Final Environmental Impact Statement for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

U.S. Navy
Pacific Division
Naval Facilities Engineering Command

July 1993

FEDERAL CONSISTENCY
SUPPLEMENTAL INFORMATION FORM

Date: March 5, 1993

Project/Activity Title or Description: Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

Location: Territory of Guam

Other applicable area(s) affected, if appropriate: _____

Est. Start Date: 1 October 1993 **Est. Duration:** thru 1996

APPLICANT

Name & Title: Stan Uehara— Code 232

Agency/Organization: Pacific Division, Naval Facilities Engineering Command

Address: Pearl Harbor, Hawaii

Zip: 96860-7300

Telephone No. during business hours:

A/C (808) 471-9338

A/C ( )

AGENT

Name & Title: Susan S. Rutka, Senior Planner

Agency/Organization: Belt Collins Hawaii

Address: 680 Ala Moana Boulevard, First Floor, Honolulu, Hawaii

Zip: 96813

Telephone No. during business hours:

A/C (808) 521-5361

A/C ( )

CATEGORY OF APPLICATION (check one only)

(X) I. Federal Activity
( ) II. Permit or License
( ) III. Grants & Assistance

TYPE OF STATEMENT (check one only)

(X) Consistency
( ) General Consistency (Category I only)
( ) Negative Determination (Category I only)
( ) Non-Consistency (Category I only)

APPROVING FEDERAL AGENCY (Category II & III only)

Agency: _____
Contact Person: _____
Telephone No. during business hours:
A/C ( ) _____
A/C ( ) _____

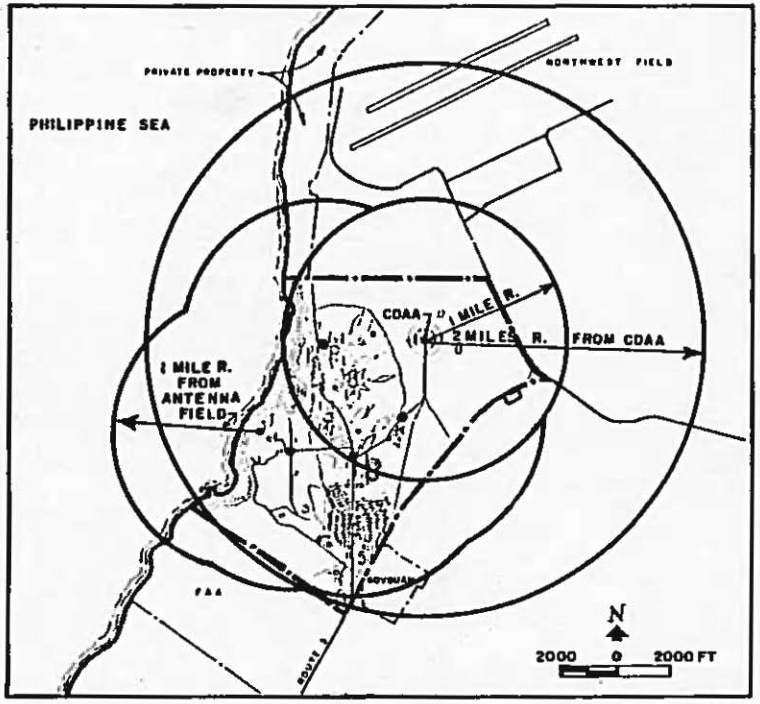
FEDERAL AUTHORITY FOR ACTIVITY

Title of Law: National Coastal Zone Management Act of 1972
Section: 15 CFR Part 930

OTHER TERRITORIAL APPROVALS REQUIRED

Agency	Type of Approval	Date of Applic.	Status

EMR zones around transmitting antennas are desirable where high density electromagnetic power may constitute a hazard to personnel, explosives or fuels, or may interfere with nonmilitary electronic equipment. General guidelines have been developed which recommend that land uses within a 1-mile radius of transmitting antennas be controlled to preclude EMR problems. The actual degree of hazard at a specific location, however, must be determined by a special study because the degree of hazard can vary with the type of antenna, radio frequencies transmitted and amount of radio frequency energy radiated. The Plan recommends that existing military lands within the 1-mile EMR zone be retained to preclude incompatible development.



EXISTING RFI-FREE ZONES (NAVCAMS Finegayan)

FIGURE D-10

It is also recommended that land uses in civilian areas lying within the 1-mile RFI and EMR zones be monitored and any potential problems that may arise be handled on an individual case-by-case basis.

The NAVCAMS Finegayan main station area is within the 2-mile RFI-free zone of the CDAA antenna. Most of the support and operational facilities of the station are sited between the 1-mile and 2-mile circles, as shown on Figure D-10. Considerable off-station areas to the north and east are inside the 1-mile and 2-mile RFI-free CDAA circles. Positive action is required to control land use within these areas.

DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

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FINAL ENVIRONMENTAL IMPACT STATEMENT (FEIS) FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

The U.S. Navy, in cooperation with the U.S. Air Force and the U.S. Army Corps of Engineers, has prepared a Final Environmental Impact Statement (FEIS) for proposed facilities development and relocation of Navy activities to the Territory of Guam from the Republic of the Philippines. The FEIS describes proposed permanent changes in military activities on Guam because of the relocation of various commands, and the construction of 25 military projects to accommodate the relocation.

The Draft EIS (DEIS) was published in April 1993 for agency and public review. Copies of the DEIS were distributed to government agencies and other interested parties who were given 45 days until May 18, 1993, to submit written comments on the DEIS. Two public hearings on the DEIS were conducted in Adelup, Guam on April 20, 1993. This Final Environmental Impact Statement (FEIS) has incorporated all comments received, either in the text or in Appendix B, which includes copies of comment and response letters.

The Department of the Navy intends to issue a Record of Decision (ROD) at least 30 days after the Notice of Availability for the Final EIS is published. The record of Decision will explain the decision regarding the proposed actions and alternatives examined in the FEIS, as well as describe any mitigation measures that will be implemented to reduce environmental impacts.

The review period for this FEIS will end on August 30, 1993. Written comments, if any, must be forwarded no later than August 30, 1993, to Mr. Stanley Uehara (Code 232), Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, HI 96860-7300; at (808) 471-9338 or by facsimile transmission at (808) 474-4890.

Sincerely,

Melvin N. Kaku

MELVIN N. KAKU
Director
Environmental Planning Division

Encl:
(1) FEIS for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines, Jul 93

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JUL 30 1993

FINAL ENVIRONMENTAL IMPACT STATEMENT FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

Lead Agency: U.S. Navy

Cooperating Agency: U.S. Air Force
U.S. Army Corps of Engineers

Coordinating Agency: Pacific Division, Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860-7300

Prepared by: Belt Collins & Associates
680 Ala Moana Boulevard, First Floor
Honolulu, Hawaii 96813

Primary Contact: Stanley Uehara, Code 232
Pacific Division, Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860-7300
Telephone 808-471-9338; Fax 808-474-4890

Abstract:

U.S. Navy facilities in the Republic of the Philippines were closed in 1992. Proposed actions include permanent changes in military activities on Guam because of the relocation of various commands, and construction of permanent facilities to accommodate the relocation. Approximately 1,380 Navy billets or positions and 1,450 dependents will ultimately be relocated to Guam.

Permanent changes in activities include relocation of the Fleet Logistics Support Squadron to Andersen Air Force Base, increase in ship port calls to Naval Station, relocation of Military Sealift Command Sub-Area Commander for Southeast Asia to Guam, increase in volume of supplies handled by the Fleet Industrial Support Center (FISC) [referred to in this document as Naval Supply Depot (NSD)], increase in work at the Ship Repair Facility, relocation of the Naval Special Warfare Unit One (NSWU-1) and Explosive Ordnance Disposal Mobile Unit Five (EODMU-5), expansion of existing activities at Naval Magazine, relocation of the Naval Air Pacific Repair Activity, and augmentation of personnel at Naval Air Station Agana, Naval Hospital, and Naval Oceanography Command Center/Joint Typhoon Warning Center. Alternative locations on Guam were considered for these activities.

A total of 25 military construction projects are proposed: 19 located in the Apra Harbor area and the remainder at Andersen Air Force Base, Naval Magazine, and Nimitz Hill. Facilities at Andersen include a hangar/apron/washrack and renovation of quarters for unaccompanied personnel. In the Apra Harbor Complex, projects include 300 family housing units, Orote Power Plant expansion, Apra Harbor Sewage Treatment Plant modifications, Child Development Center additions/alterations, NSWU-1 and EODMU-5 facilities, gantry crane and rails, waterfront utilities, hazardous material storage building, and various administrative and storage facilities. Missile magazines and an inert material storehouse are proposed at Naval Magazine, and the Oceanography Building at Nimitz Hill will be renovated. Various alternatives have been considered, including but not limited to no action, alternative sites, and use of existing facilities.

No significant adverse environmental impacts that cannot be mitigated are expected as a result of the proposed actions. Potential environmental effects include short-term impacts during construction and long-term impacts such as increased demands of infrastructure, public services, and housing, socioeconomic effects, and impacts on natural and cultural resources. Many of these impacts have meaning only when considered cumulatively, since the impacts associated with individual projects and activities are for the most part relatively minor.

The Draft Environmental Impact Statement (DEIS) was published in April 1993, and two public hearings were conducted on April 20, 1993. No oral comments were received at either meeting; written testimony was submitted by one agency. A total of eight letters was received providing comments on the DEIS, including three from federal agencies, four from Government of Guam agencies, and one from a private organization. Major comments were received regarding effects on endangered animal species (Mariana crow, Mariana fruit bat, sea turtles, and Mariana common moorhen) and impacts of hazardous waste and materials. This Final Environmental Impact Statement (FEIS) has incorporated all comments received, either in the text or in Appendix B, which includes copies of the comment and response letters.

Comments on the FEIS should be addressed to the primary contact listed above and must be received within 30 days of publication of the Notice of Availability of this document. The Navy will issue a Record of Decision regarding the proposed actions and alternatives after the end of the 30-day period.

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ACRONYMS

ABW	Air Base Wing
AE	Auxiliary Explosives
AFS	Auxiliary Fleet Supply
AGL	Above Ground Level
APZ	Accident Potential Zones
bbl	barrels
BOQ	Bachelor Officers' Quarters
BOP	Bureau of Planning

CAAA	Clean Air Act Amendments
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COE	Corps of Engineers
COMNAVMARIANAS	Commander U.S. Naval Forces Marianas
CRI	Community Resources, Inc.
CWA	Clean Water Act
CZM	Coastal Zone Management
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
DOE	Department of Education
DRMO	Defense Reutilization and Marketing Office
DTS	Diplomatic Telecommunications Service
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMI	Electromagnetic Interference
EMR	Electromagnetic Radiation
EOD	Explosive Ordnance Disposal
EODMU 5	Explosive Ordnance Disposal Mobile Unit Five
ESQD	Explosive Safety Quantity Distance
FCLP	Field Carrier Landing Practices
FICON	Federal Interagency Committee on Noise
FISC	Fleet and Industrial Supply Center (formerly Naval Supply Depot)
GAA	Guam Airport Authority
GACT	Generally Achievable Control Technology
GEPA	Guam Environmental Protection Agency
GIAT	Guam International Air Terminal
GMTA	Guam Mass Transit Authority
GOVGUAM	Government of Guam
GPA	Guam Power Authority
GTA	Guam Telephone Authority
HAP	Hazardous Air Pollutant
HERO	Hazard of Electromagnetic Radiation to Ordnance
HRS	Hazard Ranking System
HVAC	Heating, Ventilation, Air Conditioning
IR	Installation Restoration
IWPS	Island-wide Power System
KD	Known Distance
KV	kilovolt
kWh	kilowatt hours
Ldn	Day Night Average Sound Level

MAC	Military Airlift Command
MACT	Maximum Achievable Control Technology
MARS	Military Affiliate Radio System
MCL	Maximum Contaminant Levels
mgd	million gallons per day
MILCON	Military Construction
MLLW	Mean Lower Low Water
MPR	Multi-Purpose Range
MRC	Marine Research Consultants, Inc.
MSC	Military Sealift Command
MW	megawatt
MWh/yr	megawatts per hour per year
MWR	Morale, Welfare, and Recreation
NAAQS	National Ambient Air Quality Standards
NAS	Naval Air Station
NCTAMS WESTPAC	Naval Computers and Telecommunications Area Master Station, Western Pacific
NAVHOSP	Naval Hospital
NAVMAG	Naval Magazine
NAVSTA	Naval Station
Navy SEALs	Naval Special Warfare Unit One
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List (NPL)
NSD	Naval Supply Depot (now FISC)
NSR	New Source Review
PAG	Port Authority of Guam
PDN	Pacific Daily News
PL	Public Law
PSD	Prevention of Significant Deterioration
PUAG	Public Utility Agency of Guam
PWC	Public Works Center
RCRA	Resource Conservation and Recovery Act
RPB	Riverine Patrol Boats
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SDZ	Surface Danger Zones
SLAMS	State and Local Air Monitoring System
SNCO	Staff Non-Commissioned Officers' Quarters
SPCC	Spill Prevention Control and Countermeasure
SRF	Ship Repair Facility
STP	Sewage Treatment Plant

TAD	Temporary Additional Duty
TLUC	Territorial Land Use Commission
TPC	Territorial Planning Council
USFWS	U.S. Fish and Wildlife Service
VRC-50	Fleet Logistics Support Squadron
µg	micrograms

EXECUTIVE SUMMARY

INTRODUCTION

This Final Environmental Impact Statement (FEIS) has been prepared in accordance with Council on Environmental Quality and Department of Defense (DoD) regulations that implement the National Environmental Policy Act (NEPA) of 1969. It has been prepared by the U.S. Navy in cooperation with the U.S. Air Force and U.S. Army Corps of Engineers.

The proposed actions are the location of activities and development of facilities at Navy and Air Force installations on Guam. U.S. Navy facilities in the Philippines were closed in 1992 because of a decision by the U.S. and Philippine governments not to renew the lease of U.S. bases in the Philippines. As a result, certain operations and support functions are now provided on Guam to support the Department of the Navy's mission in the Western Pacific.

Actions to be covered in the EIS are in two categories: (1) changes in military activities on Guam because of the relocation of various commands, and (2) construction of permanent facilities required to accommodate the relocation. Approximately 1,380 Navy billets or positions have been relocated to Guam; an estimated 1,450 dependents will ultimately accompany personnel in these billets. There were approximately 22,575 military and dependent Navy personnel prior to the start of the relocation.

Until permanent facilities can be built, most of the relocated military personnel are being temporarily accommodated in existing facilities, as available. Some facility renovations and alterations, as well as the construction of temporary facilities, are handling the overflow of personnel and specific operations. The relocation into temporary facilities was necessary due to the short time available for the withdrawal from the Philippines. Formal environmental reviews have been completed for these temporary facilities.

Factors which mandated Guam's selection as the site for relocated naval activities included:

- U.S. policies not to establish new bases on foreign soil and to limit the number of American personnel allowed to be stationed on foreign soil (East Asia Strategy Initiative, also known as the Nunn Warner Act).
- Absence of options under existing bilateral security arrangements to establish permanent bases.
- Existence of generally adequate supporting infrastructure on Guam.
- Military operational requirements for forward deployment in the Western Pacific.
- End of the Cold War and severe reductions in the military budget, affecting the military's ability to operate and maintain overseas bases.
- The absence of alternative locations meeting these policies and requirements.

With a few exceptions, data for this FEIS was obtained prior to the issuance of the Base Closure listing to the President July 1, 1993 and prior to Typhoon Omar, which struck Guam on August 28, 1992.

PROPOSED ACTIONS AND ALTERNATIVES

Permanent Changes in Military Activities

The following permanent changes in military activities are proposed. Alternatives may be available in terms of potential locations on Guam for these activities. With a few exceptions, these alternatives are discussed in Section 2.3, Military Construction Projects. Where appropriate, training activity alternatives are discussed in Section 2.2, Changes in Military Activities.

Andersen Air Force Base:

- Permanent relocation of the Fleet Logistics Support Squadron (VRC-50).

Apra Harbor Complex:

- Increase in the number of ship port calls at the Naval Station (NAVSTA) due to training and logistic support requirements.
- Permanent relocation of Military Sealift Command (MSC) Sub-Area Commander for Southeast Asia to Guam, and increase in number of MSC administered vessels operating out of Guam.
- Increase in volume of supplies handled by the Fleet Industrial Support Center (FISC), referred to in this document as Naval Supply Depot (NSD); increase in ship resupply visits.
- Increase in work at the Ship Repair Facility (SRF) by an estimated 15 percent.
- Permanent relocation of Naval Special Warfare Unit One (NSWU-1) to Guam.
- Permanent relocation of Explosive Ordnance Disposal Mobile Unit Five (EODMU-5) to Guam.

Naval Magazine:

- Expansion in scope of existing activities; increase of about 50 percent above present tonnage of ammunition; increased use of Kilo Wharf and Alpha and Bravo Wharfs at Polaris Point.

Others:

- Permanent relocation of the Naval Air Pacific Repair Activity (NAPRA) to Naval Air Station (NAS) Agana and augmentation of two existing units; slight increase in number of aircraft operations.

- Permanent relocation of health care positions to the Naval Hospital, Guam.

- Augmentation of staff at the Naval Oceanography Center/Joint Typhoon Warning Center based on Nimitz Hill.

Military Construction Projects

It is proposed that the following permanent facilities be constructed or renovated. Various alternatives have been considered, including no action, alternative sites, and use of existing facilities.

Andersen Air Force Base:

- VRC-50 Hangar, Apron, and Washrack
- Renovation of Staff Non-Commissioned Officers' Quarters (SNCOQ)
- Renovation of Bachelor Officers' Quarters (BOQ)

Apra Harbor Complex:

- Additions and Alterations to Child Development Center
- Military Sealift Command Operations Building
- Hazardous Material Storage Building
- Gas Bottle Storage Building
- Integrated Storage and Handling Facility
- General Warehouse
- Gantry Crane and Rails
- Cold Storage Warehouse
- Supply Systems Support Building
- Ship Spares Storage Warehouse
- Naval Special Warfare Unit One Maintenance/Storage Building
- Naval Special Warfare Unit One Administration Building
- EOD Operations Facility
- Orote Power Plant Expansion
- Vehicle Repair Shop Storage
- Family Housing (300 units)
- Waterfront Utilities
- Modifications to Apra Harbor Sewage Treatment Plant

Naval Magazine:

- Missile Magazines
- Inert Storehouse

Others:

- Renovation of Oceanography Building, U.S. Naval Oceanography Command Center/Joint Typhoon Warning Center, Nimitz Hill

AFFECTED ENVIRONMENT

Guam is the southernmost of the Mariana Islands, located approximately 3,600 miles west of Hawaii and 1,400 miles south of Japan. The island measures about 32 miles in length, 4 to 8 miles in width, and has a total area of about 212 square miles.

Physiography

Guam has a mountainous southern region, a generally flat northern region, and a narrow coastal plain in between. The porous limestone formations and thin soils of the north contrast with the dense clay-based soils and volcanic material of the south. Guam's major source of potable water lies under the northern plateau.

The climate is generally warm and humid, with temperatures in the 70s and 80s. Average annual rainfall is approximately 88 inches. There is a dry season (January to April) and a wet season (July to November), separated by transitional periods. Heavy winds, rains, and occasional typhoons occur during the wet season.

Air and Water Quality

Due to nearly constant tradewinds and the lack of major industrial point source emitters, Guam is generally free from serious air pollution. An exception is a residual non-attainment area in the vicinity of Cabras Island and Apra Harbor associated with power plant operations.

Guam's groundwater resources are also remarkably clean. The Northern Lens, which supplies 70 percent of the island's potable water, has been designated as a principal source aquifer under the federal Safe Drinking Water Act. Results of well monitoring by the Guam Environmental Protection Agency (GEPA) verify that contaminant levels are well below the maximums established by the Act. Bacteriological contamination, however, remains a major cause of surface water quality violations. High fecal coliform levels are found in many streams and storm drain discharges following heavy rains.

Marine Environment

The island of Guam is surrounded by a fringing coral reef with a few deep water channels. Coral patch reefs in Apra Harbor provide habitat for a wide variety of marine life. GEPA monitoring of marine and reef flat stations indicate that marine water quality is generally within the limits set by the Guam Water Quality Standards. The exception are stations adjacent to river mouths or sewage treatment outfalls, where land-based point and non-point source pollutants enter the ocean.

Terrestrial Biota

Guam's once abundant forests have been depleted by urban and agricultural development, as well as fires and other natural forces. Predation by the introduced brown tree snake and other factors have led to the extinction of several native species. The northwest region, where undisturbed limestone forest still remains, provides nesting/roosting areas on Guam for the endangered Mariana crow and Mariana fruit bat. Naval Magazine and other

ecological areas could provide suitable habitat if the brown tree snake was controlled. Wetland and savannah areas of the south also provide valuable bird habitat.

Historic/Cultural Resources

Significant historic and prehistoric sites remain from the different cultures which have occupied Guam. The earliest sites are from the Chamorro period, prior to Western contact in 1521. Other sites show evidence of Guam's status as a possession of Spain, while numerous structures and relics attest to the island's major role in World War II.

Socioeconomic Setting

Guam is a territory of the United States. The 1990 Census figures show a population of 133,152, a 20.4 percent increase since 1980. The transfer of additional military personnel and dependents in 1992 increased Guam's population by less than two percent. The major components of the island's economy are the territorial government, the military, tourism, and construction. Tourism is the fastest growing sector. A severe labor shortage exists in several industries, requiring the importation of foreign workers. The housing market is characterized by very high demand and relatively low supply due to the scarcity of developable land, shortage of housing construction, and destruction caused by typhoons.

Infrastructure

Water. The Navy is a major supplier of water for Guam, having developed several surface sources in the southern part of the island and subsurface sources at Finegayan. Wells have also been developed at Andersen Air Force Base. Civilian communities receive water from the Public Utility Agency of Guam's (PUAG) islandwide water distribution system, which taps into the northern groundwater aquifer and rivers in the south. The agency purchases water from the Navy's Fena Reservoir and from the Air Force to supplement its output.

Power. The Guam Power Authority (GPA) and the Navy jointly provide for the island's base-load electricity requirements through the Island Wide Power System (IWPS). Under a recently concluded agreement, GPA is gradually assuming full responsibility for the system. Military energy requirements account for about 30 percent of the IWPS consumption. Electricity is generated primarily from stations at Cabras, Tanguisson, and Piti. Given rapidly increasing load growth and lack of excess capacity, Guam experiences recurring blackouts when generating units malfunction.

Sewage. The civilian wastewater system is operated by PUAG, while the Navy operates a separate wastewater system for the Apra Harbor complex and Naval Magazine. The NAS Agana and Andersen Air Force Base sewage collection systems are connected to the PUAG system.

Solid Waste. In the civilian sector, municipal waste is collected by the Department of Public Works and private haulers and transported to the Ordot Sanitary Landfill in central Guam. The Ordot Landfill has no effective excess capacity at this time, and it is eligible for priority action under the U.S. Environmental Protection Agency (EPA) Superfund program. Disposal of Navy-generated municipal solid waste is handled by the Public Works Center at

its landfill in the Apra Harbor area. Air Force-generated waste is transported to the sanitary landfill on Andersen Air Force Base.

Transportation. An ambitious road improvement program undertaken by the Government of Guam has resulted in a network in relatively good condition. The island has more than 250 miles of paved public roads. Guam International Air Terminal (GIAT) is the main civilian airport. The commercial port of Guam is located at Apra Harbor on Guam's west-central coastline. Except for military equipment, machinery, and ammunition, all goods are shipped to and from the commercial port on Cabras Island.

Military Activities

Since World War II, the U.S. military has maintained several bases on Guam. Military installations comprise approximately 30 percent of the total land area. In 1990, the military provided about 13 percent of the civilian jobs. The total military population (permanent duty personnel, dependents, and transients) on Guam in 1992, prior to the Subic rollback, was approximately 22,575.

Apra Harbor is the location for various military activities, including Naval Station, Naval Supply Depot, Ship Repair Facility, and Public Works Center. Naval Air Station Agana shares facilities with the Guam International Air Terminal. The mountainous terrain of south-central Guam is the site of the U.S. Naval Magazine. Andersen Air Force Base in the north is headquarters for the 633rd Air Base Wing, 13th Air Force, and associated units.

ENVIRONMENTAL CONSEQUENCES AND MITIGATION MEASURES

Some of the proposed actions have potentially adverse consequences, all of which will be mitigated. These impacts and mitigation measures are summarized below. No significant adverse impacts that cannot be mitigated are anticipated.

Soils and Drainage

With the exception of the housing project at Tipalao and the hangar project at Andersen Air Force Base, construction of new facilities will occur on previously disturbed and graded sites. To mitigate potential impacts to surface and coastal waters during construction, pollution prevention measures and best management practices (BMPs) will be implemented. All contractors will be required to acquire an NPDES stormwater permit for construction activity which will include appropriate management practices. In addition, as stated in Section 5.2 of the DEIS, the proposed actions will be carried out in consultation with the Guam Bureau of Planning, which is charged with administering Coastal Management Program Consistency Certification. The cumulative impact of increased urban runoff will be addressed to prevent chemicals, sediments, and other contaminants from entering receiving waters in accordance with the Clean Water Act storm water permit requirements.

Water Resources

None of the proposed projects or activities are expected to cause contamination of, or otherwise impact the ground water resources in the Northern Lens or surface waters in the southern watersheds. There will be a cumulative impact of increased water withdrawal,

particularly on the Navy's Fena Reservoir system during drought conditions. Vigorous water conservation measures, including facilities design features, can help alleviate dry season drawdowns. Increased demand will not have a significant impact on the available water supply of the Northern Lens.

Marine Environment

Additional discharge from the expanded wastewater treatment plant will not have a significant effect on the marine environment. Runoff from Apra Harbor construction sites has the potential to enter marine waters, but this can be controlled through standard erosion control and best management practices (BMPs). Potential effects of underwater demolition training exercises on harbor traffic and turtles which may frequent the area will be mitigated through Notices to Mariners and positive surveillance and exercise control during training periods.

There are potential cumulative impacts on the marine environment due to increased harbor activity: introduction of alien marine organisms from ship ballast water, damage to coral reef ecosystems from ship anchors and chains, and increased risk of oil spills. One of the main ways in which ships can prevent foreign organisms from entering the coastal marine waters of Guam is to pump and exchange ballast water in the ocean, prior to entering an exclusionary zone around the port of entry. Currently, there are no regulations, policies, or initiatives in place at a national or territorial level concerning ballast water discharge or measures ships must take in order to prevent the introduction of foreign marine organisms into the coastal waters of Guam. Mitigations includes the placement of moorings away from reef area and implementing the Spill Prevention Control and Countermeasure Plan (SPCC).

Terrestrial Biota

The proposed actions were planned taking into consideration the Critical Habitat and Refuge Overlay areas proposed by the U.S. Fish & Wildlife Service. VRC-50 flight operations at Andersen, particularly the field carrier landing practices (FCLPs), may adversely affect the endangered Mariana crow and Mariana fruit bat. A survey initiated in the fall of 1992 will be continued to assess the impacts, if any, of the VRC-50 relocation on these species, particularly their nesting/roosting behavior.

Development of housing in the Tipalao expansion areas has the potential to hinder the future use of certain wetlands and native forests as wildlife habitat, as well as to affect the nearby Orote Peninsula Ecological Reserve. The housing will be sited to avoid and buffer these areas, and wetlands will be fenced

Noise

There are potential noise impacts associated with FCLPs at Naval Air Station Agana, which is the alternative to Andersen Air Force Base, the preferred site for these practices. The VRC-50 activity will cause an insignificant increase, as defined by the *Federal Agency Review of Selected Airport Noise Analysis Issues*, by the Federal Interagency Committee on Noise (FICON). The area of increased noise levels is confined to the area immediately adjacent to the base and results from the small size of the VRC-50 FCLP tracks.

Air Quality

Proposed expansion of the Orote Power Plant appears capable of complying with the National Ambient Air Quality Standards and Guam Air Quality Standards. However, the expansion would create a "major source" within an attainment area (which is adjacent to a non-attainment area) and would be subject to Prevention of Significant Deterioration (PSD) review. The PSD rules require one year of pre-construction continuous air monitoring if certain de minimus levels are exceeded; analysis indicates that these levels will be exceeded. A waiver to allow construction to occur during this monitoring is awaiting approval by the EPA. Mitigations to limit impacts to area air quality will be designed into the expansion, and may include a combination of one or more of the following, to be identified in the PSD permit issued by the EPA: limit sulfur content of fuel, raise Orote stack heights, limit operating hours or fuel consumption, and install emission controls.

Historic/Cultural Resources

Results of field investigations at Andersen Air Force Base and Naval Magazine revealed no archaeological sites in areas affected by the proposed actions. With the exception of the proposed family housing site (and alternative housing sites), there were no indications of cultural materials in any of the other surveyed areas in the Apra Harbor complex.

The archaeological survey of areas at Tipalao with potential for direct impact due to housing construction identified 17 sites or possible sites. One of these sites, a sinkhole or cave, was found to contain unique prehistoric artifacts and will be avoided. Based on current data, no other archaeological sites found in the direct impact areas are considered to be eligible for the National Register.

Selected shoreline areas on the Naval Station, while not planned for construction, were also surveyed because of the potential for indirect impacts caused by increased access and activity. Survey results show 25 archaeological sites in these areas, including a prehistoric rock shelter and caves built by the Japanese during World War II. Some of these sites, particularly along Dadi Beach, are vulnerable to vandalism. Measures to mitigate indirect impacts include flagging selected sites during construction and signage to inform area users of the presence and signifigance of historic resources.

Socioeconomics

Localized impacts will be experienced on military bases where the actions occur, while cumulative impacts will be regional or islandwide. In the short-term, socioeconomic effects will include a potentially large increase in housing demand, an imbalance between new demand for and the existing supply of public services, and increases in spending and jobs. Until construction and other relocation activities are completed, there will be a temporary need for more in-migrant civilian workers.

Over time, many of the initial impacts associated with the relocation will fade. Proposed new housing will help to absorb the increased demand. Until this housing is available, Navy policy attempts to limit the impact of additional families on a tight housing market by postponing dependents' arrival in Guam until housing (either on- or off-base) is obtained. No significant impacts on parks, health care facilities, or police and fire protection are

expected—particularly because the military provides many of these services for its personnel and dependents. The school system will be the most affected public service, but new students can be accommodated in existing and soon-to-be-built facilities. The Navy will coordinate closely with the Department of Education, as well as encourage proper registration and reporting of military dependents to aid the complete availability of federal funds for education.

