SCOPE OF WORK

with a

Plan of Action, Deliverable Products, Schedule, & Budget

for Establishment of

A Long-Term Environmental Monitoring Program

On Certain Properties Belonging To

The United States Navy, Guam

Prepared for the Pacific Island Ecosystems Research Center

of the

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By

Pacific Analytics, L.L.C.
Albany, Oregon

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SCOPE OF WORK

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I. EXECUTIVE SUMMARY

The U.S. Department of the Navy (Navy) proposes to develop a comprehensive long-term environmental monitoring program (LTEMP) to assist in management of its properties in Guam. The Navy has management responsibility for over 6,000 hectares (15,000 acres) of land on Guam. These properties contain natural resources of significant economic, environmental, and social values. Concurrent to its national defense mission, the Navy recognizes a responsibility for the protection of native flora and fauna, the recovery of endangered and threatened species, and the maintenance of native biological integrity on lands under its jurisdiction. Development and implementation of a LTEMP will provide the information necessary to undertake effective and efficient management of these lands and thereby help fulfill management goals and supply the scientific justification for natural resource management activity.

The objective of this Scope of Work is to outline the development and implementation of a long-term environmental monitoring program (LTEMP) for U.S. Navy natural resource properties on Guam. This report includes a discussion of the objective of this Scope Of Work (SOW). A presentation is made of the issues to be considered during the development of the LTEMP for Navy lands on Guam and a discussion is included of a seven-step process for planning of long-term monitoring. The SOW follows with descriptions of the LTEMP tasks to be accomplished this year, organized into nine modules. Advocated is the establishment of standardized manuals and procedures for natural resource management on Navy lands and planning for adaptive management of these resources. A list of specific, deliverable products, a schedule, and a budget are also provided. Included in this SOW is a list of authorities for environmental conservation of the Navy's natural resource properties on Guam, and a short description of those properties.

When completed, the LTEMP will become an owners manual for the natural resources on Navy lands in Guam. It will describe in detail how to gather data about specific, important natural resources and how the data will be analyzed, interpreted, and reported. The plan will provide a step-by-step guide for integrating this information into management and operational decisions. Future management decisions will be based on scientific inference integrated with operational efficiency.

II. OBJECTIVE

The objective of this Scope of Work is to outline the development and implementation of a long-term environmental monitoring program (LTEMP) for certain lands under U.S. Navy jurisdiction on Guam.

Consistent with their national defense mission, the U.S. Department of the Navy (Navy) has a responsibility for the protection of native flora and fauna, the recovery of endangered and threatened species, and the maintenance of native biological integrity on Navy lands in Guam. Through their participation in the establishment and management of the Guam National Wildlife Refuge overlay units, the Navy has exhibited a commitment to responsible management of the natural resources on properties under its jurisdiction.

In order to facilitate natural resource management, the Navy contracted for a series of Natural Resources Survey reports to provide updated inventories of the natural resources of seven naval installations on Guam. Further, the Navy engaged the U.S. Fish and Wildlife Service (USFWS) and the U.S. Geological Survey/Biological Resources Division Pacific Island Ecosystems Research Center (PIERC/BRD) to develop an Integrated Navy Resource Management Plan (INRMP). The INRMP calls for a statistically designed monitoring plan to be developed and implemented. This Scope of Work provides the details for planning, designing, and implementing the first cycle of the desired long-term environmental monitoring program (LTEMP).

III. CONSIDERATIONS

Environmental monitoring is the investigation of the changes in environmental functions, attributes and characteristics that happen over time. Monitoring provides the information necessary for adaptive management of natural systems, biogeographical areas, and their biotic components. The knowledge gained through a properly designed monitoring program will provide the Navy with inferences about ecological changes and the impacts of its management strategies on its natural resources. The ultimate goal of monitoring is to aid in good stewardship and conservation of the natural world. The LTEMP will be designed to collect the best scientific information available and will ensure the Navy's compliance with all applicable NRM laws and directives.

Clarity of purpose is important in planning a monitoring program for Navy land in Guam. While the most general purposes of monitoring are to learn about environmental changes and to increase understanding of the impacts of management activities on native systems, the Navy may have one or more of the following specific purposes for monitoring natural resources on Guam:

- To provide historical records of environmental phenomena, attributes, and characteristics.
- To detect threshold events, or critical levels of environmental phenomena, attributes, and characteristics.
- To detect hazards and risks to valued ecosystem attributes and functions.
- To detect specific changes in the environment.
- To detect trends and/or patterns in those changes.
- To correlate auxiliary attributes and characteristics with trends and patterns of change.
- To predict future changes in environmental functions, attributes, and characteristics.
- To evaluate management activities and provide information useful in modifying management actions.

All these monitoring purposes apply to management and conservation of the ecosystems and natural resources of Guam.

Guam is the southernmost member of the Mariana Islands, a Pacific archipelago. Guam has a unique environment with rare endemic plants and animals. Like most Pacific islands, Guam ecosystems have sustained significant impact from human beings over the last few centuries. These impacts have resulted in alterations, extinctions, and introductions of populations of plants and animals. Detection, prediction, and modification of these environmental changes is vitally important to long-term management of Guam's natural resources.

