Monitoring, Habitat Structure Module.

Sampling System:

Sampling Measurements

2.4.4A) Measurements following installation
- **1)** Sizes, shapes, colors, and content of any educational signs used
- **2)** Locations of any educational signs used

Sampling Intensities

2.4.4A all) Describe each type of educational signs used and their locations. Locations should be accurate to ± 1 foot relative to fixed reference points, such as existing building corners or survey monuments.

Sampling Frequencies

2.4.4A all) Once, following sign installation.

Sampling Protocol:

2.4.4A all) **Tools:** 100′ tape measure, camera

Procedures: Measure distance, azimuth, and slope from fixed reference points to each educational sign. Photograph sign for record of content.

Data Management: See Data Management, Results Section

Analysis and Interpretation Systems:

2.4.4A all) Descriptions with photographs

Reporting System:

2.4.4A all) A written report within two months of completion of installation of educational signs, and include in the Construction Completion and Post-Construction Reports.

2.5 - DUST MODULE

Question of Interest 2.5.1

When and in what quantity has water been applied to excavation sites and cinder stockpiles created by earthmoving activities?

Justification:

Excessive deposition of ash and dust from excavation activity may alter the structure of Wēkiu bug habitat in Pu'u Hau Oki crater, (see Recommendation V-1 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To provide an historical record of Wēkiu bug habitat protection activities. See also Effectiveness Monitoring, Habitat Structure Module.

Sampling System:

Sampling Measurements

2.5.1A) Measurements during construction
- **1)** The number of excavations
- **2)** The dates when water was applied to excavation sites and cinder stockpiles
- **3)** The quantity and dates of water trucked to the construction site

Sampling Intensities

2.5.1A all) 100% review of Contractors' Log Book

Sampling Frequencies

2.5.1A all) Once per month, during construction.

Sampling Protocol: See Protocols, Contractors' Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.5.1A1) Time series, dates of excavation activity.

2.5.1A2) Time series, dates water was applied to excavation sites and cinder stockpiles.

2.5.1A3) Time series, quantity of water delivered at dates.

Reporting:

2.5.1A all) If water is not being used to suppress dust, it should be reported immediately. Otherwise, include in Quarterly Reports, and in the Construction Completion Report within two months after completion of construction activities.

Question of Interest 2.5.2

When have dust-generating activities been suspended, (to prevent dust from being blown into Wēkiu bug habitat in Pu'u Hau Oki crater)?

Justification:

High winds at the summit are capable of blowing dust from recently exposed cinder and ash onto habitat slopes. Excessive deposition of ash and dust from excavation activity may alter the structure of Wēkiu bug habitat in Pu'u Hau Oki crater, (see Recommendation V-2 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To provide an historical record of Wēkiu bug habitat protection activities, (see also Effectiveness Monitoring, Habitat Structure Module), and to associate auxiliary phenomena, attributes, and characteristics with trends and patterns of change in key phenomena, attributes, and characteristics.

Sampling System:

Sampling Measurements

2.5.2A) Measurements during construction
- **1)** Dates of suspension of dust-generating activities.
- **2)** Wind speed in miles per hour.

Sampling Intensities

2.5.2A1) 100% review of Contractors' Log Book.

2.5.2A2) Records from available meteorological information.

Sampling Frequencies

2.5.2A1) Once per month during the construction phase of the project.

2.5.2A2) As recorded by existing weather monitoring equipment.

Sampling Protocol: See Protocols, Contractors' Log Book and Meteorological Station

Data Management: See Results, Data Management

Analysis and Interpretation:

2.5.2A1) Time series, dates of suspension of dust-generating activities.

2.5.2A2) Time series daily high and lows. Comparison with suspension dates.

Reporting:

2.5.2A all) If dust-generating activities are not being suspended during periods of high winds, it should be reported immediately. Otherwise, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.5.3

Where and when have excavated materials and cinder stockpiles been covered, (to prevent dust from being blown into Wēkiu bug habitat in Pu'u Hau Oki crater)?

Justification:

High winds at the summit are capable of blowing dust from recently exposed cinder and ash onto habitat slopes. Excessive deposition of ash and dust from excavation activity may alter the structure of Wēkiu bug habitat in Pu'u Hau Oki crater, (see Recommendation V-2 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To provide an historical record of Wēkiu bug habitat protection activities, (see also Effectiveness Monitoring, Habitat Structure Module).

Sampling System:

Sampling Measurements

2.5.3A) Measurements during construction
- **1)** Dates excavated materials have been covered
- **2)** Wind speed in miles per hour.

Sampling Intensities

2.5.3A1) 100% review of Contractors' Log Book.

2.5.3A2) Records from available meteorological information.

Sampling Frequencies

2.5.3A1) Once per month during the construction phase of the project.

2.5.3A2) As recorded by existing weather monitoring equipment.

Sampling Protocol: See Protocols, Contractors' Log Book and Meteorological Station

Data Management: See Results, Data Management

Analysis and Interpretation:

2.5.3A1) Time series, dates excavated materials have been covered.

2.5.3A2) Time series daily high and lows. Comparison with covering dates.

Reporting:

2.5.3A all) If excavated materials and stockpiles are not being covered during periods of high winds, it should be reported immediately. Otherwise, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.5.4

Where, when, and in what quantities have soil-binding compounds been used?

Justification:

Application of soil-binding compounds may reduce dust created during excavation or generated from vehicle traffic. Soil-binding compounds should not be applied to Wēkiu Bug habitat, (see Recommendation V-3 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To provide an historical record of Wēkiu bug habitat protection activities. See also Effectiveness Monitoring, Habitat Structure Module.

Sampling System:

Sampling Measurements

2.5.4A) Professional review of soil-binding compounds prior to use at the construction site.

2.5.4B) Locations, dates, and quantities of soil-binding compounds applied.

Sampling Intensities

2.5.4A) Review of soil-binding compounds plans.

2.5.4B) 100% review of Contractors' Log Book.

Sampling Frequencies:

2.5.4A) Once, prior to application of soil-binding compounds.

2.5.4B) Once per month during the construction phase of the project.

Sampling Protocol: See Protocols, Contractors' Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.5.4B) Spatial time series: locations, dates, and quantities of soil-binding compounds.

Reporting:

2.5.4A) Written review of soil-binding compounds proposed for application, delivery prior to application.

2.5.4B) Include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

2.6 - HAZARDOUS MATERIALS MODULE

Question of Interest 2.6.1

Where, when, and in what quantities have chemicals been used for recoating observatory mirrors? Have all regulatory guidelines been followed, including the proper disposal of associated compounds, tools, and containers?

Justification:

When managed properly according to Federal guidelines, hazardous materials used during the mirror-washing procedures at WKMO pose little danger to the surrounding environment. Monitoring mirror-washing procedures provides assurance of safety, (see Recommendation VI-1 in the Wēkiu Bug Mitigation Report)

Monitoring Goals:

To detect threshold events, or critical levels, of environmental phenomena, attributes, and characteristics, and to provide an historical record of Wēkiu bug habitat protection activities.

Sampling System:

Sampling Measurements

2.6.1A) Measurements made during mirror washing activities
- **1)** Dates, locations, and quantities of chemicals used in mirror washing.
- **2)** Chemical and container disposal procedures followed.

Sampling Intensities

2.6.1A1 & 2.6.1A2) 100% review of procedural reports. CARA personnel currently report on procedures used in mirror washing, in accordance with Federal guidelines. CARA personnel will keep an Activity Log Book that will be available for review during monthly site inspections.

Sampling Frequencies

2.6.1A1 & 2.6.1A2) On dates when mirror washing occurs.

Sampling Protocol:

2.6.1A1) Monthly review of Activity Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.6.1A1) Time series, Dates, locations, and quantities of chemicals used in mirror washing activities.

2.6.1A2) Descriptive statistics of chemical and container disposal procedures.

Reporting:

2.6.1A1 & 2.6.1A2) Include in Quarterly Reports, and in the Post-Construction Report.

Question of Interest 2.6.2

Where, when, and in what quantities have contractors used paints, thinners, and solvents on-site? Have all regulatory guidelines been followed, including the proper disposal of associated compounds, tools, and containers?

Justification:

Paints, thinners and other solvents are toxic to Wēkiu bugs, and spills could impact Wēkiu bug populations. Monitoring the use of paints, thinners, and solvents on-site provides assurance of safety, (see Recommendation VI-2 in the Wēkiu Bug Mitigation Report)

Monitoring Goals:

To detect hazards and risks to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities.

Sampling System:

Sampling Measurements

2.6.2A) Review of Contractors' hazardous materials plans prior to use of paints, thinners, and solvents on-site.

2.6.2B) Locations, dates, and quantities of paints, thinners, and solvents used on-site, including equipment washing activities and disposal of chemicals and containers.

Sampling Intensities

2.6.2A) 100% review of Contractors' hazardous materials plans

2.6.2B) 100% review of Contractors' Log Book

Sampling Frequencies

2.6.2A) Once, prior to prior to use of paints, thinners, and solvents on-site.

2.6.2B) Once per month during the construction phase of the project.

Sampling Protocol: See Protocols, Contractors' Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.6.2B) Spatial time series: locations, dates, and quantities of paints, thinners, and solvents used on-site including equipment washing activities and disposal of chemicals and containers

Reporting:

2.6.2 all) If a spill occurs, or improper procedures are being used, it should be reported immediately. Otherwise, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.6.3

Where, when, and in what quantities have spills of hazardous materials occurred? In the case of spills, have all regulatory guidelines for spill cleanup been followed?

Justification:

If spilled onto Wēkiu bug habitat, paints, thinners, solvents, or other hazardous materials can impact Wēkiu bug populations. Should spills occur, monitoring of their impact and associated clean-up efforts is necessary, (see Recommendation VI-2 in the Wēkiu Bug Mitigation Report)

Monitoring Goals:

To detect hazards and risks to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities.