Incomes on Guam will receive a modest boost from the increased construction and operations. After an initial jump in revenues during the construction period, long-term operations will create approximately $8.1 million in annual tax (personal income, corporate income, and gross receipts) revenues and federal grants for the Government of Guam. Short- and long-term government costs associated with the proposed actions are estimated to be in the range of $4.9 to $5.5 million annually. The cumulative balance of tax revenues minus costs to the local government is expected to be over $63 million through 1997.

Impacts on military families are anticipated due to separation before housing becomes available, the stress of relocation, and the high cost of living. Steps to mitigate these impacts include assuring that family support services are fully staffed and meeting interim needs for child care until new facilities are built. Although no significant social impacts on Guam's civilian population are expected, the Navy will continue or expand existing programs to help prevent problems (for example, substance abuse control and intercultural awareness briefings).

Infrastructure/Utilities

Impacts of the proposed actions relative to infrastructure and utilities will be considered cumulatively on a regional or even islandwide basis.

Traffic. The anticipated increase in peak hour commuter traffic will have little impact on the public road network because of the on-base location of both housing and employment centers. Off-peak travel on public roads is projected to increase slightly. Internal traffic volumes will increase at the Naval Station, and there are safety concerns about the five-way intersection formed by Harbor Road and Sumay Drive. Ingress and egress for the housing project will be designated to provide safe turning movements.

Water. Increased demand on the Navy's Fena water system may exceed the treatment plant design capacity during the wet season. Mitigation may include expanding treatment facilities to meet peak capacity or using part of the reservoir supply. During times of severe drought, demand is expected to exceed the sustainable dry season production of the Fena Reservoir. Water conservation and leak detection programs, as well as increasing treated water storage capacity, can help to alleviate this impact. The use of wells to recover subsurface reservoir losses may also be necessary.

Power. Increased energy use on Guam as a result of the relocation represents an increase in the amount of refined fuels which must be imported. In a global context, however, this is a transfer of existing fuel requirements from one location to another, not new demand. Cumulative maximum electrical demand from all of the proposed actions represents an increase of 2 to 2.5 percent over the projected 1995 demand. Expansion of the Orote Power Plant will have a positive impact on power generation capacity.

Sewage. Impacts upon Guam's sewage system will vary, depending on the region. Facilities at Andersen Air Force Base and the Tanguisson plant in the Northern Sewage District have excess capacity. In the Central Sewage District, new flows associated with the relocation represent a small incremental increase. However, since baseline flows will be approaching the treatment capacity of the Agana Sewage Treatment Plant, flows associated with future private or commercial development in the Central Sewage District may need to be diverted elsewhere.

Solid Waste. With the relocation, the Andersen Landfill is expected to reach capacity by mid-1994, and the Apra Harbor Landfill by mid-1997. More aggressive recycling efforts, composting, and incineration could extend the life span of these landfills. Plans for eventual closure, replacement sites, and alternative disposal methods will be formulated. Ordot Landfill may be affected by military personnel living within the civilian rental market, particularly in the short-term. With Ordot currently beyond capacity, the Government of Guam is considering alternatives such as composting to address cumulative impacts.

Hazardous Waste

The Defense Reutilization and Marketing Office (DRMO), which is responsible for storing hazardous waste and materials for military installations on Guam, does not anticipate a significant increase in hazardous waste volumes as a result of the relocation. In addition to handling waste generated on Guam, DRMO has assumed responsibility for hazardous waste and material disposal for the Naval base at Diego Garcia. Because of the Naval and Air Force hazardous waste minimization programs, volumes of RCRA waste handled by DRMO have decreased since 1991. With the construction of the new hazardous materials storage facility and increased staffing of DRMO Guam, volumes are expected to decrease further.

Other Hazards

Several types of hazards may be related to the expansion of military activities on Guam. These include potential hazards from explosives, firearms training, aircraft accidents, and electromagnetic radiation. Explosives are stored within designated hazard zones proscribed by Explosive Safety Quantity Distance (ESQD) arcs. Existing ESQD arcs at Naval Magazine will accommodate increased tonnage. Activation of the maximum ESQD arc during unloading of munitions at Kilo Wharf will cause the closing of Gab Gab Beach for an estimated 32 days per year. Other beaches are available as alternative recreation sites. Access to Old Wives Beach will be improved.

While not part of the proposed actions, the Guam Army National Guard proposes to expand the existing Naval Station rifle range. The Surface Danger Zone (SDZ) surrounding the range will have to be adjusted accordingly. Accident Potential Zones (APZ) at Andersen Air Force Base and NAS Agana, located around the approach-departure zones, will not be affected by the relocation.

Many of the proposed facilities will be equipped with fire alarm transmitter antennas, which will generate electromagnetic radiation (EMR), but levels will not be significant.

EIS Review Process

The Draft Environmental Impact Statement (DEIS) was published in April 1993. More than 100 copies of the DEIS were distributed to government agencies and other interested parties, which were given 45 days until May 18, 1993, to submit written comments on the DEIS. Two public hearings were conducted in Adelup, Guam on April 20, 1993. Recipients of the DEIS were informed of the hearings, and a Notice of Availability of the DEIS and hearing announcement was published in the *Pacific Daily News.*

No oral comments were received at either meeting; written testimony was submitted by one agency. A total of eight letters were received providing comments on the DEIS, including three from federal agencies, four from Government of Guam agencies, and one from a private organization. Major comments were received regarding effects on endangered animal species (Mariana crow, Mariana fruit bat, sea turtles, and Mariana common moorhen) and impacts of hazardous waste and materials. This Final Environmental Impact Statement (FEIS) has incorporated all comments received, either in the text or in Appendix B, which includes copies of the comment and response letters.

The Department of the Navy will issue a Record of Decision after a waiting period of at least 30 days from publication of the Notice of Availability of the FEIS. The Record of Decision will explain the decision regarding the proposed actions and alternatives examined in the FEIS, as well as describe mitigation measures committed to as part of the decision.

CHAPTER 1

INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This Final Environmental Impact Statement (FEIS) has been prepared in accordance with Council on Environmental Quality and Department of Defense regulations that implement the National Environmental Policy Act (NEPA) of 1969. It has been prepared by the U.S. Navy in cooperation with the U.S. Air Force and U.S. Army Corps of Engineers.

The proposed actions are the location of activities and development of facilities at Navy and Air Force installations on Guam required by the closure of naval bases in the Philippines. Actions to be covered in the EIS are in two categories: changes in military activities that will occur on Guam because of the relocation of various commands, and construction of permanent facilities required to accommodate the relocation. (See location maps, Figures 1.1.1 and 1.1.2.) Approximately 1,380 Navy billets or positions were relocated from the Philippines to Guam in 1992. An estimated 1,450 dependents will ultimately accompany personnel in these billets. There were approximately 22,575 military and dependent Navy personnel prior to the start of the relocation.

The National Environmental Policy Act requires that an environmental impact statement (EIS) be prepared to assure that effects of the proposed actions on the environment are considered in the decision-making process, that adverse effects which cannot be avoided be made known, and that means for minimizing or avoiding potentially adverse effects are considered. It also requires that alternatives to the proposed actions be analyzed and that provision be made for public interaction during preparation of the EIS.

1.2 ORGANIZATION OF THIS DOCUMENT

The basis for the proposed actions, scope of the EIS, summaries of alternatives and impacts, description of the scoping phase, and description of related environmental documents are presented in this first chapter. Detailed descriptions of the alternatives considered for each of the actions, as well as the purpose and need for each, are given in Chapter 2. Chapter 3 contains a general overview description of the environmental setting. The purpose of this chapter is to establish an islandwide perspective as a foundation for Chapter 4, which focuses on site-specific or regional conditions, environmental consequences, and mitigation measures. In Chapter 4, discussion of the various actions are divided into the following geographic regions: Andersen Air Force Base, Apra Harbor Complex, Naval Magazine, and others (Naval Air Station, Naval Hospital, and Nimitz Hill). The Apra Harbor Complex includes the Naval Station, Public Works Center, Naval Supply Depot, Ship Repair Facility, Camp Covington, and Naval Dental Clinic. Consistency of the proposed actions with land use plans, policies, and controls is discussed in Chapter 5. The final chapters list the preparers of this FEIS and references used.

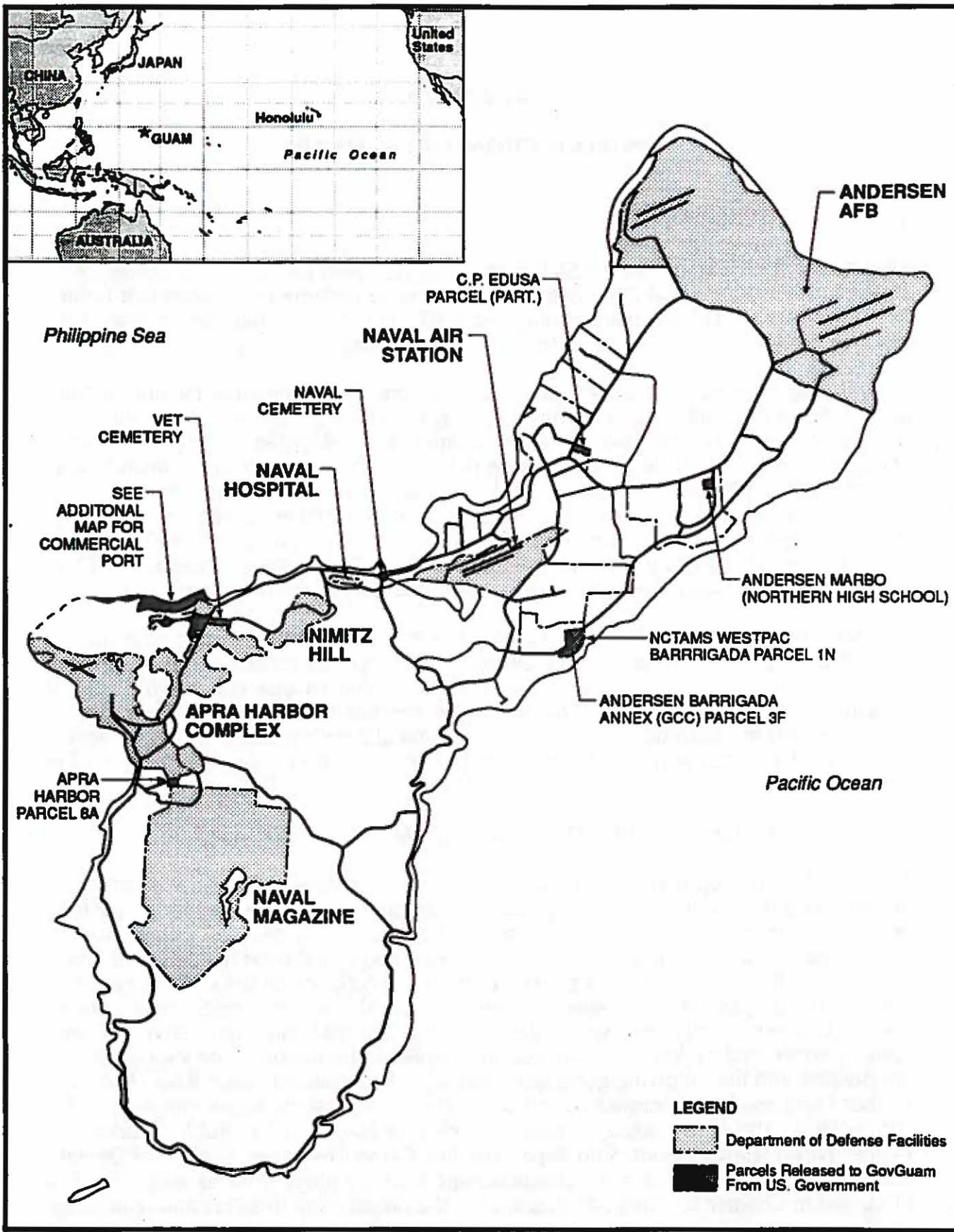


Figure 1.1.1
PROJECT LOCATION
Guam Development EIS
April 1993

242.0101/01

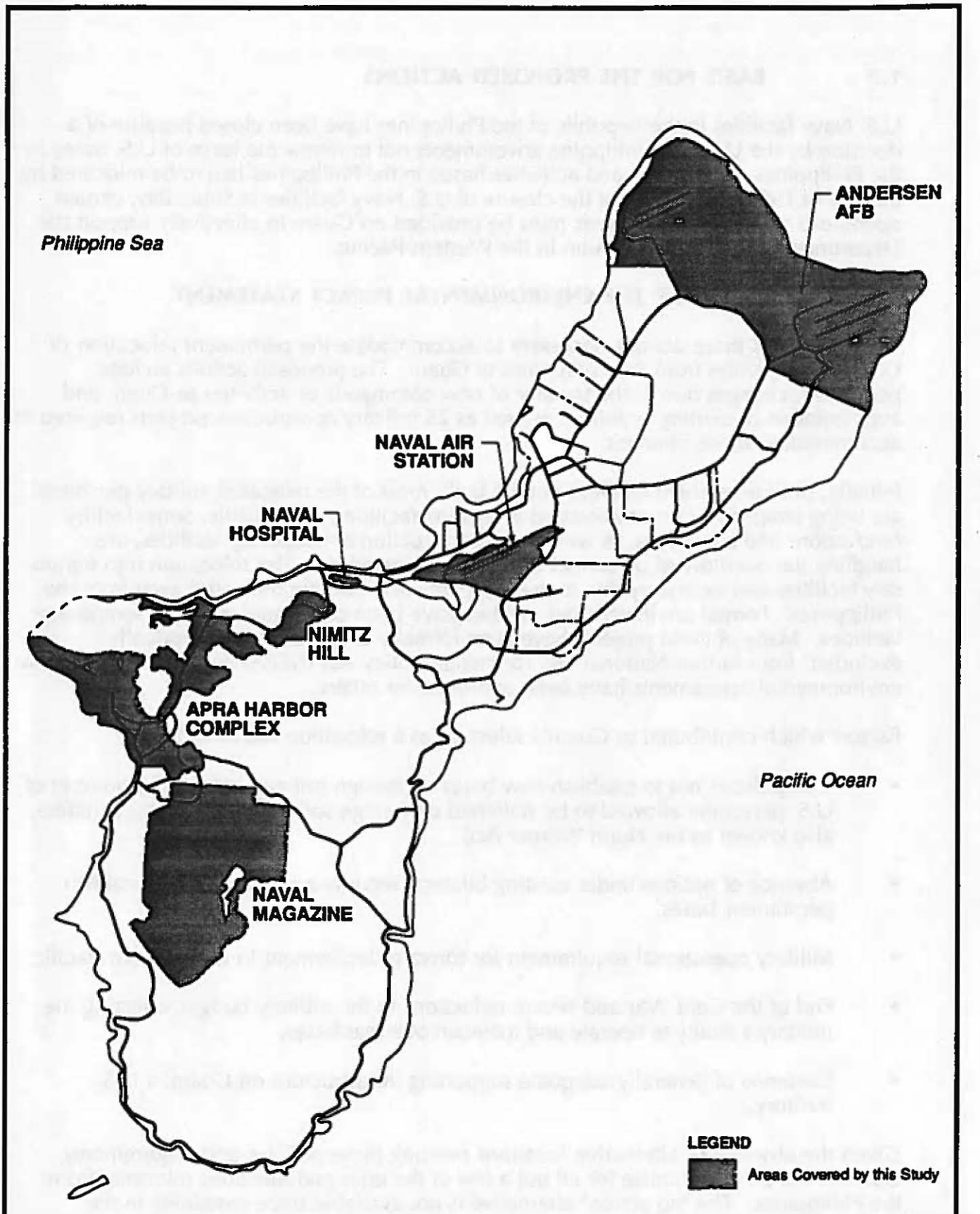


Figure 1.1.2
AREAS OF PROPOSED ACTIONS
Guam Development EIS
April 1993

242.0101/02

1.3 BASIS FOR THE PROPOSED ACTIONS

U.S. Navy facilities in the Republic of the Philippines have been closed because of a decision by the U.S. and Philippine governments not to renew the lease of U.S. bases in the Philippines. Navy units and activities based in the Philippines had to be relocated by the end of 1992. As a result of the closure of U.S. Navy facilities at Subic Bay, certain operations and support functions must be provided on Guam to effectively support the Department of the Navy's mission in the Western Pacific.

1.4 SCOPE OF THE ENVIRONMENTAL IMPACT STATEMENT

This EIS covers those actions necessary to accommodate the *permanent* relocation of U.S. Navy activities from the Philippines to Guam. The proposed actions include permanent changes due to the transfer of new commands or activities to Guam and augmentation of existing activities, as well as 25 military construction projects required to accommodate those changes.

Initially, until permanent facilities can be built, most of the relocated military personnel are being temporarily accommodated in existing facilities, as available. Some facility renovations and alterations, as well as the construction of temporary facilities, are handling the overflow of personnel and specific operations. The relocation into temporary facilities was necessary due to the short time available for the withdrawal from the Philippines. Formal environmental reviews have been completed for these temporary facilities. Many of these projects have been formally exempted or "categorically excluded" from further National Environmental Policy Act (NEPA) documentation, while environmental assessments have been approved for others.

Factors which contributed to Guam's selection as a relocation site included:

- U.S. policies not to establish new bases on foreign soil and to limit the number of U.S. personnel allowed to be stationed on foreign soil (East Asia Strategy Initiate, also known as the Nunn Warner Act).
- Absence of options under existing bilateral security arrangements to establish permanent bases.
- Military operational requirement for forward deployment in the Western Pacific.
- End of the Cold War and severe reductions in the military budget, affecting the military's ability to operate and maintain overseas bases.
- Existence of generally adequate supporting infrastructure on Guam, a U.S. territory.

Given the absence of alternative locations meeting these policies and requirements, Guam is the only alternative for all but a few of the units and functions relocated from the Philippines. The "no action" alternative is not available since remaining in the Philippines was not a viable option. See Section 2.1 in the following chapter for a detailed discussion of Department of Defense (DoD) strategy and policy and world events that influenced the relocation decisions.

1.5 SUMMARY OF ALTERNATIVES

1.5.1 Permanent Changes in Military Activities

The following permanent changes in military activities are proposed. Alternatives may be available in terms of potential locations on Guam for these activities. Most of these alternatives are discussed in Section 2.3, Military Construction Projects. Where appropriate, training activity alternatives are discussed in Section 2.2, Changes in Military Activities.

1.5.1.1 Andersen Air Force Base

- Permanent relocation of the Fleet Logistics Support Squadron (VRC-50).

1.5.1.2 Apra Harbor Complex

- Increase in the number of ship port calls at the Naval Station (NAVSTA) due to training and logistic support requirements.
- Permanent relocation of Military Sealift Command (MSC) Sub-Area Commander for Southeast Asia to Guam, and increase in number of MSC administered vessels operating out of Guam.
- Increase in volume of supplies handled by the Fleet and Industrial Supply Center (FISC), referred to in this document as Naval Supply Depot (NSD); increase in ship resupply visits.
- Increase in work at the Ship Repair Facility (SRF) by an estimated 15 percent.
- Permanent relocation of Naval Special Warfare Unit One (NSWU-1) to Guam.
- Permanent relocation of Explosive Ordnance Disposal Mobile Unit Five (EODMU-5) to Guam.

1.5.1.3 Naval Magazine (NAVMAG) Guam

- Expansion in scope of existing activities at NAVMAG; increase of about 50 percent above present tonnage of ammunition; expanded use of Kilo Wharf and Alpha and Bravo Wharfs at Polaris Point.

1.5.1.4 Others

- Permanent relocation of the Naval Air Pacific Repair Activity to Naval Air Station Agana and augmentation of two existing units; slight increase in number of aircraft operations.
- Permanent relocation of health care positions from Subic to the Naval Hospital, Guam.

- Augmentation of staff at the Naval Oceanography Center/Joint Typhoon Warning Center based on Nimitz Hill.

1.5.2 Military Construction Projects

It is proposed that the following permanent facilities be constructed or renovated. Various alternatives have been considered, including but not limited to no action, alternative sites, and use of existing facilities.

1.5.2.1 Andersen Air Force Base

- VRC-50 Hangar, Apron, and Washrack
- Renovation of Staff Non-Commissioned Officers' Quarters (SNCOQ)
- Renovation of Bachelor Officers' Quarters (BOQ)

1.5.2.2 Apra Harbor Complex

- Additions and Alterations to Child Development Center
- Military Sealift Command Operations Building
- Hazardous Material Storage Building
- Gas Bottle Storage Building
- Integrated Storage and Handling Facility
- General Warehouse
- Gantry Crane and Rails
- Cold Storage Warehouse
- Supply Systems Support Building
- Ship Spares Storage Warehouse
- Naval Special Warfare Unit Maintenance/Storage Building
- Naval Special Warfare Unit One Administration Building
- EOD Operations Facility
- Orote Power Plant Expansion
- Vehicle Repair Shop Storage
- Family Housing (300 units)
- Waterfront Utilities
- Modifications to Apra Harbor Sewage Treatment Plant

1.5.2.3 Naval Magazine (NAVMAG) Guam

- Missile Magazines
- Inert Storehouse

1.5.2.4 Others

- Renovation of Oceanography Building, U.S. Naval Oceanography Command Center/Joint Typhoon Warning Center, Nimitz Hill

1.6 SCOPING PROCESS AND AGENCY CONSULTATION

The preparation of an EIS is a process that involves more than the preparation of a document. The public is given various opportunities throughout the process to participate in developing the EIS. The first part of the process is called scoping. The following objectives of the scoping phase are established in Council on Environmental Quality (CEQ) regulations, 40 Code of Federal Regulations (CFR) 1501.7:

- Identify the various actions and their alternatives and refine the list of alternatives that will be focused on in the EIS.
- Determine the scope of issues to be addressed.
- Identify significant issues related to the proposed action.
- Invite participation by affected agencies and individuals.
- Eliminate from detailed study matters not significant or covered by prior reviews.
- Indicate any related environmental assessments being prepared that are not part of the EIS.
- Define the EIS schedule and project decisions.

Identification of project alternatives was accomplished through site visits and discussions with representatives of Navy activities to be relocated from the Philippines, representatives of existing Navy and Air Force activities on Guam that will be expanding as a result of the relocation, and personnel responsible for the planning and design of proposed facilities to accommodate the relocation. Reports, studies, and other documents were reviewed.

To accomplish the other objectives, the EIS project team carried out the following tasks:

- Reviewed relevant written documents, including environmental reviews and assessments, base master plans, natural and cultural resources management plans, archaeological survey reports, correspondence, newspaper articles, etc.
- Met on April 21, 1992 with Governor Joseph Ada.
- Met on April 21-24, 1992 with representatives of the following Government of Guam agencies:

  Bureau of Planning
  Department of Agriculture, Division of Aquatic and Wildlife Resources
  Department of Commerce
  Department of Education
  Department of Labor
  Department of Mental Health
  Department of Parks and Recreation, Historic Preservation Division
  Department of Public Health & Social Services

Department of Public Works
Department of Revenue & Taxation
Department of Youth Affairs
Guam Economic Development Authority
Guam Environmental Protection Agency
Guam Police
Guam Power Authority
Land Management Department
Port Authority of Guam
Public Utilities Agency of Guam
Territorial Planning Council

- Met with representatives of Navy and Air Force activities affected by the relocation actions.

- Published and distributed a Notice of Intent (NOI) to Prepare an EIS. The notice was published in the *Pacific Daily News* and *Guam Tribune,* on May 13-15, 1992, and in the *Federal Register* on May 13, 1992. The NOI was also mailed to approximately 140 government agencies, community organizations, and private individuals. It announced a public scoping meeting and invited the public to help identify environmental concerns that should be addressed during preparation of the EIS. The public was given 30 days, until June 12, 1992, to submit written comments.

- Conducted two public scoping meetings on May 28, 1992, at 2:00 p.m. and 7:00 p.m. at the Cabinet Conference Room in Adelup, Guam. The purpose of the meetings was to provide information to the public about the proposed actions and to receive oral comments on the proposed actions. Verbatim transcripts and videotapes of the meetings are on file and are available for review upon written request.

The issues identified during the scoping process are listed in Appendix A. Issues of concern which are within the scope of this FEIS and the area of influence of the affected resource are discussed in Chapter 4. Some of the issues raised are not specifically addressed in this document because they are outside the scope of the EIS or the area of influence.

1.7 DRAFT AND FINAL ENVIRONMENTAL IMPACT STATEMENTS

The Draft Environmental Impact Statement (DEIS) was published in April 1993. A Notice of Availability (NOA) was published in the *Federal Register* on April 2, 1993, and in the *Pacific Daily News* on April 2, 3, and 4, 1993 (see Appendix B-1). Copies of the DEIS were distributed to the interested parties listed in Appendix B-2. The public was given 45 days, until May 18, 1993, to submit written comments on the DEIS.

On April 20, 1993, two public hearings were conducted, at 2:00 p.m. and 7:00 p.m. at the Cabinet Conference Room in Adelup, Guam. The purpose of the hearings was to provide information to the public about the DEIS findings and to recieve oral comments on the document. No oral comments were received at either meeting; written testimony was submitted by one agency.

Written comments were received from the following parties. Copies of comment and response letters are contained in Appendix B-3.

Government of Guam:
- Office of the Governor
- Bureau of Planning
- Department of Agriculture
- Guam Environmental Protection Agency

Federal Government:
- Department of the Army, U.S. Engineer District, Honolulu
- Department of the Interior
- Environmental Protection Agency, Region IX

Others:
- Unitarian Universalist Service Committee

The distribution list for this Final Environmental Impact Statement is contained in Appendix B-4.

1.8 SUMMARY OF POTENTIAL IMPACTS

The findings of the scoping phase provided the framework for this FEIS. The environmental analysis addressed, but was not limited to, direct and indirect effects, as well as the cumulative impacts of the proposed actions. A number of special studies and surveys were conducted to determine the significance of these impacts and to help develop mitigation measures.

Criteria for evaluating potential impacts and determining their significance are specified in the Council on Environmental Quality (CEQ) Code of Federal Regulations (CFR). 40 CFR 1508.27 states that significance is determined by the intensity or severity of the impact and the context in which it occurs. Intensity criteria are based on relative changes:

- in public health and safety;
- to unique characteristics of the geographic area, such as visual quality, prime agricultural land, archaeological sites, wetlands, and ecologically critical areas;
- in the potential for environmental or scientific controversy;
- involving unique, uncertain, or unknown risks;
- that may establish a precedent for future actions or represent a decision in principle about a future consideration;
- in cumulative impact;

- affecting sites or districts listed in or eligible for the National Register of Historic Places or causing loss or destruction of significant scientific, cultural, or historic resources;

- likely to adversely affect threatened or endangered species or their habitat; and

- in the potential for violating federal, state, or local laws or requirements that are in place to protect the environment.

In addition, the significance of an impact should be assessed in the context of society as a whole, affected interests, and/or the affected region and locality. The size of the area potentially affected defines the appropriate context or area of influence for each resource. Duration of impact (short-term or long-term) should also be considered.

Using these criteria, the following levels of impact can be identified:

- Little or no impact. Little or no impact is predicted.

- Not a significant impact. An impact is predicted, but it does not meet the significance criteria for the given resource relative to intensity and context.

- Significant impact. The predicted impact meets the significance criteria for the given resource. Significant impacts may be reduced to an insignificant level by implementing appropriate mitigation measures.

Potential environmental effects due to the proposed actions include short-term impacts during construction (noise, dust, runoff) and long-term impacts such as increases in traffic, increased demands on infrastructure, public services, and housing, socioeconomic effects, and impacts on natural and cultural resources. Many of these impacts have meaning only when considered cumulatively, since the impacts associated with individual projects and activities are for the most part relatively minor.

Table 1.7.1 summarizes the level of significance of the environmental impacts expected as a result of the various alternatives for each action. The assessment of significance is based on the three levels of impact defined above. Both beneficial and adverse impacts are addressed.

Because the categories of impacts vary in importance, the assigned scores for each alternative cannot be added together to provide meaningful total scores. For comparative purposes within each category, the impacts are ranked as follows. These rankings are assigned under the assumption that feasible mitigation measures described in this document will be implemented.

Table Legend:

+2	Significant beneficial impact
+1	Beneficial impact, but not significant
0	Little or no impact
-1	Adverse impact, but not significant
-2	Significant adverse impact

The potential impacts associated with the preferred alternatives and proposed mitigation for each are summarized in Table 4.26.1 at the end of Chapter 4.

1.9 RELATED ENVIRONMENTAL DOCUMENTS

Separate from this EIS, but as a related matter, an environmental assessment (EA) was prepared for temporary flight operations of the VRC-50 squadron at Andersen Air Force Base. The scope of the EA covered VRC-50 air operations over the short term, including flight operations, maintenance, and repair activities. Cumulative impacts of the permanent relocation of the squadron, as well as impacts associated with permanent facilities to accommodate it, are covered in this EIS.

A list of those projects necessary for temporary relocation in 1992 is presented in Appendix C and includes temporary buildings, interior renovations, or additions/alterations to existing facilities.