The Navy's management of natural resources under its jurisdiction needs to be an iterative process of monitoring and management actions on a continuous basis. Observational monitoring and experimental monitoring will increase understanding of ecosystem dynamics and the effects of management actions. Monitoring will serve as a feedback mechanism to promote better integration of conservation efforts. As knowledge accumulates, management strategies will be adjusted, and management will become more effective at achieving the goals stated in the INRMP. Because of this adaptive benefit, monitoring of long-term ecosystem changes has been mandated as an integral component of conservation-oriented management on most federally controlled land.

Planning of long-term monitoring for Navy lands on Guam is a complex undertaking because the environment is an intricate web of inter-relationships and dependencies.

Monitoring change in Guam natural areas is complicated by habitat fragmentation, invasion of alien species, development near area boundaries, commercial, military and recreational use, and natural disturbances. The Navy needs scientifically detailed and reliable information about species within its management jurisdictions, about the impacts of management decisions to those species, and about changes in populations of those species over time.

The difficulties in planning for complex, multi-resource monitoring are mitigated by employing a step-by-step planning process. We have identified the following seven-step process for planning of long-term monitoring:

1. Prepare clear statements of the questions of interest.
2. Design the sampling systems
3. Develop sampling protocols for data collection
4. Prepare the data management systems, including GIS
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 plan. Furthermore, the steps must be undertaken in a comprehensive manner. Planning decisions made in any one stage affect decisions at all the other stages.

1. Prepare clear statements of the questions of interest.

The first step in developing a monitoring plan requires clearly defining the questions of interest. 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 identifying the important issues and concerns, and reducing general problems to questions of specific, measurable attributes. Some of these general problems appear in the Navy's INRMP. Identifying other issues of concern will require extensive interviews with Navy personnel, PIERC/BRD scientists, USFWS specialists, the University of Guam, concerned environmental groups, and local citizens. Much effort will be spent investigating the key monitoring questions. They must be well-considered and carefully elucidated.

2. Design the sampling systems

The second step in monitoring planning is designing the sampling systems. It is expected that many quantifiable questions of interest will be elucidated in the first stage. Each key question must then be evaluated for utility and efficiency. Proposed questions of interest must be prioritized based on the projected costs to collect the data and the projected value of the knowledge to be gained. The effort expended to answer

each question must lead to useful gains in knowledge and remain within budgetary and logistical constraints. Some questions are simply too expensive to answer efficiently. Some questions cannot be answered without controlled experimentation. Designed experiments, based on expected operational activities, should be incorporated into the sampling system.

Expertise in statistics, biometrics, and cost/benefit analysis are required for sampling system design. Some of the design techniques which should be 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 must also be developed. Monitoring is the investigation of change over time, so timing of sampling is an essential element in sampling system design.

Another consideration in sampling system design is the type of sampling unit. The decision to use permanent plots, transects, or points selected at random is largely driven by the questions of interest. Each type of sampling unit must be considered and applied where appropriate.

3. Develop sampling protocols for data collection

The third step in monitoring planning is to develop the data collection system(s). Sampling protocols are necessary to standardize data collection. Data gathered in the future must be comparable to data gathered today in order to statistically detect significant environmental changes. Protocols should include specific methods to be used for every habitat and each animal or plant type, descriptions of the tools necessary for data collection, and randomization schemes for determining trap placement, plant selection, or measurement device location. Protocols should be field-tested to assure feasibility and efficiency. Field data collection crews should then be trained and tested in the use of the sampling protocols.

4. Prepare the data management systems, including GIS

The fourth step in monitoring planning is the preparation of a data management plan. The data collected in each sampling exercise must be checked for errors and corrected. Data sets must be entered into a database for easy access and retrieval. The database must be properly archived to be useful many years in the future. Monitoring requires comparisons of attributes over sometimes lengthy periods of time. 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 on Guam, they will also provide information potentially useful for management elsewhere in the Pacific.

A geographic information system (GIS) is an important component of LTEMP data management. The changes over time detected and predicted by monitoring must also be placed in spatial contexts. One aspect of environmental change is the movement of floral and faunal attributes through migration, displacement, reintroduction, and

revegetation. A GIS allows monitoring data to be applied to maps in layers such that information about spatial relationships is easily visualized.

5. Plan the analysis and interpretation systems

The fifth step in monitoring planning is 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. The sampling design and the statistical structure of the data must be accounted for in the analysis plan. Techniques of exploratory data analysis (EDA), graphics, statistical distribution tests, data transformations, and modeling should be developed in the plan. Much of the inference 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 should be specified in the planning process. Failure to specify analytical forms could cause gaps and inefficiencies in sampling design and data collection. Prior planning for analysis will help ensure completeness and timeliness of the sampling and prevent wasteful effort.

6. Develop of a reporting system

The sixth step in monitoring planning is the development of a plan for the reporting the results. The new knowledge acquired through monitoring should be communicated to responsible Navy personnel and interested agencies for use in determining management decisions. Charts, tables, and maps may be the immediate products of analysis but do not stand alone. Reports should be carefully planned and clearly written with consideration of the intended audience and the appropriate application of the findings. The reports should clearly explain the results of data analysis and the implications to natural resource management. Monitoring reports need to be produced on time and updated on a regular schedule.