Sampling System:

Sampling Measurements

2.6.3A) Review of spill response sections of the Contractors' hazardous materials plans, prior to use of paints, thinners, and solvents on-site.

2.6.3B) Measurements during construction

1) Locations, dates, and quantities of spills, should they occur.
2) Locations, dates, and procedures followed in clean-up of spills, should they occur.

Sampling Intensities

2.6.3A) 100% review of Contractors' hazardous materials plans

2.6.3B1 & 2.6.3B2) 100% review of Contractors' Log Book

Sampling Frequencies

2.6.3A) Once, prior to prior to use of paints, thinners, and solvents on-site

2.6.3B1 & 2.6.3B2) Once per month during the construction phase of the project.

Sampling Protocol: See Protocols, Contractors' Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.6.3B1 & 2.6.3B2) Spatial time series: locations, dates, and quantities of spills and clean-up efforts.

Reporting:

2.6.3 all) In case of a spill, report immediately, with monthly follow-up reports on the spill extent and clean-up actions. If no spills occur, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

2.7 - TRASH MODULE

Question of Interest 2.7.1

Where and when have roll-off trash containers been tightly covered, (or uncovered)?

Justification:

High winds at the summit can extract construction debris from containers and disperse the material. Covering containers will decrease the amount of construction debris that could be blown onto Wēkiu bug habitat, (see Recommendation VII-1 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To detect hazards and risks to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities.

Sampling System:

Sampling Measurements

2.7.1A) Measurements during construction
- **1)** Locations and dates roll-off trash containers at construction site.
- **2)** Wind speed in miles per hour.

Sampling Intensities

2.7.1A1) 100% review of Contractors' Log Book

2.7.1A2) Records from available meteorological information.

Sampling Frequencies

2.7.1A1) Once per month during the construction phase of the project.

2.7.1A2) As recorded by existing weather monitoring equipment.

Sampling Protocol: See Protocols, Contractors' Log Book and Meteorological Station

Data Management: See Results, Data Management

Analysis and Interpretation:

2.7.1A1) Time series, Dates roll-off trash containers have been covered.

2.7.1A2) Time series daily high and lows. Comparison with covering dates.

Reporting:

2.7.1 all) If roll-off trash containers are not being covered during periods of high winds, it should be reported immediately. Otherwise, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.7.2

Where and when have construction materials stored at the site been covered with tarps, or anchored in place to prevent movement by wind (or left uncovered and/or unsecured)?

Justification:

High winds at the summit can potentially blow construction materials onto habitat slopes. Covering construction materials stored at the site will decrease the amount of construction debris that could be blown into Wēkiu bug habitat, (see Recommendation VII-2 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To detect hazards and risks to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities.

Sampling System:

Sampling Measurements

2.7.2A) Measurements during construction
- **1)** Locations and dates construction materials at construction site.
- **2)** Wind speed in miles per hour.

Sampling Intensities

2.7.2A1) 100% review of Contractors' Log Book

2.7.2A2) Records from available meteorological information.

Sampling Frequencies

2.7.2A1) Once per month during the construction phase of the project. I

2.7.2A2) As recorded by existing weather monitoring equipment.

Sampling Protocol: See Protocols, Contractors' Log Book and Meteorological Station

Data Management: See Results, Data Management

Analysis and Interpretation:

2.7.2A1) Time series, Dates construction materials have been covered.

2.7.2A2) Time series daily high and lows. Comparison with covering dates.

Reporting:

2.7.2 all) If construction materials are not being covered during periods of high winds, it should be reported immediately. Otherwise, include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.7.3

What kind of outdoor trash receptacles have been installed to prevent trash from being blown into Wēkiu bug habitat in Pu'u Hau Oki crater, where have they been installed, and when were they installed?

Justification:

Workers and visitors to the WKMO often bring trash, (lunch bags, film canisters, wrappers, etc.). Trash receptacles provide workers and visitors with a place to dispose of their trash and prevent it from being blown into Wēkiu bug habitat, (see Recommendation VII-3 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To detect hazards and risks, to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities.

Sampling System:

Sampling Measurements

2.7.3A) Measurements during construction
- **1)** Review of plans prior to construction and installation of trash receptacles.
- **2)** Locations and dates of installation of trash receptacles.

Sampling Intensities

2.7.3A1) 100% review of trash receptacle plans

2.7.3A2) 100% review of Contractors' Log Book

Sampling Frequencies

2.7.3A1) Once, prior to installation

2.7.3A2) Once, after installation.

Sampling Protocol: See Protocols, Contractors' Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.7.3A2) Descriptions of trash receptacles with dates of installation

Reporting:

2.7.3 all) Include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.7.4

Where, when, what kind, and in what quantities have construction materials and other trash been blown into Wēkiu bug habitat in Puʻu Hau Oki crater? Where, when, and what methods have been used to collect construction materials and other trash blown into Wēkiu bug habitat in Puʻu Hau Oki crater?

Justification:

Despite efforts to prevent wind-blown construction materials and trash, some debris could end up in Wēkiu bug habitat. Retrieving this debris from sensitive areas should be done without disturbing the habitat, (see Recommendation VII-4 in the Wēkiu Bug Mitigation Report).

Monitoring Goals:

To detect hazards and risks, to valued ecosystem attributes and functions, and to provide an historical record of Wēkiu bug habitat protection activities.

Sampling System:

Sampling Measurements

2.7.4A) Measurements during construction
- **1)** Review of plans prior to collection of debris from Wēkiu bug habitat in Puʻu Hau Oki crater.
- **2)** Locations and dates of trash collection.

Sampling Intensities

2.7.4A1) 100% review of trash collection plans

2.7.4A2) 100% review of Contractors' Log Book

Sampling Frequencies

2.7.4A1) Once

2.7.4A2) Once per month during the construction phase of the project.

Sampling Protocol: See Protocols, Contractors' Log Book

Analysis and Interpretation:

2.7.4A2) Descriptions of trash collection activities, with dates and locations

Reporting:

2.7.4 all) Include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

2.8 - ALIEN ARTHROPODS MODULE

Question of Interest 2.8.1

Where and when have ants been detected at storage yards and staging areas, and what eradication actions have been taken?

Justification:

Ants in storage yards and staging areas may be accidentally transported to the construction site. Several species of ants have established populations on the Island that could pose a threat to Wēkiu bugs. Efforts must be made to ensure that ants are not transported to the summit, (see Recommendation VIII-1 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To detect hazards and risks to Wēkiu bugs, and to provide an historical record of Wēkiu Bug habitat protection activities.

Sampling System:

Sampling Measurements

2.8.1A) Measurements at storage yards and staging areas within the MKSR
- **1)** Presence/absence of ants on the ground
- **2)** Presence/absence of ants on vehicles
- **3)** Review of ant eradication plans
- **4)** Actions taken to eradicate ants

Sampling Intensities:

2.8.1A1) Place baited ant traps on a randomly located 40′x40′ grid, (one measurement per 1600 square feet). Sampling target 25 traps per storage yard or staging area.

2.8.1A2) All vehicles at storage yard or staging area at time of inspection.

2.8.1A3) 100% review of ant eradication plans

2.8.1A4) 100% review of Contractors' Log Book

Sampling Frequencies:

2.8.1A1, 2.8.1A2, & 2.8.1A4) Once per month during the construction phase of the project.

2.8.1A3) Once, prior to initiation of ant eradication activities

Sampling Protocol:

2.8.1A1) Locate random sampling points (See Protocols, Habitat) and set freshly baited traps. Return after 3 hours and record presence/absence of ants.

2.8.1A2) See Protocols, Alien Arthropod Inspection

2.8.1A4) Review Contractors' Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.8.1A1 & 2.8.1A2) Time series, presence/absence of ants on dates.

2.8.1A4) Description

Reporting:

2.8.1A all) If ants are found at storage yards or staging areas within the MKSR, it should be reported immediately. Otherwise include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.8.2

Where and when have alien arthropods, or soil, dirt, or vegetation capable of harboring alien arthropods, been found on earth-moving equipment? When has earth-moving equipment been pressured-washed (to remove alien arthropods) before being moved to the construction site?

Justification:

Mud and dirt attached to earth-moving equipment should be removed before transport to the summit, where alien arthropods may pose a threat to Wēkiu bugs, (see Recommendation VIII-1 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To detect hazards and risks to Wēkiu bugs, and to provide an historical record of Wēkiu Bug habitat protection activities.

Sampling System:

Sampling Measurements

2.8.2A) Measurements taken during construction
- **1)** Presence/absence of alien arthropods on earth-moving equipment.
- **2)** Presence/absence of soil, dirt, and vegetation on earth-moving equipment.

2.8.2B) Information from contractors and subcontractors
- **1)** Date and description of most recent pressure washing of vehicles and earth-moving equipment used at the construction site.

Sampling Intensities:

2.8.2A1 & 2.8.2A2) All earth-moving equipment at construction site, or MKSR storage yards or staging areas, at time of inspection

2.8.2B1) 100% review of Contractors' Log Book

Sampling Frequencies:

2.8.2A1 & 2.8.2A2) Once per month during the construction phase of the project.

2.8.2B1) Once for each earth-moving equipment contractor and subcontractor

Sampling Protocol:

2.8.2A1 & 2.8.2A2) See Protocols, Alien Arthropod Inspection

2.8.2B1) Review Contractors' Log Book

Data Management: See Results, Data Management

Analysis and Interpretation:

2.8.2A1 & 2.8.2A2) Time series, number of vehicles with alien arthropods, soil, dirt, or vegetation at dates.