Table 1.7.1
Matrix of Alternatives

	Soils and Drainage	Hydrol/ Water Res	Terrestrial Biota	Marine Environ	Water Quality	Air Quality	Noise	Visual Setting	Historic Features	Housing	Jobs	Economic	Social	Public Services	Traffic	Elec	Water	Sewage	Solid Waste	Haz Waste	Other Hazards
CHANGES IN MILITARY ACTIVITIES																					
ANDERSEN AIR FORCE BASE																					
Permanent relocation of VRC-50:																					
•All activities at Andersen AFB	0	0	See Note 1	0	0	0	–1	0	0	–1	0	+1	0	0	0	0	0	0	–1	–1	0
•FCLPs at NAS Agana	0	0	0	0	0	0	–1	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
APRA HARBOR COMPLEX																					
New/expanded activities:																					
Naval Station	0	0	0	–1	–1	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	–1	0
Military Sealift Command	0	0	0	–1	–1	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	0	0	0
Naval Supply Depot	0	0	0	0	0	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	–1	0	0
Ship Repair Facility	0	0	0	–1	–1	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	–1	–1	0
Naval Special Warfare Unit One	0	0	0	–1	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	0	0
EOD Mobile Unit Five	0	0	0	–1	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	+1	–1
NAVAL MAGAZINE																					
Expansion of existing activities	0	0	0	0	0	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	0	–1	–1
OTHERS																					
New/expanded activities:																					
NAS Agana	0	0	0	0	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	–1	0
Naval Hospital	0	0	0	0	0	0	0	0	0	–1	0	+1	+1	0	0	0	0	0	0	0	0
Naval Oceanog Command Center/JTWC	0	0	0	0	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	0	0
CUMULATIVE IMPACTS	0	0	0	0	–1	0	–1	0	0	–1	+1	+1	–1	0	0	0	–1	0	–1	–1	0
												See Note 2	See Note 4	See Note 5							
MILITARY CONSTRUCTION PROJECTS																					
ANDERSEN AIR FORCE BASE																					
P-203 Hangar, Apron, and Washrack																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	–1	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative sites	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	–1	0
•Use existing Andersen facilities	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	–1	0
•Use facilities at NAS Agana	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	–1	0	0	0	0	–1	0
P-207 SNCOQ Renovations																					
•Proposed action	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•No action	0	0	0	NA	0	0	0	0	0	–1	0	0	–1	NA	0	0	0	0	0	0	0
•Use other existing Andersen facilities	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	NA	0	0	0	0	0	–1	0	0	0	NA	–1	0	0	0	0	0	0
•Use off-post housing	0	0	0	NA	0	0	0	0	0	–2	0	0	–1	NA	0	0	0	0	0	0	0
P-209 BOQ Renovations																					
•Proposed action	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•No action	0	0	0	NA	0	0	0	0	0	–1	0	0	–1	NA	0	0	0	0	0	0	0
•Use other existing Andersen facilities	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	NA	0	0	0	0	0	–1	0	0	0	NA	–1	0	0	0	0	0	0
•Use off-post housing	0	0	0	NA	0	0	0	0	0	–2	0	0	–1	NA	0	0	0	0	0	0	0

Note 1. Pending results of Mariana crow/bat monitoring program.
Note 2. Net increase in federal expenditures and GovGuam revenues.
Note 3. Impact will be site specific.
Note 4. Impact will be primarily on relocated personnel and dependents during adjustment period.
Note 5. Cumulative impact on schools; positive impacts due to enhanced GovGuam revenues.
Note 6. Short-term benefits during construction period.
NA = Not Applicable

Table 1.7.1
Matrix of Alternatives

	Soils and Drainage	Hydrol/ Water Res	Terrestrial Biota	Marine Environ	Water Quality	Air Quality	Noise	Visual Setting	Historic Features	Housing	Jobs	Economic	Social	Public Services	Traffic	Elec	Water	Sewage	Solid Waste	Haz Waste	Other Hazards
CHANGES IN MILITARY ACTIVITIES																					
ANDERSEN AIR FORCE BASE																					
Permanent relocation of VRC-50:																					
•All activities at Andersen AFB	0	0	See Note 1	0	0	0	–1	0	0	–1	0	+1	0	0	0	0	0	0	–1	–1	0
•FCLPs at NAS Agana	0	0	0	0	0	0	–1	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
APRA HARBOR COMPLEX																					
New/expanded activities:																					
Naval Station	0	0	0	–1	–1	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	–1	0
Military Sealift Command	0	0	0	–1	–1	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	0	0	0
Naval Supply Depot	0	0	0	0	0	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	–1	0	0
Ship Repair Facility	0	0	0	–1	–1	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	–1	–1	0
Naval Special Warfare Unit One	0	0	0	–1	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	0	0
EOD Mobile Unit Five	0	0	0	–1	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	+1	–1
NAVAL MAGAZINE																					
Expansion of existing activities	0	0	0	0	0	0	0	0	0	–1	+1	+1	0	0	0	0	0	0	0	–1	–1
OTHERS																					
New/expanded activities:																					
NAS Agana	0	0	0	0	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	–1	0
Naval Hospital	0	0	0	0	0	0	0	0	0	–1	0	+1	+1	0	0	0	0	0	0	0	0
Naval Oceanog Command Center/JTWC	0	0	0	0	0	0	0	0	0	–1	0	+1	0	0	0	0	0	0	0	0	0
CUMULATIVE IMPACTS	0	0	0	0	–1	0	–1	0	0	–1	+1	+1	–1	0	0	0	–1	0	–1	–1	0
												See Note 2	See Note 4	See Note 5							
MILITARY CONSTRUCTION PROJECTS																					
ANDERSEN AIR FORCE BASE																					
P-203 Hangar, Apron, and Washrack																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	–1	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative sites	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	–1	0
•Use existing Andersen facilities	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	–1	0
•Use facilities at NAS Agana	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	–1	0	0	0	0	–1	0
P-207 SNCOQ Renovations																					
•Proposed action	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•No action	0	0	0	NA	0	0	0	0	0	–1	0	0	–1	NA	0	0	0	0	0	0	0
•Use other existing Andersen facilities	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	NA	0	0	0	0	0	–1	0	0	0	NA	–1	0	0	0	0	0	0
•Use off-post housing	0	0	0	NA	0	0	0	0	0	–2	0	0	–1	NA	0	0	0	0	0	0	0
P-209 BOQ Renovations																					
•Proposed action	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•No action	0	0	0	NA	0	0	0	0	0	–1	0	0	–1	NA	0	0	0	0	0	0	0
•Use other existing Andersen facilities	0	0	0	NA	0	0	0	0	0	+1	See Note 6	See Note 6	0	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	NA	0	0	0	0	0	–1	0	0	0	NA	–1	0	0	0	0	0	0
•Use off-post housing	0	0	0	NA	0	0	0	0	0	–2	0	0	–1	NA	0	0	0	0	0	0	0

Note 1. Pending results of Mariana crow/bat monitoring program.
Note 2. Net increase in federal expenditures and GovGuam revenues.
Note 3. Impact will be site specific.
Note 4. Impact will be primarily on relocated personnel and dependents during adjustment period.
Note 5. Cumulative impact on schools; positive impacts due to enhanced GovGuam revenues.
Note 6. Short-term benefits during construction period.
NA = Not Applicable

Table 1.7.1
Matrix of Alternatives

	Soils and Drainage	Hydrol/ Water Res	Terrestrial Biota	Marine Environ	Water Quality	Air Quality	Noise	Visual Setting	Historic Features	Housing	Jobs	Economic	Social	Public Services	Traffic	Elec	Water	Sewage	Solid Waste	Haz Waste	Other Hazards
APRA HARBOR COMPLEX																					
NAVAL STATION																					
P-391/392 Child Development Center																					
Additions and Alterations																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	+2	NA	–1	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	–2	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	+2	NA	See Note 3	0	0	0	0	0	0
•Use off-base facilities	0	0	0	0	0	0	0	0	0	NA	0	0	+2	NA	0	0	0	0	0	0	0
•Use outside service provider contractors	0	0	0	0	0	0	0	0	0	NA	0	0	+2	NA	0	0	0	0	0	0	0
•Use home care providers	0	0	0	0	0	0	0	0	0	NA	0	0	+2	NA	0	0	0	0	0	0	0
MILITARY SEALIFT COMMAND																					
P-160 Operations Building																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
NAVAL SUPPLY DEPOT																					
P-141 Hazardous Material Storage Building																					
•Proposed action	+1	0	0	0	+1	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	+1	0
•No action	–1	0	0	0	–1	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	–1	0
•Alternative site	+1	0	See Note 3	See Note 3	+1	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	+1	0
•Use existing Naval Station facilities	–1	0	0	0	–1	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	–1	0
P-151 Gas Bottle Storage																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	+1
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	–1
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	+1
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	+1
P-152 Integrated Storage & Handling Facility																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
P-153 General Warehouse																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
P-156 Gantry Crane and Rails																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
*Building provides for proper storage of materials and lessens likelihood of soil/water contamination.																					

Table 1.7.1
Matrix of Alternatives

	Soils and Drainage	Hydrol/ Water Res	Terrestrial Biota	Marine Environ	Water Quality	Air Quality	Noise	Visual Setting	Historic Features	Housing	Jobs	Economic	Social	Public Services	Traffic	Elec	Water	Sewage	Solid Waste	Haz Waste	Other Hazards
P-157 Cold Storage Warehouse																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
P-158 Supply Systems Support Building																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
SHIP REPAIR FACILITY																					
P-168 Ship Spares Storage Warehouse																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
NAVAL SPECIAL WARFARE UNIT ONE																					
P-394 Maintenance/Storage Building																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	See Note 3	See Note 3	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
P-395 Naval Special Warfare Unit Bldg																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	See Note 3	See Note 3	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
EOD MOBILE UNIT FIVE																					
P-393 EOD Operations Facility																					
•Proposed action	0	0	0	–1*	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	See Note 3	See Note 3	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
PUBLIC WORKS CENTER																					
P-234 Orote Power Plan Expansion																					
•Proposed action	–1	–1	0	0	–1	–1	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	+2	0	0	0	–1	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	–2	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	See Note 3	See Note 3	See Note 3	0	See Note 3	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	+2	0	0	0	–1	0
•Expand Piti Power Plant	0	0	0	0	0	–2	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	+1	0	0	0	–1	0
P-235 Repair Shop Storage																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Station facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
*Temporary impacts during construction.																					

Table 1.7.1
Matrix of Alternatives

	Soils and Drainage	Hydrol/ Water Res	Terrestrial Biota	Marine Environ	Water Quality	Air Quality	Noise	Visual Setting	Historic Features	Housing	Jobs	Economic	Social	Public Services	Traffic	Elec	Water	Sewage	Solid Waste	Haz Waste	Other Hazards
P-236 Family Housing																					
•Proposed action - Tipalao	–1	0	–1	0	0	0	0	0	–1	+2	See Note 6	See Note 6	+2	0	–1	–1	–1	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	–2	0	0	–2	0	0	0	0	0	0	0	0
•Alternative site - New Apra Heights	–2	0	–1	0	0	0	0	0	–1	+2	See Note 6	See Note 6	+2	0	–1	–1	–1	0	0	0	0
•Alternative site - Polaris Point	–1	0	–1	0	0	0	0	0	0	+2	See Note 6	See Note 6	+2	0	–1	–1	–1	0	0	0	0
•Public/private construction venture	See Note 3	0	See Note 3	See Note 3	See Note 3	0	0	0	See Note 3	+2	See Note 6	See Note 6	+2	0	–1	–1	–1	0	0	0	0
•Purchase/lease agreements	0	0	0	0	0	0	0	0	0	–2	0	0	–1	0	0	0	0	0	0	0	0
P-237 Waterfront Utilities																					
•Proposed action	0	0	0	+1	+1	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	–1	–1	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
P-239 Apra Harbor Sewage Treatment																					
Plant Modifications																					
•Proposed action	0	0	0	+1	+1	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	+2	–1	0	0
•No action	0	0	0	–1	–1	0	0	0	0	NA	0	0	NA	NA	0	0	0	–2	0	0	0
•Construct new facility on alternative site	See Note 3	0	See Note 3	See Note 3	See Note 3	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	+2	–1	0	0
•Replace existing facility with joint	0	0	0	+1	+1	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	+2	–1	0	0
GovGuam/Navy facility																					
NAVAL MAGAZINE																					
P-829 Missile Magazines																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Magazine facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
P-830 Inert Storehouse																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Use existing Naval Magazine facilities	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Use facilities at other Navy bases	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
OTHER																					
NAVAL OCEANOGRAPHY COMMAND																					
CTR/JOINT TYPHOON WARNING CTR																					
P-001 Oceanography Bldg Renovation																					
•Proposed action	0	0	0	0	0	0	0	0	0	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•No action	0	0	0	0	0	0	0	0	0	NA	0	0	NA	NA	0	0	0	0	0	0	0
•Alternative site	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
•Construct new building	See Note 3	0	See Note 3	0	0	0	0	0	See Note 3	NA	See Note 6	See Note 6	NA	NA	0	0	0	0	0	0	0
CUMULATIVE IMPACTS	0	0	0	–1*	–1	0	0	0	0	–1**	+1	+1	0	0	0	+1	–1	+1	–1	–1	0
*Temporary impacts during construction.																					
**Increased demand on housing by workers during construction period.																					

CHAPTER 2

PROPOSED ACTIONS AND ALTERNATIVES

2.1 INTRODUCTION

The treaty-mandated closure of the Subic Naval Complex has required that activities formerly conducted in the Philippines be withdrawn. This section provides a discussion of the Department of Defense strategy and policy and world events that have influenced the proposed actions presented here.

2.1.1 U.S. Asia-Pacific Strategy

The U.S. Asia-Pacific strategy, as outlined in the Department of Defense 1992 report to Congress titled "A Strategic Framework for the Asian/Pacific Rim," centers on the need for sustained security in the region. Military forward presence, sufficient overseas base structure to support those forces, and a strong system of bilateral security arrangements are the main principles of the U.S. security policy in Asia. The report also recognizes the "shifting U.S. military posture in Southeast Asia from a large, permanent presence at a single complex of bases in the Philippines to a more widely distributed, less fixed posture. This posture consists of regional access, mutual training arrangements, periodic ship visits, intelligence exchanges, and professional military educational programs rather than permanently stationed forces."

The 1990 East Asia Strategy Initiative (EASI), often referred to as Nunn-Warner, requires an orderly, phased reduction in the number of authorized U.S. military personnel in Japan and Korea. Phase I required a reduction of approximately 12 percent by December 31, 1992. This initiative essentially precludes relocation of significant functions and support personnel to either Korea or Japan.

World events center on the end of the Cold War and call for correspondingly severe military budget reductions. These budget reductions would not only affect force levels but also the military's ability to operate and maintain bases throughout the world. Public pressure continues to mount in opposition to maintaining overseas bases at the expense of domestic bases being closed under the Base Realignment and Closure program.

2.1.2 Withdrawal Planning

With the preceding as background, the initial task was to decide which units were of continuing military necessity with respect to the strategy stated above and therefore required relocation, and which were no longer necessary and could be disestablished or deactivated. Imminent and mandatory force reductions placed particular emphasis on disestablishing as many units as possible. Following these objectives, it was determined that when Subic Bay closed, units amounting to only about one-fourth of the total assigned personnel (1,700 of 6,200) required relocation. Many of the units that could be disestablished basically performed site specific functions associated with base infrastructure and support such as the Navy Exchange, Personnel Support Detachment, and the Public Works Center.

The magnitude of reductions resulting from this initial assessment greatly simplified the task of relocation planning. Many of the units would not be relocated. Due to anticipated severe budget constraints, many more of those units requiring relocation would have to be consolidated with similar functions elsewhere as much as feasible within the constraints of the Asia-Pacific Strategy and without exceeding EASI limits. The driving philosophy was clear; withdrawal did not mean replication of the large permanent presence in another country or area.

Deciding where to relocate specific activities and functions then became a relatively straightforward process. Military operational requirements were reviewed with respect to EASI limits and regional bilateral security arrangements. Existing operational capabilities at other locations within the Western Pacific were reviewed with preference given to augmenting those capabilities with relocating forces rather than duplicating them at a new site. Existing base and infrastructure capabilities were reviewed to determine their ability to support additional missions and personnel. The use of existing facilities and infrastructure at these bases was specifically emphasized to keep new construction cost to a minimum.

Early planning concluded, for instance, that the Cubi Point rotary wing intermediate maintenance activities could be redistributed to existing naval activities in Japan. Supply functions previously performed by the Naval Supply Depot Subic Bay could be redistributed primarily between Yokosuka and Guam. Subic Bay formerly held over two-thirds of the stock and performed 60 percent of the issues of the three WESTPAC depots (Yokosuka, Guam, and Subic). Most of the repair parts for aviation, surface, and submarine support could be integrated with existing stocks in Yokosuka. Bulk consumables, provisions, and ship store stock capabilities could be relocated to Guam to supplement existing missions.

From this process, it became clear that Guam should be the predominant receiving site for most relocating functions. While bilateral security arrangements provide additional operational capabilities and flexibility in projecting forward presence, they do so without allowing significant permanent basing. Relocating units to Japan would require a careful balancing of the need to functionally consolidate similar units (and thereby increase personnel loadings) with the need to remain under EASI limits. Basically, those functions requiring intensive military manpower were not feasible for relocation to Japan. In addition, facility construction in Japan is a major problem. The Government of Japan has excluded funding for Philippines withdrawal related construction from its host nation funded construction program. When taken together with Congress' adamant stand against funding any military construction in Japan, there is no feasible way to construct required operational and personnel support facilities.

Guam, on the other hand, offers significant capabilities that have historically been underutilized. Infrastructure is generally adequate to support the required relocations. In a few instances, additional facilities will be required, but cost of construction of necessary facilities on Guam would be much less than for an area with little or no existing infrastructure. Most of the changes summarized in Chapter 1 augment operations that already exist on Guam. None of these will require use of federal lands that have previously been declared excess.

When taken as a whole, the need to remain forward deployed in keeping with existing strategy, the need to reduce force levels as well as supporting bases and infrastructure, the constraining limits imposed by EASI, and the absence of permanent basing rights in existing bilateral security arrangements synergistically combine to make Guam the only alternative for all but a few of the units and functions relocating from the Philippines. The remainder of this document will be directed toward evaluating the environmental impacts resulting from proposed development and accommodation of relocated Philippine functions on Guam. A broad "no action" alternative is not feasible and will not be further evaluated because remaining in the Philippines was not a viable option.

2.2 CHANGES IN MILITARY ACTIVITIES

The personnel numbers given below represent authorized billets or positions. These are approximate numbers only, especially since all billets may not be filled. The numbers of accompanying dependents are estimates as well. Dependent families may not come to Guam until they are assigned to family housing or have found housing in the private sector.

2.2.1 Andersen Air Force Base

The Fleet Logistics Support Squadron Fifty (VRC-50) is a new activity at Andersen Air Force Base (AFB). VRC-50 delivers parts, passengers, and mail to Naval activities and deployed units including carrier battle groups in the Western Pacific. Approximately 17 new aircraft have been added, including C-130s, C-2As, and US-3As. The squadron consists of 73 officers and 432 enlisted personnel. There are approximately 580 accompanying dependents anticipated. Permanent flight operations associated with the squadron will include approximately 1,580 arrivals, 1,580 departures, 3,900 touch and go operations, and 7,200 field carrier landing practices (FCLPs) per year. These flight operations were covered as temporary activities in a separate environmental assessment (Navy, 1992e). Cumulative impacts of the permanent relocation of the squadron, as well as impacts associated with permanent support facilities, are covered in this EIS.

An alternative site for FCLPs is at Naval Air Station Agana, which may be used should Andersen Air Force Base prove an undesirable location. There is a potential for adverse effects upon the endangered Mariana crow and fruit bat at Andersen, and the effects of FCLP maneuvers on these species is being investigated by the Navy in cooperation with the U.S. Fish and Wildlife Service and Guam Division of Aquatic and Wildlife Resources.

2.2.2 Apra Harbor Complex

2.2.2.1 Naval Station

The mission at Naval Station (NAVSTA) Guam is to maintain and operate facilities and to provide materials in support of the operating forces of the U.S. Navy and shore activities as assigned (Navy, 1986a). Ship port calls at Naval Station are expected to increase because of training and logistic support requirements. Port calls in 1990 totaled 129 visits, 1991 port calls totaled 109 visits, and 1992 port calls totaled approximately 122 visits (Communication with COMNAVMAR, 1992). The increase in ship activity at the Naval Station will bring larger vessels to the piers in inner Apra Harbor. Some of these ships will require up to 600 feet of pier space. The harbor can accommodate all

projected ship traffic. Support of fleet training evaluation programs will be provided from Guam, with a training ship operating from Naval Station on a daily basis about three-fourths of the time. There will be eight permanent personnel and about 50 temporary duty personnel associated with these at-sea training evaluations. In a separate mission change, the U.S. Marine Security Detachment has been relieved from duty at the Naval Magazine. There were 298 enlisted and 11 officer billets in the Marine Security Detachment. The approximately 160 unaccompanied personnel who lived at the Naval Station are no longer using these facilities. These facilities are being occupied by NSWU-1 personnel.

2.2.2.2 Military Sealift Command

The mission of the Military Sealift Command (MSC) is to transport goods and NSD supplies by sea using military or civilian hire vessels. MSC Guam is responsible for administration and operations of vessels at Guam and those visiting Guam. The MSC Sub-Area Commander for Southeast Asia will transfer to Guam, and the number of MSC administrated vessels operating out of Guam will increase as a result of the proposed actions. Increases in MSC vessels will be necessary to accommodate the additional Naval Magazine and Navy Supply Depot (NSD) activities. The three existing Guam-based supply vessels (USS Niagara Falls, USS White Plains, and USS San Jose), will be transferred to MSC control by October 1993. The Diego Garcia resupply vessel (MSC Cleveland) and three additional fleet logistic support vessels (T-AFS Spica, T-AFT Sioux, and T-AE Kilauea) will move to Guam and come under Guam MSC control. The MSC is responsible for all administrative and operational matters relating to these vessels. Additional personnel to manage the increased shore-based workload will include 5 officers, 13 enlisted, 15 Department of Defense positions, and 15 other civilian positions of various categories. Although the new MSC vessels assigned to Guam are technically homeported in Oakland, California, some military dependents will be sponsored by the Navy in Guam. Most of the personnel on the three additional MSC vessels will be civilian mariners (approximately 310). Since these civilian mariners will be homeported in Oakland, the Navy will not need to house any of their dependents on Guam and there will be no increased need for family housing associated with this activity.

2.2.2.3 Naval Supply Depot

The Naval Supply Depot (NSD) Guam provides supply and logistic support services to fleet and shore activities on Guam. The Depot also provides supply support to homeported and transient ships, to all aircraft operating from Naval Air Station, Agana, and specified support to every military activity located on Guam (Apra Harbor Master Plan, 1986). NSD Guam will experience an increase in the volume of supplies to various customers. Ship resupply visits will increase from approximately 120 to 128 visits per year. NSD now services the Indian Ocean (Diego Garcia) resupply run provided by the Military Sealift Command charter vessel. An additional Auxiliary Fleet Supply ship (T–AFS Spica) ship originates from Guam. Together, it is estimated that on average, 150 additional containers of cargo per month will be delivered to NSD via the commercial Port of Guam. Personnel will increase approximately 35 percent, consisting of 30 military personnel and 137 civilians in various categories, mostly locally hired.

2.2.2.4 Ship Repair Facility

The Ship Repair Facility (SRF) on Guam provides drydocking, alteration, conversion, voyage and emergency repairs, and other services for U.S. Naval ships, service craft, and other U.S. Government ships as directed (Apra Harbor Master Plan, 1986). Work at the Ship Repair Facility (SRF) will grow by an estimated 15 percent, increasing from a current annual level of 135,000 person-days to 155,000 person-days. A person-day is equivalent to an 8-hour work shift. This growth is expected to originate from the three additional Military Sealift Command ships in Guam as well as from additional voyage repairs. Ship visits to the SRF for voyage repairs are anticipated to increase from approximately 4 to 40 ships per year (Interview with Commanding Officer of SRF, April 22, 1992). The duration of each visit is expected to be from one to three days. There will be no changes in the way the Ship Repair Facility functions; the same methods will continue to be used. The SRF will have an increase in military personnel of one officer and 29 enlisted personnel, and the civilian work force is anticipated to grow from the existing 895 authorized positions to a level of 1,050 to 1,100. The SRF has an apprenticeship program to train locally hired civilians for its work force.

2.2.2.5 Naval Special Warfare Unit One (NSWU-1)

The Naval Special Warfare Unit One (NSWU-1) is a tactical operating unit being transferred to Guam, comprising a permanent party of 11 officers and 25 enlisted personnel and a detachment of 179 personnel on temporary additional duty (TAD). Activities include training in underwater demolition, small arms and demolition at existing ranges, water and small boat operations, helicopter insertion/extraction techniques, and parachuting. The NSWU-1 will also participate in jungle warfare training at Northwest Field, Andersen South, Orote Point, and NAVMAG. There will be live weapons fire and demolition exercises conducted at ranges and facilities at both NAVSTA and Andersen Air Force Base. They will be based at the new NSWU-1 facilities in the vicinity of Victor Wharf. In addition to various inflatable boats, the unit has five boats in the 36-foot range and two 65-foot boats, and will acquire two 170-foot vessels, all to be berthed in Inner Apra Harbor in the vicinity of Victor Pier.

2.2.2.6 Explosive Ordnance Disposal Mobile Unit Five (EODMU-5)

This new activity is comprised of 9 officers and 38 enlisted personnel transferring to permanent duty in Guam. EODMU-5 is responsible for disposing of unexploded ordnance in the Western Pacific area, excluding Guam. Training activities include demolition at existing ranges, underwater demolition, underwater retrieval of dummy munitions, small boat operations, and parachuting. The unit has 11 boats in the 18- to 27-foot range that will be moored at the EODMU-5 bulkhead along Sumay Cove.

The EODMU-5 is required to conduct training exercises in underwater demolition to maintain requisite skills and operational readiness. The scheduled exercises or Mine Counter Measure (MCM) training requires the detonation of no more than three charges per exercise. Each of the charges is no greater than 20 lbs. net explosive weight. Up to eight of these mine-warfare operations will occur annually in outer Apra Harbor in approximately 140 feet of water (PWC Guam, 1992). Environmental reviews and consultations with concerned agencies have been conducted regarding these activities. The impacts of the EODMU-5 training activities are discussed further in Section 4.6.2.3.

2.2.3 Naval Magazine

The mission of the Naval Magazine (NAVMAG) Guam is to receive, renovate, maintain, store, and issue ammunition, explosives, expendable ordnance items and weapons, and technical ordnance material (NAVMAG GUAM Master Plan, 1991). The Naval Magazine will experience an expansion in the scope of its existing activities, but there will be no significant change in type of activities. Approximately 15 percent of the ammunition from Naval Magazine Subic has been transferred to NAVMAG Guam, resulting in an increase of about 50 percent above present tonnage. There will be expanded use of Kilo wharf on Orote Peninsula, associated with the addition of the Auxiliary Explosive (AE) vessel Kilauea utilizing the magazine and wharf. Annually, the period when the full Explosive Safety Quantity Distance (ESQD) arc surrounding Kilo wharf will be in effect is estimated to be 32 days. Wharves Alpha and Bravo on Polaris Point will also experience greater use for loading and unloading Tomahawk missiles. A Naval Airborne Weapons Maintenance Unit is relocating to NAVMAG Guam, and an existing Mobile Mine Assembly unit and a Security Detachment are being augmented. NAVMAG personnel will increase by five officers, 145 enlisted, and 22 civilians in various categories. In a separate mission change, the U.S. Marine security detachment at the Naval Magazine has been disestablished and personnel transferred to other duty off-island stations. There were 298 enlisted men and 11 officer billets in the Marine Security Detachment.

2.2.4 Others

2.2.4.1 Naval Air Station

The Naval Air Station Agana (NAS Agana) will receive approximately 151 additional military billets. These will include augmentation of the fleet Imaging Center (photography) unit by 5 billets, augmentation of the Aircraft Intermediate Maintenance Department by 57 billets, an aircraft operations detachment of 49 billets, and a security detachment of approximately 34 billets. The relocated Naval Air Pacific Repair Activity (NAPRA) at NAS will have one officer and 5 enlisted billets, plus a maximum of 56 civilian billets. Billets will be filled with local hires to the extent technically qualified individuals are available.

The mission of NAPRA Guam is to provide complex repair services to active in-service Pacific Fleet aircraft which operate in the southeast Asia and Indian Ocean area, including aircraft based on Guam. It is in essence a repair hub. Routine aircraft maintenance is usually provided by technicians assigned to the particular squadrons. When more complex repair is required, the aircraft is directed to the NAPRA for servicing. Aircraft requiring NAPRA services often cannot be flown to another location for repair and NAPRA services must be performed at the location of the aircraft.

At the present time, more Navy aircraft are assigned to and utilize NAS Agana for operations than Andersen Air Force Base. Eighty-five percent of NAPRA's Guam workload is at NAS Agana and only 15 percent of the workload would be for VRC-50 at Andersen. If NAPRA were located at Andersen, maintenance teams would be required to travel by vehicle from Andersen to NAS Agana for most of their work. By locating NAPRA Guam at NAS Agana, this travel is minimized as maintenance teams from the NAPRA would commute to Andersen AFB only to repair VRC-50 aircraft.

VRC-50 Field Carrier Landing Practice (FCLP) flights will continue at NAS Agana as an alternative site to Andersen.

The 1993 Defense Base Closure and Realignment Commission recently recommended the closure of NAS Agana and the movement of aircraft, personnel, and associated equipment to Andersen Air Force Base. The President has concurred with this recommendation, and a final decision must now be made by Congress. Once the recommendation is approved, the Navy must initiate the closure and realignment within two years and must complete all actions within six years. These actions will be carried out in compliance with the National Environmental Policy Act.

In the interim, the Navy will use NAS Agana to accommodate the relocation of activities from the Philippines. Therefore, all activities relocating to NAS Agana will continue as planned, with the understanding that they will be moving to Andersen AFB within six years.

2.2.4.2 Naval Hospital

There will be an increase in health care positions transferring from Subic to the Naval Hospital, consisting of 20 officers and 50 enlisted personnel.

2.2.4.3 Nimitz Hill

The U.S. Naval Oceanography Command in the Philippines is being closed and many of its functions are being reassigned to Guam. A total of ten positions and two new civilian hires are being added to the Naval Oceanography Command Center/ Joint Typhoon Warning Center based on Nimitz Hill. This is the sole activity responsible for issuing warnings of tropical cyclone development throughout the entire Western Pacific and Indian Oceans. It also provides warnings on extratropical storms, high winds and seas, and other hazardous weather phenomena.

2.3 MILITARY CONSTRUCTION PROJECTS

The following military construction projects are listed by their designated military construction (MILCON) numbers for each of the separate activities. A discussion of alternatives is included with each project description.

2.3.1 Andersen Air Force Base

The locations of military construction projects at Andersen Air Force Base are shown in Figure 2.3.1.