7. Develop a monitoring sustainability plan

The seventh step in monitoring planning is development of a monitoring sustainability plan. Institutional commitment 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 Navy must consider the LTEMP, as part of the INRMP, as a permanent fixture in future budgets. Involving other stakeholders, such as PIERC/BRD, USFWS, the University of Guam, local environmental groups, and Guam citizens will help to build community commitment to the LTEMP. Planning for sustainability and commitment is a necessary element in long-term environmental monitoring.

In summary, monitoring of ecosystems and natural resources on Navy lands in Guam should be comprehensive, cost-effective, statistically designed, executed with analytical integrity, presented to decision makers by way of meaningful reports, charts,

and maps, and updated regularly over many decades. Consideration and application of the seven steps will improve efficiency and effectiveness of knowledge acquisition and guarantee managers, regulators, scientists, and citizens useful information on which rational management decisions may be based. Conscientious planning and implementation of a properly designed monitoring plan will provide the Navy the necessary prerequisites for continued good stewardship of its properties.

IV. PROPOSED TASKS

The proposed tasks in this Scope of Work are organized into nine modules. These modules incorporate the seven steps for developing a monitoring plan discussed in the previous section, and include establishment of a GIS system and implementation of initial monitoring field work. Inclusion and completion of each module is necessary to produce and implement an environmental monitoring plan for Navy lands on Guam. Specific tasks and a report or other deliverable product are associated with each module.

Module 1. Develop and determine the Questions of Interest (QOI's) to be addressed by the monitoring program.

Development of the QOI's is the process of identifying specific problems and issues that will be addressed by the long-term environmental monitoring program (LTEMP). Each problem or issue will be further divided into hypotheses or key questions with quantifiable answers. Elucidation of the QOI's will establish the specificity of the LTEMP. Existing inventories and synopses of Guam environmental characteristics will be used to develop the QOI's.

The QOI's will be developed in close consultation with all stakeholders. Extensive interviews, on Guam, will be undertaken with Navy personnel, USFWS specialists, the University of Guam, concerned environmental groups, and local citizens. Additional consultations will be made with PIERC/BRD and USFWS scientists in Hawaii who have expertise in environmental issues on Guam. Outreach to these parties will help build involvement and commitment to the monitoring program, as well as aid in development of the QOI's.

The QOI's will be consistent with the Navy's national defense mission of defense and management goals identified in the INRMP. These include military uses, conservation and restoration of terrestrial, aquatic, and marine habitats, preservation of endangered, threatened, or rare native flora and fauna, and investigation of environmental responses to management and use. The Module 1 report will identify, prioritize, and select QOI's for evaluation by the Navy. This report will indicate what environmental attributes, characteristics, or functions will be measured, counted, or otherwise investigated in the LTEMP.

Module 2. Design the sampling systems

Sampling systems will be designed that will address the QOI's identified and selected in Module 1. These statistically valid sampling systems will be robust, cost-efficient, and effective at answering the QOI's.

The elements of monitoring design will use statistical methodologies including randomization, replication, stratification, blocking, and covariate measurement. Control areas will be planned for operational management treatments where applicable.

Sampling systems will be designed for each QOI, using the most appropriate and efficient methodologies. These may include quadrats, transects, plots, relevès, traps, telemetry, or other sampling methods. Evaluation will be made of the desirability of permanent sampling stations versus temporary stations.

Sample size determinations will be made for each QOI. These will be based on estimated inferential strength measures such as variance, standard deviation, and distributional assumptions, and population considerations. Power analyses will be applied to aid in sample size determinations. Because monitoring is the investigation of change over time, schedules of repeated samplings will be developed for each QOI. The frequency of measurement will also be based on inferential strength measures desired and estimated rates of change.

Analysis will be made of cost versus utility for each sampling system. Evaluation will be made of the projected cost of sampling and the potential value of the information to be gained through sampling for each QOI. Estimates will be made of the risks and hazards to management goals from low intensity sampling. When applicable, cost allocation algorithms will be applied to each sampling system to build in efficiency.

Sampling systems designed will include procedures for evaluating operational treatments and management activities. These will utilize experimental design principles including controls, factorization, blocking designs, and factorial arrangement of treatment levels. Efforts will be made to incorporate such designs into operational treatments with the most efficiency and least disruption to management activities and uses.

The Module 2 report will describe in detail each sampling system designed. This report will indicate the intensity and schedule for measurements, counts, or other investigations in the LTEMP.