2.8.2B1) Description

Reporting:

2.8.2A1 & 2.8.2A2) If alien arthropods are found on earth-moving equipment, or if soil, dirt, or vegetation is found on earth-moving equipment at the construction site, it should be reported immediately. Otherwise include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

2.8.2B1) Include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.8.3

Where and when have large trucks, tractors, other vehicles, and construction materials been inspected before being transported to the summit? Have any alien arthropods been found in those inspections? What actions have been taken to eradicate any alien arthropods found in those inspections?

Justification:

Large trucks, tractors, other vehicles, and construction materials should be inspected before transport to the summit, where alien arthropods may pose a threat to Wēkiu bugs, (see Recommendation VIII-2 in the Wēkiu Bug Mitigation Report).

Monitoring goals:

To detect hazards and risks to Wēkiu bugs, and to provide an historical record of Wēkiu Bug habitat protection activities.

Sampling System:

Sampling Measurements

2.8.3A) Information obtained from operators of large trucks, tractors, other vehicles, and construction materials (see Protocols, Contractors' Log Book).

1) Inspections conducted for alien arthropods.
2) Actions taken to remove alien arthropods.

Sampling Intensities:

2.8.3A1 & 2.8.3A2) 100% review of Contractors' Log Book

Sampling Frequencies:

2.8.3A1 & 2.8.3A2) Once per month during the construction phase of the project, consisting of visual inspections of large trucks, tractors, other vehicles, and construction materials at the site during the inspection visit.

Sampling Protocol:

2.8.3A1 & 2.8.3A2) See Protocols, Contractors' Log Book and Alien Arthropod Inspection

Data Management: See Results, Data Management

Analysis and Interpretation:

2.8.3A1) Time series, number of large trucks, tractors, other vehicles, and construction materials found with alien arthropods at dates.

2.8.3A2) Description

Reporting:

2.8.3A1 & 2.8.3A2) If alien arthropods are found on large trucks, tractors, other vehicles, and construction materials at the construction site, it should be reported immediately. Otherwise include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.8.4

When have shipping crates and boxes been inspected for spider webs, egg masses, and other signs of alien arthropods before being transported to the summit? Have any alien arthropods been found in those inspections? What actions have been taken to eradicate any alien arthropods found in those inspections?

Justification:

Inspection and removal of alien arthropods will reduce the chance that these species will establish populations in Wēkiu bug habitat in Pu'u Hau Oki crater, (Wēkiu Bug Mitigation Report recommendation VIII-2).

Monitoring goals:

To detect hazards and risks to Wēkiu bugs, and to provide an historical record of Wēkiu Bug habitat protection activities.

Sampling System:

Sampling Measurements

2.8.4A) Information obtained from Contractors' Log Book (see Protocols, Contractors' Log Book and Alien Arthropod Inspection).

1) Inspections conducted for alien arthropods.
2) Actions taken to remove alien arthropods.

Sampling Intensities:

2.8.4A1 & 2.8.4A2) 100 % review of Contractors' Log Book

Sampling Frequencies:

2.8.4A1 & 2.8.4A2) Once per month during the construction phase of the project.

Sampling Protocol:

2.8.4A1 & 2.8.4A2) See Protocols, Contractors' Log Book and Alien Arthropod Inspection.

Data Management: See Results, Data Management

Analysis and Interpretation:

2.8.4A1) Time series, number of shipping crates and boxes found with alien arthropods at dates.

2.8.4A2) Description

Reporting:

2.8.4A1 & 2.8.4A2) If alien arthropods found on shipping crates and boxes, it should be reported immediately. Otherwise include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

Question of Interest 2.8.5

Where, when, and in what quantities have alien arthropods been found at the WKMO observatory site? Where, when, and what actions have been taken to eradicate any alien arthropods found in those inspections?

Justification:

Monitoring for of visible signs of alien arthropods, and eradicating alien arthropods if detected, will reduce the chance of these species from establishing populations will establish populations in Wēkiu bug habitat in Pu'u Hau Oki crater, (Wēkiu Bug Mitigation Report recommendation VIII-4).

Monitoring goals:

To detect hazards and risks to Wēkiu bugs, and to provide an historical record of Wēkiu Bug habitat protection activities.

Sampling System:

Sampling Measurements

2.8.5A) Measurements of alien arthropods

1) Presence/absence of ants.
2) Presence/absence spider webs on buildings, trailers, other observatory structures, and/or construction materials stored at the construction site.
3) Presence/absence of yellowjackets.

2.8.5B) Quantitative description of actions taken to eradicate any alien arthropods found during inspections.

Sampling Intensities:

2.8.5A1) Place baited ant traps on the ground next to temporary and permanent buildings at 40-foot intervals, at 20-foot intervals around construction materials stored at the construction site.

2.8.5A2) Visual inspection of temporary and permanent buildings, trailers other observatory structures, and construction materials stored at the construction site. See Protocols, Alien Arthropod Inspection.

2.8.5A3) Place 10 yellowjacket traps around the construction site, including locations near trash containers and portable toilets.

2.8.5B) Descriptions of actions taken, if and when they are taken.

Sampling Frequencies:

2.8.5A all) Once per month during the construction phase of the project.

2.8.5B) Descriptions of actions taken, if and when they are taken.

Sampling Protocol:

2.8.5A1) Locate sampling points and set freshly baited traps. Return after 3 hours and record number of ants at the trap.

2.8.5A2) See Protocols, Alien Arthropod Inspection

2.8.5A3) Locate sampling points and set freshly baited traps. Return after 3 hours and record number of yellowjackets in the traps.

2.8.5B) Quantitative descriptions of actions taken, if and when they are taken, including dates, locations, control methods applied, control method applicators, etc.

Data Management: See Results, Data Management

Analysis and Interpretation:

2.8.5A1) Spatial time series, number of traps that captured ants at dates and locations.

2.8.5A2) Spatial time series, number of spider webs at dates and locations.

2.8.5A3) Spatial time series, number of traps that captured yellowjackets at dates and locations.

2.8.5B) Quantitative description. Compare pre- and post-control-action trap counts.

Reporting:

2.8.5A all) If alien arthropods are found at the observatory site, it should be reported immediately. Otherwise include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

2.8.5A4) Actions taken to eradicate alien arthropods found at the observatory site should be reported monthly. Otherwise include in Quarterly Reports, and in the Construction Completion Report within two months after the completion of construction activities.

EFFECTIVENESS MONITORING

3.1 - INTRODUCTION

Effectiveness monitoring will investigate the changes in the Wēkiu bug population and habitat that happen concurrently with construction and operation of the Outrigger Telescopes. In essence, effectiveness monitoring asks whether the environmental controls adopted and mitigation treatments undertaken were successful in conserving the Wēkiu bug. Monitoring for changes in the population and habitat will give the operators, oversight agencies, and the public the information necessary to ensure that natural resources are protected during the Outrigger Telescope project.

This Effectiveness Monitoring Section is organized in four modules:

3.1 Introduction
3.2 Listing of the Questions of Interest
3.3 Population Change Module
3.4 Habitat Structure Module

More Questions of Interest (QOI's) may be added, or some deleted, if and when necessary. The Monitoring Program is thus adaptable to new conditions and findings.

Each Module contains a comprehensive discussion of each of the associated QOI's, including justification, monitoring goals, sampling systems, sampling protocols, analysis and interpretation, and reporting.

Subsections on data management, analysis, and reporting may be found in Section 4 – Results. Reports called for in this Monitoring Plan include Quarterly Reports during construction, a synthesis report upon Construction Completion, and a Post-Construction Report one year following completion. Special reports for some QOI's are also planned.

3.2 - LISTING OF THE EFFECTIVENESS MONITORING QUESTIONS OF INTEREST

3.3 - Population Change Module

3.3.1 How, where and when are the Wēkiu bug and other resident arthropod populations changing? Locations of interest include newly restored Wēkiu bug habitat, current habitat in Pu'u Hau Oki crater, and undisturbed Wēkiu bug habitat in other Mauna Kea summit areas (for comparison).

3.3.2 Are weather phenomena, human activities, and/or other factors associated with Wēkiu bug and/or other resident arthropod population change?

3.4 - Habitat Structure Module

3.4.1 How, where and when has existing Wēkiu bug habitat been damaged by new construction?

3.3 - POPULATION CHANGE MODULE

Question of Interest 3.3.1

How, where and when are the Wēkiu bug and other resident arthropod populations changing? Locations of interest include newly restored Wēkiu bug habitat, current habitat in Pu'u Hau Oki crater, and undisturbed Wēkiu bug habitat in other Mauna Kea summit areas (for comparison).

Justification:

Monitoring both the Wēkiu bug population and resident arthropod populations will yield reliable scientific information about population change, and whether mitigation and habitat restoration efforts have been successful at protecting and enhancing Wēkiu bugs and their habitat.

Monitoring goals:

1) To provide historical records of change in environmental phenomena, attributes, and characteristics,

2) To detect trends, periodicities, cycles, and/or other patterns in those changes, and

3) To associate auxiliary phenomena, attributes, and characteristics with trends and patterns of change in key phenomena, attributes, and characteristics

Sampling System:

Sampling Measurements

3.3.1A) Wēkiu bug population measurements
- **1)** in restored habitat
- **2)** in Pu'u Hau Oki crater
- **3)** in undisturbed Wēkiu bug habitat in other Mauna Kea summit areas

3.3.1B) Resident arthropod population measurements

1) in restored habitat
2) in Puʻu Hau ʻOki crater
3) in undisturbed Wēkiu bug habitat in Puʻu Wēkiu

Sampling Intensities

3.3.1A1 and 3.3.1B1) 3 pitfall traps in restored habitat

3.3.1A2 and 3.3.1B2) 5 pitfall traps in current habitat in Puʻu Hau ʻOki crater

3.3.1A3 and 3.3.1B3) 5 pitfall traps in undisturbed Wēkiu bug habitat in Puʻu Wēkiu.

Sampling Frequencies

3.3.1A all and 3.3.1B all) 21 day trapping sessions, four times per year (late winter, spring, summer, late fall).