P-203 VRC-50 Hangar, Apron, and Washrack Facility This project calls for the construction of a 78,915-square-foot, steel framed aircraft maintenance hangar, washrack, drainage retention basin, aircraft apron, hazardous and flammable materials storage, and other aircraft maintenance supporting facilities at Andersen Air Force Base (see Figure 2.3.2). The hangar will have a shop area on the first floor and an administrative area on the second floor. This facility is necessary to provide support for the relocated VRC-50 Fleet Logistics Support Squadron. The hangar will be large enough to

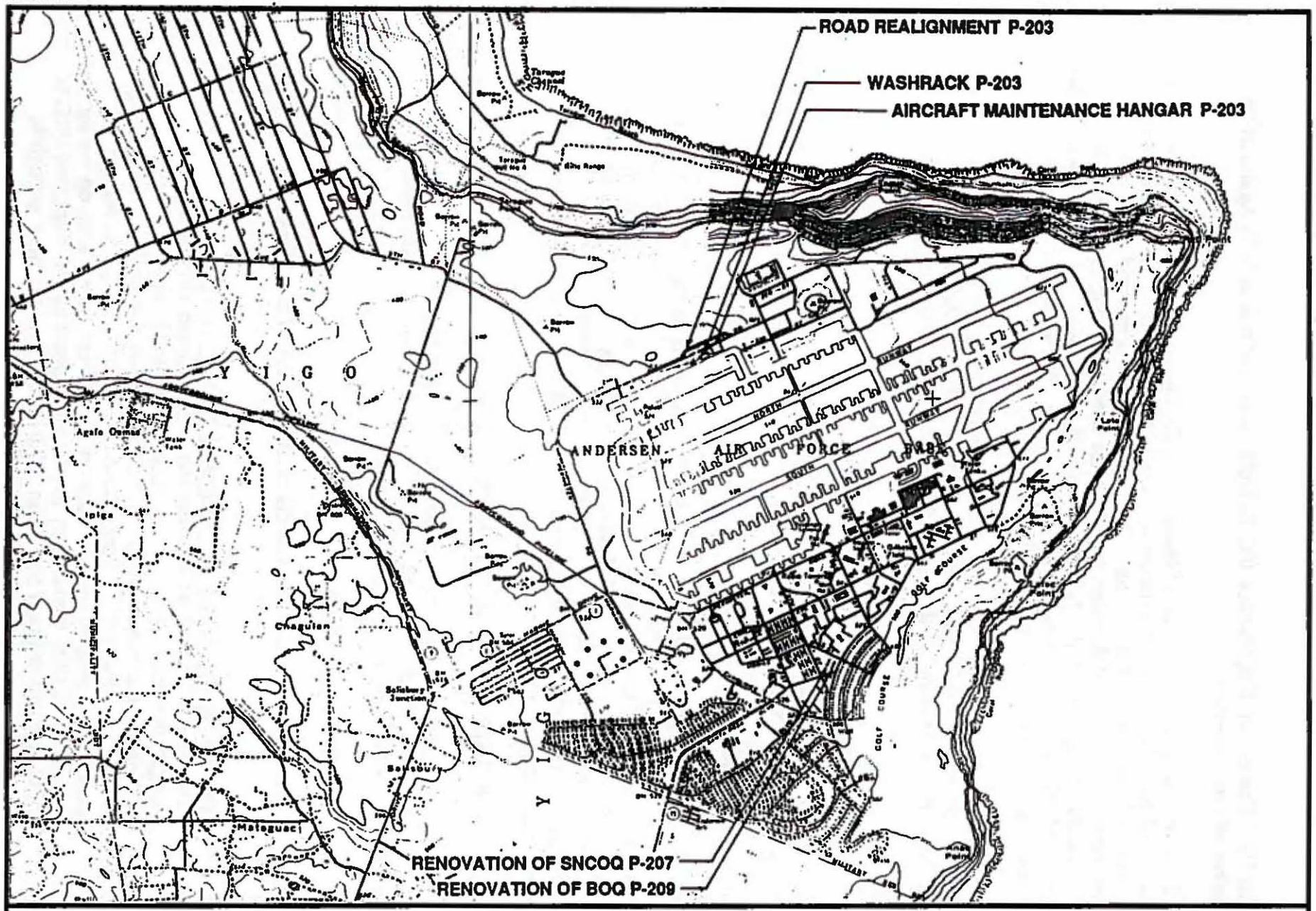
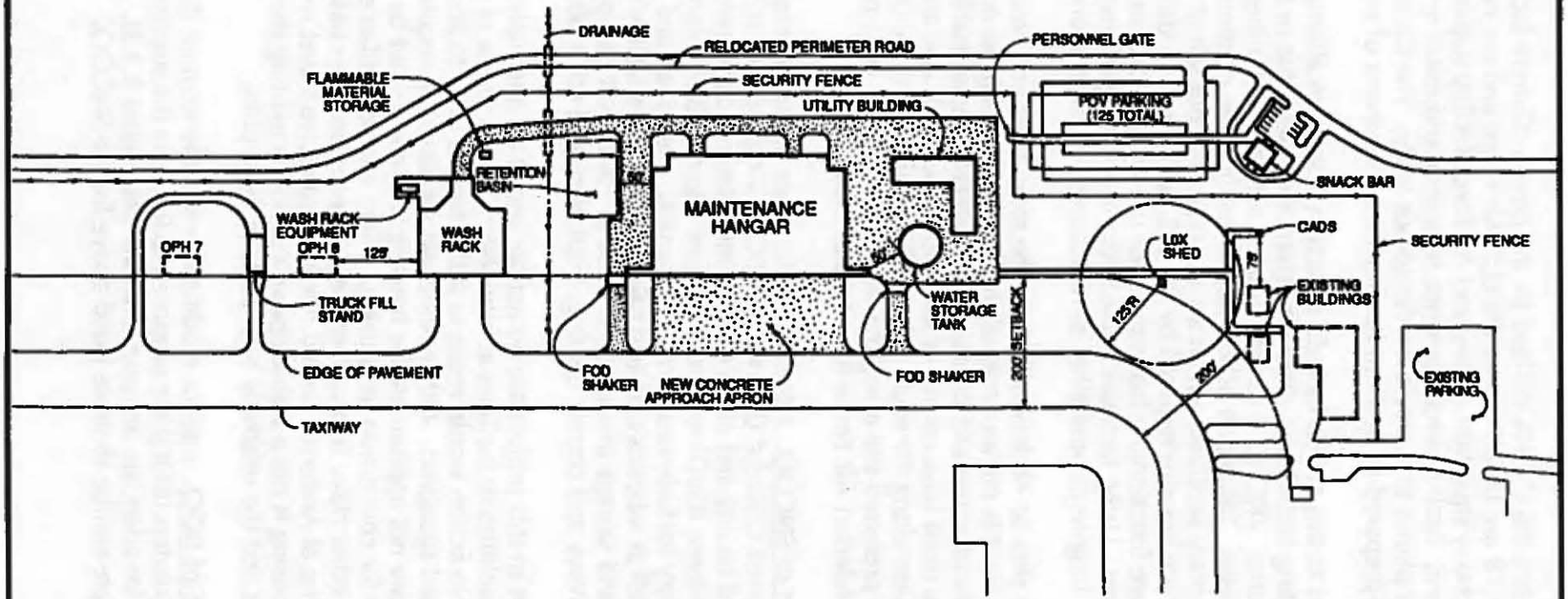


Figure 2.3.1
ANDERSEN AIR FORCE BASE PROJECTS
Guam Development EIS
April 1993



Source: *Preliminary Engineering Submittal, Volume IIA, Project Engineering Report, Maintenance Hangar*, CDS International, November 1992

North

0 100 200 400

Scale in Feet

Figure 2.3.2
ANDERSEN AIR FORCE BASE FACILITY:
P-203
Guam-Subic Relocation EIS
April 1993

accommodate the C-130s utilized by the group. Current facilities at Andersen AFB are in full use by the U.S. Air Force and are not suited for use by the Navy squadron. Navy and Air Force facility requirements are very different. Lack of a maintenance hangar would result in poorly maintained planes that would be dangerous to fly. The squadron would then be ill-prepared to perform its mission in the event of emergencies.

Alternatives to this action include no action, use of an alternative site, or use of existing facilities at either Andersen Air Force Base or Naval Air Station Agana. VRC-50 is currently using temporary facilities at Andersen Air Force Base. Taking no action would result in the continued use of these temporary facilities, which are operationally not suited for Naval use and which are also required by the U.S. Air Force. Existing facilities at Andersen are functionally inadequate for use by VRC-50, and are not a viable option. Using facilities at NAS Agana is not a preferred alternative due to the long-term possibility of relocating NAS operations to Andersen.

Alternative sites at Andersen include the main base and Northwest Field. Northwest Field is not an acceptable alternative as it lacks operational support infrastructure and contains endangered species habitat. Alternatives on the main base consist of sites along the south side and south taxiway. Sites along the south side conflict with existing Air Force operations. The preferred site along the north runway area does not conflict with the Andersen Air Force Base Master Plan.

P-207 Renovation of SNCOQ. Interior modifications to the existing Staff Non-Commissioned Officers' Quarters (SNCOQ) are proposed to improve the substandard facility and allow for accommodations consistent with Department of Defense (DoD) requirements (see Figure 2.3.3). Renovations of the dormitory include structural, mechanical, electrical, and interior design work, as well as asbestos and lead paint removal. The facility's living, common, and storage areas, constructed in 1948, will be upgraded to provide privacy and correct lighting, insulation, and other obsolete systems.

Alternatives to this project are no action, use of an alternative site (other Andersen facilities or facilities at other Navy bases), or use of off-post housing. No action would result in a shortage of units to accommodate the relocated squadron. Other Andersen facilities are required for other functions, are not appropriate for housing use, and would be economically prohibitive for conversion to housing. There are no available accommodations on other Navy bases. Providing housing on other bases for personnel operating at Andersen would result in excessive travel requirements. Off-post housing is not a viable option due to the existing shortfall of private sector units and the relatively high costs of these units.

P-209 Renovation of BOQ. Interior modifications to the existing Bachelor Officers' Quarters (BOQ) are proposed to improve the substandard facility and allow for adequate accommodations (see Figure 2.3.3). Items to be renovated are similar to those listed above for the SNCOQ.

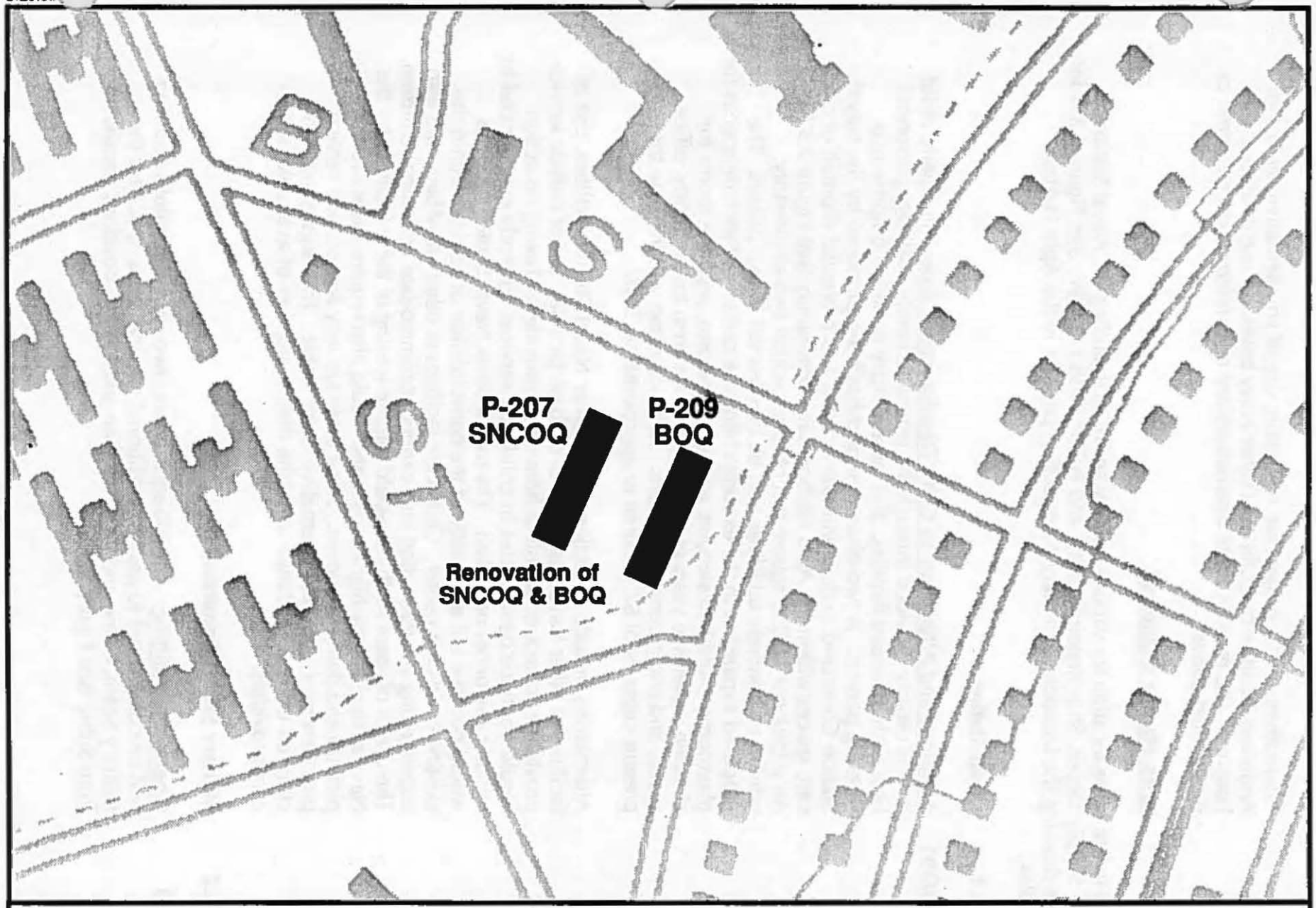


Figure 2.3.3
ANDERSEN AIR FORCE BASE FACILITIES:
P-207, P-209
Guam Development EIS
April 1993

Alternatives to this project are no action, use of an alternative site (other Andersen facilities or facilities at other Navy bases), or use of off-post housing. The reasons these alternatives are not preferred are the same as those listed above.

2.3.2 Apra Harbor Complex

Apra Harbor is the location for various military activities including the Naval Station, Naval Supply Depot, Ship Repair Facility, and Public Works Center. See Figure 2.3.4 for a map showing the location of military construction projects in the Apra Harbor Complex.

2.3.2.1 Naval Station

P-389/391 Additions and Alterations to Child Development Center. In Guam, child care is usually provided through the extended family. Military personnel lack such extended families, and most military families comprise two working parents. A two-phased project has been proposed by the Naval Station Command to deal with the existing and projected shortfall of child care spaces within the Apra Harbor Navy community (see Figure 2.3.5). An additional 17,850 square feet of space within two single-story, reinforced concrete buildings will be constructed in two phases. The proposed expansion to the existing child care center will include spaces for playrooms, multi-bed sleeping rooms, classrooms, separate rooms for children under two years of age, food service area, toilets, lobby, office space, and playground equipment. This expansion will increase the present capacity of 62 children to approximately 300.

Alternatives include no action, use of other Naval Station facilities, use of facilities at other Navy bases, use of off-base facilities, use of outside service provider contractors, or use of home-care providers. Taking no action would continue deficiencies in child care services currently experienced by military personnel on Guam. The use of other Naval Station facilities would not take full advantage of the consolidation of services within the existing child care center. Child care facilities at other Navy bases are also experiencing overcrowding and cannot accommodate additional children. The use of off-base facilities would require leasing of these facilities by the Navy at significantly higher costs, and would also require excessive travel to pick up and deliver children. Since there are very few outside service providers on Guam, this alternative is not viable. The large number of children excludes reliance upon the limited number of available home-care providers.

2.3.2.2 Military Sealift Command

P-160 Operations Building. A 6,300-square-foot, two-story operations building will be constructed to provide additional administrative space for the Military Sealift Command (MSC) civilian and military positions transferring from Subic (see Figure 2.3.6).

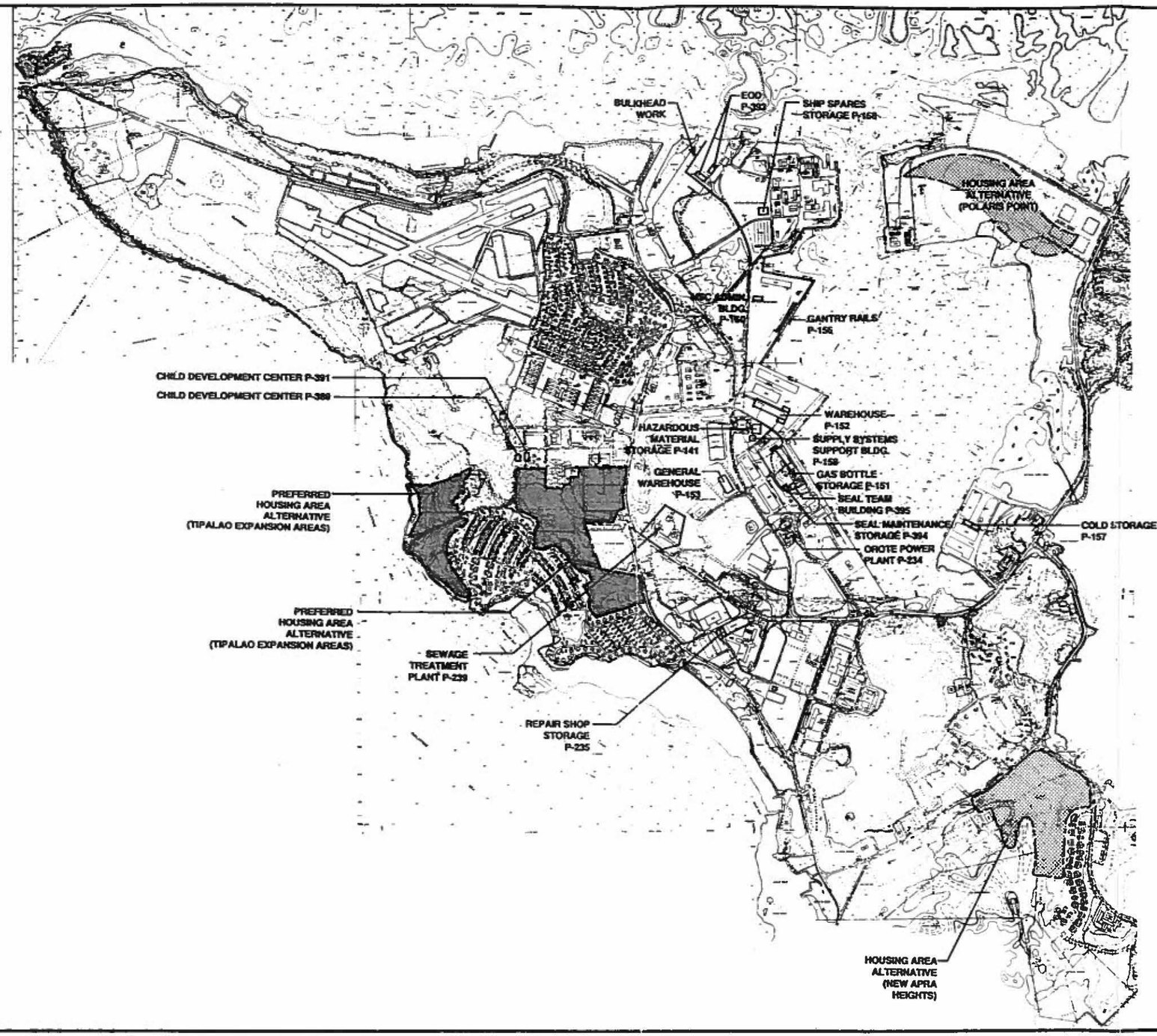


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Figure 2.3.4
APRA HARBOR COMPLEX PROJECTS
Guam Development EIS
April 1993

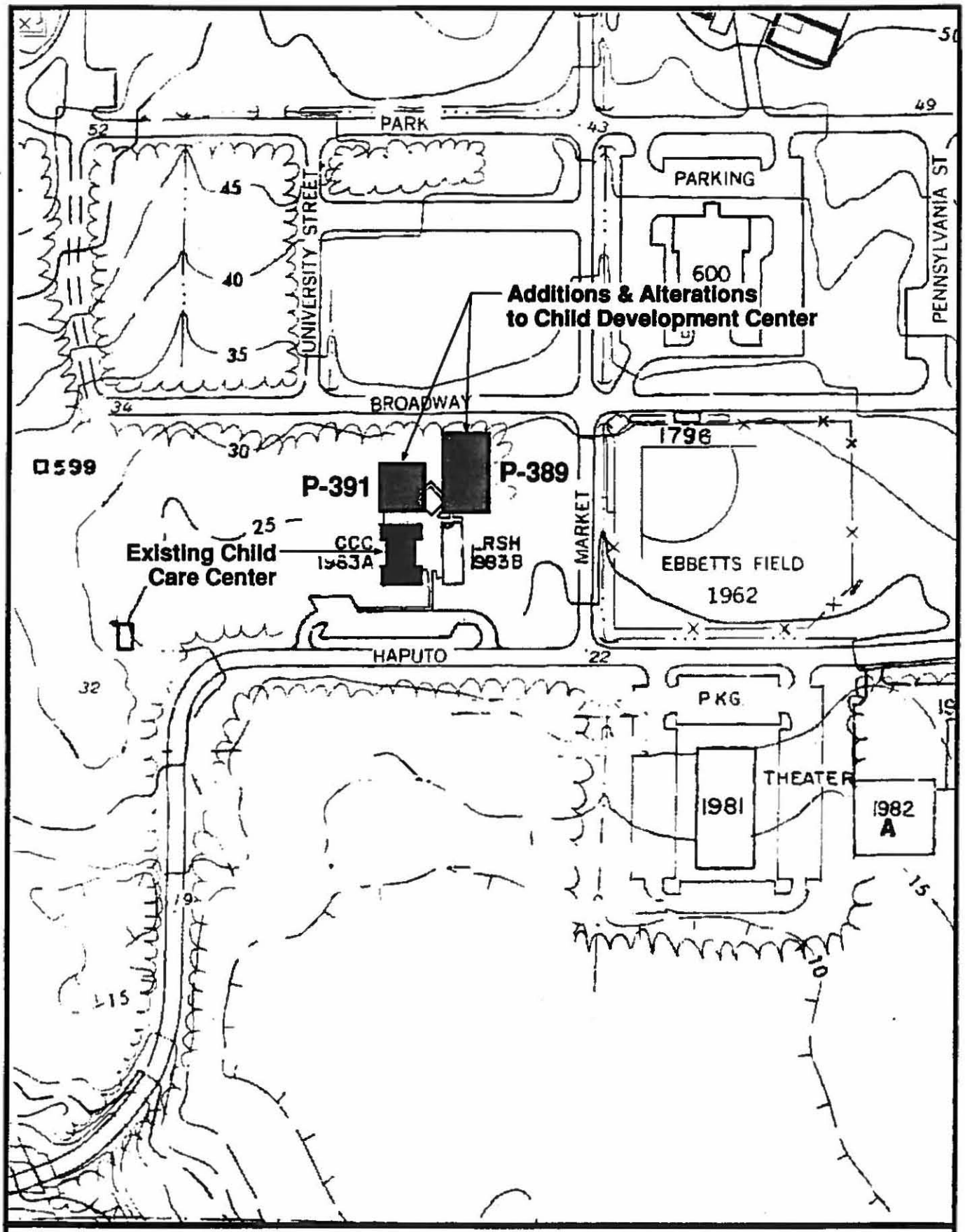

Figure 2.3.5
APRA HARBOR COMPLEX FACILITIES:
P-391, P-389
Guam Development EIS
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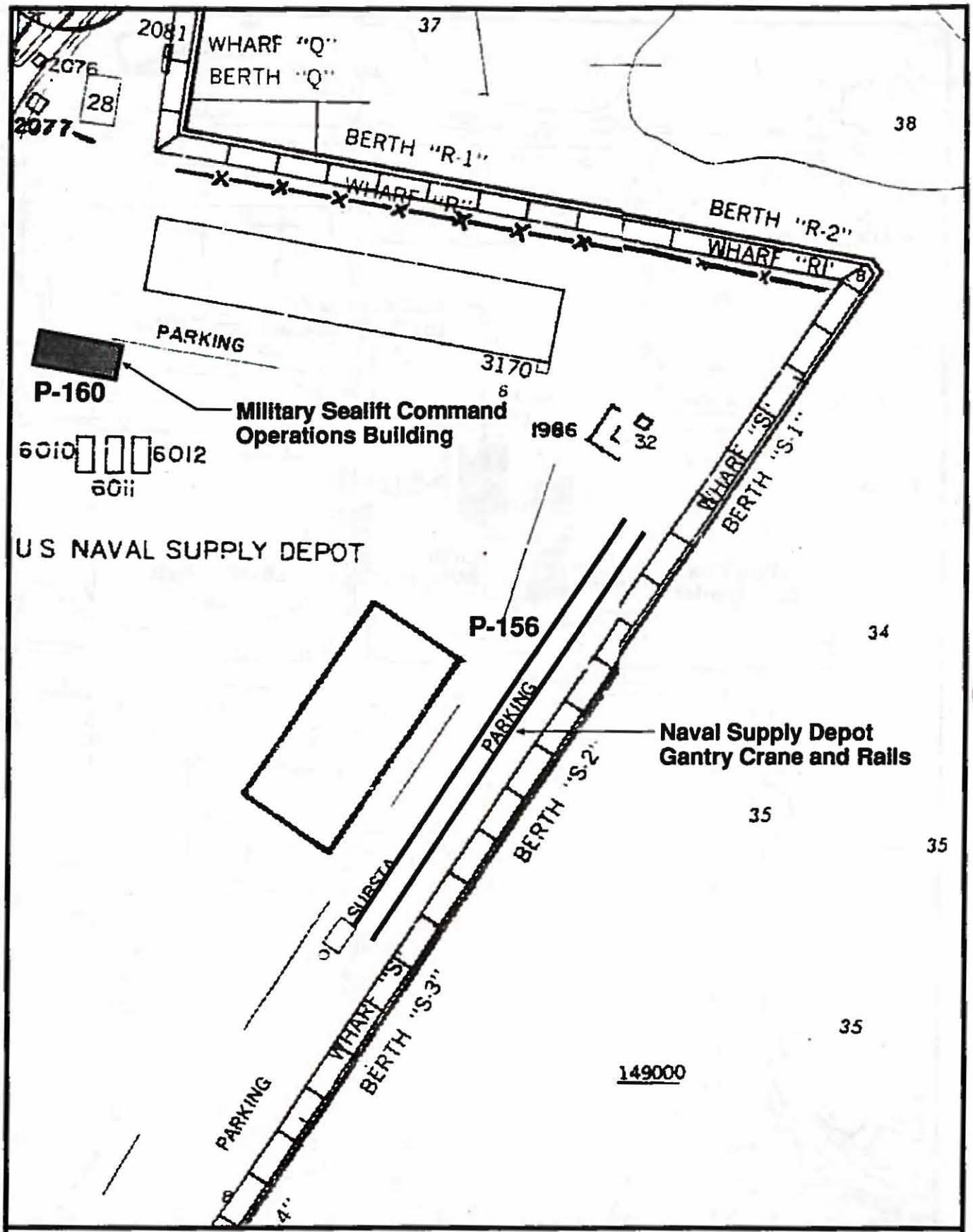

Figure 2.3.6
APRA HARBOR COMPLEX FACLITIES:
P-160, P-156
Guam Development EIS
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242.0101/09

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. The existing MSC operations building is inadequate to accommodate the additional personnel assigned to MSC Guam. Therefore, no action is not a practical alternative. Use of an alternative site within the wharf area would result in a lack of consolidation among MSC activities and facilities and would compromise operations of other activities sharing the wharf area. Use of existing Naval Station facilities would cause a separation between the administrative activities and the base of MSC operations at the wharves.

2.3.2.3 Naval Supply Depot

P-141 Hazardous Material Storage Building. This project will provide for segregated storage of paints, acids, corrosives, petroleum products, and other hazardous materials stocked within a 43,000-square-foot building (see Figure 2.3.7). An increase in overall activities will mean an increase in the use and supply of hazardous materials. Currently, NSD Guam does not have a facility that meets Navy standards for the storage of hazardous materials. Thus, materials are stored in a variety of non-conforming locations, including general warehouses, storage sheds, and open areas. The deteriorating conditions of these non-conforming buildings are causing some of the hazardous materials to deteriorate and become non-serviceable, which results in their becoming hazardous waste. Approximately six people are expected to be assigned to this facility. The location of this project was driven by its proximity to the Defense Reutilization and Marketing Office (DRMO) facility.

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. No action would continue the current substandard conditions for the storage of hazardous materials, and the existing storage area is insufficient to accommodate present and new space requirements. The desire to place the project along the existing road system within the NSD area makes alternative sites on the Naval Station impractical. Existing Naval Station facilities would require renovations and conversions to allow for hazardous material storage and would result in the displacement of other existing activities.

P-151 Gas Bottle Storage. Construction of a 10,000-square-foot building is proposed to provide compressed gas bottle storage within the secure NSD compound (see Figure 2.3.8). Current storage of the various gases (oxygen, helium, freon, chlorine, acetylene, nitrogen, and carbon dioxide) is in open areas and exposed to direct sunlight and inclement weather. This causes a potential safety hazard due to temperature and pressure fluctuations of the compressed gases and possible corrosion and leakage of the tanks due to rain. Existing gas bottle storage facilities on Guam are inadequate to support the stated local requirements. There is no excess capacity for the additional loads due to the relocation actions.