Module 3. Develop and test field sampling protocols

Sampling protocols (field manuals that guide data collection) will be developed for each sampling system designed and selected in Module 3. These may include nondestructive sampling techniques for:

a) Vegetation, including measurements of trees, culturally significant plants, threatened or rare plants, invasive weeds, vegetative structure, and habitat characteristics
b) Sea or Shore birds, including measurement of population densities
c) Arthropods, including measurement of population densities
d) Mammals, including measurement of population densities
e) Mollusks, including measurement of population densities
f) Watershed functions, including measurement of surface water quality and quantity
g) Near-shore marine habitats, flora, and fauna
h) Historic values, including locating and mapping culturally significant sites
i) Recreation, including measurement of user days and user impacts
j) Experimental design in operational monitoring
k) Measurement of the aquatic biota living in streams, lakes, and reservoirs.
l) Other sampling protocols to be specified. These may include methodologies for determining air quality monitoring, noise monitoring, visual resource monitoring or others

Each sampling protocol will be tested in the field to determine the efficacy of the methodologies. Tests will include time-and-motion studies to evaluate the time, labor, equipment, and materials requirements of each protocol. Preliminary estimated population variances developed in these tests will aid in determining appropriate sampling intensities.

Sampling protocols will utilize the reference grid developed in the Phase I efforts of PIERC/BRD in 1998. Referencing geographically positioned points will aid in exact mapping for future data collection and analysis.

The products for this task will be a collection of the field manuals for implementing the sampling systems designed in Module 2. A summary report will list the protocols, the results of the field testing, and include recommendations for efficient multi-resource monitoring. Combining protocols in sampling sessions is one way of adding efficiency to the LTEMP. The protocols and report will indicate how environmental attributes, characteristics, or functions will be measured, counted, or otherwise investigated in the LTEMP.

Module 4. Develop a plan and database for archiving collected monitoring data

A data management plan and a database will be developed for the sampling system protocols developed in prior Modules. Data management is an important component of long-term monitoring. Archiving and retrieval of data over many years are necessary for statistically valid comparisons that will detect and predict environmental change.

The data management plan will evaluate and recommend data entry methodologies including hand-held field computers. The plan will also evaluate and recommend error-checking procedures and algorithms to ensure the accuracy and precision of measurements and counts. Archiving and data backup methodologies will be discussed, including archival of associated protocols and field notes. Metadata issues will be considered and discussed in the report. Database software will be specified and appropriate data fields will be elucidated. Issues of data ownership and future use will be discussed and recommendations made. Recommendations for curation of scientific specimens and field sample materials will be made. Recommendations for computer hardware needs will also be included.

The Module 4 data management plan report will include all of the above. The report will indicate how the monitoring data will be managed in the LTEMP.

A relational database will be created for implementation of the LTEMP, using the specified software and data field. The database will include a user interface for ease of data entry and retrieval. Error checking algorithms will be built in. Links to the GIS system specified in Module 5 will be developed and included. Efforts will be made to ensure that the database is compatible with the GIS being developed. The Navy will assume ownership of the database and may, at its discretion, provide copies to its specific assignees.

Module 5. Establish a comprehensive geographic information system

A comprehensive Geographic Information System (GIS) will be created for Naval lands in Guam. The GIS will be an important monitoring tool for evaluating environmental change across landscapes, including location and movement of floral and faunal attributes through migration, displacement, reintroduction, and revegetation. The GIS developed will include base layers (such as terrain, rivers, roads, and political boundaries) as well as field data collected in the monitoring program. Data will be created in thematic layers that are accurately georeferenced to the underlying base map. Through the use of overlaid map layers, the field data can be analyzed and presented in map format.

Available geospatial data for Guam, such as will be used to create the base map layers, currently are available in a variety of map projections, using a range of datums. These available base layer data will be compiled and projected into a common projection and coordinate system using a single map datum; these will be determined based on

discussion of alternatives and Navy needs. All spatially-referenced monitoring data will be collected in this system, providing a complete set of fully compatible map data layers.

The GIS will be based in ArcView. Field data will be augmented with location data collected using a differentially-corrected Global Positioning System (GPS) to provide accurate locations for the creation of thematic map layers. Map layers can then be overlaid for analysis and map making using ArcView. Analysis of field data will allow detection of changes in the biophysical attributes over time and space.

As part of the GIS creation, the issue of base and reserve boundaries will be addressed. Currently available map sources show a number a variations in the exact locations of base and reserve boundaries; these will be clarified using GPS to complement accurate legal survey descriptions of boundaries.

Development of the GIS will be determined by the applications for which the GIS will be used. Efficient design of the system is influenced by its ultimate use. Interviews with end users will be conducted to determine the type of information expected to be retrieved from the GIS. Considerations will be made for different types of data, and allow attribute information retrieval from both point and area features

Another issue to be addressed during the development of the GIS is the determination of base and reserve boundaries. Accurate text, digital, and/or survey boundary information will be incorporated into the GIS.

The Module 5 report will be a discussion of the applications of GIS for monitoring and management and include details of the GIS. The report will indicate how the monitoring data will be mapped in the LTEMP.

Module 6. Develop a plan for analysis and interpretation of monitoring data

A data analysis and interpretation plan will be developed for the LTEMP. Statistical analysis and scientific interpretation are necessary to produce logical inferences and new knowledge from monitoring data.