Sampling Protocol: See Protocols, Population

Data Management: See Results, Data Management

Analysis and Interpretation:

3.3.1A all and 3.3.1B all) Spatial time series, capture rates at dates and locations, comparison with undisturbed sites. Include auxiliary weather data (QOI 3.3.2, this Module) in analyses.

Reporting:

3.3.1A all and 3.3.1B all) Include in Quarterly Reports, Construction Completion Report within two months after the completion of construction activities, and in the Post-Construction Report.

Question of Interest 3.3.2

Are weather phenomena, human activities, and/or other factors associated with Wēkiu bug and/or other resident arthropod population change?

Justification:

Snow, rain, day/night temperatures, and other weather phenomena may be associated with Wēkiu Bug population change. Human activities such as dust generation, side cast of debris on to habitat slopes, or other activities, and the presence/absence of alien arthropods may also be associated with population change. Monitoring these indirect factors will aid in analysis of mitigation success.

Monitoring goals:

1) To provide historical records of change in environmental phenomena, attributes, and characteristics,

2) To detect trends, periodicities, cycles, and/or other patterns in those changes, and

3) To associate auxiliary phenomena, attributes, and characteristics with trends and patterns of change in key phenomena, attributes, and characteristics

Sampling System:

Sampling Measurements

3.3.2A) Desirable meteorological measurements

1) Temperature
2) Wind speed
3) Barometric pressure
4) Relative humidity
5) Precipitation
6) Snow pack depth and extent

3.3.2B) Human activity measurements

1) Slope stability control activities
2) Dust control activities
3) Hazardous materials control activities
4) Trash control activities
5) Alien arthropod control activities

Sampling Intensities

3.3.2A all) As recorded by existing weather monitoring equipment.

3.3.2A6) Measure snow accumulations in Pu'u Hau Oki crater, should they occur. Measurement points every 120 feet horizontally along the upper edge of Pu'u Hau Oki crater and along the slope base at the bottom of Pu'u Hau Oki crater. Sampling target: 8 located measurement points. Map snow pack extent beyond Pu'u Hau Oki crater from aerial photographs, if available.

3.3.2B all) See Compliance Monitoring

Sampling Frequencies

3.3.2A all) As recorded by existing weather monitoring equipment.

3.3.2A6) Once per month, during periods when snow accumulates.

3.3.2B all) See Compliance Monitoring

Sampling Protocol:

3.3.2A all) See Protocols, Meteorological Station

3.3.2A6) **Tools:** Prepare measuring rods, using 12-foot-long fiberglass or metal fence posts, by painting white with red or black marks at one inch increments from top.

Procedures: Drive measuring rods securely into the slope every 120 feet on the contour, 10 feet slope distance below edge of construction areas for Outrigger Telescopes 1 & 2 (on the Pu'u Hau Oki crater side) and every 120 feet along the

slope base at the crater bottom (below the W.M. Keck site). Repair and restore (by raking) the slope surface around each measuring rod. Record the vertical distance (length in inches) from the surface to the top of each measuring rod. Subsequent measurements should be made using binoculars to view the rods from upslope and down slope positions (to minimize any further habitat disturbance). Repeat these measurements every month when snow pack is present.

3.3.2B all) See Compliance Monitoring

Data Management System: See Results, Data Management

Analysis and Interpretation Systems:

3.3.2A all) Time series analysis.

3.3.2A6) Spatial time series, dates and locations (depth and extent) of snow pack. Maps at dates (GIS).

3.3.2B all) Time series analysis.

Reporting System:

3.3.2A all) Include in Quarterly Reports, Construction Completion Report within two months after the completion of construction activities, and in the Post-Construction Report one year after completion of construction activities.

3.3.2B all) Include in Quarterly Reports, Construction Completion Report within two months after the completion of construction activities, and in the Post-Construction Report.

3.4 - HABITAT STRUCTURE MODULE

Question of Interest 3.4.1

3.4.1 How, where and when has existing Wēkiu bug habitat been damaged by new construction?

Justification:

Measurement of habitat damaged as a result of Outrigger Telescope construction is necessary to determine the appropriate amount of restoration needed for mitigation.

Monitoring goals:

1) To provide historical records of change in environmental phenomena, attributes, and characteristics.

Sampling Measurements

3.4.1A) Size and location of newly damaged Wēkiu bug habitat.

Sampling Intensities

3.4.1A) Locate perimeter points every 20 feet around the newly damaged areas. Locations should be accurate to ± 2 feet relative to fixed reference points, such as existing building corners or survey monuments. Sampling target: 15-20 located perimeter points, suitable for mapping the areas.

Sampling Frequencies

3.4.1A) Once after construction is complete.

Sampling Protocol: See Protocols, Wēkiu Bug Habitat

Data Management: See Results, Data Management

Analysis and Interpretation Systems:

3.4.1A all) Spatial time series, dates and locations, porosity profiles (cinder size distribution at depths below surface).

Reporting System:

3.4.1A all) Include in Construction Completion Report within two months after the completion of construction activities, and in the Post-Construction Report.

RESULTS

4.1 - DATA MANAGEMENT

The primary purpose of monitoring, as with any investigation, is to increase knowledge. Therefore the results, findings, and other forms of new information gained must be transmitted to decision-makers and stakeholders. The compilation, analysis, and presentation of results are key steps in the monitoring process.

Compilation of the findings is called data management. Much effort will be expended in the collection of raw data from field. That data must be checked for errors and archived for retrieval, as needed many years into the future.

Error checking is the first and most immediate task in data management. Field forms and types of raw data collected in this Monitoring Program will be examined for improper recording, blanks, or other errors. Error checking will be done daily during field collection sessions, at the end of the field day or that evening. If errors are found, they will be corrected immediately, or recollected the following day.

When appropriate, computerized error checking algorithms will be employed. Algorithms are useful for checking numerical data that conforms to known or expected distributions. For instance, weather data may be expected to fall into known ranges of temperature, wind speed, or precipitation. The error algorithm program will flag data values outside expected ranges. Investigators will be alerted, and the unusual data values can be verified or corrected through re-measurement or reentry into the database files. Utilization of error checking algorithms requires immediate entry into the computer, preferably on a daily basis.

Some types of data cannot be checked with algorithms. Records of dust suppression activities, snow plowing, barrier construction, and similar events must be "hand checked".

Data values will be entered into a set of database files. These will consist of prepared spreadsheets linked together for electronic queries. Data entry will be immediate, done daily during field collection sessions, at the end of the field day or that evening. Numerical data values may be recorded on hand-held or "palm" computers. Error checking algorithms may be included in the hand-held computer programs, thereby allowing error checking at the moment

of data entry in the field. Hand-held computer data will be downloaded into database files daily.

The database files will be backed up by storage in multiple computer data storage media and by hard copies.

The database files will contain all the field data. The files will be proprietary to the sponsors of the Monitoring Program. Data files will be released (shared) only with written permission of the sponsors. Released data files will always be accompanied by descriptions of the data collection methodology. Released data files may also be accompanied by analyses.

Some data will be spatial values indicating locations of events, activities, or phenomena. Spatial data will be stored in geographic information systems (GIS). GIS files may be shared with existing systems owned by IfA, UH, or other entities chosen by the sponsors.

4.2 - DATA ANALYSIS

Statistical analysis and scientific interpretation are necessary to produce logical inferences and new knowledge from monitoring data.

All data files will be initially evaluated using exploratory data analysis (EDA). EDA is a set of techniques for graphically examining data. Histograms, time series charts, multiple point plots, and other graphs aid in the visual examination of data. Visualization of data is a way of "decoding" quantitative and categorical information. Visual perception links numbers to understanding. Proper EDA includes display of mathematical (statistical) functions fit to the raw data. Simply graphing the data, without fitting and displaying the associated statistical models, may visually omit important traits of the data. Techniques employed will follow EDA guidelines elucidated by William S. Cleveland in his book "Visualizing Data", (Hobart Press, 1993).

Most of the data collected in monitoring is in the form of time series, a collection of observations made sequentially in time. The special characteristic of time series is that successive observations are not independent. Hence analyses of time series data must take into account the order of the observations. Non-independence means that future values are at least partially determined by past values. Because time series are deterministic, future values may often be predicted from past values, to some degree of accuracy. As a result, predictive models may be created for phenomena such as wildlife population changes.

There are many statistical methods for analyzing time series. The principal approach is the use of autocorrelation functions that quantify the deterministic links in processes through time. Frequency analysis, also called spectral analysis, is useful for analyzing the frequency of events. Survival analysis evaluates the time duration until an event occurs.

Time series often contain multiple patterns. The simplest pattern is trend, the increase or decrease of values over relatively long periods of time. Cycles may be detectable within trends, periodic fluctuations of values appearing over relatively shorter periods of time. Wildlife population changes often exhibit both long-term trends and short-term cycles.

Trends and cycles may best be evaluated using residual analysis. In residual analysis a trend model is fit to the data. The differences between the

actual values and the model values are known as the "residuals". Evaluating the model fit involves examination of the residuals for patterns. Once a good fit is established for the trend model, a cycle model may then be fit to the residuals. Again, the differences between the residuals and the cycle model are evaluated. These "second order" residuals are then examined for patterns. If the trend and cycle models are well fitted, the second order residuals should have no patterns; they should be small and random. This process often involves repeated (iterative) model fitting until the smallest and most random residuals result.

Wildlife population changes may be correlated with other phenomena, such as weather patterns, habitat changes, etc. The correlated phenomena are often also in the form of time series. Multivariate cross-correlation analyses are statistical methods for combining two or more time series. These methods are similar to the univariate methods described above, with the addition of cross-covariance terms in the models.