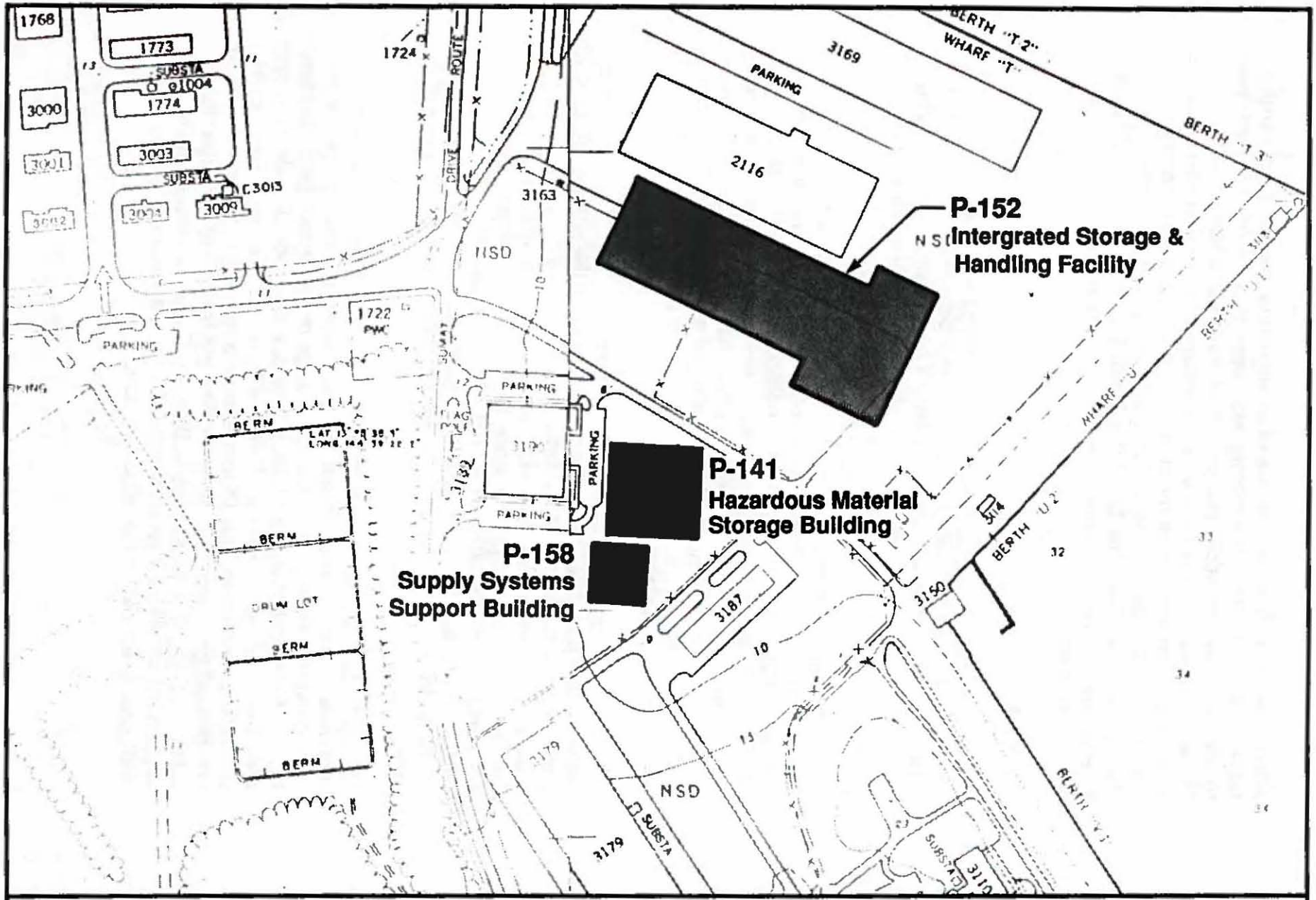


Figure 2.3.7
APRA HARBOR COMPLEX FACILITIES:
P-141, P-152, P-158
Guam Development EIS
April 1993

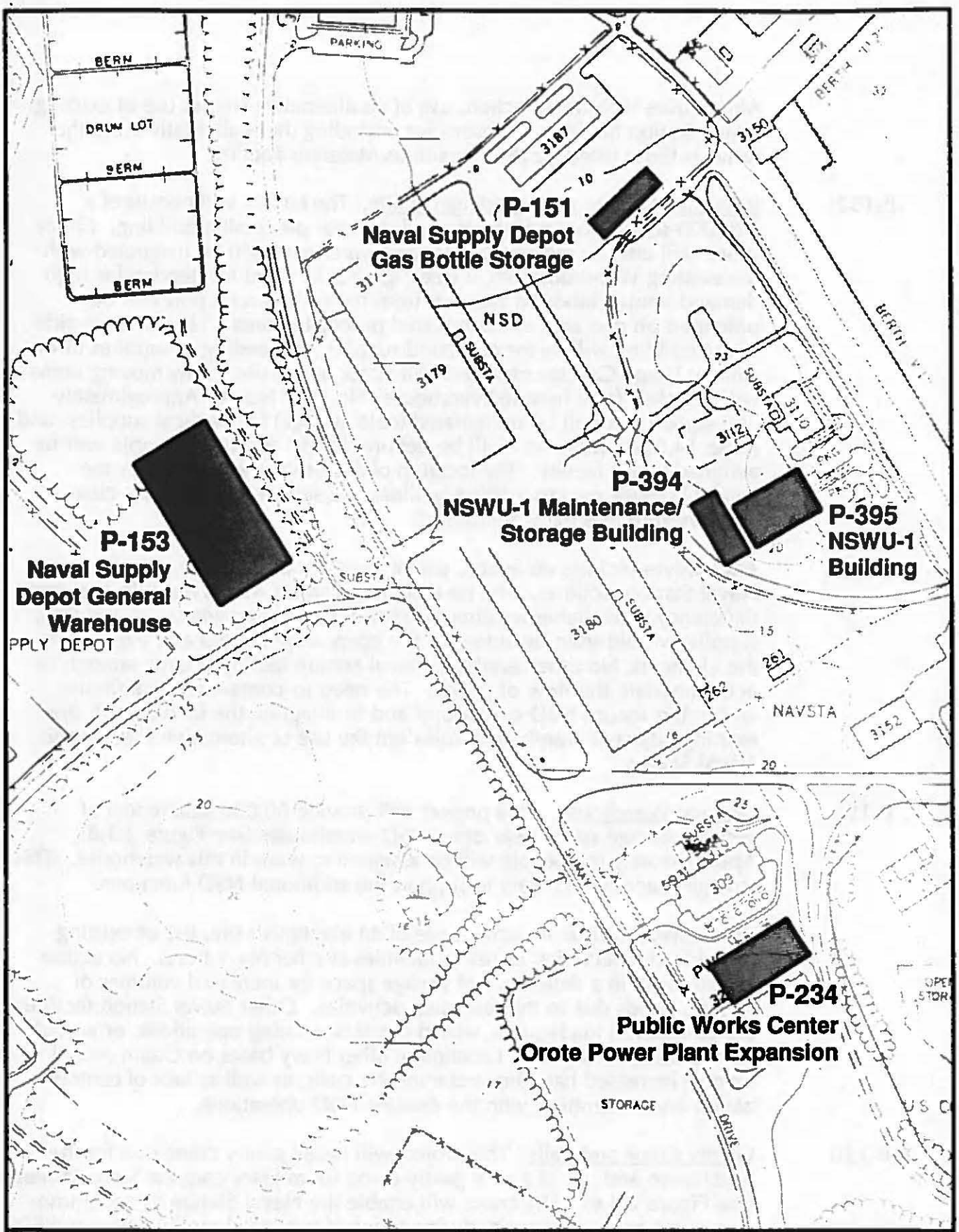


Figure 2.3.8
APRA HARBOR COMPLEX FACILITIES:
P-151, P-153, P-394, P-395, P-234
Guam Development EIS
April 1993

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. Reasons for excluding these alternatives are the same as those listed for the Hazardous Materials Facility.

P-152 Integrated Storage and Handling Facility. The facility will consist of a 120,000-square-foot warehouse and material processing building. Office space will also be provided. The new warehouse will be integrated with the existing Warehouse No. 2 (see Figure 2.3.7) and is intended for high demand items. Inbound supplies from the commercial port will be unloaded on one side of the material processing area. The opposite side of the building will be for outbound supplies. Reloading of supplies in the smaller Diego Garcia containers will occur at this site. Slow moving items will be taken from here to Warehouses No. 3 or No. 4. Approximately 300 square feet will be refrigerated (cold storage) for medical supplies, and some 14,000 square feet will be dehumidified. About 25 people will be assigned to this facility. The location of this project was driven by the available space next to existing facilities of a similar function (i.e., clear space next to existing warehouses).

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. The no action alternative would result in a severe deficiency of available warehouse space for incoming goods. In addition, supplies would then be stored in the open, unprotected and exposed to the elements. No other available Naval Station facility is large enough to accommodate the flow of goods. The need to contain the warehouse within the secure NSD compound and to integrate the facility with the existing adjacent warehouses rules out the use of alternative sites on the Naval Station.

P-153 General Warehouse. This project will provide 60,000 square feet of general storage space near other NSD warehouses (see Figure 2.3.8). Approximately ten people will be assigned to work in this warehouse. This storage space is necessary to support the additional NSD functions.

Alternatives include no action, use of an alternative site, use of existing Naval Station facilities, or use of facilities at other Navy bases. No action would result in a deficiency of storage space for increased volumes of general goods due to the relocated activities. Other Naval Station facilities are considered inadequate, would displace existing operations, or would be too costly to convert. Location at other Navy bases on Guam would involve increased handling and transport costs, as well as lack of centralization and integration with the existing NSD operations.

P-156 Gantry Crane and Rails. This project will install gantry crane rails for the installation and use of a new gantry crane for military cargo at Sierra Wharf (see Figure 2.3.6). The crane will enable the Naval Station to accommodate surge or peak capacity during times of increased mobilization at NSD.

Alternatives include no action or postponed action on the purchase of the crane. Taking no action or postponing action on this project would not

address the problems associated with insufficient civilian service due to military cargo requirements at commercial facilities during times of military mobilization. The continuation of insufficient civilian service during such times could result in a degradation of the quality of life for Guam residents as necessary routine cargo is delayed.

P-157 Cold Storage Warehouse. This project will provide 25,700 square feet of new refrigerated storage space for perishable goods. It will be located next to existing cold storage warehouses in X-Ray compound (see Figure 2.3.9).

Approximately 10 people will be assigned to this building. Current cold storage facilities lack sufficient capacity to accommodate the additional goods associated with the relocation.

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. No action would result in a deficiency of cold storage space for the increased volume of perishable goods. Alternative sites would require the installation of infrastructure to support cold storage and would increase transport and handling costs due to the separation from existing cold storage units. Other Naval Station facilities are at capacity and would require displacement of existing operations if converted to cold storage.

P-158 Supply Systems Support Building. A new building is proposed to provide 11,000 square feet of additional space for approximately 50 people engaged in general administrative services. The building will be located next to the existing administration building to take advantage of present functions (see Figure 2.3.7). Present facilities are insufficient to accommodate new space requirements, including space required for the relocated personnel from NSD Subic.

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. The no action alternative would result in a continued space deficiency to house the additional administrative positions transferred from Subic. The need to integrate this facility with existing NSD administrative operations in the adjacent building makes alternative sites on the Naval Station impractical. Use of other Naval Station facilities or existing temporary structures would displace existing activities or require costly renovations to upgrade substandard structures.

2.3.2.4 Ship Repair Facility

P-168 Ship Spares Storage Warehouse. A 26,300-square-foot warehouse will be constructed to store spare parts and materials used in the repair of ships (see Figure 2.3.10). It will consist of a single-story structure with masonry unit walls. The building will support the ship repair needs of the three Military Sealift Command ships scheduled for relocation from the Philippines to Guam. These ships will require "voyage repairs," "mid-term availabilities," and "regular overhauls" at the Ship Repair Facility (SRF). The short lead time scheduling of these repairs requires that materials be

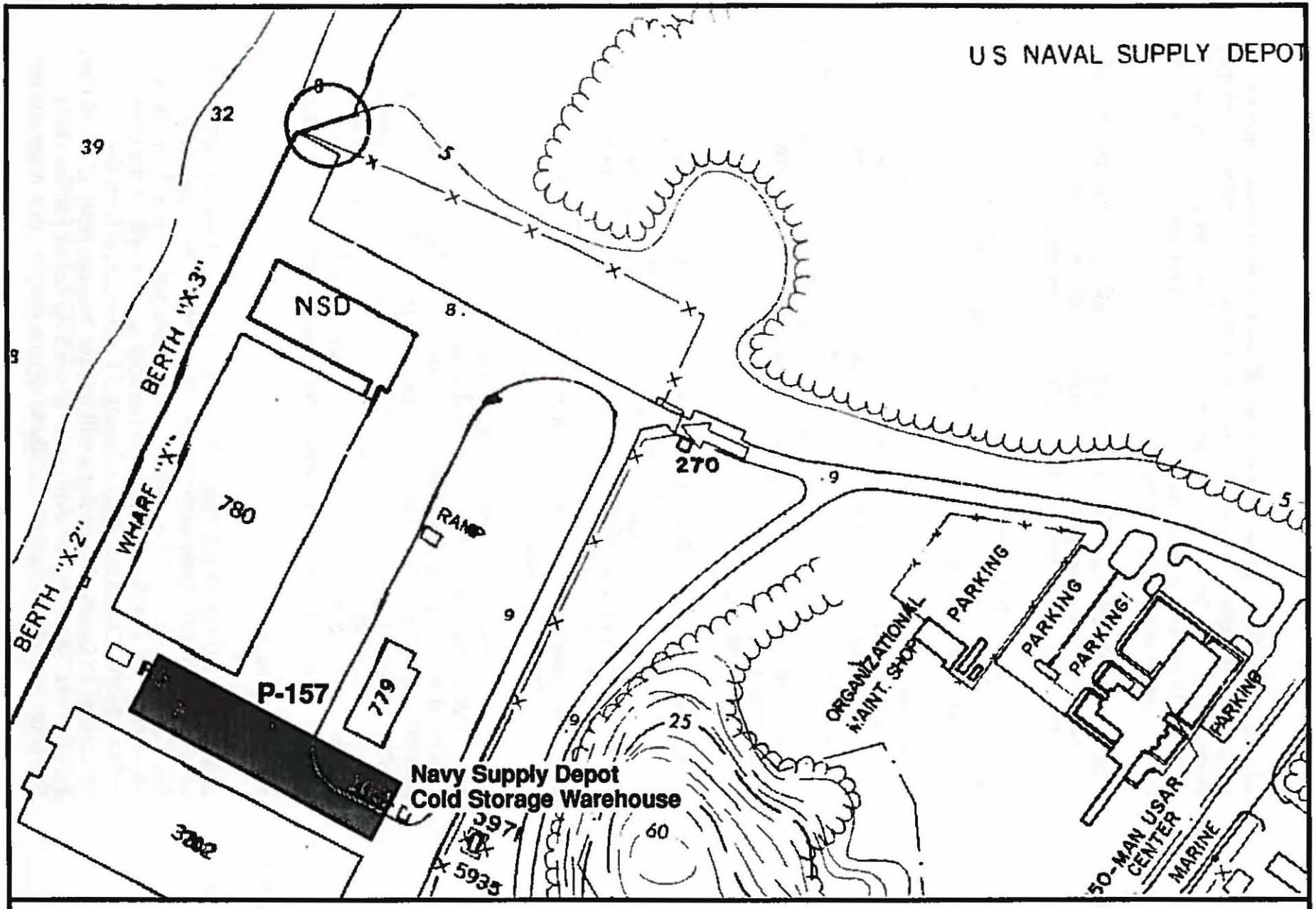


Figure 2.3.9
APRA HARBOR COMPLEX FACILITY: P-157
Guam Development EIS
April 1993

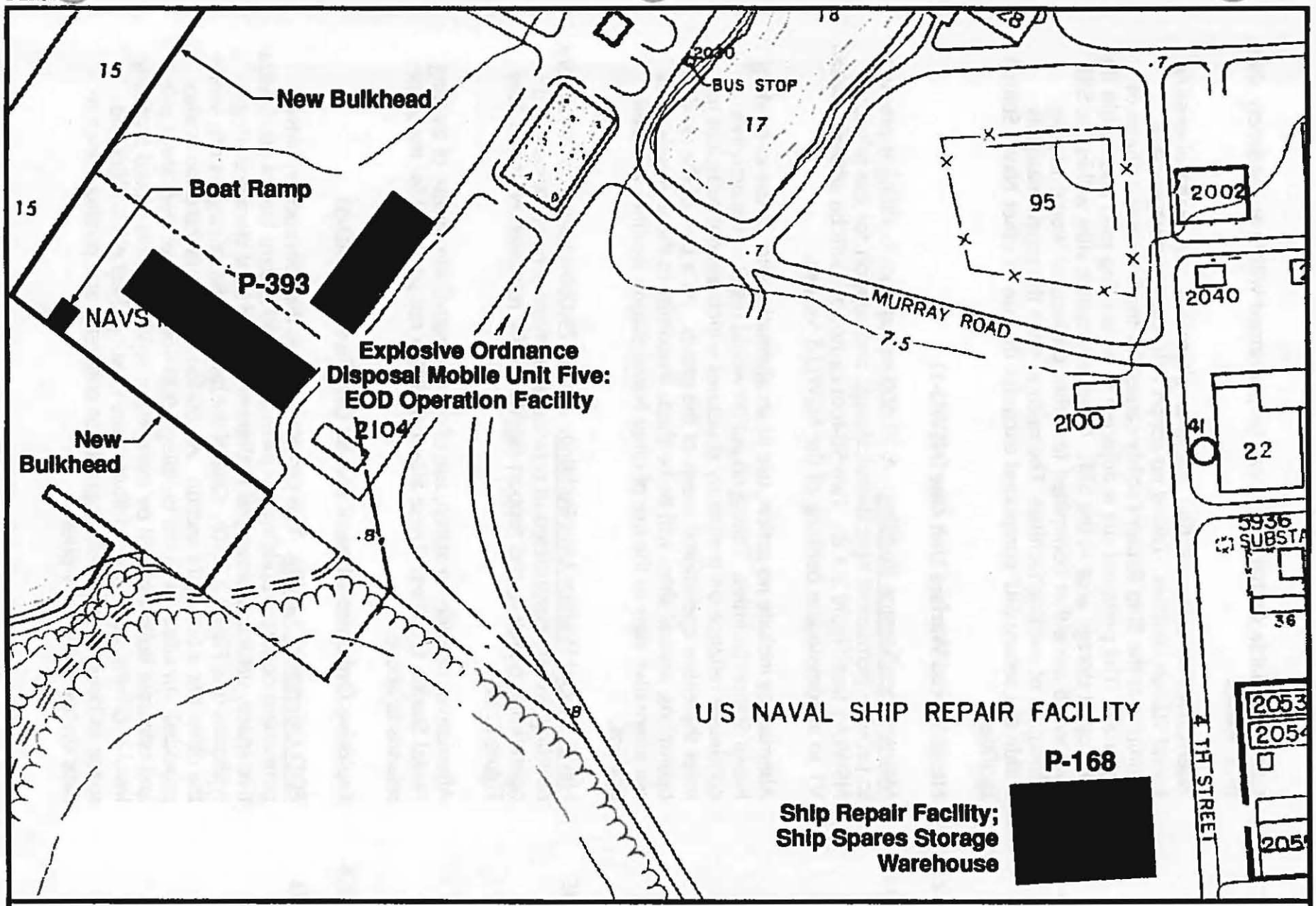


Figure 2.3.10
APRA HARBOR COMPLEX FACILITIES:
P-168, P-393
Guam Development EIS
April 1993

readily available so that repairs can be performed within an extremely short time frame.

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. Taking no action will result in storage space shortages at the Ship Repair Facility caused by the increased volume of materials. The preferred site is adjacent to an existing road and within the only open storage area in the SRF. Other alternative sites within the SRF compound are either committed for other projects or would require relocation of existing facilities. The need to store the repair materials within the secure SRF compound excludes the use of other Naval Station facilities.

2.3.2.5 Naval Special Warfare Unit One (NSWU-1)

P-394 Maintenance/Storage Building. A 29,500-square-foot building is proposed to provide permanent operational storage and support for the relocated NSWU-1 (see Figure 2.3.8). Two 90-foot causeways will be added to wharf V1 to accommodate berthing of the NSWU-1 vessels.

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. Taking no action would result in the activity's continued reliance on temporary structures which are not sufficient to meet the entire operational needs of the group. As a part of the unit's operations, several ships will be berthed. Proximity to these vessels rules out alternative sites or the use of other Naval Station facilities as viable options.

P-395 Naval Special Warfare Unit Building. A new 29,000-square-foot, two-story building will be constructed to provide a permanent headquarters and operational planning and support facility for the relocated NSWU-1 (see Figure 2.3.8).

Alternatives include no action, use of an alternative site, or use of existing Naval Station facilities. These alternatives are not preferred for the same reasons as above.

2.3.2.6 Explosive Ordnance Disposal Mobile Unit Five (EODMU-5)

P-393 EOD Operations Facility. This project includes the construction of two permanent concrete buildings to provide 40,780 square feet of administrative space, vehicle storage and maintenance, and boat storage during typhoons (see Figure 2.3.10). One of the buildings has a single story, while the other has a two-story section. An 80-foot-high parachute loft is also provided. In addition to the buildings, 900 linear feet of steel sheet pile and concrete bulkhead will be replaced or repaired. This would probably involve driving sheet piles in front of the existing sheet piles, filling the space in between with either gravel or concrete, and putting concrete caps on top of the new piles.

Alternatives include no action, use of an alternative site, use of existing Naval Station facilities, or use of facilities at other Navy bases. Taking no action would result in the continued use of temporary buildings which are not adequate for long-term storage. The unit's requirements for a secure compound area and proximity to the water make alternative sites, existing Naval Station facilities, and facilities at other Navy bases undesirable alternatives.

2.3.2.7 Public Works Center

P-234 Orote Power Plant Expansion. Three 6.6-megawatt (MW) diesel generators are proposed to replace the existing ten 700-KW generators within the Apra Harbor Complex. These three new generators, originally slated for installation at Subic, will be installed in a single-story, reinforced concrete building adjacent to the existing Orote Power Plant (see Figure 2.3.8). Two 90,000-gallon, above-ground fuel storage tanks will also be constructed. The existing Orote Power Plant consists of ten 700-kilowatt diesel engine generators. These units were installed over 40 years ago and have reached the end of their useful life. These generators have been shut down and are not intended to be operated again. The portable Mobile Utility Support Equipment (MUSE) generators will remain operational until the new 6.6 MW diesel generators are fully operational. The project will ensure an emergency military power supply and help meet the peak demands that are not met by the islandwide power system.

Alternatives include no action, use of an alternative site, or expansion of the Piti Power Plant. Taking no action could severely affect military operations during times of emergency power demand supply and help meet the peak demands that are not being met by the islandwide power system. The need to integrate operations with the existing Orote Power Plant effectively rules out the use of alternative sites on the Naval Station. As the Piti Power Plant's first responsibility is to supply the Island Wide Power Network, its expansion would not increase the military's emergency power generation capacity. In addition, the Piti Power Plant's location within an Environmental Protection Agency air quality non-attainment area prohibits any expansions which would increase air emissions from the plant.

P-235 Repair Shop Storage. A 10,000-square-foot, one-story concrete warehouse will be constructed for the storage of government vehicle maintenance and repair parts (see Figure 2.3.11). A secured, controlled, and centralized storage and issue facility is required.

Alternatives include no action, use of an alternative site, use of existing Naval Station facilities, or use of facilities at other Navy bases. Taking no action would result in storage deficiencies due to the increased volumes of material as a result of the relocation actions. The need to have a secured, controlled, and centralized facility integrated with existing Public Works Center vehicle maintenance areas makes alternative sites, existing Naval Station facilities, or facilities at other Navy bases impractical from a transport and handling standpoint.

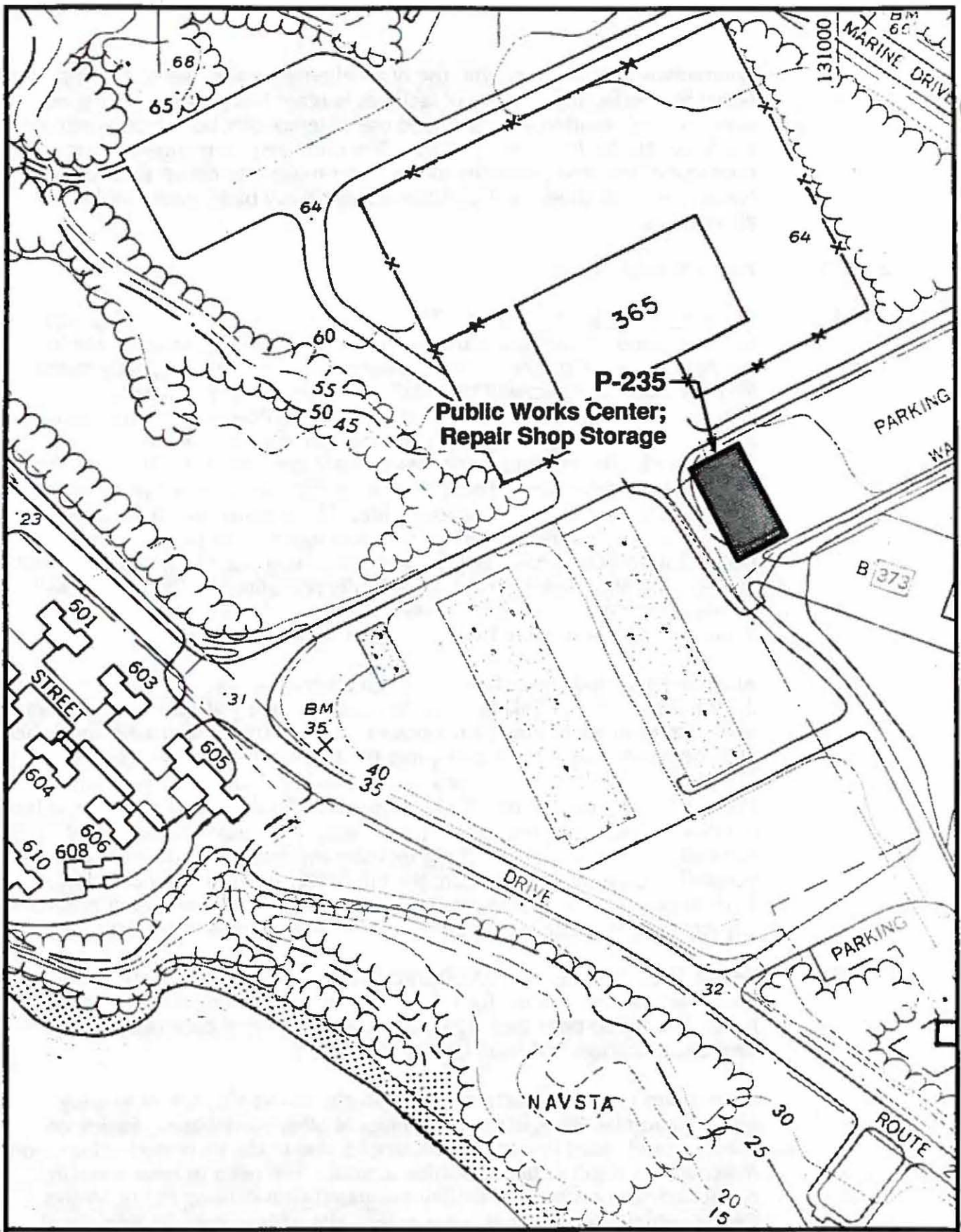


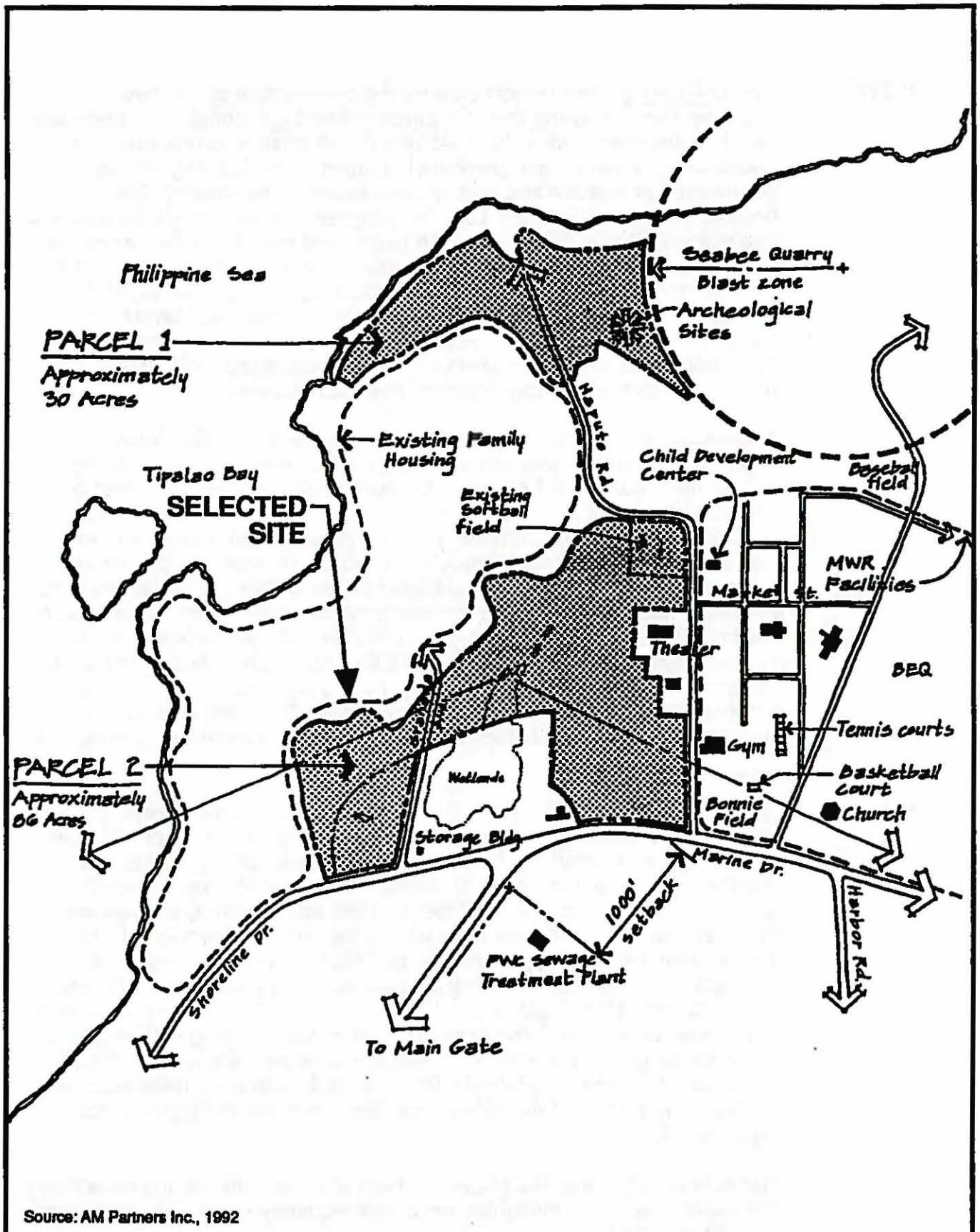
Figure 2.3.11
APRA HARBOR COMPLEX FACILITY:
P-235
Guam Development EIS
April 1993

P-236 Family Housing. This project calls for the construction of 300 two-bedroom family housing units for junior enlisted personnel. The two-story, concrete structures will help to address the shortfall resulting from the relocation of activities and personnel to Guam. The housing will be constructed as western and eastern expansions of the existing Tipalao housing area (see Figure 2.3.12). The proposed expansion will be split into two parcels. Parcel 1 is the western parcel and Parcel 2 is the eastern one. The proposed layout for Parcel 1 occupies land south of Haputo Road to increase the buffer difference between the ESQD arc and to avoid the archeological sites (see Figure 2.3.13). There is a proposed layout for Parcel 2 (see Figure 2.3.14). Site investigation to delineate wetlands and to identify other unsuitable areas have been completed. All wetlands will be avoided in the final development plan (see Appendix J).

Alternatives include no action, use of alternative sites, public/private construction venture, and purchase/lease agreements with local owners. Taking no action would continue the current deficient military housing situation and result in more military families competing in the private housing market. Purchase/lease agreements with local owners would also result in military personnel removing housing units from the private sector, creating additional shortages and higher prices within the civilian market. Public/private construction ventures are not considered reasonable given the immediate need for housing. Alternative sites were considered at Polaris Point, New Apra Heights, and Old Orote Village but were found undesirable due to excessive engineering requirements, costs, the existence of sensitive habitats, or other constraints. The siting analysis and study discusses these alternative sites in detail and is included as Appendix I.