The data analysis and interpretation plan will include discussion of techniques of Exploratory Data Analysis (EDA), graphics, statistical distribution tests, data transformations, and modeling. Monitoring models such as time trend analysis, survival analysis, growth and mortality models, diversity index models, and population change models will be evaluated and recommendations for selection made. Evaluations will include review of the accepted sampling system designs and the statistical structure of the data to be collected.

The data analysis and interpretation plan will include discussion of the QOI's and the environmental parameters to be estimated. Inferential strength measures appropriate to each QOI will be evaluated. Methods of biological interpretation will be discussed.

The Module 6 report will include discussion and evaluation of the recommended models and analytical procedures. This report will indicate how the monitoring data will be analyzed and interpreted in the LTEMP.

Module 7. Develop a plan for reporting results and findings

A monitoring report and presentation plan will be developed for the LTEMP. The knowledge acquired through monitoring should be communicated to responsible Navy personnel and interested agencies for use in determining management decisions.

The report and presentation plan will include discussion of the types of reports, publishable units, and demonstrations that are applicable and appropriate to the LTEMP. Consideration will be made of the intended audience and the appropriate application of the monitoring findings. Discussion will include evaluations and recommendations for the types of charts, tables, and maps that will be included in reports and presentations.

A schedule for reporting will be developed. Monitoring reports must be submitted on time and on a regular schedule to be useful to management.

The Module 7 report will be produced that discusses and evaluates the recommended monitoring reporting and presentation procedures. This report will indicate how the monitoring results and findings will be communicated to managers and stakeholders in the LTEMP.

Module 8. Develop a plan for long-term sustainability and commitment to monitoring

A plan for long-term sustainability and institutional commitment to monitoring will be developed for the LTEMP. Institutional commitment to monitoring must be developed to ensure that the prescribed future monitoring efforts are undertaken. The monitoring program, as well as the management programs should become permanent fixtures in the Navy's standard operating procedures and future budgets.

The sustainability and commitment plan will include evaluation and recommendations for involving other stakeholders, such as PIERC/BRD, USFWS, the University of Guam, local environmental groups, and Guam citizens will help to build community commitment to the programs. The discussion will include public outreach and

involvement, with the goal of creating acceptance and support for the INRMP and Navy management.

The Sikes Act of 1960 (as amended) and directive OPNAVINST 5090.1-B require a review of the INRMP every 5 years. Incorporated into the sustainability plan will be a plan for integrating into this review a reexamination of the questions of interest on which the monitoring plan is based. Goals and questions may change over time but consideration should be given to the value and importance of archived data and the continuation of data collection for long-term continuity and analysis.

The Module 8 report will discuss and evaluate the recommended methods for building commitment to monitoring. This report will indicate how the monitoring efforts in the LTEMP will be sustained over many years.

Module 9. Implement the monitoring plan through initial field sampling

After completion and acceptance of the preceding eight Modules, initial field sampling will be undertaken. The locations for sampling, the sampling intensities, procedures, protocols, equipment, and data management processes will have been specified, so that field work may be initiated and completed with efficiency, reproducibility, and applicability to the LTEMP goals.

A field team will be organized. Transportation and field equipment will be obtained or acquired. Field data collectors will receive the necessary training. Coordination with Navy management practices and uses will be implemented. Field measurements will then be undertaken.

Collected data will be incorporated into the prepared database and error checking and data cleaning will be undertaken. Initial statistical analysis will be performed and reports of initial findings will be created and presented. Outreach to stakeholders will be undertaken. The LTEMP will be underway.

Summary

Long-term environmental monitoring is a complex undertaking. Application of the procedures described in the nine Modules will facilitate a successful LTEMP, aid in conservation and enhancement of environmental resources, and provide a sound basis for ongoing management and stewardship of Navy lands on Guam.

V. DELIVERABLE PRODUCTS

The following research products will be developed and furnished to the Navy and their assignees following the schedule given in the next section. Reports, systems, protocols, and plans will be submitted in final form in 3-ring binders to facilitate adaptive monitoring and management goals.

Module 1. *Develop and determine the Questions of Interest (QOI's) to be addressed by the monitoring program*

A report on identification, prioritization, and selection of LTEMP QOI's.

Module 2. *Design the sampling systems*

A report describing in detail each sampling system designed, including the intensity and schedule for measurements, counts, or other investigations in the LTEMP.

Module 3. *Develop and test field sampling protocols*

A collection of the field protocol manuals for implementing the sampling systems.

A summary report listing the protocols, the results of the field testing, and including recommendations for multi-resource monitoring.

Module 4. *Develop a plan and database for archiving collected monitoring data*

A database for monitoring data archiving and retrieval.

A data management plan report evaluating and recommending methodologies for data entry, error checking, archiving, and retrieval of monitoring data. Included will be specifications for the database software, and recommendations for data propriety and curation of scientific specimens and field sample materials.

Module 5. *Establish a comprehensive geographic information system*

A comprehensive geographic information system (GIS) compatible with Arcview software.

A report on the details of the GIS and mapping of LTEMP data.

Module 6. *Develop a plan for analysis and interpretation of monitoring data*

A data analysis and interpretation plan report that evaluates and recommends statistical models and analytical procedures for the LTEMP.