The ultimate purpose of time series analysis in monitoring is to develop models for predicting (and sometimes understanding) the changes. Prediction is simpler than understanding. Many phenomena that occur on a regular basis are highly predictable, even if we do not understand why they occur. For instance, the Monitoring Program may find that Wēkiu bug populations fluctuate with snowfall events or the lack thereof. Such fluctuations may be predictable, even if we do not understand the biological mechanisms at work.

Other statistical methods may also be employed. Mark-and-recapture techniques may be useful in making population estimates. In mark-and-recapture of insects, non-toxic phosphorescent dyes are carefully placed on captured bugs, which are then released. The percentage of marked individuals subsequently recaptured yields potentially more accurate inferences about the size of the population than simple trap counts.

Spatial analyses, using statistical methods for evaluating location data, may also be useful. It is unlikely, however, that the projected sampling intensities will reveal detectable patterns in the locations of Wēkiu bug population changes. To detect such changes many times more traps would be necessary. In this Monitoring Plan we have chosen to minimize habitat damage by data collectors and focus on population changes detectable with the fewest traps, and hence the least habitat disturbance.

4.3 - REPORTING

The new knowledge acquired through monitoring will be communicated to sponsors and stakeholders through reports. Five types of reports are anticipated:

1. Reviews. This Monitoring Plan calls for reviews of habitat restoration plans; soil-binding compounds to be applied, and hazardous material spill response plans, among others. These reviews will be done on a timely basis, so that construction activities are not delayed.

2. Quarterly Reports. Results from monitoring will be reported every three months during construction of the Outrigger Telescope. Progress on compliance, including restoration of habitat, installation of barriers, dust suppression activities, trash control activities, etc., will be conveyed in the Quarterly Reports.

3. Construction Completion Report. Within two months after completion of construction activities a comprehensive report will be issued. This report will address all the Questions of Interest, and provide a historical record of compliance with guidelines and the effectiveness of mitigation activities.

4. Post-Construction Report. Eighteen months after completion of habitat restoration activities a second comprehensive report will be issued. This report will address primarily the Effectiveness Monitoring QOI's; including any Wēkiu bug population changes detected.

5. Immediate Reports. If any special problems or events happen during or after construction, those situations will be reported immediately. Such occurrences as hazardous material spills, excessive side cast of cinder or trash into Wēkiu bug habitat, or establishment of colonies of alien arthropods at the Keck site, will be reported upon detection to the proper authorities, (selected by the Monitoring Program sponsors).

All the reports will be clearly written for use by the intended audience: JPL, NASA, CARA, IfA, UH, DLNR, and other stakeholder groups and individuals. The reports will include charts, tables, maps, photographs and other visual displays of the information acquired through monitoring.

As the Monitoring Program progresses, feedback from stakeholders will be used to improve the reports to enhance understanding of the results. Future decision-making may then be based on clear, reliable, new information about the Wēkiu bug and the effects of mitigation activities.

SCHEDULE

The schedule for monitoring is dependent upon start of the Outrigger Telescopes Project and is still to be determined. The schedule in this section is generic and representative of the actual time. The dates are undetermined and are dependent upon permitting for the Outriggers Telescope Project.

Updates to this schedule can be found on the World Wide Web at:

http://www.statpros.com/Wekiu_Bug.html

MONITORING SCHEDULE		CONSTRUCTION MONITORING MONTHS																				
		CM1	CM2	CM3	CM4	CM5	CM6	CM7	CM8	CM9	CM10	CM11	CM12	CM13	CM14	CM15	CM16	CM17	CM18	CM19	CM20	CM21
Phases		2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a	2a
		2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b	2b
Compliance Monitoring																						
Module	QOI																					
2.3 Habitat Restoration	1	A,B																B,C				
2.4 Slope Stability	1	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B
	2	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	3								A	A	A	A	A								A	A
	4																	A				
2.5 Dust	1	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	2	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	3	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	4	A,B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
2.6 Hazardous Materials	1	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	2	A,B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
	3	A,B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
2.7 Trash	1	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	2	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	3	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	4	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
2.8 Alien Arthropods	1	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	2	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B
	3	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	4	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	5	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B
Effectiveness Monitoring																						
Module																						
3.3 Population	1	A,B			A,B			A,B			A,B			A,B			A,B			A,B		
	2	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B
3.4 Habitat	1																	A				

				POST CONSTRUCTION MONITORING MONTHS																		
CM22	CM23	CM24	CM25	PCM1	PCM2	PCM3	PCM4	PCM5	PCM6	PCM7	PCM8	PCM9	PCM10	PCM11	PCM12	PCM13	PCM14	PCM15	PCM16	PCM17	PCM18	
2a	2a	2a	2a	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
2b	2b	2b	2b																			
																						QOI
			C																		C	1
A,B	A,B	A,B	A,B																			1
A	A	A																			A	2
A	A	A								A	A	A	A	A								3
			A																			4
A	A	A																				1
A	A	A																				2
A	A	A																				3
B	B	B																				4
A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	1
B	B	B																				2
B	B	B																				3
A	A	A																				1
A	A	A																				2
A	A	A																				3
A	A	A																				4
A	A	A																				1
A,B	A,B	A,B																				2
A	A	A																				3
A	A	A																				4
A,B	A,B	A,B																				5
A,B			A,B			A,B			A,B			A,B			A,B			A,B			A,B	1
A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	2
			A																			1

PROTOCOLS

Protocols for the sampling systems are included in the Compliance and Effectiveness Monitoring sections above. Some protocols are too complicated to be included in those sections and are given in this section. Protocols included in this section include, Wēkiu Bug Population Sampling, Wēkiu Bug Habitat Sampling, Contractor's Log Books, Meteorological Data Gathering, Alien Arthropod Inspections, and Compliance Visual Inspections.

6.1 - WEKIU BUG POPULATION PROTOCOL

Population estimates are classified into three types, relative estimates, absolute estimates, and population indices. Relative estimation is based on the catch per unit effort and is the most appropriate method for monitoring Wēkiu bug population change. Absolute estimates are collected by sampling known fractions of the habitat. This technique would be destructive of habitat, and is therefore inappropriate for Wēkiu bug population monitoring. Population indices are derived from measurements of animal products (e.g. frass, webs, nests) or effects (plant damage) and are not applicable to Wēkiu bugs.

Nondestructive sampling is the best approach to monitoring rare and sensitive invertebrate species. Data on relative abundance can be collected with specially designed live traps that cause minimal disturbance to Wēkiu bugs or their habitats.

Monitoring during Outrigger construction and operation will involve capturing Wēkiu bugs in improved live-traps similar to those used in the 1997-98 MKSR arthropod assessment. These traps provide Wēkiu bugs with food, moisture, and protection from predators and can sustain captured individuals for several days. Traps will be checked for Wēkiu bugs every three days during the sampling session. Captured bugs will be counted, marked with non-toxic, luminous powder, and released. The number of recaptured marked bugs will provide additional information about population change.

Materials

10 oz clear plastic drinking cups
12 oz clear plastic drinking cups
¼" mesh hardware cloth (12.5" square)
coffee filters
dried shrimp
luminous powder (various colors)
gum Arabic
mortar and pestle
trowel

30 foot ladder
½″ rebar (18″ lengths)
¼″ nylon rope
small sledge hammer
dark-cup illuminator
dusting bulb insufflator

Luminous Dust

Fluorescent substances, whose presence can be detected by placing the marked animals under an UV light, have been used extensively by entomologists in capture-recapture studies. The markers are considered safe for most insects, although some species are sensitive, and experience decreased longevity when exposed to some fluorescent substances.

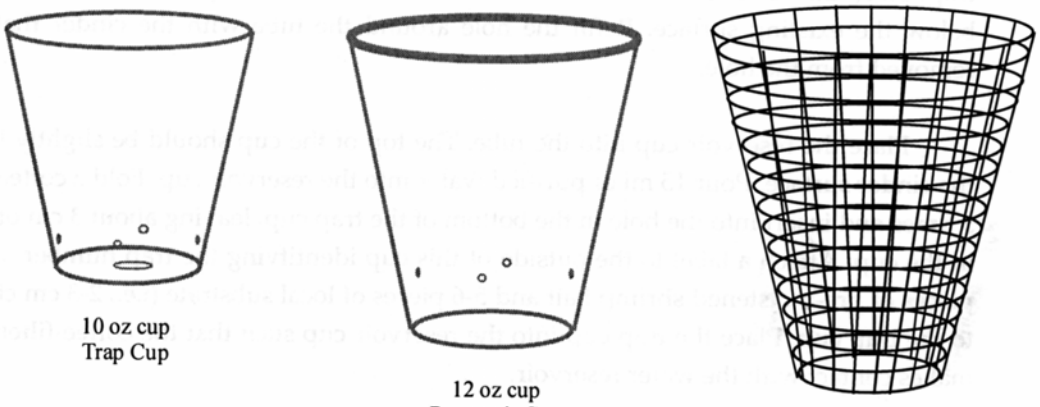
Specially formulated luminous powders are available from entomology equipment suppliers, and are considered the safest insect marking substance. They may be applied directly, but better adhesion is obtained when the dusts are combined with gum arabic. Mix one part luminous dust with six parts gum arabic until a paste is formed. Allow the paste to dry for at least 3 days. Pulverize the dry mixture to dust in a mortar. Store the dust mixture in sealed vials until needed. Apply dust with a dust bulb insufflator.

Traps

Construction

1. Remove the rim of the 10 oz cup and cut a hole 1.5 cm diameter hole in the bottom.
2. Punch four 2 mm holes around the side of the 10 oz cup about 1 cm from the bottom. Punch four 2 mm holes around the side of the 12 oz cup about 4 cm from the bottom.
3. Connect opposite edges of the hardware cloth making a wire tube the 12 oz cup will fit into.

4. Fold a coffee filter 5 times and insert into the hole at the bottom of the 10 oz cup, leaving about 3 cm sticking up into the cup.