P-237 Waterfront Utilities. This project consists of upgrading the existing sewage pumping and collection systems, installing and upgrading electrical power substations, and installing shore power outlet assemblies and electrical distribution lines at Lima through Sierra, and Bravo wharves. A steam generation system, consisting of fuel oil fired steam boilers, support equipment, and steam distribution lines will be installed at Bravo wharf. An above-ground steel storage tank will be installed within a bermed area adjacent to the structure housing the boilers. Two sewage holding tanks (140,000 and 160,000 gallons) will be installed at Alpha and Bravo wharves to provide surge control and aeration. Differential relaying will be provided at the Orote power substation. These upgrades are necessary to ensure the reliability of shore utilities to the increased number of ships expected on Guam as a result of the military roll-back from the Philippines. See Figure 2.3.15.

The only alternative to the project consists of no action. Taking no action is not viable given the immediate need to adequately service the additional ships coming to Guam.



Source: AM Partners Inc., 1992

North

0 400 800 1600

Scale in Feet

Figure 2.3.12
NAVAL STATION
PROPOSED FAMILY HOUSING SITES
Guam Development EIS
April 1993

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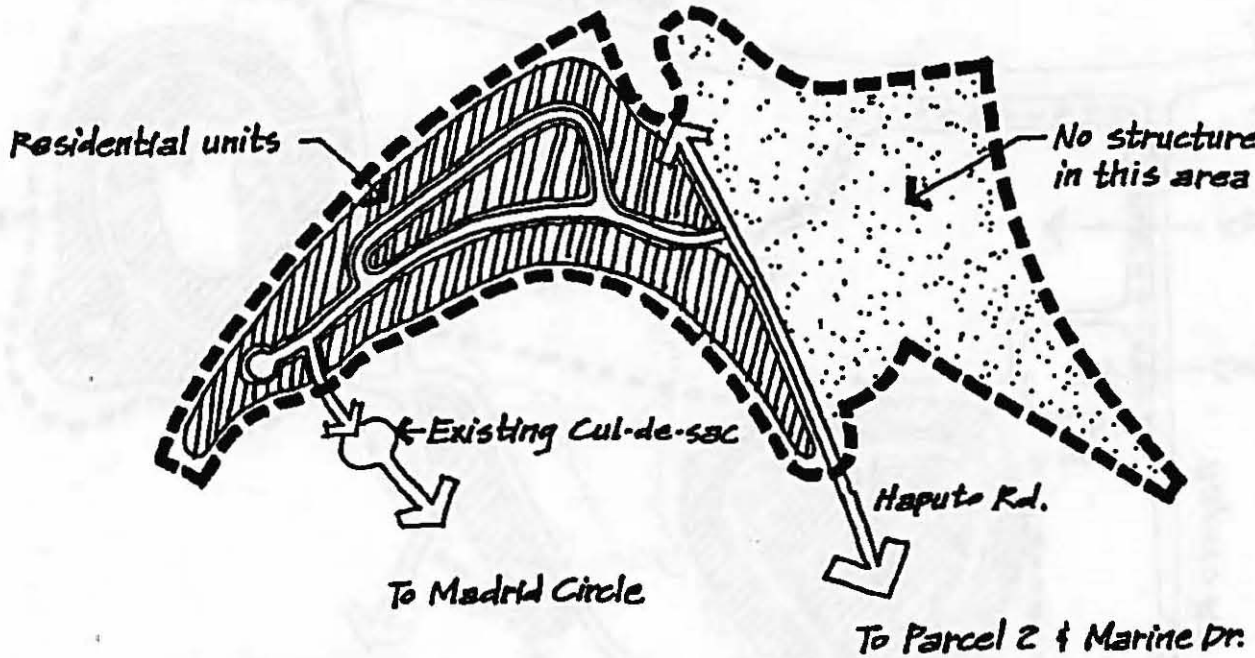

Source: AM Partners Inc., 1992

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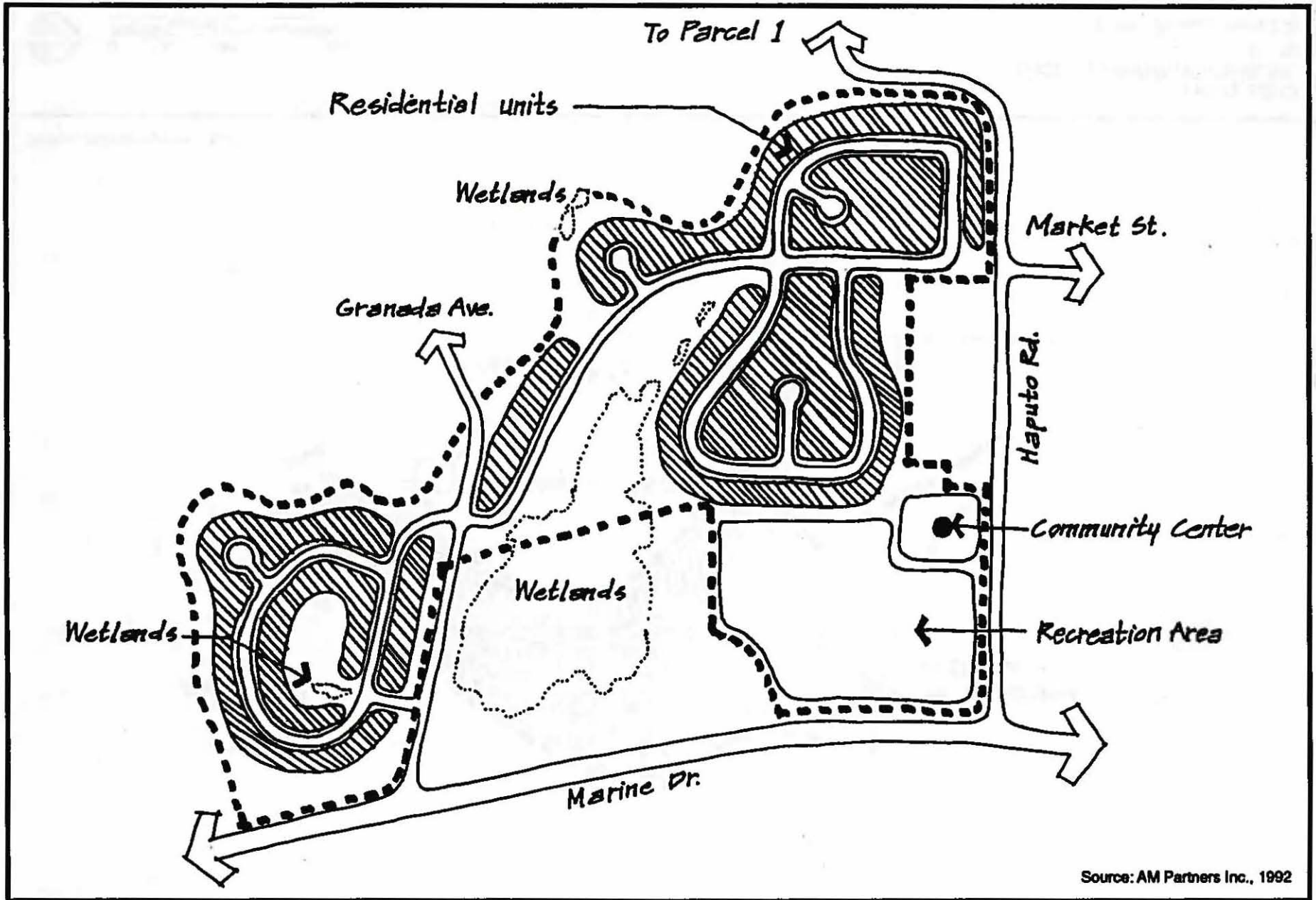
Scale in Feet

Figure 2.3.13
PARCEL 1 HOUSING SITE PLAN: P-236
Guam Development EIS
April 1993



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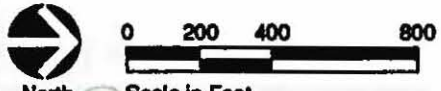


Figure 2.3.14
PRELIMINARY LAYOUT—PARCEL 2 HOUSING SITE PLAN: P-236
Guam Development EIS
April 1993

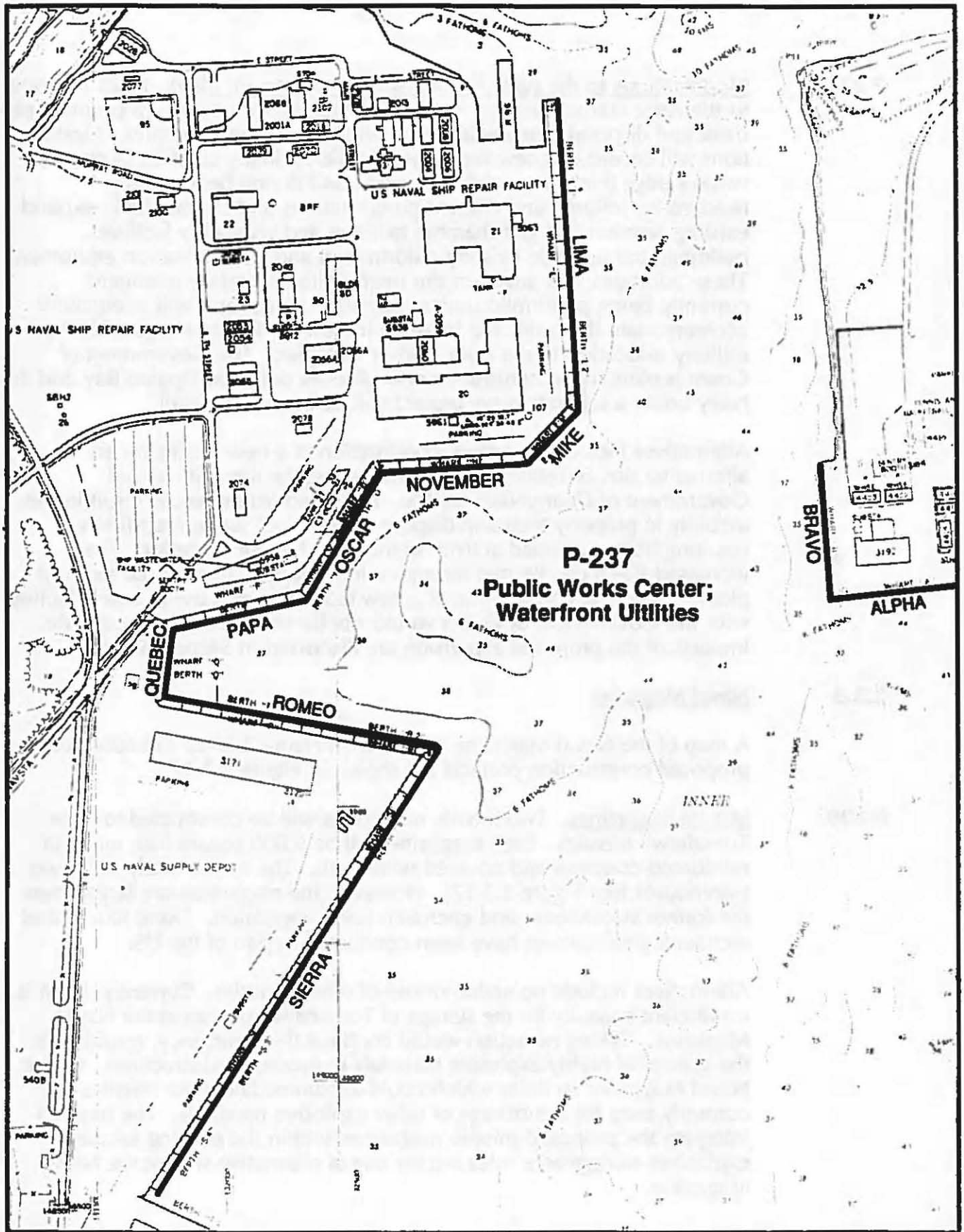


Figure 2.3.15
APRA HARBOR COMPLEX FACILITY:
P-237
Guam Development EIS
April 1993

P-239 Modifications to the Apra Harbor Sewage Treatment Plant. Modifications to the Apra Harbor Sewage Treatment Plant (STP) will ensure proper treatment and disposal of the wastewater within the Naval Complex. Modifications will consist of a new secondary clarifier, primary clarifier, biotower, waste sludge thickener, solids contactor, and drying beds; modify headworks, influent and effluent pump stations and contact tank; expand existing aeration and grit chamber facilities and secondary facilities building; and upgrade existing chlorination and dechlorination equipment. These additions will augment the upgrade to secondary treatment currently being performed under separate contract and will adequately accommodate the projected increase in flow of about .4 mgd with the military relocation to the Apra Harbor Complex. The Government of Guam is planning to construct a new offshore outfall at Tipalao Bay and the Navy under a separate Navy project will tie in to that outfall.

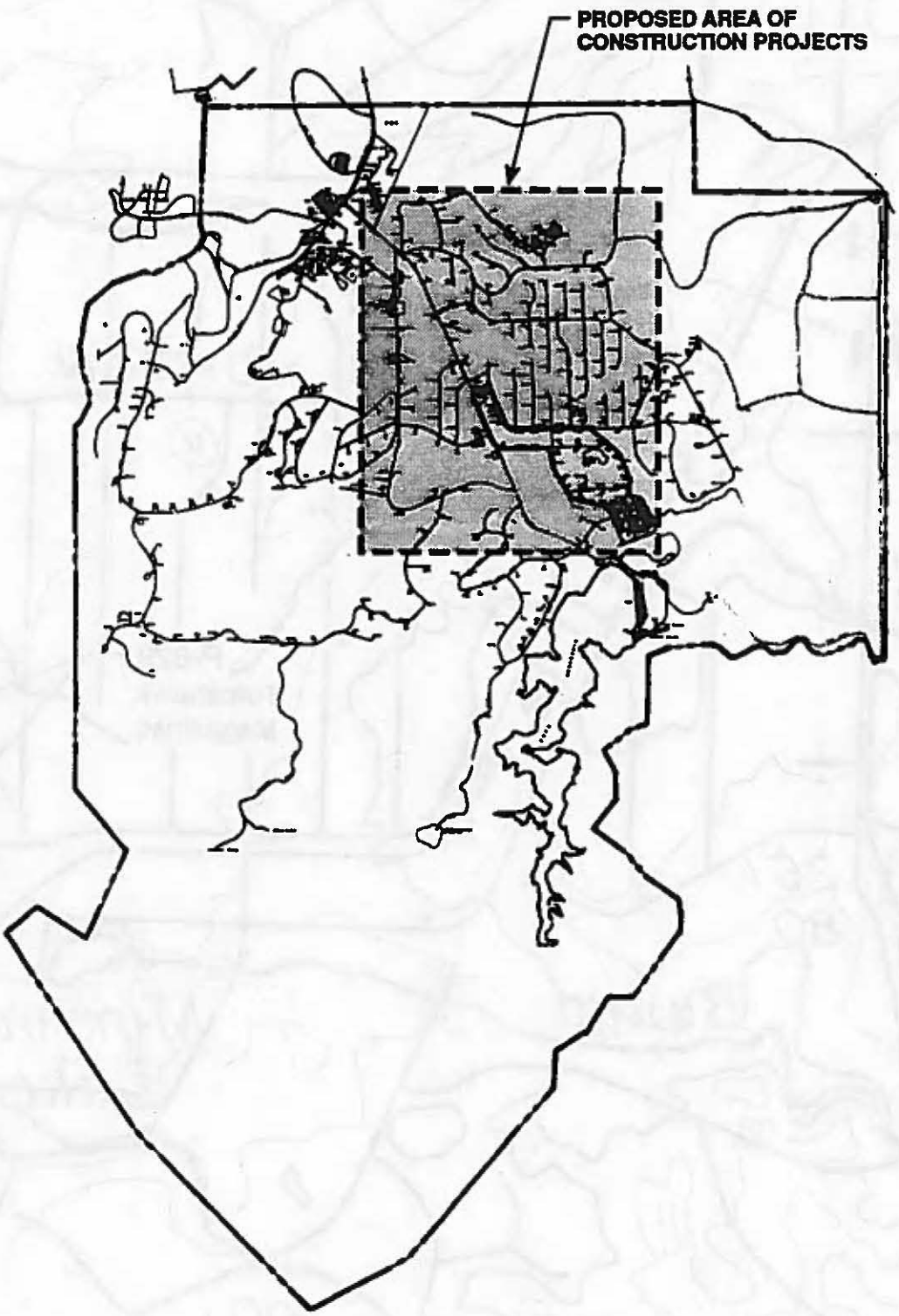
Alternatives include no action, construction of a new facility on an alternative site, or replacement of the existing facility with a joint Government of Guam/Navy facility. Taking no action would result in the inability to properly treat and dispose of increased wastewater flows resulting from expanded activity in the Apra Harbor Complex. The increased flows can be met through minor modifications to the existing plant. Therefore, construction of a new facility or joint use of a new facility with the Government of Guam would not be economically reasonable. Impacts of the proposed expansion are discussed in Section 4.6.2.1.

2.3.3 Naval Magazine

A map of the Naval Magazine is shown on Figure 2.3.16. Locations of the proposed construction projects are shown in Figure 2.3.17.

P-829 Missile Magazines. Two missile magazines will be constructed to store Tomahawk missiles. Each magazine will be 9,000 square feet, made of reinforced concrete and covered with earth. The site formerly held two storehouses (see Figure 2.3.17). However, the magazines are larger than the former storehouses and encroach upon vegetation. Flora, fauna, and archaeological surveys have been conducted as part of the EIS.

Alternatives include no action or use of other facilities. Currently, there is insufficient capacity for the storage of Tomahawk missiles at the Naval Magazine. Taking no action would continue this deficiency, resulting in the storage of highly explosive materials in substandard structures. Other Naval Magazine facilities which could accommodate these missiles are currently used for the storage of other explosive materials. The need to integrate the proposed missile magazines within the existing secured explosives storage area rules out the use of alternative sites at the Naval Magazine.



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Scale in Feet

Figure 2.3.16
GUAM NAVAL MAGAZINE
Guam Development EIS
April 1993

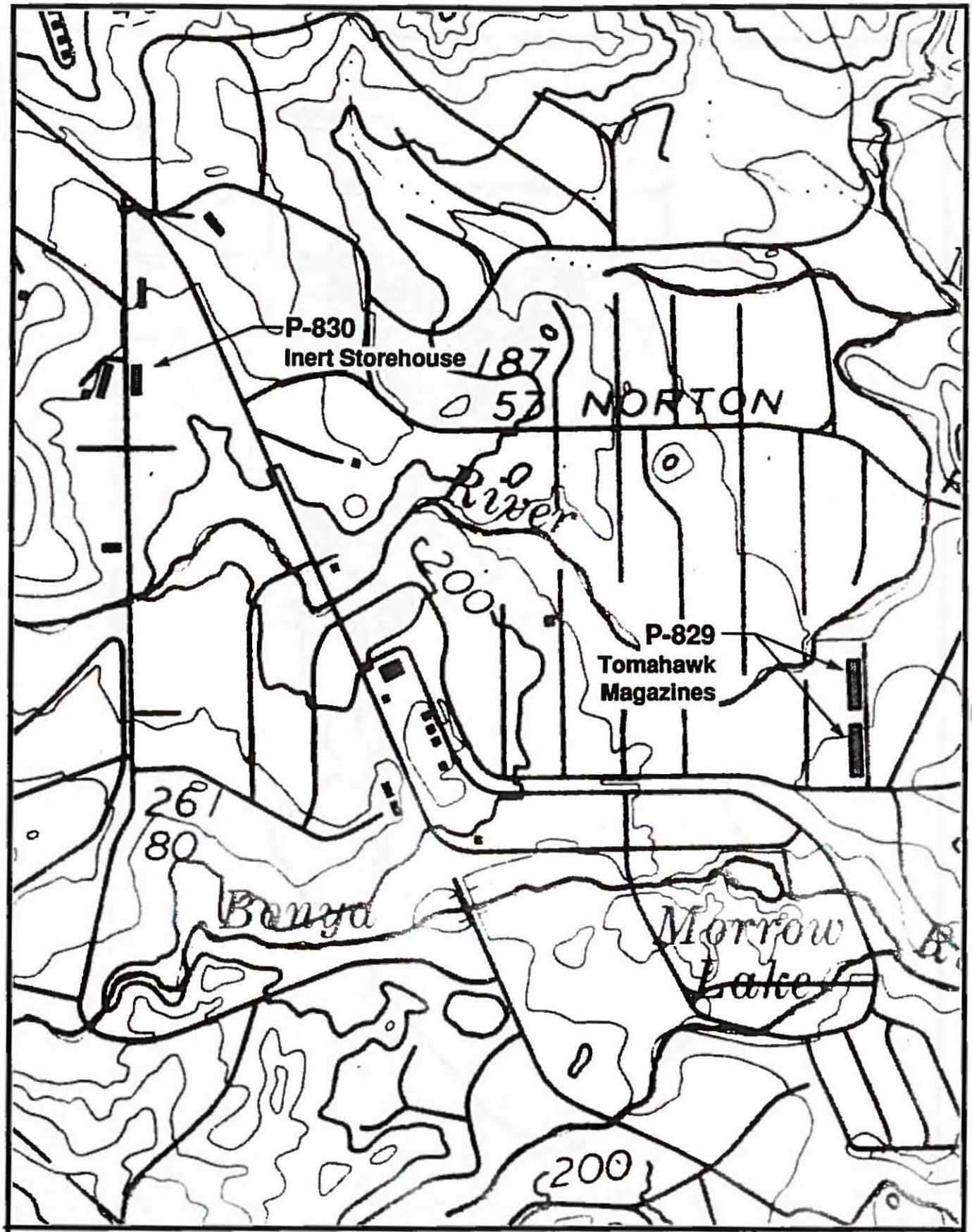

Figure 2.3.17
GUAM NAVAL MAGAZINE PROJECTS
Guam Development EIS
April 1993

242/0101/18

P-830 Inert Storehouse. This project provides for 17,000 square feet of warehouse space for the storage of inert, non-explosive items, such as bomb fins, pallets, containers, etc. As a part of the proposed actions, NAVMAG will receive an additional 4,000 pallets of inert materials. This project addresses this deficiency created by the proposed actions in this document. The site is a concrete apron on the edge of a small gully (see Figure 2.3.17). The storehouses will exceed the width of the apron, which will require fill to extend the edge of the embankment to provide sufficient at-grade support.

Alternatives include no action, use of an alternative site, use of existing Naval Magazine facilities, or use of facilities at other Navy bases. Taking no action would not address the current or projected deficiency in the storage of inert materials and is not considered a viable option. No other Naval Magazine facilities are available for storage of extra materials as a result of the proposed Naval relocation. Use of facilities at other Navy bases is also not a viable alternative due to the excessive transport and handling costs involved. The need to consolidate existing and planned inert storage facilities within a single area in close proximity to the ordnance department eliminates the use of other facilities at the Naval Magazine. Alternative sites identified were either too far from the existing ordnance department, within the explosives arcs, or environmentally constrained by slope, soil, or hydrology.

2.3.4 Nimitz Hill

2.3.4.1 U.S. Naval Oceanography Command Center/Joint Typhoon Warning Center

P-001 Renovation of Oceanography Building. This project includes complete renovation of 11,800 square feet of existing space in the Building 200 annex, including modernization of electrical, mechanical, and HVAC systems (see Figure 2.3.18). The existing arrangement and configuration of the building is obsolete and inadequate to support the increased operational fleet meteorological and oceanographic requirements. NAVOCEANCOMCEN/JTWC will receive an additional ten positions, two new civilian hires, computer equipment and systems.

Alternatives include no action, use of alternate sites, or construction of a new building. Taking no action is not viable because the existing facilities are inadequate to fully support the increased operational requirements relocated to NAVOCEANCOMCEN/JTWC. No other facilities of this type are available that could share this activity. The center is the sole activity responsible for issuing timely and accurate warnings on typhoons, tropical storms, depressions, and high winds and seas throughout the Western Pacific and Indian Oceans. The increased operations can be met by alteration to the existing building. Therefore, construction of a new facility is not economically reasonable.

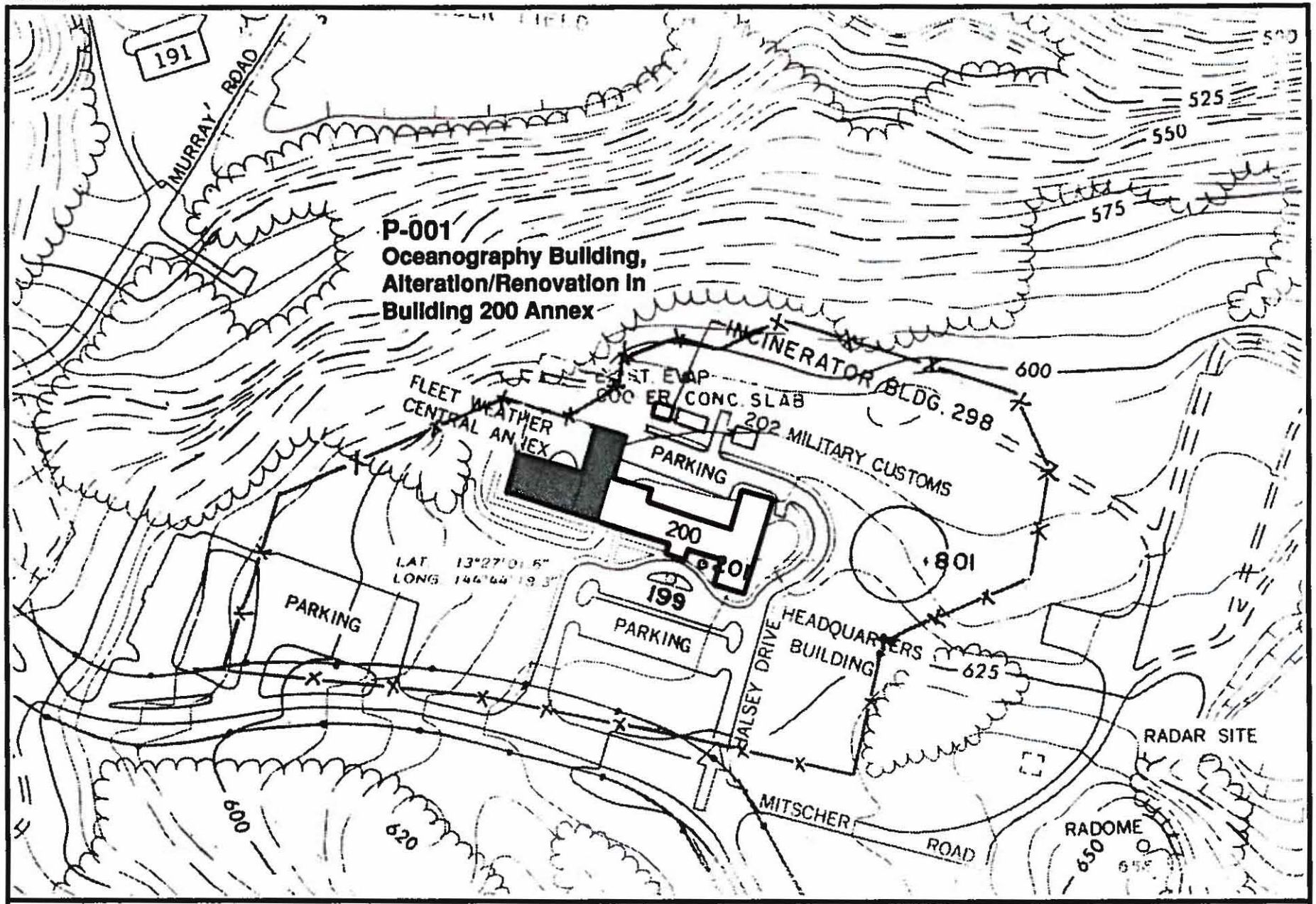

Figure 2.3.18
NIMITZ HILL FACILITY:
P-001
Guam Development EIS
April 1993

Chapter 3

Islandwide Environmental Setting

CHAPTER 3

ISLANDWIDE ENVIRONMENTAL SETTING

3.1 PHYSICAL ENVIRONMENT

3.1.1 Overview

Guam is the southernmost and largest of the Mariana Islands, a group of 15 islands located approximately 3,600 miles west of Hawaii and 1,400 miles south of Japan (refer to Figure 1.1.1). The island measures approximately 32 miles in length, 4 to 8 miles in width, and has a total area of about 212 square miles (Navy, 1991a; Guam Department of Parks and Recreation, 1976).

The formation of Guam occurred when two oceanic volcanos fused together into the present land mass. The northern volcano had already been capped by a thick layer of coralliferous limestone by the time the southern volcano joined it.

The whole island is surrounded by a coral table reef with deep water channels. The coastline areas are characterized by sandy beaches, rocky cliff lines, and mangroves (Navy, 1985).

3.1.1.1 Topography

Guam's topography features three distinct landforms which characterize the southern, central, and northern regions. The southern portion is highly mountainous and largely volcanic in nature. A mountain range located on the western side of this area reaches approximately 1,336 feet at the peak of its highest point, Mount Lamlam. Saltwater marshes, swamps, and rugged terrain also cover this region.

The central portion of the island acts as a transitional area between the northern and southern regions. This narrow low-lying area features rolling hills and gently sloping plateaus. It is on average 4 miles wide and about 66 feet above sea level.

The northern portion of Guam provides a contrast to the rest of the island as it features an expansive coralline-limestone plateau, presumably originating from the older oceanic volcano responsible for Guam's origin. The elevation of the plateau ranges from 300 to 600 feet, with Mount Santa Rosa, rising 850 feet above sea level, as the only break in the steady expanse. The plateau continues all the way to the sea where its steep cliffs meet the ocean (Guam Department of Parks and Recreation, 1976).

3.1.1.2 Soils

Soil associations on Guam generally follow the differences in topography between each region. Southern Guam features a reddish, brownish, and yellowish acidic clay soil that lies on hilly to mountainous volcanic material.

Central Guam has moderately deep deposits of yellowish-brown and red plastic clay covering its predominantly hilly terrain.

The limestone plateau of the northern region is covered by a generally thin soil mantle that is slightly alkaline, yet rich in hydrated oxides of iron and aluminum. The red, soft soil is friable and porous throughout. Thicknesses of soil range from a few inches on ridge tops to a few feet in small depressions (U.S. Soil Conservation Service, 1988).

3.1.1.3 Climate

The climate on Guam is generally warm and humid all year long. The average temperatures for the island range between 85 to 89 degrees F in the afternoon and 70 to 75 degrees F in the evening. Relative humidity varies from 65 to 75 percent in the afternoon and 85 to 100 percent in the evening.