Module 7. *Develop a plan for reporting results and findings*

A report that evaluates the recommends monitoring reporting and presentation procedures for communicating LTEMP results and findings to managers and stakeholders.

Module 8. *Develop a plan for long-term sustainability and commitment to monitoring*

A report that evaluates and recommends methods for building commitment to monitoring sustainability among stakeholders.

Module 9. *Implementation the monitoring plan, initiate field sampling*

A collection of reports on the results and findings of the initial LTEMP field sampling.

VI. SCHEDULE

The following schedule is suggested for 1999:

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Module												
1: Questions of Interest												
2: Sampling System												
3: Sampling Protocols												
4: Database												
5: GIS												
6: Analytical Procedures												
7: Reporting												
8: Sustainability												
9: Implementation												

VIII. AUTHORITIES

The Sikes Act of 1960, as amended, promotes effectual planning, development, maintenance, and coordination of wildlife, fish and game conservation and rehabilitation in military reservations. Amendments to the Sikes Act require cooperation among the Navy, federal agencies, and the Government of Guam in the development of research plans. The Act provides that these plans reflect mutual agreement of all parties concerning conservation, protection, and management of fish and wildlife resources. DOD and Navy directives provide guidance for implementing the Sikes Act and other compliance requirements.

The Navy is authorized to contract with the appropriate Federal agency under the provisions of the Sikes Act of 1960, as amended and under Section 601 of the Economy Act, as amended (31 U.S.C. 686) which provides for services to be performed by Federal agencies for other Federal agencies. The preparation of this document is being performed as a Statistical Services Agreement between the Department of the Interior, US Geological Service, Biological Resources Division, Pacific Island Ecosystems Research Center and Pacific Analytics, L.L.C. dated December 29, 1998. The contract is for the performance of work agreed to as part of an Interagency Service Agreement between the Department of the Navy Pacific Division, Naval Facilities Engineering Command and the Department of the Interior, US Geological Service, Biological Resources Division, Pacific Island Ecosystems Research Center dated June 15, 1998.

Legal authority authorizing the Navy to conduct resource management and delineating responsibility in this area can be found in the INRMP for Guam. A List of Authorizations follows for the person(s) setting out to conduct inventory and monitoring work on Guam Navy lands. The agreements with U.S. Fish and Wildlife Service and/or the Guam Government as co-signatures are important in delineating which species the USFWS and the Guam government recognize as important for special attention at the Federal and local levels. Wide involvement in the LTEMP will also aid in building long-term commitment to the program.

List of Authorizations. All are current unless otherwise noted.

Executive Order 13089: Coral Reef Protection. Dated 6.16.98. Creation of a Coral Reef Task Force to include the Secretary of Defense. Action items include (a) identify agency actions that may affect U.S. coral reef ecosystems; (b) utilize their programs and authorities to protect and enhance the conditions of such ecosystems; and (c) to the extent permitted by law, ensure that any actions the agency authorizes, funds, or carries out will not degrade the conditions of such ecosystems. Superceded by (1) war or national emergency; (2) when necessary for reasons of national security; (3) during emergencies posing as an unacceptable threat to human health or safety or to the marine environment and admitting of no other feasible solution; or (4) in any case that

constitutes a danger to human life or a real threat to vessels, aircraft, platforms or other man-made structures at sea. May require NEPA review in any area affecting coral ecosystems.

Clean Water Act of 1977 as amended (33 U.S.C. 1251, *et seq.)*

Coastal Zone Management Act (16 U.S.C. 1451, *et seq.)*

Magnuson-Stevens Fishery Conservation and Management Act (16 U. S. C. 1801, *et seq.)*

National Environmental Policy Act of 1969, as amended (42 U. S. C. 4321, *et seq.)*

National Marines Sanctuaries Act (16 U. S. C. 1431, *et seq.)*

National Park Service Organic Act (16 U. S. C. 1, *et seq.)*

National Wildlife Refuge System Administration Act (16 U. S. C. 668dd-ee)

The Sikes Improvement Act of 1997. Provides for preparation of an Integrated Natural Resources Management Plan to include the Department of Defense. Amends the Sikes Act of 1960 (16 U. S.C. 670a, *et seq.).*

DoD Instruction No. 4715.3, for the Environmental Conservation Program, 3 May 1996. Applies to the Secretary of Defense and all military departments including the Navy.

DoD Directive No. 4715.1, for Environmental Security, 24 Feb 1997.

Naval Instruction OPNAVINST 5090.1B, CH-2, draft of 25 April 1997, Ch. 22, for Natural Resources Management.

Memorandum of Understanding to Foster the Ecosystem Approach. 15 Dec 1995. Includes Departments of Defense, Interior, EPA, Commerce, and Agriculture. Concerns executive level commitment to provide leadership in and cooperate with activities that foster an ecosystem approach to natural resource management, protection and assistance. Directs information coordination and problem solving among agencies. Effective through Dec 15, 1999.

Command Level Cooperative Agreements and Regulations.

Cooperative Agreement for the Establishment of the Guam National Wildlife Refuge, Navy Overlay Units. U. S. Navy and U. S. Fish & Wildlife Service.