10 oz cup
Trap Cup

12 oz cup
Reservoir Cup

wire tube

Location

Traps in Wēkiu bug habitat will be installed at permanent monitoring stations and capped when not in use. Thirteen permanent stations will be established, five in Pu'u Hau Oki, five in Pu'u Wēkiu, and three in newly restored habitat.

Installation

Extend the ladder to its full open position on the crater floor. The bottom of the ladder should just touch the cinder slope below the sampling station. Drive an 18" length of rebar into the substrate on each side of the bottom of the ladder. Attach the bottom of the ladder to the rebar using nylon rope. Tie a 50 foot length of rope to the top rung of the ladder. Stand the ladder upright. Holding onto the rope attached to the top, gently lower the ladder onto the slope. Drive an 18" length of rebar into the substrate on

each side of the top of the ladder. Attach the top of the ladder to the rebar using nylon rope. Repeat for each sampling station.

Install a trap at each sampling station (at the top of the ladders) by carefully digging into the cinder, disturbing only the amount of cinder necessary to set up the trap. Place the hardware cloth tube into the hole so that the top of the tube is slightly below the existing surface. Refill the hole around the tube with the cinder that was removed from the hole.

Place the reservoir cup into the tube. The top of the cup should be slightly below the cinder surface. Pour 15 ml of purified water into the reservoir cup. Fold a coffee filter 5 times and insert into the hole in the bottom of the trap cup, leaving about 3 cm of filter in the cup. Attach a label to the outside of this cup identifying the trap number. Add 3 pieces of pre-moistened shrimp bait and 5-6 pieces of local substrate (i.e., 2-3 cm cinder) to the trap cup. Place the trap cup into the reservoir cup such that the coffee-filter wick makes contact with the water reservoir.

Distribute chum, consisting of pureed pre-moistened shrimp, around the trap and place the trap cover such that the entire trap is shaded from sunlight. Attach a flag to the trap cover. Record on data sheet the trap number, date set, time set, and distance to nearest snow patch.

Collection

Remove the cap rock and remove the trap-cup from the trap. Carefully inspect the cinder in the cup, and record the number of Wēkiu bugs and presence of other arthropods in the trap.

Gently place captured Wēkiu bugs into the dark-cup illuminator and inspect each Wēkiu bug for luminous powder. Record the number of individuals with luminous dust and the colors of the dust if any is found. Dust all captured bugs with luminous powder using the dust bulb insufflator. Record the number of bugs marked and the dust color on the data sheet.

Release all live specimens at least one meter away from the sampling station. Wēkiu bugs should not be handled or exposed to direct sunlight for more than 30-45 seconds. Observe released bugs for one minute, making sure they find cover.

At the end of the sampling session remove the reservoir cup and replace the cap rock and flag. Remove the ladders from the crater.

6.2 - WEKIU BUG HABITAT PROTOCOL

Monitoring during Outrigger construction and operation will include sampling Wēkiu bug habitat to measure the locations and extents of restored habitat and habitat mitigation structures. In addition, the cinder structure in restored and mitigated habitat will be measured and monitored for changes.

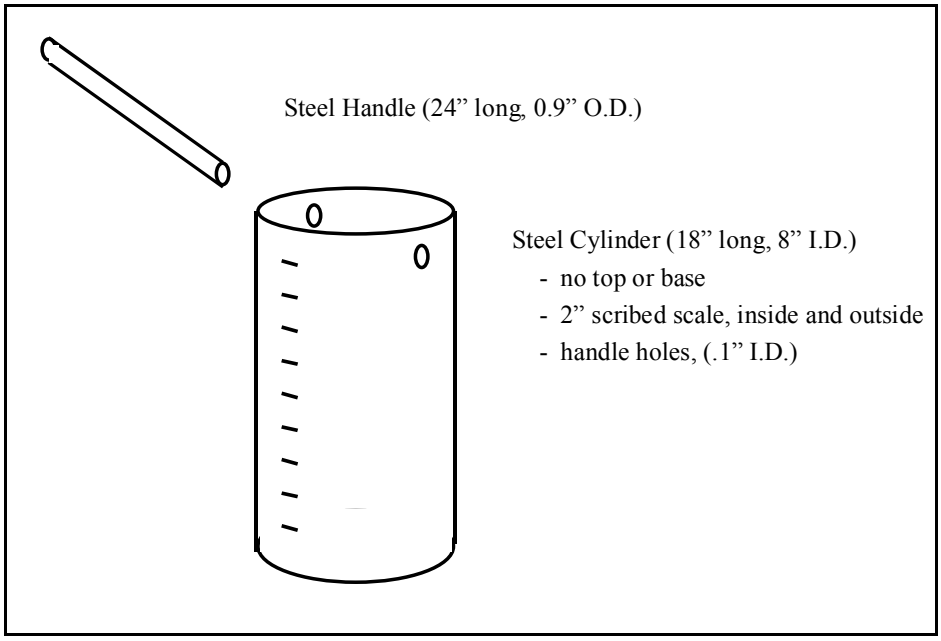
Researchers have determined that Wēkiu bugs live in the interstitial spaces, or voids, between the rocks in the surface layer. In the alpine environment of Mauna Kea's summit ice, frost heaving, and snowmelt wash and stratify the surface layer of cinder in the summit cones. Progressively larger rocks are lifted to the surface and washed clean of ash, which in turn accumulates in a layer 12 to 18 inches below the surface. This process is thought to create the interstitial spaces in which Wēkiu bugs live. The surface layer in restored habitat areas will be monitored for changes in interstitial porosity.

Materials

1 cylindrical shovel (see next section)
1 small trowel
~ 100 lidded containers (1/2 gallon)
100′ tape
3 screens (1″, 1/2″, 1/8″ meshes) ~ 12″x12″
scale
graduated cylinder or beaker (1 liter)

Cylindrical Shovel

The cylindrical shovel is a steel tube 8 inches in diameter and 18 inches long. The shovel has a drive handle and scribing that allows the operator to determine the depth the shovel is driven.



Locating Sampling Points

Thirteen sampling points in Wēkiu bug habitat will be installed at temporary monitoring stations: five in Puʻu Hau Oki, five in Puʻu Wēkiu, and three in newly restored habitat or habitat mitigation structures. These points will be established at trapping locations (see Population Protocol). This protocol will be implemented at those points prior to trap installation.

Additional sampling points in Wēkiu bug habitat will be necessary to monitor habitat structure changes over time, (any and all sampling point locations may be used only once). Additional points will be located using a grid established with a random starting point and random azimuth.

1) Place a grid map over a map of the site.
2) Randomly select one point on the grip as a starting point, (use a random number generator to select *x* and *y* coordinates).
3) Randomly select an azimuth, (use a random number generator to select a number between 0 and 360).
4) Re-orient the grid map, pivoting on the randomly chosen starting point, aligning the grid lines with the randomly chosen azimuth.
5) Sampling points may then be located at the re-oriented grid line intersections.

Field Collection

Drive the cylindrical shovel, perpendicular to the surface, as deep as possible. Carefully extract the cinder from within the cylinder in two-inch depth increments. Place each two-inch layer in a separate container for lab analysis. Mark each container with the sampling point number and the depth increment, (such as, Point 4 Hau Oki, 6-8 inches below surface). If necessary, drive the shovel deeper after extracting the top layers, so that 18" of cinder is eventually cored and removed. Following extraction of 9 two-inch layers, remove the shovel and fill the hole with loose cinder from the immediate vicinity.

Lab Analysis

For each two-inch layer sample, separate cinder particles by size using the three screens. Four fractions will be thus created. Submerge each fraction in a graduated beaker containing a known volume of water, and record the volume displacement, (i.e. the volume of the fraction). A wetting agent may be used in the water to eliminate small air bubbles that may cling to the cinder particles.

Calculate the particle size distribution of each two-inch layer (volume by particle-size-class). Calculate the porosity of each two-inch layer, (1 minus the ratio of the combined volume of the fractions to the total field volume of the layer). Note that each layer had a total field volume of $2\pi 4^2 = 100.5$ cubic inches.

6.3 - CONTRACTORS' LOG BOOK PROTOCOL

INSTRUCTIONS FOR FORM 1 - TRUCKS, EQUIPMENT, MATERIALS

The function of Form 1, Contractors' Log Book, is to provide a record of all trucks, heavy equipment, and construction materials that are transported to the Mauna Kea summit during construction of the Outrigger telescopes.

The purpose is to monitor for possible introductions of alien arthropods into Wēkiu bug habitat. Efforts to prevent alien arthropods from reaching the summit will help insure that the Wēkiu bug population is protected.

Information about each truck that arrives at the summit should be recorded in one column of Form 1, (one column per truck). The following numbered instructions correspond to the numbered rows on Form 1.

1: Arrival Time & Date

The **Arrival Time** is the hour, plus AM or PM, when each truck arrives at the construction site. The **Date** is the month, day, and year of arrival. Write down the hour of day and the date, (mm/dd/yy), when a truck arrives at the site.

2: Departure Time & Date

The **Departure Time** is the hour, plus AM or PM, when the truck leaves the construction site. The **Date** is the month, day, and year of departure. Write down the hour of day and the date, (mm/dd/yy), when the truck leaves the site. **One column per truck** means that the truck departing must be the same truck whose arrival is noted in the blank space above in the same column.

TRUCKS

3: Truck ID

The best **Identification Number** of a truck is its license plate number. Write down the license plate number of each truck that visits the construction site.

4: Number of Axles

Write down the number of axles, including those on any trailers attached to the truck.

5: Contents

Write down the contents of the load carried by the truck when it arrives at the construction site. **Contents** may be such things as: water, heavy equipment, construction materials, etc.

6: Loading location

Write down the address where the contents were loaded onto the truck. Include the **Name**, **Street Address,** and **City.**

7: Truck Owner

Write down the name of the person or company who owns the truck.