Although temperature and humidity remain fairly constant throughout the year, rainfall and wind conditions vary markedly from season to season. Guam has two primary and two secondary seasons. The primary seasons are the dry season, lasting from January through April, and the wet season which lasts from July to December. Heavy winds, rains, and occasionally typhoons characterize the wet season. The dry season features very little precipitation and more consistent trade winds blowing east to northeast at 15 to 25 miles an hour. The secondary seasons separate the dry and wet seasons and are transitional in nature (Navy, 1991a, 1985).

3.1.1.4 Hydrology/Drainage

Drainage capabilities vary considerably between southern Guam and northern Guam. In the southern region, the dense clay-based soils and volcanic material make drainage fairly difficult. Most of the area is highly susceptible to runoff overflows, as can be evidenced by the more than forty streams which cover it. By contrast, the northern region has no streams. The porous limestone rock formations and thin soils of this region can easily absorb any surface runoff produced by heavy rains (U.S. Army Corps of Engineers, 1980).

Guam's water supply comes from three main sources: the Northern Lens Aquifer, the Fena Watershed and reservoir, and the Ugum River. The Northern Lens aquifers consist of thick porous limestone comprised from the Barrigada and Mariana Limestone formations. These formations are interlaced with pores and channels that readily transmit surface water into the aquifers and eventually into the ocean. The Fena Watershed is located in the southern portion of the island and is formed by damming surface waters from a 6-square-mile watershed. The Ugum River has water diverted into treatment plants and then piped to consumers throughout the southern regions (Navy, 1991a, 1985).

3.1.2 Terrestrial Biota

The past few decades have seen a considerable decline in the number of fauna species throughout Guam. Efforts to protect the remaining species include reintroduction programs, habitat safeguarding, and the proposed designation of various areas as critical habitat. Critical habitats are defined in the Endangered Species Act and attempt to

promote preservation of the species by protecting areas surrounding their respective nesting and roosting sites. As an alternative, the Navy has proposed delineating a wildlife refuge overlay. This option provides similar protection by the U.S. Fish and Wildlife Service but also allows for more flexibility of activities within the delineated areas.

3.1.2.1 Vegetative Associations

Guam features a wide variety of plants and vegetated areas. The whole island was, at one time, covered by wide expanses of native vegetation, but due to the spread of urban and agricultural development, very few large stretches of uniform vegetation remain. Most of the vegetated areas are interspersed to form a sort of mosaic of small patches with widely varying appearances.

The southern part of the island is characterized predominantly by scrub forests and large areas of coarse grass. The existing forests are mostly second-growth and typically have a dense, tangled undergrowth. Coconut groves can be found in the scrubby grass areas along the coast, along with a variety of swamps and marsh lands.

Limestone forest areas dominate the northern region of Guam. Due to natural forces and, in particular, encroachment by man, undisturbed areas of these forests are now scarce. Weed patches, partially revegetated clearings, dead trees, and thickets of fast-growing, soft-wooded trees have replaced many areas which were once primarily covered by large, old growth trees. The western end of the region features one of the few remaining areas of undisturbed limestone forest (Navy, 1985).

3.1.2.2 Wildlife

Unlike the vegetation of Guam, wildlife populations are somewhat limited throughout the island. Native species have declined dramatically over the past 20 to 30 years due to predation by the introduced brown tree snake. The loss of habitat areas through urban and agricultural development have contributed to this decline.

The scrub forests and grasslands of the southern portion of Guam feature a variety of transient bird species. Many migrant and a few native species of birds are found in the wetland and savannah areas, although no species is particularly abundant in the region. Several of the forested areas in the west-central portion have been proposed as critical habitats for reintroduction of Guam's native bird and bat species. Mammals such as feral dogs, cats, deer, pigs, and other small rodents, as well as reptiles including the brown tree snake, skinks, geckos, and lizards, are also found in this region.

Guam's endangered bird and bat species inhabit the limestone forests in the northern portion of Guam. Because of the presence of these endangered species, most of the limestone forests, as well as several surrounding areas, have been proposed as potential critical habitat areas. Mammal and reptile populations similar to those seen in the southern portion are also found in the mature and second-growth forest areas (Whistler, 1992; Navy, 1985).

3.1.3 Water Quality

Water quality is monitored by the Guam Environmental Protection Agency (GEPA) in compliance with existing federal and local legislation. Guam's groundwater and ocean water resources have the rare advantage of being free from the pollution discharges of other neighboring land masses. The result is an islandwide water quality that remains at a consistently high level.

Groundwater generated by the Northern Lens goes through a natural filtration process in basal and parabasal aquifers. In the basal aquifers, fresh water floats on top of saline ocean water present in the limestone. In the parabasal aquifers, fresh water overlies the volcanic formation. The result is groundwater of a typically high quality, generally free from both organic and inorganic contaminants (Navy, 1990c).

Surface water quality is more difficult to maintain as it is more susceptible to detrimental factors such as bacteriological contamination. Sewage disposal overflows and animal wastes are carried into streams during periods of heavy rain and subsequently cause fecal coliform levels to exceed safety levels. Marine and reef flat stations, with the exception of those close to river mouths or sewage treatment outfalls, are relatively free from this type of contamination (GEPA, 1990).

3.1.4 Air Quality

Guam is generally free from any serious air pollution. Despite the high concentration of human activity in the Agana-Tamuning metropolitan area, favorable meteorological conditions, in particular the nearly constant tradewinds, have prevented the build-up of any significant amount of pollutants (Navy, 1985). Exceptions to these generally clean environs are residual non-attainment areas associated with power plant operations in the vicinities of Cabras Island, Tanguisson, and Apra Harbor.

Other activities which may impact air quality on Guam take place at the two airport facilities: Naval Air Station Agana/Guam International Air Terminal (GIAT) and Andersen Air Force Base (AFB). Despite a considerable number of flights at both facilities, the favorable meteorological conditions once again keep the build up of aircraft related pollutants at a minimum.

3.1.5 Noise

The Agana-Tamuning metropolitan area, located in the central portion of the island, has noise and congestion problems similar to those of any highly urbanized area. Most business and government offices are located in this area and rush-hour traffic jams have become common [Guam Department Public Works (DPW), 1991c].

Other major sources of noise are aircraft flying into/out of Andersen AFB and NAS Agana/GIAT. Noise levels are also generated at these sites by aircraft engine run-ups, a procedure used for maintenance by which aircraft sit in a designated part of the air field with their engines running.

The Day Night Average Sound Level (Ldn) Contours for NAS Agana extend well beyond the actual air base into the neighboring area of Dededo and out over the ocean through Agana. Noise level contours at Andersen AFB extend over unpopulated or very low density rural areas of the northern portion of the island (Navy, 1992e, 1988a).

3.1.6 Visual Setting/Aesthetics

Guam's visual setting is defined by the ocean, the island's topographical features, and the built environment. The low-lying hills in the south and the upland plateaus of the north provide a number of vantage points of the surrounding ocean. Several large expanses of undeveloped land exist in the northern and southern regions, while the central portion provides a contrast with its urbanized center and dense housing areas. Steep cliffs line the northern end of the island, while mountain ranges and hills serve as a backdrop to the western and central areas.

3.1.7 Natural Hazards

The main natural hazards Guam faces are earthquakes and typhoons. Guam is located in an active seismic zone and has recorded, in this century alone, over 84 earthquakes with Richter scale magnitudes of 6.0 or more. Because of the frequency and strength of the earthquakes, Guam is designated in seismic probability zone 3 (zone 0 means no damage; zone 4 means major damage).

Guam also lies in a typhoon belt and is frequently subjected to the heavy rains and winds that accompany these storms. An average of 1.4 typhoons per year pass within 120 nautical miles of Guam, and there is a 20 percent chance that a typhoon will pass directly over the island in any given year. The probability of a typhoon is greatest between the months of July and December (the wet season), with high winds in excess of 150 miles per hour and extending out more than 100 miles from the center of the storm. Typhoons occurring between January and April are less probable and much weaker in the event they do occur (Navy, 1991a, 1985).

3.2 HISTORY

Guam's society is characterized by the many different cultures which have influenced the island throughout its history. The first known settlers, the Chamorros, were Malayo-Polynesians presumably originating from Southeast Asia. It is believed they had emigrated across the Pacific Ocean to Guam by 1000 B.C.

The Chamorros' had their first contact with European explorers in 1521. A little over 40 years later, the Spanish claimed title to the island and made it a colonial possession. Spanish missionaries eventually arrived in Guam in 1668 for the purpose of converting the Chamorros to Christianity and providing education. The island remained a Spanish possession for over two centuries while it served as a valuable port for the golden galleons and other Spanish merchantmen.

Upon the conclusion of the Spanish-American War in 1898, Guam was ceded to the United States as a war concession from Spain. Under the administration of the U.S. Navy, the island became a coaling station and later a naval base for the Western Pacific.

The Japanese occupied Guam in 1941, shortly after the beginning of World War II, and controlled the island until 1944 when they were ousted by the U.S.

Guam remained under the jurisdiction of the U.S. Navy until 1950. At that time, President Harry Truman signed the Organic Act of Guam which ended military control and made Guam a U.S. Territory. The administration of the island then became the responsibility of a newly appointed civil governor and an elected unicameral legislature (Navy, 1985).

In 1962, the requirement of security clearances to enter Guam was dropped, thus allowing for the expansion of business and tourism, concurrent with the growth of the Japanese economy, that has continued to the present day. In 1970, the first governor and lieutenant governor in the history of Guam were elected by the people. And in 1973, Guam sent its first non-voting representative to the United States Congress (Guam Department of Parks and Recreation, 1976).

3.2.1 Historic Features

Guam's diverse past has given the island a rich cultural heritage. Many significant historic and prehistoric sites remain from the different cultures which occupied the island throughout its history. The strong Spanish influence resulting from Guam's long-time status as a possession of that nation has survived through the centuries. In addition, numerous structures and relics attest to Guam's major role in World War II. These sites help paint a clearer picture of what life was like on Guam decades and even centuries ago.

3.3 SOCIOECONOMIC SETTING

Since the end of World War II, Guam has experienced steady and considerable growth of its tourist industry and business community. It has become a hub of Western Pacific transportation and communication in addition to serving as one of the main U.S. military installations in the Western Pacific.

3.3.1 Government

Guam is a territory of the United States of America, and its people are United States citizens. The government of Guam consists of a unicameral legislature, a judicial branch, and an executive branch. In addition, there are 19 municipal mayors and councils. The island also has a representative in Congress.

3.3.2 Population

Guam's population totalled 133,152 people in 1990, a 20.4 percent increase from 1980. The ethnic composition of the island is 43 percent Chamorro or part-Chamorro, 23 percent Filipino, 14 percent Caucasian, 5 percent other Pacific Islanders, and 15 percent other ethnic groups. Approximately half of all Guam residents were born on Guam, and 70 percent of them were under the age of 34 in 1990 [Community Resources, Inc. (CRI), 1992].

3.3.3 Economy

The major components of Guam's economy are the government, the military, tourism, and construction. Government and military employment account for approximately one out of every three jobs, while tourism is the fastest growing industry. Unemployment on the island is relatively low at about 3.2 percent. In several industries, most notably construction, there exists a severe labor shortage which calls for the importation of foreign workers to fill the positions (CRI, 1992).

3.3.4 Housing

Housing on Guam is very difficult to obtain as the market suffers from very high demand and a relatively low supply, especially a shortage of affordable rental units. The scarcity of developable land and lack of housing construction, in addition to the destruction caused by typhoons, represent the main reasons for the housing shortage. The result of these constraints coupled with the steadily growing demand is very expensive housing. Prior to Typhoon Omar, the average purchasing price for a house was approximately $130,000, while the median gross rents for apartments was about $550 (CRI, 1992).

3.3.5 Land Use

Long-range physical and economic planning is carried out by the Government of Guam Bureau of Planning, as well as by a number of departments throughout the government. These other functional planning offices are integral parts of the day-to-day operations of the Territorial government and include the Departments of Public Works, Land Management, Parks and Recreation, Agriculture, Commerce, Public Health and Social Services, the Guam Environmental Protection Agency (GEPA), and the Guam Economic Development Authority (see Section 1.6 for a complete list of the participating Government of Guam agencies). Zoning approvals are the responsibility of the Department of Land Management in conjunction with the Building Permit Section of the Department of Public Works (Navy, 1985).

Guam is currently implementing its land use regulations under the 1966 zoning plan. This version provides the Territorial Land Use Commission (TLUC) with little guidance in making land use decisions concerning zoning changes and the approval or disapproval of development. According to the Territorial Planning Council (TPC), the result has been widescale growth on Guam. While the physical and socioeconomic development has been very beneficial to most residents of Guam, many people feel it is in their best interests to formulate a plan which sustains economic development in a way that also preserves the cultural, environmental, social, and natural resources unique to the island.

In order to provide some foresight and direction for the future, TPC has been given the responsibility of devising the Guam Land Use Plan. It is intended as part of the Comprehensive Master Plan for Guam which will outline the roles of various public agencies in monitoring the future growth of the island. The Plan will carefully consider citizen viewpoints through village meetings. The purpose of the plan is to combine public and private interests in short-term and long-range land use plans incorporating multi-use zoning, performance standards, a capital improvement program, and a concurrency management system. The Plan will hopefully manage the future growth of

the island in a more efficient and harmonious manner so as to preserve and enhance the quality of living on Guam (Guam Territorial Planning Council, 1992).

3.3.5.1 Coastal Areas

Due to its small size, the official boundaries of Guam's coastal lands differ from other states and territories. Under the Government of Guam's Coastal Management Plan, the entire island as well as the surrounding ocean out to three nautical miles fall within this jurisdiction. By law, federally owned lands are excluded (Navy, 1985).

Shore area development in the designated coastal zone can only occur if the project is so dependent on the specific location that no other feasible alternatives exist. The development must not detract from the environmental or aesthetic quality or beach accessibility of the site.

3.3.5.2 Urban Areas

Urban intensity development is permitted in those areas with adequate infrastructure and lacking natural constraints. The main urban areas are located in the central part of Guam, including the Agana and Tamuning areas and extending into the neighboring municipality of Dededo to the north. Other urban areas are along major highways and in village centers.

The Territorial Planning Council's 25-year Land Use Plan calls for greater intensities at village centers, at regional hubs such as Agat, and in areas with adequate infrastructure.

3.3.5.3 Rural Areas

Rural intensity development includes agricultural use and single-family residences on larger size lots, with minimal commercial and service developments. This predominantly occurs in northern and southern private lands and in areas lacking sewer facilities. The 25-year Land Use Plan will require similar low intensity land uses over the aquifer recharge areas and in steeper sloped lands. These areas are predominantly in the central-northern part of the island and throughout the south.

3.4 MILITARY FACILITIES/OPERATIONS

Due to its location in the Western Pacific Ocean, Guam offers a prime strategic location for military installations. Its use as a major base for wartime operations dates back to World War II when it served as a launching point for bombing runs on Japan. During the Korean War and the Vietnam War, additional forces were sent to Guam to perform long-distance reconnaissance and combat missions.

To keep a strong presence in the Pacific and Asia, the U.S. military has continued to maintain several bases on Guam. These bases currently have fewer personnel than in the past as they primarily perform a support role for military exercises in the Pacific. Military installations comprise approximately 30 percent of the 212 square miles of the island's total land area (Navy, 1985).

3.4.1 Andersen Air Force Base

Andersen Air Force Base, located in the northeastern end of the island, comprises about 11,095 acres. The base is the headquarters for the 633d Air Base Wing (633 ABW) and the 13th Air Force, along with numerous associated units. These units include the 909th Air Refueling Squadron, the 605th Military Airlift Support Group, the 750th Space Group, and the expected addition of the Navy VRC-50 Fleet Logistics Support Squadron. As one of the westernmost U.S military bases on American soil, Andersen stands as the basis for support for nearly all military operations in the Western Pacific (U.S. Air Force, 1992).

3.4.2 Apra Harbor Complex

The Apra Harbor Complex is located on the west-central coast of Guam, about eight miles south of the capital city of Agana. The harbor is made up of a 650-acre inner harbor and a larger outer harbor; the total land areas is approximately 4,480 acres. The main function of the complex is to house various activities and entities which fulfill the support role for military operations on Guam. Along with numerous stores, recreational facilities, and community service centers, major real estate holders at the Apra Harbor Complex include the Naval Station (NAVSTA), Naval Supply Depot (NSD), the Naval Ship Repair Facility (SRF), and the Public Works Center (PWC). Naval Hospital (NAVHOSP) is located to the northeast of Apra Harbor (Navy, 1986a, 1985).

3.4.3 Naval Air Station (NAS) Agana

NAS Agana encompasses approximately 2,214 acres and is located on the west coast of Guam, about three miles northeast of Agana. The air station shares facilities with the GIAT, so all non-military flights coming into or flying out of Guam also utilize NAS Agana's two runways. The station maintains facilities which provide services and material support for these transiting aircraft as well as for the military tenants. Along with Andersen AFB, NAS Agana helps serve the important air support function for military operations in the Western Pacific (Navy, 1985).

3.4.4 Naval Magazine

The U.S. Naval Magazine (NAVMAG Guam) consists of approximately 8,840 acres of land situated in the mountainous terrain of south-central Guam. The area is used primarily for ordnance storage, operations, administration, training, and support. NAVMAG's location in the Pacific represents the westernmost ammunition supply point on U.S. soil. Its close proximity to U.S. operating forces on the Western Pacific rim makes it a vital link in the ammunition logistics system providing ordnance to the Seventh Fleet (Navy, 1991).

3.4.5 Others

Other military facilities located on Guam include the Naval Computers and Telecommunications Area Master Stations (NCTAMS WESTPAC) at Finegayan and Barrigada and the Naval Oceanography Command Center/Joint Typhoon Warning Center (NAVOCEANCOMCEN/JTWC) on Nimitz Hill (Navy, 1985).

3.5 INFRASTRUCTURE, UTILITIES, AND PUBLIC SERVICES

3.5.1 Water Supply

The Public Utility Agency of Guam (PUAG) maintains and operates the islandwide water distribution system. This integrated system has a capacity of 30 millions gallons per day (mgd) and services a majority of the civilian areas on Guam. PUAG's main sources of water are wells located in the northern portion of the island which tap into the Northern Lens aquifers. These limestone aquifers have an estimated sustainable yield of up to 60 mgd and provide approximately 70 percent of the island's potable water supply. PUAG utilizes 92 wells to pump water from the aquifers for distribution to Guam's residents. PUAG's recent Ugum River Diversion Project diverts 2-4 mgd from Ugum River located in south-central Guam to supply the districts of Talofofo and Umatac. The PUAG system relies on direct well-to-consumer service with only a minimal amount of storage. Therefore, any power outages significantly hinder its water distribution capabilities.

In addition to PUAG's facilities, the Navy and Air Force also operate 5 and 10 wells, respectively. The Navy sells water to PUAG from its Fena Watershed system for distribution to civilian areas in southern Guam. There are also eight private wells located on civilian property throughout Guam (PUAG, 1992; Navy, 1985).

3.5.2 Electricity

The Guam Power Authority (GPA) is the main supplier for Guam's electrical power needs. Electricity is produced primarily through the operation of three base load steam-electric generating stations at Cabras, Tanguisson, and Piti. Cabras is the main source of power generation as its capacity exceeds the other two stations combined.

Prior to the construction of GPA facilities in the early seventies, the Navy was the sole provider of electrical power to the whole island. A series of joint use agreements since 1972 have slowly shifted the power generation responsibilities to GPA. A new Customer Supplier Agreement approved in August 1992 establishes the Navy and Air Force as customers of GPA. All Navy and Air Force installations maintain facilities for emergency power and peak power generation, in addition to the regular supply from GPA (GPA, 1992).

3.5.3 Transportation

3.5.3.1 Harbors

Apra Harbor is a naturally formed harbor which, with the help of several manmade improvements, provides a sheltered anchorage 4 miles long and 1.5 miles wide. The outer harbor features a general anchorage area for the commercial port as well as 14 mooring sites for use by the Navy. The Navy also owns and operates the entire inner harbor, along with its 11 mooring sites, located to the south of the main port area.

The commercial Port of Guam handles all commercial activity and is managed by the Port Authority of Guam (PAG). All goods shipped to Guam, with the exception of military weapons, ammunition, and heavy equipment, are received at the Port of Guam. As the tourist industry grows and Guam continues to ship in approximately 90 percent of

its commercial goods, the port stands as one of the busiest and most important areas on the island (PAG, 1992).

3.5.3.2 Airports

The only civilian air transportation facility on Guam is the GIAT. The facility is run by the Guam Airport Authority (GAA), a public corporation and autonomous agency of the Government of Guam. Located three miles northeast of the capital city of Agana, and sharing facilities with the Naval Air Station at Agana, this complex handles nearly all military and commercial flights into and out of Guam. NAS Agana provides runways, fire protection, and air traffic control services to GIAT, and GIAT provides some funds to offset operating and maintenance cost. Its two runways are used by eight major airlines which link Guam to several other large airports, making it the hub of air transportation for Micronesia and the Western Pacific. Guam's economy is heavily dependent on the growing tourism and business industries, so it relies on GIAT to provide viable air transportation for tourists and air cargo.

The only other airport facility on Guam can be found at Andersen AFB on the north-eastern tip of the island. Air Mobility Command flights for military personnel and their dependents operate out of Andersen. Although the majority of flight operations are military in nature, commercial aircraft may occasionally fly through Andersen's airspace, but only with permission from the Andersen Control Tower (Air Force, 1992; Navy, 1985).

3.5.3.3 Roads

Guam's public road network is managed by the Government of Guam DPW and consists of over 250 miles of paved roads. These roads range from a seven-lane urban arterial to two-lane rural roads which provide access to nearly all parts of the island. The majority of highway infrastructure was constructed by the U.S. military following the end of World War II and generally reflects the wartime emphasis on efficient connections between military installations. There are approximately 103,000 non-governmental and governmental vehicles registered on Guam. Mass Transit service is provided by the Guam Mass Transit Authority (GMTA) which operates buses on nine routes, connecting most communities on the island (Guam DPW, 1992).

Chapter 4
Existing Conditions, Environmental Consequences, and Mitigation Measures

CHAPTER 4

EXISTING CONDITIONS, ENVIRONMENTAL CONSEQUENCES, AND MITIGATION MEASURES

4.1 SOILS

Soil descriptions were obtained from the U.S. Department of Agriculture Soil Survey for the Territory of Guam and are shown in Figure 4.1.1.

4.1.1 Existing Conditions

4.1.1.1 Andersen Air Force Base

There are three main soil units in the Andersen Air Force Base (AFB) area: Guam, Guam-Urban land-Pulantat, and Ritidian-Rock outcrop-Guam units.

Guam. The Guam soil unit appears in the more inland areas of the base and is generally a very shallow, well-drained soil located on nearly level to moderately sloping plateaus. Guam soil types make up approximately 90 percent of this unit with the remaining 10 percent existing as minor components. The soil composition consists primarily of a red cobbly clay loam overlaying porous limestone. Soil depths range from about 10 to 25 centimeters. This soil is used for agricultural production, urban development, wildlife habitat, and watershed. However, due to its shallow depth, the soil is poorly suited for agricultural and urban development.

Guam-Urban land-Pulantat. This soil unit appears in the main base areas and throughout Northwest Field. It is generally a very shallow, well-drained soil unit located on level to gently sloping plateaus and urban land. The unit consists of 40 percent Guam soils, 40 percent Urban land, 15 percent Pulantat soils, and 5 percent minor components. The Guam soil type is, as mentioned above, well-drained and ranges in depth from 10 to 25 centimeters. The urban land characterized by this unit consists of areas covered by roads, buildings, parking lots, airfields, and other impervious surfaces. The Pulantat soils are shallow and well-drained clays and silty clays overlaying porous limestone. The depth of this soil type ranges from 25 to 51 centimeters. The Guam-Urban land-Pulantat soil unit is used for homesite and urban development such as airfields and military facilities. The main limitation of this unit is the depth of the bedrock which may cause problems during excavation.

Ritidian-Rock Outcrop-Guam. This soil unit surrounds Andersen on its coastal boundaries, generally comprising the steep, rocky cliffs of the area. It is very shallow, well-drained, and lies on gently sloping to extremely steep rock outcrops, plateaus, mountains, and escarpments. The unit consists of 45 percent Ritidian soils, 35 percent Rock outcrop, 15 percent Guam soils, and 5 percent minor components. Ritidian soils are very shallow and well-drained cobbly clay loam and are only about 10 centimeters deep. Rock outcrops occur as jagged peaks and cliff faces of porous limestone.

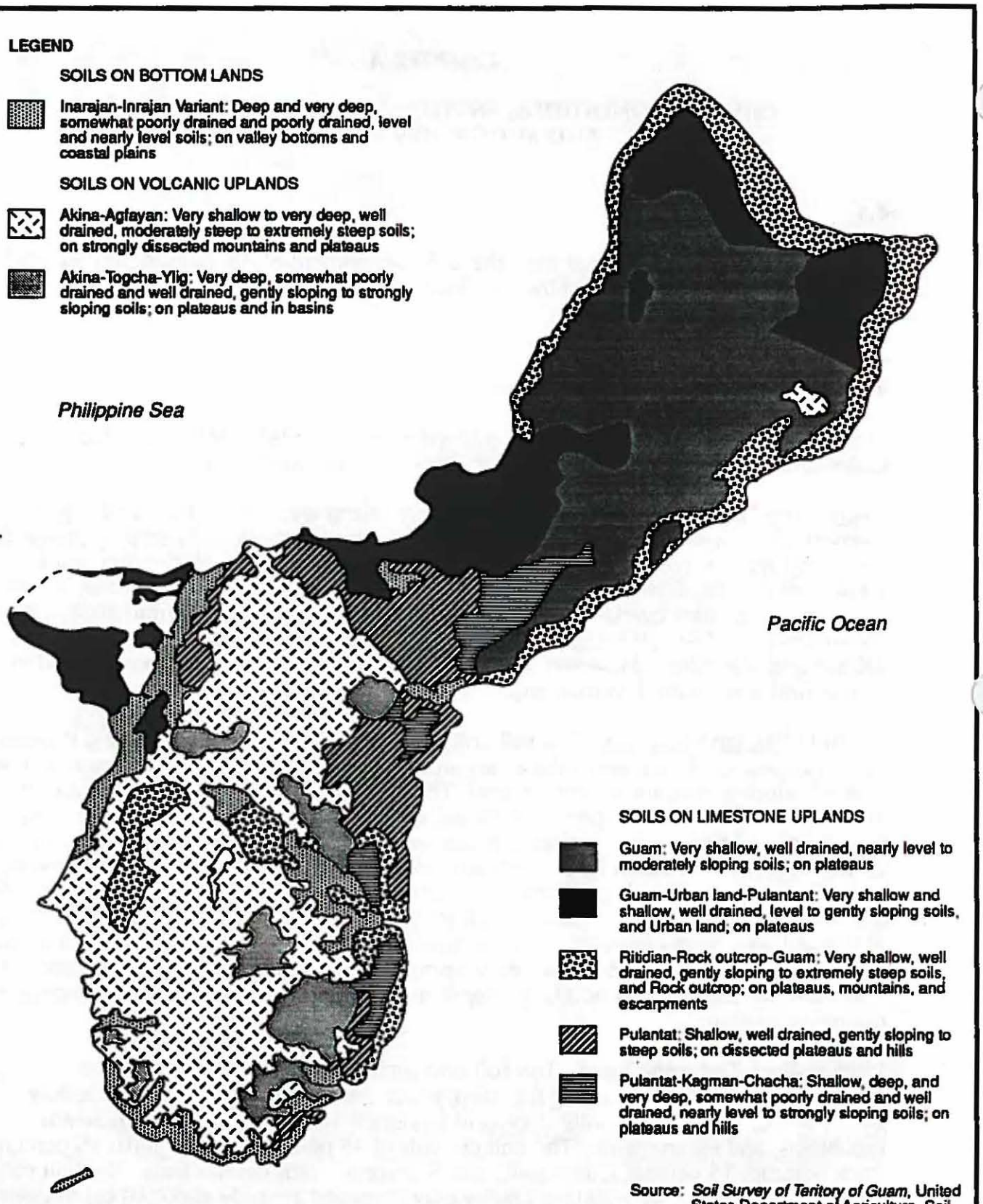

Figure 4.1.1
GUAM GENERAL SOIL MAP
Guam Development EIS
April 1993

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The Guam soils are very shallow and well-drained cobbly clay loam that are usually about 10 to 25 centimeters deep. Extremely steep slopes, rock outcrops, and the shallowness of the soils prevent any urban development or agriculture on this unit. It is used primarily as watershed and as a valuable wildlife refuge that provides native habitats for several of Guam's endangered bird and bat species.

4.1.1.2 Apra Harbor Complex

The predominant soil units around the Apra Harbor Naval Complex are Inarajan-Inarajan Variant, Guam-Urban land-Pulantat, and Pulantat.

Inarajan-Inarajan Variant. This soil appears along the coastline extending from upper Apra Harbor past the inner harbor. It is generally deep and poorly drained and can be found on fairly level valley bottoms and coastal plains. This soil unit consists of 70 percent Inarajan soils and 15 percent Inarajan Variant soils, with the remaining 15 percent existing as minor components. Inarajan soils are deep, poorly drained soils located in valleys and coastal plains. They formed in alluvium derived mostly from volcanic material and marine sediment and are predominantly clay throughout. Inarajan-Variant soils are also deep, poorly drained clay soils located on coastal plains. They feature thin layers of organic material throughout their composition. Both soil types are subject to saturation and long periods of flooding in the rainy season. Their primary uses are as sites for agriculture, homes, urban development, wildlife habitat, and watersheds. The level slopes of the unit make it suitable for development; flooding, soil wetness, and low soil strength are the main limitations.

Guam-Urban land-Pulantat. This soil unit is found in the areas extending out to sea such as Orote Peninsula, Polaris Point, and the top portion of Outer Apra Harbor. Its characteristics are identical to the same soil unit found on Andersen.

Pulantat. This soil unit appears in the more inland areas of the complex. It is shallow, well drained, and is usually found on gently sloping to steep hills and plateaus. The composition of this unit is approximately 80 percent Pulantat soils and about 20 percent minor components. The Pulantat soils are identical to those found on Andersen—well-drained clay overlaying porous limestone at a depth of about 25 to 51 centimeters. Land on top of this soil unit is used for low density housing, recreation, limited agriculture, watershed, and wildlife habitat. The steep slopes of the units are incompatible with agriculture and homesite development, while the depressional areas created by these hills provide important wetland and wildlife habitats.

4.1.1.3 Naval Magazine (NAVMAG)

NAVMAG sits atop Inarajan-Inarajan Variant, Akina-Agfayan, and Ritidian-Rock outcrop-Guam soil units.

Inarajan-Inarajan Variant. This unit is found in a small area in the northeastern corner of the site. Its characteristics are the same as those found in the unit running along the coastal areas of Apra Harbor.