Memorandum of Understanding among the Government of Guam and the U. S. Air Force and Navy, and the U. S. Fish & Wildlife Service, for the establishment and

management of the Guam National Wildlife Refuge, Guam, dated 14 Dec 1993. Signed by Assistant Secretary, Navy.

Memorandum of Agreement for Cooperative Law Enforcement between the U. S. Fish & Wildlife Service and Division of Aquatic and Wildlife Resources Department of Agriculture, Territory of Guam, 09 Jul 1990.

Memorandum of Agreement for Concurrent Jurisdiction regarding Law Enforcement, 01 Sept 1988. Signed by Commander, Naval Forces Marianas.

Memorandum of Agreement for control/eradication of the brown tree snake, 12 Aug 1993. Expired 5/98 and currently under revision. Signed by Secretaries of Defense, Agriculture, Interior, AG Guam, and State of Hawaii.

Cooperative Agreement for the Protection, Development and Management of Fish & Wildlife Resources at U. S. Navy Public Works Center, 11 Apr 1988.

Cooperative Agreement for the Protection, Development and Management of Fish and Wildlife Resources at U. S. Naval Magazine, Guam, 07 Mar 1988.

Cooperative Agreement for the Protection, Development and Management of Fish and Wildlife Resources at U. S. Naval Station, Guam, 12 Apr 1988.

Cooperative Agreement for the Protection, Development and Management of Fish & Wildlife Resources at U. S. Naval Supply Depot, Guam, 29 Feb 1988.

Cooperative Agreement for the Protection, Development and Management of Fish and Wildlife Resources at U. S. Naval Facility, Guam, 27 May 1988.

Cooperative Agreement for the Protection, Development and Management of Fish and Wildlife Resources at U. S. Naval Air Station, Guam, 06 Jan 1988.

Cooperative Agreement for the Protection, Development and Management of Fish & Wildlife
Resources at Anderson Air Force Base, Territory of Guam, 04 Feb 1986. Signed by the Dept. of the Air Force, U. S. Fish & Wildlife Service, and the Government of Guam.

Memorandum of Agreement (reg. Marine environmental protection and response to marine pollution) 29 Jun 1993. Signed by U. S. Coast Guard and Government of Guam.

U.S. Naval Activities, Guam Instruction 5090.6. Management and Recreation of Natural and Cultural Resources, 22 Apr 1997. Includes land an coconut crab hunting regulations and procedures and natural an cultural resources recreational programs at

Ordnance Annex and U. S. Naval Activities, Guam. Cancels NAVACTSGUINST 1106.1.

IX. PROPERTY DESCRIPTIONS

Regional Study Area

Guam is the largest and southernmost of the Mariana Islands, a north-south chain of 15 islands located approximately 6080 km (3600 mi) west of Hawaii and 2400 km (1400 mi) south of Japan, at the boundary between the Pacific Ocean and the Philippine Sea. Guam is about 45 km long and 6 to 13 km wide (27 by 4-8 mi).

The northern half of the island is a limestone plateau 91-183 m (300-600 ft) high with cliffs near the coast. It has alkaline soils with a substantial groundwater lens, but without permanent streams. The southern half of the island consists of hilly volcanic terrain with elevations up to 406 m (1330 ft), acid volcanic soil, no groundwater lens, and numerous permanent streams. The central part of the island is a low-lying area less than 20 in (66 ft) in elevation with a mixture of soil types.

Because of Guam's low topography, variation in rainfall across the island is low. The yearly average rainfall is 241 cm (95 in) of rain on the east or windward coast of the island, and 203 cm (80 in) on the west coast (NOAA 1984). However, differences in soils and topography, together with the effects of typhoons and of human activities, have produced markedly different vegetation and forest types in the northern and southern halves of the island.

The fauna of Guam has been drastically altered by human activities. Mammals include endemic bats and introduced ungulates, dogs, cats, and rats. The avifauna once included 14 native land birds, seven introduced land birds, several native seabirds, and numerous migrant species. Population declines in avifauna have been attributed to predation by an introduced snake, although disease and habitat loss are also contributing factors.

Naval bases are located throughout Guam (Map 1) and encompass the full range of landforms, soils, groundwater, vegetation, and habitats found on the island. The Finegayan Communications Annex and Barrigada Communications Annex are on the northern part of the island. The Ordnance Annex, Waterfront Annex, Public Works Center, and Nimitz Hill Annex are on the southern part of the island. The Public Works Center has facilities distributed over the entire island, including Fena Reservoir within the Ordnance Annex.

Ordinance Annex:

The Ordinance Annex includes a large storage facility for explosives comprising 3578 ha (8840 ac) of land in south-central Guam. Mountains, rolling hills, streams, and valleys produce a varied topography, ranging in elevation from 15 to 400 in (50 to 1300 ft) with the peak at Mount Lamlam, the highest point on the island. Habitat types include limestone forests in the higher elevations, dense ravine forests in the sheltered valleys, swordgrass savanna in the exposed uplands, and mowed lawns in developed areas. The savanna is thought to be the result of aboriginal clearings and subsequent burning, which has continued to the present day (Mueller-Dombois 1981). Buildings and other facilities occupy a small part of the base, including a high-security, limited-access enclosure.