8: Truck Storage Yard

Write down the address where the truck (and trailer if applicable) is(are) stored when not in use. Include the **Street Address** and **City.**

9: Excess Mud on Truck?

Walk completely around the truck (and trailer if applicable) and note the presence of mud, dirt, or vegetation. In particular, inspect the undercarriage, axles, and wheel wells. Write down **YES** if the truck has clumps of mud or dirt larger than your fist, or if vegetation is clinging to the undercarriage. Write down **NO** if excess mud, dirt, or vegetation are not present on the truck (and trailer if applicable).

HEAVY EQUIPMENT

10: Heavy Equipment ID

Write down the **License Plate or Vehicle Identification Number** of each piece of heavy equipment arriving at the construction site**.** It is expected that heavy equipment will arrive on trucks Therefore, the information on each piece of heavy equipment should go in the same column as the information on the truck that transported it.

11: Type

Write down the **Type** of heavy equipment this piece is**.** Types of heavy equipment may be such things as loader, grader/scraper, back hoe, bulldozer, ditcher/excavator, fork lift, crane, snow plow, etc.

12: HE Owner

Write down the name of the person or company who owns this piece of heavy equipment**.**

13: HE Storage Yard Location

Write down the address where this piece of heavy equipment is stored when not in use. Include the **Street Address** and **City.**

14: Excess Mud on HE

Walk completely around this piece of heavy equipment and note the presence of mud, dirt, or vegetation. In particular, inspect the undercarriage, axles, wheel wells, tracks, and attachments. Write down **YES** if the heavy equipment has clumps of mud or dirt larger than your fist, or if vegetation is clinging to the undercarriage. Write down **NO** if mud, dirt, or vegetation are not present on the heavy equipment.

MATERIALS

15: Type of Materials

If the contents of the truck are construction materials, then write down the **Type** of materials arriving at the construction site. Types of materials may be such things as lumber and plywood, reinforcement bar (re-bar), concrete, steel beams and girders, building blocks, paints and/or solvents, etc.

16: Quantity

Write down the quantity of the construction materials on the truck. Also, be sure to specify the units, (gallons, pallets, cubic yards, etc.).

17: Evidence of Arthropods?

Examine the materials for signs of arthropods. Write down **YES** if there are signs of arthropods on the arriving materials. Write down **NO** if signs of arthropods are not present. Signs of arthropods include:

a. Ants, spiders, or other insects crawling on the materials
b. Spider webs on or among the materials
c. Small piles of sand-grain sized particles (frass) on wood objects
d. Clumps of mud or dirt
e. Clumps of vegetation

WEKIU BUG MONITORING PLAN - CONTRACTORS' LOG BOOK

FORM 1 - TRUCKS, EQUIPMENT, MATERIALS

Instruction Note No.		Example		
1	Arrival Time & Date	10 AM, 6/21/01		
2	Departure Time & Date	4 PM, 6/22/01		
	TRUCKS			
3	Truck ID	Lic: ABC123		
4	Number of axles	3		
5	Contents	Water		
6	Loading location	Co. Water Dept., XXXX Kaumana Dr., Hilo		
7	Truck Owner	A-1 Trucking		
8	Truck storage yard	XXXX Hinano St., Hilo		
9	Excess mud on Truck?	No		
	HEAVY EQUIPMENT			
10	Heavy Equipment ID			
11	Heavy Equipment Type			
12	H eavy Equipment Owner			
13	HE storage yard location			
14	Excess mud on HE?			
	MATERIALS			
15	Type	Water		
16	Quantity	1,000 gals		
17	Evidence of arthropods?	No		

WEKIU BUG MONITORING PLAN - CONTRACTORS' LOG BOOK

FORM 1 - TRUCKS, EQUIPMENT, MATERIALS

Instruction Note No.				
1	Arrival Time & Date			
2	Departure Time & Date			
	TRUCKS			
3	Truck ID			
4	Number of axles			
5	Contents			
6	Loading location	o		
7	Truck Owner			
8	Truck storage yard			
9	Excess mud on Truck?			
	HEAVY EQUIPMENT			
10	Heavy Equipment ID			
11	Heavy Equipment Type			
12	Heavy Equipment Owner			
13	HE storage yard location			
14	Excess mud on HE?			
	MATERIALS			
15	Type			
16	Quantity			
17	Evidence of arthropods?			

INSTRUCTIONS FOR FORM 2 - DUST, TRASH, HAZARDOUS MATERIALS

The function of Form 2, Contractors' Log Book, is to provide a record of all efforts to control dust, trash, and hazardous materials during construction of the Outrigger telescopes.

The purpose is to monitor for possible impacts to Wēkiu bug habitat. Recording control efforts will help insure that Wēkiu bug habitat is protected.

Information about daily control efforts should be recorded in one column of Form 2, (one column per day). The following numbered instructions correspond to the numbered rows on Form 2.

1: Date

Write down the **Date** of the log entry, month/day/year. Use one column per day, unless you require more room to record numerous control activities taking place on the same day . In that case, use a second or third column as needed, but be sure to clearly mark the **Date** in each column, (mm/dd/yy).

DUST CONTROL

2: Substrate type

The **Substrate Type** means the surface or substance to which dust control measures are be applied. Write down the substrate type where the dust-generating activity occurred. Common substrate types are: excavation (hole), cinder stock pile, road, parking lot, staging area, screened cinder, etc.

3: Location

Write down the location of the dust-generating activity. When excavations are for foundations and footings, specify the number of the nearest Outrigger (1 – 4). When excavations are for light tunnels, specify the origin and destination of the light tunnel. Write down the number of the nearest Outrigger (1 – 4) or staging area designation for cinder piles and construction pads.

4: Water applied? Quantity?

Write down **YES** if water was applied to the substrate to control dust. Write down **NO** if no water was used during the dust generating activity. Also write down the approximate quantity of water (in gallons) applied to the substrate.

5: Soil binders used? Type? Quantity?

Soil binders are chemicals that hold soil and dust particles together and prevent dust from being dispersed into the air. Soil binders may be mixed with water and applied to the substrate to control dust. Write down **YES** if soil binders were applied to the substrate, or **NO** if soil binders were not applied to the substrate. Write down the **Type or Brand Name** of the soil binder. Types of soil binders may be manufactured substances, soybean oilsoapstock, or lignins. Brands of manufactured substances include Soil-Sement, Pennzsuppress, and others. Record the Brand from the container. Report the **Quantity** of soil binder used, before mixing with water, and the units. **Reminder**: no soil binding compounds should be applied to cinder that will be used for habitat restoration.

6: Suspended for high winds?

Write down **YES** if any construction activity was suspended because of wind. Write down **NO** if no construction activities were suspended due to winds.

7: Covered? Type?

Some substrate, such as excavations or cinder stock piles, may be covered to prevent wind-generated dust. Write down **YES** if a substrate was covered, or **NO**, if the substrate was not covered. Also write down the **Type** of cover used. Cover types include tarps, plywood, etc.

TRASH

8: Roll-off containers covered?

Roll-off containers are large containers that are left at the site to receive waste materials. Write down **YES** if roll-off containers are securely covered to prevent wind-blown trash Write down **NO** if roll-off containers are not covered. Write down **NONE** if there are no roll-off containers on site on this day.

9: Construction materials covered?

Construction materials may be covered or tied down to prevent them from being blown off the site by high winds. Write down **YES** if construction materials were covered or anchored on this day. Write down **NO** if construction materials were not covered or anchored on this day.

10: Wind-blown debris?

Wind-blown debris may be trash, construction materials, or other items blown beyond the construction site boundaries. Write down **YES** if any debris was blown or fell beyond the construction site boundaries on this day. Write down **NO** if no debris was blown or fell beyond the construction site boundaries on this day.

11: If yes to 10, types, quantities.

If you wrote YES to No. 10, describe the types of debris and the quantities blown beyond the construction site boundaries on this day. **Types** of wind-blown debris include such things as plywood, plastic sheeting, packing material, paper, sheet metal, or other material. Estimate the size and number of the items.

HAZARDOUS MATERIALS

12: Chemicals used on site?

Chemicals are manufactured substances that are used during construction and maintenance of the Outriggers and the Observatory. These include paints, thinners, solvents, fuels, cleaners, acids, and mirror-coating materials. Write down **YES** if chemicals were used at the site on this day. Write down **NO** if chemicals were not used at the site on this day.

13: Types, quantities.

Write down the **Types** of chemicals (noted in No. 12) that were used at the site on this day. Write down the quantities of the chemicals used. Quantities may be a count of the number of containers (specify capacity), or the volume or weight of the chemicals used on this day. Be sure to specify the units.

14: Spills?

Spills are defined as any quantity of a chemical coming in contact with a surface or substrate to which it was not intended to be applied. Write down **YES** if a spill occurred on this day. Write down **NO** if no spill occurred on this day.

15: If yes to 14, to whom reported?

Spills should be reported to:

_____, ph _____ or to

_____, ph_____ .

Write down the name of the person to whom the spill was reported, and their phone number.

WEKIU BUG MONITORING PLAN - CONTRACTORS' LOG BOOK

FORM 2 - DUST, TRASH, HAZARDOUS MATERIALS

Instruction Note No.		Example		
1	Date	6/21/01		
	DUST CONTROL			
2	Substrate type	Excavation		
3	Location	O1 to JB4		
4	Water applied?, Quantity?	Yes, 250 gal		
5	Soil binders used? Type?, Qty?	Yes, SoilSement, 1qt.		
6	Suspended for high winds?	No		
7	Covered?, Type?	Yes, tarp		
	TRASH			
8	Roll-off containers covered?	Yes		
9	Construction materials covered?	Yes		
10	Wind-blown debris?	No		
11	If yes to 10, types, quantities	None		
	HAZARDOUS MATERIALS			
12	Chemicals used on site?	Yes		
13	Types, quantities	water-base paint, 5 gal		
14	Spills?	No		
15	If yes to 14, to whom reported	None		

WEKIU BUG MONITORING PLAN - CONTRACTORS' LOG BOOK

FORM 2 - DUST, TRASH, HAZARDOUS MATERIALS

Instruction Note No.				
1	Date			
	DUST CONTROL			
2	Substrate type			
3	Location			
4	Water applied?, Quantity?			
5	Soil binders used? Type?, Qty?			
6	Suspended for high winds?			
7	Covered?, Type?			
	TRASH			
8	Roll-off containers covered?			
9	Construction materials covered?			
10	Wind-blown debris?			
11	If yes to 10, types, quantities			
	HAZARDOUS MATERIALS			
12	Chemicals used on site?			
13	Types, quantities			
14	Spills?			
15	If yes to 14, to whom reported			

6.4 - METEOROLOGICAL STATION PROTOCOL

Monitoring weather during Outrigger construction and operation will include frequent sampling of temperature, humidity, windspeed, and precipitation. Wēkiu bugs are found only in the extreme alpine environment of Mauna Kea's summit. Extreme weather phenomena are thought to be associated with Wēkiu bug population change. Monitoring weather will provide measured variables to include in population change analyses. In addition, wind speed monitoring will provide data for determination of daily mitigation actions, such as dust control.

Several of the observatories have weather stations, and the information is readily available over the internet. Using existing weather stations will save costs and disturbance to habitat from installation of new equipment.

Tools

Computer with internet access.

Procedures

Access weather data at Mauna Kea Weather Center web site at http://hokukea.soest.hawaii.edu/index.html . Download weather information from UKIRT data logger. .

Download digital data monthly.

6.5 - ALIEN ARTHROPOD INSPECTION PROTOCOL

Arthropods that do not occur naturally at the summit area have the potential to disturb Wēkiu bug populations. Predators like ants and spiders are especially threatening. Regular inspections called for in the monitoring plan are intended to detect alien species so that they may be eradicated before being transported to the construction site.

This protocol is designed to be implemented by non-technical personnel and should detect most viable alien arthropod colonies present. Solitary arthropods are unlikely to establish populations at the summit and represent only a small threat to Wēkiu bugs.

Tools magnifying glass, knife, trowel. Notebook.

Targets soil, mud, vegetation, ants, spiders and spider webs, egg masses, frass, and yellowjacket nests.

Procedures

1. **Construction materials** Walk slowly around construction materials, trash containers, and shipping crates and examine all sides for ants, spiders, spider webs, egg masses, frass, and yellowjacket nests.

2. **Vehicles** Examine all of the wheel wells, wheels, tires, treads, and undercarriages of earth-moving equipment, large trucks, tractors, and other heavy equipment. Examine for ants, spiders, spider webs, egg masses, and yellowjacket nests. Also examine for soil, mud, dirt, vegetation, and other debris attached.

3. **Buildings** Examine sides of each building or structure, from base to 10 feet above the ground. Examine for ants, spiders, spider webs, egg masses, and yellowjacket nests.

Reporting

Type Describe what was inspected (e.g. construction material, vehicle, equipment, building)

Location Describe the general location of the subject inspected relative to fixed reference points.

Findings Describe the types and numbers of arthropods detected (e.g. ants, spiders, etc.), the types of arthropod artifacts detected (e.g. spider webs, yellowjacket nests, frass, etc.), and/or the type of arthropod habitats detected (e.g. soil, mud, vegetation, etc.).

6.6 - COMPLIANCE VISUAL INSPECTION PROTOCOL

Compliance monitoring investigates whether programs and personnel are following the guidelines established for protection of the Wēkiu bug. Random site inspections averaging one per month will be conducted during Outrigger construction to ensure compliance with the guidelines. The results of the random site inspections will be included in the quarterly reports

Tools

100′ tape measure, compass, notebook

Procedures

1. Note the locations of temporary barriers and verify their installation near excavations and other earth-moving activities (see QOI 2.4.1). Inspect and record the condition of the barriers (e.g. holding side-cast cinder, failing, etc.). Verify compliance with Wēkiu Bug Mitigation Plan Recommendation IV-3. Temporary, and if possible, permanent barriers should be built along the slope breaks above the inner slopes of Pu‘u Hau Oki crater. Report non-compliance or barrier failures to the construction-site manager.

2. Visually inspect for side-cast material (see QOI 2.4.2). Verify compliance with Wēkiu Bug Mitigation Plan Recommendation IV-3. Under no circumstances should cinder or other materials be side-cast into Wēkiu bug habitat. Report side-cast cinder to the construction-site manager.

3. Visually inspect active earth-moving operations, excavated materials and cinder stock piles (see QOI 2.5.1, QOI 2.5.2, & QOI 2.5.3). Verify compliance with Wēkiu Bug Mitigation Plan Recommendation V-1. Water should be applied to excavation sites and cinder stockpiles. Verify Contractors′ Log Book entries regarding Dust Control (CLB Form 2, Lines 2-7). Verify compliance with Wēkiu Bug Mitigation Plan Recommendation V-2. Dust-generating activities should be suspended and construction materials secured during high winds, and water should be applied to

recently exposed cinder and ash. Report non-compliance to the construction-site manager.

4. Visually inspect applications of soil-binding compounds (see QOI 2.5.4). Verify compliance with Wēkiu Bug Mitigation Plan Recommendation V-3. Soil-binding amendments should be used sparingly, and should never be applied to Wēkiu bug habitat. Verify Contractors' Log Book entries regarding Dust Control (CLB Form 2, Line 5). Report non-compliance to the construction-site manager.

5. Locate and observe the use of paints, thinners, and solvents and cleanup procedures. Describe cleanup and disposal activities (see QOI 2.6.2 and QOI 2.6.3). Describe spills, if any. Verify compliance with Wēkiu Bug Mitigation Plan Recommendation VI-2. Contractors should minimize the on-site use of paints, thinners, and solvents. Painting and construction equipment should not be cleaned on-site. Contractors should keep a log of hazardous materials brought on-site and report spills to a designated WMKO representative. Verify Contractors' Log Book entries regarding Hazardous Materials (CLB Form 2, Lines 12-15).Report non-compliance to the construction-site manager.

6. Visually inspect construction trash containers (see QOI 2.7.1). Describe trash containers, covers, and anchoring devices. Verify compliance with Wēkiu Bug Mitigation Plan Recommendation VII-1. Construction trash containers should be tightly covered to prevent construction wastes from being dispersed by wind. Verify Contractors' Log Book entries regarding Trash (CLB Form 2, Lines 8-11). Report non-compliance to the construction-site manager.

7. Visually inspect construction materials stored at the site (see QOI 2.7.2 and QOI 2.8.3). Describe material, covers, and anchoring devices. Verify compliance with Wēkiu Bug Mitigation Plan Recommendation VII-2. Construction materials stored at the site should be covered with tarps, or anchored in place, and not be susceptible to movement by wind. Verify Contractors' Log Book entries regarding Dust Control (CLB Form 2, Line 9). Walk slowly around the materials and examine for ants, spiders, spider webs, and yellowjacket nests. Report uncovered or unanchored material, or alien arthropods to the construction-site manager.

8. Locate and describe outdoor trash receptacles, and their lids and anchors (see QOI 2.7.3). Verify compliance with Wēkiu Bug Mitigation Plan Recommendation VII-3. Outdoor trash receptacles should be secured to the ground and have attached lids. Report non-compliance to the construction-site manager.

9. Locate and describe construction materials, trash, and wind-blown debris in Wēkiu bug habitat (see QOI 2.7.4). Describe the debris, general location, and retrieval activities if any. Verify compliance with Wēkiu Bug Mitigation Plan Recommendation VII-4. If construction materials and trash are blown into Wēkiu bug habitat, they should be collected without disturbing the habitat. Verify Contractors' Log Book entries regarding Trash (CLB Form 2, Lines 10-11). Report non-compliance to the construction-site manager.

10. Locate all large trucks, tractors, and other heavy equipment (see QOI 2.8.2 and QOI 2.8.3). Record vehicle identification numbers. Verify Contractors' Log Book entries regarding Trucks (CLB Form 1, Lines 1-14).Verify compliance with Wēkiu Bug Mitigation Plan Recommendation VIII-1. Earthmoving equipment should be free of large deposits of soil, dirt and vegetation debris that could harbor alien arthropods. Walk slowly around each vehicle and examine all of the wheel wells, wheels, tires, treads, and undercarriages. Examine and record the presence of spiders, spider webs, egg masses, ants, and other arthropods. Also examine and record the presence of soil, mud, dirt, vegetation, and other debris attached. Describe the presence of arthropods or arthropod harboring debris if any are found. Report alien arthropod presence to the construction-site manager.

11. Locate shipping crates and boxes. Examine and record the presence of spiders, spider webs, egg masses, ants, and other arthropods(see QOI 2.8.4). Also examine and record the presence of soil, mud, dirt, vegetation, and other debris attached. Describe the presence of arthropods or arthropod harboring debris if any are found. Verify Contractors' Log Book entries regarding Materials (CLB Form 1, Lines 15-17). Report alien arthropod presence to the construction-site manager.

12. Locate portable buildings and toilet facilities. Walk slowly around these structures and examine for ants, spiders, spider webs, or yellowjacket nests (see QOI 2.8.5). Record the presence of alien arthropods and describe their general location and the

degree of infestation. Report alien arthropod presence to the construction-site manager.

13. Walk slowly around the observatory building and outriggers, and examine for ants, spiders, spider webs, or yellowjacket nests (see QOI 2.8.5). Record the presence of alien arthropods, and describe their general location and the degree of infestation. Report alien arthropod presence to the construction-site manager.