The Ordinance Annex site includes most of the surface water resources to be found on Navy lands, including permanent streams, several wetlands, and Fena Reservoir, the largest freshwater lake on Guam. The reservoir is operated by Public Works Center but is physically part of the Ordinance Annex site. Since 1946, the Navy has preserved and maintained a large forested area around the reservoir as a watershed. Although rivers go underground, sometimes reappearing as rivers or springs, no developable groundwater resources occur at Ordinance Annex.

Fena Reservoir is 3 km long and 0.6 km wide (1-8 by 0.4 mi), with a surface area of 79.3 hectares (196 acres). Spillway elevation is 34 m (111 ft) and the reservoir contains 9.7 million cubic meters (2.4 billion gallons) of water when full. The deepest point of the reservoir is 20 m (66 ft), near the dam and spillway. Normal annual draw down is 2.4 m (8 ft). The watershed basin covers an area of 15 kM^2 (3700 acres). Three major rivers enter the reservoir from the watershed basin: Imono, Almaosa, and Maulap.

The soil of the Ordinance Annex is typically a reddish weathered clay (laterite), but in several areas a limestone cap remains over the volcanic soil. This cap provides substrate for limestone forests, and also results in the underground disappearance of a small river.

Waterfront Annex and Public Works Center:

According to the Naval Station Master Plan, the Waterfront Annex and Public Works Center occupies 624 hectares (1,543 acres). The site, located in southwestern Guam, includes much of the Apra Harbor complex and Nimitz Hill. The Apra Harbor complex includes Orote Peninsula, Camp Covington, Polaris, Point, portions of the Glass Breakwater, and Dry Dock Island.

Large sections of Waterfront Annex and Public Works Center are occupied by buildings and an abandoned airstrip, Natural habitats are limited to introduced-mixed limestone forest, savanna, and small patches of ravine forest. Orote Peninsula and Camp Covington have relatively level terrain, with elevations seldom exceeding 60 m

(200 ft). On Orote Peninsula, forested areas near abandoned runways are degraded and characterized by open stands of *Casuarina and Leucaena.* Similar areas of disturbed vegetation occur within Camp Covington. The northern and southern cliff lines of the. peninsula still contain stands of mature limestone forest; these native forests are bordered inland by introduced tangantangan scrub forests. The Orote Ecological Reserve Area is located on the southwestern tip of the peninsula and extends from the cliff line down to below sea level. Several well-developed wetlands occur on the Orote Peninsula and Camp Covington.

Polaris Point, Dry Dock Peninsula, and the Glass Breakwater are dominated by open grasslands and mangrove swamps, and have little natural terrestrial vegetation. Nimitz Hill is characterized by steep to rolling, hills, ranging, in elevation from 91 m to 213 m (300 to 700 ft).

Finegayan and Barrigada Communications Annex:

According to the Naval Communication Area Master Station Master Plan, the Finegayan Communications Annex occupies 1,195 hectares (2952 acres) on the northwest coast of Guam, and Barrigada Communications Annex occupies 748 hectares (1848 acres) in central Guam.

Finegayan, on the northern limestone plateau, has relatively level terrain except along the western cliffs, which descend precipitously from 122 m (400 ft) to sea level. Well-developed limestone forest occurs primarily along the coastal cliffs at the northern and southern boundaries of the facility. The Haputo Ecological Reserve Area, created in 1983, encompasses much of the limestone forest habitat of the coastal cliffs. Bands of strand vegetation occur along portions of the shoreline bench.

Extensive areas of degraded limestone forest occur throughout the base. Large, open, well-maintained, grassy fields are interspersed with disturbed patches of native vegetation around most of the radio tower locations. Clusters of buildings are located near the entrance of the base. No permanent streams, ponds, or marshes occur in this area because the limestone substrate is porous.

The terrain at Barricada is also relatively flat except where it rises 183 m (650 ft) at the southern edge of Mount Barrigada. Habitats on this facility consist mostly of open areas surrounding antenna fields, developments, and the Navy golf course. Sections of limestone forest occur near Mount Barrigada and in the northwest and southwest corners of the property. A degraded limestone forest occurs alone, the southern border; sections of tangantangan scrub forest are located throughout the base. Although no surface water bodies are found on site, several small wetlands are located there.

ATTACHMENT A

PROPOSED BUDGET

The following budget is suggested for implementing this Scope of Work:

Module 1. Development and determination of Questions of Interest	$38,600
Module 2. Design the Sampling Systems	$32,000
Module 3. Develop and Test Sampling Protocols	$70,600
Module 4. Develop a Data Management Plan and Database	$14,000
Module 5. Establish a Comprehensive GIS	$49,000
Module 6. Develop a Plan for Analysis and Interpretation	$20,000
Module 7. Develop a Reporting Plan	$12,000
Module 8. Develop a Sustainability Plan	$16,110
Module 9. Implement the Monitoring Plan	$82,600
Total budget:	$334,910