Akina-Agfayan. Most of the base sits on Akina-Agfayan soils, the most common to the central portion of the southern side of the island. Soils in this unit are well-drained, range from very shallow to very deep, and appear on moderately to extremely steep mountains and plateaus. The unit is comprised of 45 percent Akina soils, 30 percent Agfayan soils, and 25 percent minor components. Akina soils are red, acidic silty clays which are characterized as very deep, well-drained, and predominantly present on side slopes and ridgetops. These soils overlay saprolitic tuff at a depth of 51 to 102 centimeters and are presumed to have formed in residuum resulting from volcanic tuff or tuff breccia. Agfayan soils, by contrast, are very shallow, yet well-drained clays which range from slightly acidic to neutral and also appear on side slopes and ridgetops. The Agfayan soils formed in residuum from marine deposited tuffaceous sandstone and overlay weathered bedrock at a depth of 10 to 38 centimeters. Due to the steepness of the slope and the severe erosion hazard, this soil is not suitable for urban development or agriculture. Its primary uses are watershed and wildlife preservation.

Ritidian-Rock outcrop-Guam. This soil unit is found in two small patches on the western and eastern side of the site. The characteristics of this unit is the same as those seen in the unit found around Andersen.

4.1.1.4 Others—Naval Air Station (NAS) Agana

All of NAS Agana sits atop a Guam-Urban land-Pulantat soil unit. This generally shallow, well-drained soil unit shares the same characteristics as the Guam-Urban land-Pulantat soil units found at Andersen Air Force Base and the Apra Harbor Naval Complex.

4.1.2 Potential Impacts and Proposed Mitigation

4.1.2.1 Andersen Air Force Base

New development and activities at Andersen should have no significant impact on the soils or soil unit delineations. All scheduled urban development such as the new hangar/apron/washrack will take place on or adjacent to previously developed land, so incompatibility of soil units will not be a factor. No mitigation measures are required.

4.1.2.2 Apra Harbor Complex

The new housing and facilities scheduled for construction around Apra Harbor will take place on soil units where such development is compatible. Most new facilities have been sited on Orote Peninsula which features the shallow and well-drained Guam-Urban land-Pulantat soil unit that is suitable for most kinds of development. Standard erosion control measures will be implemented during construction.

The non-preferred housing sites pose potential problems due to soil conditions. Portions of the New Apra Heights and Polaris Point alternative housing sites are located on the deep and poorly drained Inarajan-Inarajan Variant soil unit which has a propensity to flood. The possibility for flooding increases when structures are placed on areas deemed prone to soil saturation.

4.1.2.3 Naval Magazine

The new magazines and storage facilities scheduled for construction at NAVMAG will be built in the northern portion of the site, an area that covers all three soil units. The Akina-Agfayan and Ritidian-Rock outcrop-Guam units are well-drained and most suitable for this development, while the Inarajan-Inarajan Variant unit is deep and poorly drained. Nevertheless, the steep slopes of the region make all three soil units prone to flooding and erosion. Siting of buildings will take into consideration both topography and soil unit drainage to avoid adverse impacts. Standard erosion control measures will be implemented during construction (e.g., drainage swales and retention basins).

4.1.2.4 Others—Naval Air Station (NAS) Agana

No construction is proposed at NAS Agana; therefore, no impacts are expected.

4.1.3 Cumulative Impacts

No soils-related cumulative impacts are anticipated.

4.2 HYDROLOGY/WATER RESOURCES

4.2.1 General Existing Conditions

The two major freshwater resources on Guam are the Northern Lens Aquifer and the Fena Watershed and reservoir. Freshwater in the northern tip of Guam comes from the underground fresh water lens that exists throughout the northern half of the island in basal aquifers. In these aquifers, freshwater filters through from the surface and floats in a layer on top of saline ocean water. The limestone aquifers act as natural filtering systems and water quality is generally excellent (Navy, 1991a). This water is accessed by various public and private wells across the northern half of the island. The average sustainable yield of the aquifer is estimated to be 60 million gallons per day (mgd), of which 35 mgd is estimated to be available for future development (PUAG, 1992a). Recharge of water resources occurs as surface waters accumulate and percolate through the limestone to collect in the aquifers. The entire Northern Plateau of Guam is considered to be an aquifer recharge zone, and surface water collecting and entering the subsurface in this area is closely monitored for contamination by the Guam Environmental Protection Agency (GEPA).

The Fena Reservoir, which lies in the southern half of Guam, near the southeastern corner of the Naval Magazine, is formed by the damming and collection of surface waters from a 6-square-mile uninhabited watershed. It is estimated that the useable storage of this reservoir is 2.1 billion gallons (Navy, 1984). The recharge rate of the reservoir varies with the season and is dependant upon the rainfall. This water, as well as water from Almagosa and Bona Springs, is treated at the Fena treatment plant and piped around the island to the Naval facilities.

A recent PUAG project has created a second source of freshwater in the southern half of Guam. The Ugum River Project redirects approximately 2 mgd of the river flow to a newly constructed reservoir, where it is treated and pumped from a new pump station through PUAG lines to residents from Talofofo to Umatac. The Ugum River flows fairly

consistently all year down from the South Central Mountains, and barring the occurrence of a devastating drought, it is likely that this source will remain reliable. There should be no significant difference between wet and dry season water production rates (Pacific Daily News, Oct. 6, 1992).

4.2.2 Potential Impacts and Proposed Mitigation Measures

4.2.2.1 Andersen Air Force Base

The proposed hangar/apron/washrack (P-203) will be constructed with oil water separators, an enclosed sewer system, and other necessary groundwater contamination safeguards. Therefore, construction of these facilities are not expected to impact these water resources.

In-flight operations associated with the VRC-50 squadron do not involve a demand upon the hydrological resources of the Northern Lens. Compared to other uses, the activity will have no discernable impact on water resources other than minor amounts (approx. 5,000 gpd) of water used for aircraft washing (Navy, 1992e).

4.2.2.2 Apra Harbor Complex

Navy facilities in this region get their water from three primary sources in the southern half of the island: Almagosa and Bona Springs and the Fena Reservoir. In addition, the Navy has three wells at the Naval Computers and Telecommunications Area Master Station, Western Pacific (NCTAMS WESTPAC) Finegayan on standby for dry periods (Navy, 1984). With the number of increased activities and facilities in this region, there will be an increased demand upon the Fena Reservoir system that will be particularly felt during drought seasons. This increased demand is discussed further in Section 4.16.3.

There are different hydrologic conditions at the proposed and alternative family housing sites in the Apra Harbor Complex. The proposed eastern Tipalao housing expansion site is not in any aquifer recharge zone or watershed, but there are three wetland areas within the proposed development zones, and planning with the appropriate federal agencies will take place to insure that the wetlands are not negatively impacted (see Appendix J). The proposed western Tipalao housing expansion site is not in a watershed, aquifer recharge zone, wetland, or otherwise hydrologically constrained area, and development in this area would not have any adverse impacts on area hydrology or water resources. There are no aquifer recharge zones or watersheds at the Polaris Point alternative site. However, wetlands constrain approximately 35 acres along Marine Drive. There are no aquifer recharge zones or watersheds on the New Apra Heights alternative housing site, but there is wetland area at the western end.

4.2.2.3 Naval Magazine

Two major watersheds, the Fena Valley Watershed (3,670 acres) and the Tolaeyuus River Watershed (4,400 acres), are located within NAVMAG Guam (see Figure 4.2.1). The Fena watershed is uninhabited and, as mentioned above, the water from the reservoir is a major source of potable water for Naval activities. The Tolaeyuus River Watershed is the land upon which the new construction projects are planned. This watershed drains into a low lying sump area and is close to the northeast portion of the

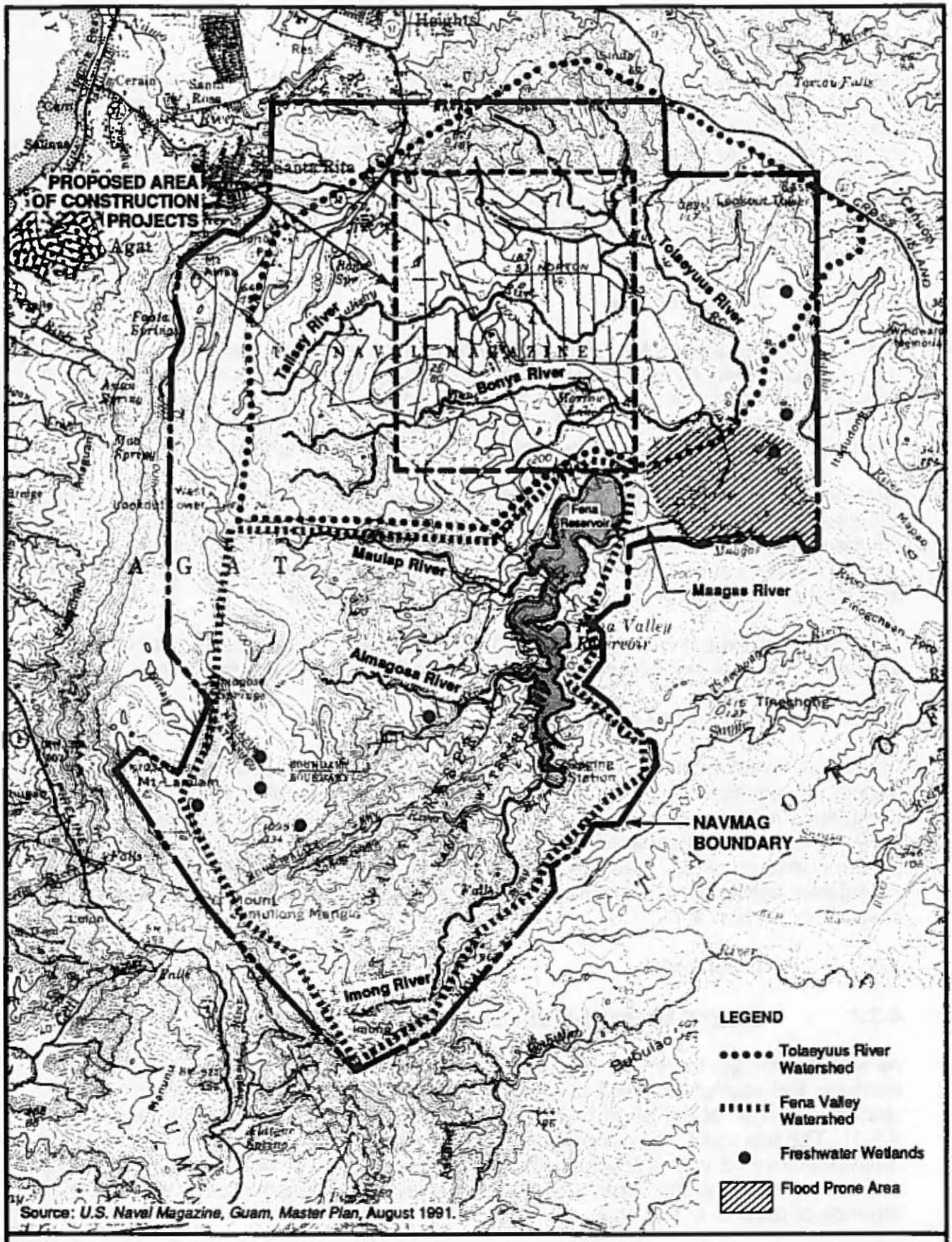

Figure 4.2.1
WATERSHED AND WETLAND AREAS
Guam Development EIS
April 1993

Fena Reservoir (Navy, 1991b). None of the proposed projects at Naval Magazine include the use or addition of any aboveground storage tanks (ASTs), Underground Storage Tanks (USTs), underground injection wells, or other facilities or activities that could contaminate water resources in the Tolaeyuus Watershed. Both the Fena and the Tolaeyuus sump flow into the Maagas River downstream from the spillway, but USGS maps do not show any direct surface connection between the two watersheds, and drainage from the project is not expected to impact the potable water quality of the Fena Reservoir.

4.2.2.4 Other Impacts

The Naval Air Station (NAS) Agana is located along the western coast of Guam, with a large part of it lying over a wedge of brackish groundwater that has infiltrated from the ocean. Because of this, there is little probability of developing local wells or other groundwater resources on base. The station purchases its potable water from Public Works Center (PWC) Guam, whose primary source is the Fena Reservoir.

Drainage on the air station follows a pattern of sheet flow, sinkholes, and percolation, as described in Section 4.3.1. These sinkholes serve as major recharge points for the Ghyben-Hertzberg basal lens that is a major part of the northern Guam aquifer system, and part of the southwestern portion of the station is designated as an aquifer recharge area by the Government of Guam (GOVGUAM) (Navy, 1984).

No new development or increase in pollutant discharges is planned or anticipated at the air station, so there will be no impacts on area hydrology or water resources.

4.2.3 Cumulative Impacts

In general, none of the proposed military construction projects or activities will adversely impact any aquifer recharge areas, or watersheds. Although there are no significant cumulative impacts upon the capacity of the Northern Lens aquifer, there are cumulative impacts associated with the increased withdrawal from the Fena Reservoir system due to increased activities and facilities in the Apra Harbor Complex. These cumulative effects of water withdrawal for operations and domestic consumption are covered in Section 4.16.

4.3 DRAINAGE

4.3.1 General Existing Conditions

As with hydrology, there is a significant difference in drainage conditions between the northern and southern regions of Guam. The division between the northern and southern "halves" of the islind is delineated by the Adelup-Pago Fault Line (see Figure 4.3.1). The sub-soil of the northern half of Guam is mostly composed of highly porous limestone covered with a relatively thin soil layer. Because of high percolation rates in these areas, water settles rapidly into the subsurface. This phenomenon explains the absence of streams in this area.

Andersen Air Force Base occupies the northern tip of the island where the subsoil is composed of Mariana limestone. The infiltration rate is 1 inch in 5 to 15 minutes, or

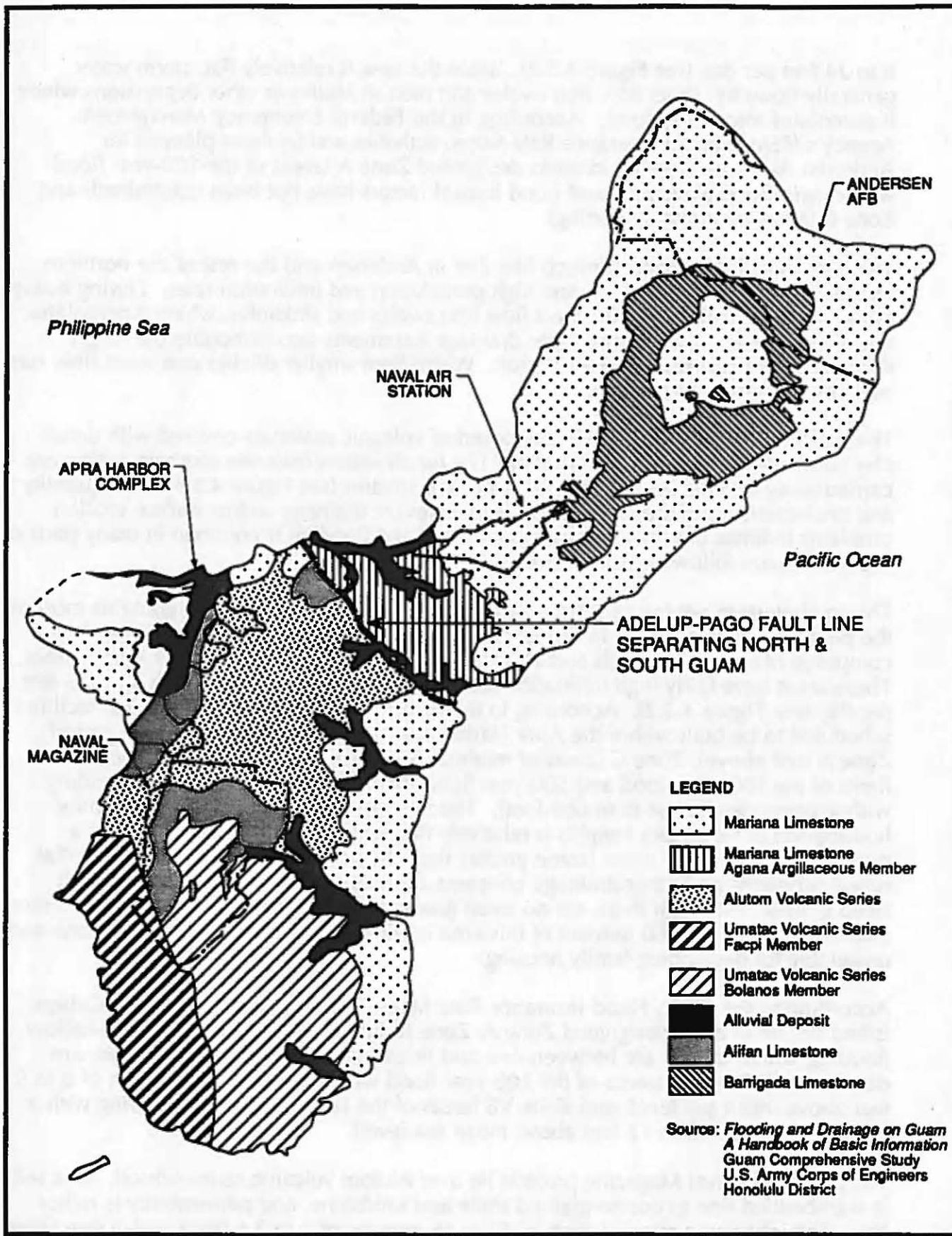

Figure 4.3.1
GEOLOGY
Guam Development EIS
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8 to 24 feet per day (see Figure 4.3.2). Since the area is relatively flat, storm water generally flows by sheet flow into swales and then sinkholes or other depressions where it percolates into the ground. According to the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps, activities and facilities planned for Andersen Air Force Base lie in areas designated Zone A (areas of the 100-year flood where base flood elevations and flood hazard factors have not been determined) and Zone C (areas of minimal flooding).

The subsoil at NAS Agana is much like that at Andersen and the rest of the northern plateau, with porous limestone and high percolation and infiltration rates. During heavy rains, water generally flows by sheet flow into swales and sinkholes, where it percolates into the ground. Several manmade drainage easements accommodate the larger drainage water courses at the air station. Water from smaller ditches and sheet flow runs over the cliff onto private land.

The southern half of the island is composed of volcanic materials covered with dense clay soil, where there is less infiltration The runoff waters from the southern region are carried away into the sea via over 40 rivers and streams (see Figure 4.3.3). The quantity and characteristics of these rivers can lead to severe drainage and/or surface erosion problems in times of heavy precipitation. Localized flooding is common in many parts of southern Guam following heavy rainfall.

The southwestern peninsula (Orote Peninsula) of the Apra Harbor area contains most of the proposed developments in the Apra Harbor Naval Complex. Orote Peninsula is composed of coastal lowlands and alluvial valley floors that surround inner Apra Harbor. These areas have fairly high infiltration rates: 1 inch in 16 to 30 minutes or 4 to 7.5 feet per day (see Figure 4.3.2). According to the FEMA Flood Insurance Rate Maps, facilities scheduled to be built within the Apra Harbor Naval complex lie in areas designated Zone A (see above), Zone C (areas of minimal flooding), and Zone B (areas between limits of the 100-year flood and 500-year flood; or areas subject to 100-year flooding with average depths less than one foot). The western edge of the alternative family housing site at New Apra Heights is relatively flat, while the eastern half contains a number of steep slope areas (some greater then 20 percent), and there are potential runoff problems and other drainage concerns associated with development of such steep grades. Although there are no steep grades to affect drainage at the Polaris Point alternative site, about 60 percent of this area is within the tsunami inundation zone and unsuitable for developing family housing.

According to the FEMA Flood Insurance Rate Maps, facilities proposed for the Cabras Island site lie in areas designated Zone A, Zone B, Zone AH (areas of 100-year shallow flooding where depths are between one and three feet; no flood hazard factors are determined), Zone A6 (areas of the 100-year flood with a base flood elevation of 8 to 9 feet above mean sea level, and Zone V8 (areas of the 100-year coastal flooding with a base elevation of 10 to 12 feet above mean sea level).

The proposed Naval Magazine projects lie over Alutom volcanic series subsoil. This soil is well-bedded fine to coarse grained shale and sandstone, and permeability is rather low. The infiltration rate is 1 inch in 40 to 46 minutes or 2 to 2.6 feet per day (see Figure 4.3.2). According to the FEMA Flood Insurance Rate Maps, facilities proposed for the Naval Magazine lie in areas designated as Zone A and Zone C.

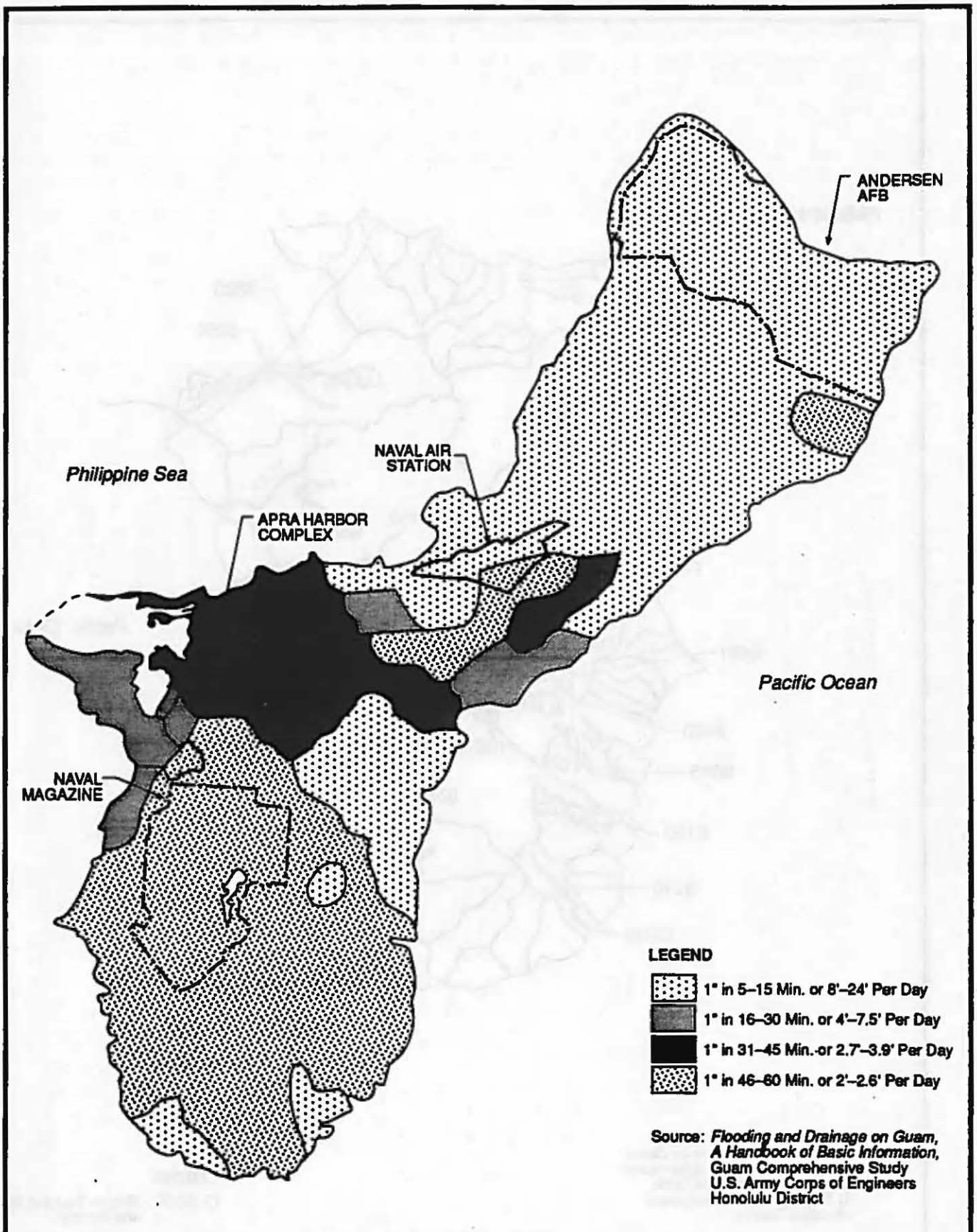

Figure 4.3.2
INFILTRATION RATES
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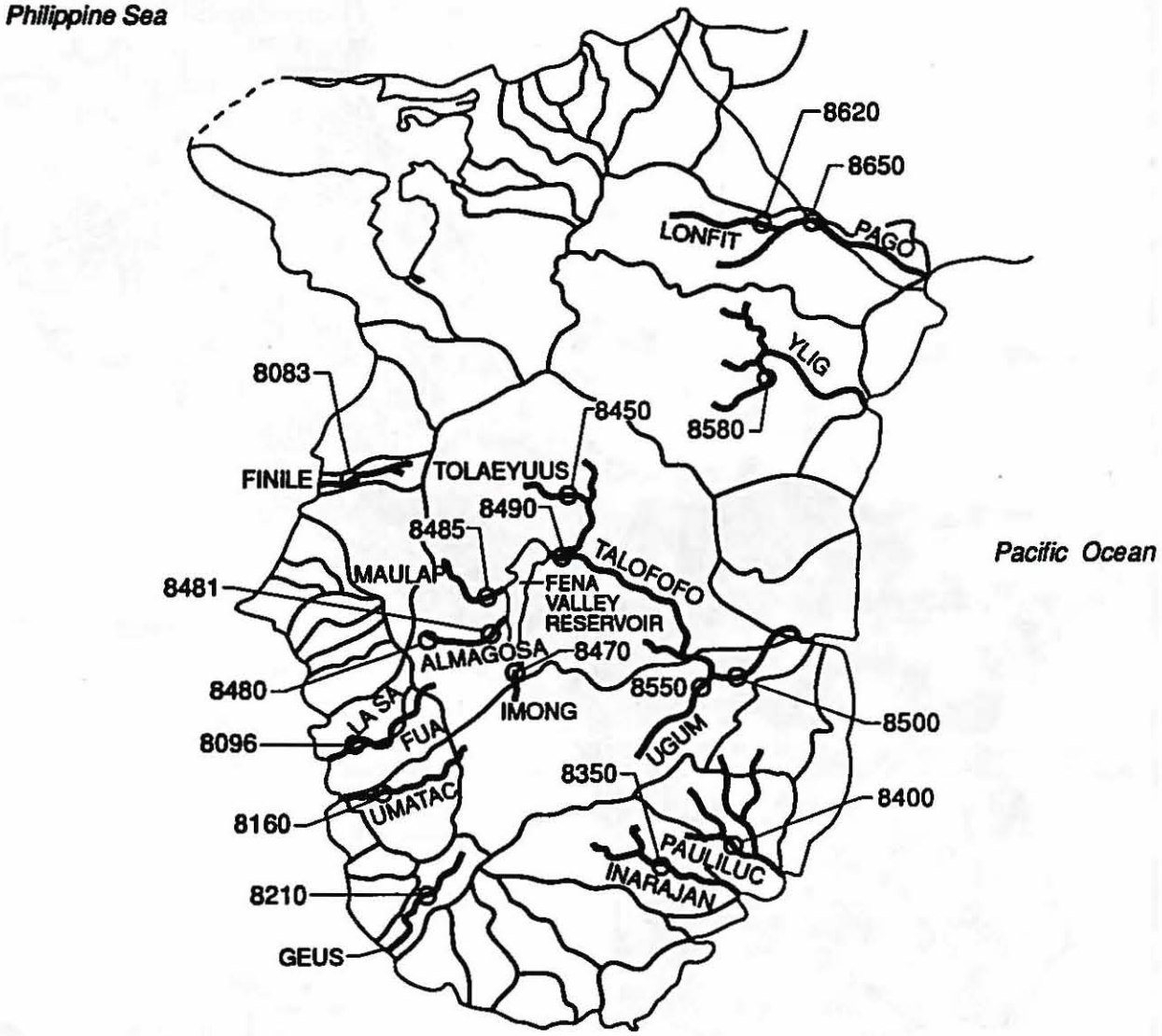

Source: *Flooding and Drainage on Guam*
A Handbook of Basic Information
Guam Comprehensive Study
U.S. Army Corps of Engineers
Honolulu District

LEGEND

O 8000 Stream Gauging Station and Number

North

0 1 2 3

Scale in Miles

Figure 4.3.3
STREAMS IN SOUTHERN GUAM
Guam Development EIS
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4.3.2 Potential Impacts and Proposed Mitigation Measures

4.3.2.1 Andersen Air Force Base

The majority of the area necessary for the proposed hangar/apron/washrack facility is developed and graded with a drainage system already in place. The portions of the rerouted fuel line, chain link fence, underground power line, and roadway that will occupy the vegetated area to the north are close enough to the existing infrastructure so that runoff or drainage from project areas can be easily handled.

Refueling operations will take place in a specific refueling area to be built along with the hangar and apron. Drainage from the hangar floor, wash down area, and refueling stand will pass through a physical separation type oil/water separator and drain to an enclosed sewer system. A hazardous/flammable materials storage facility will be constructed as part of the VRC-50 hangar facility for brake fluid, hydraulic fluid, paint and lubricants used for aircraft maintenance. Use and disposal of hazardous materials will be in accordance with applicable regulations and the Navy's hazardous wash minimization program. (Transmittal from HQ PACAF/DEV to PACDIVNAVFACENGCOM, Nov. 11, 1992).

The renovations of the SNCOQ and BOQ will involve only interior renovations and have no impact on drainage in the surrounding area.

4.3.2.2 Apra Harbor Complex

The Military Sealift Command operations building (P-160), Administration Office Building (P-158), Integrated Storage and Handling Facility (P-152), Repair Shop Storage (P-235), NSWU-1 Maintenance and Storage Building (P-394), NSWU-1 Team Building (P-395), Cold Storage Facility (P-157), Child Development Centers (P-389/391), Gantry Crane (P-156), Gas Bottle Storage Building (P-151), General Warehouse (P-153), EOD Operations Facility (P-393), and Ships/Spares Storage (P-168) are all planned for construction on or close to previously developed and graded lands. They are close to existing structures, roadways, and drainage systems, and there is little risk of runoff or drainage impacts on nearby lands. However, during construction and grading, care will be taken to insure that washout or runoff from the sites does not impact surrounding roadways or vegetation, or enter and pollute marine waters. This can be done through the use of standard erosion control techniques and Best Management Practices (BMPs), such as the use of berms to contain runoff.

The proposed expansion of the Orote Power Plant (P-234) and the modifications to the Apra Harbor Sewage Treatment Plant (P-239) do not infringe upon surrounding lands enough to create any adverse drainage impacts. The facilities will be in well developed areas of the Naval Station where the needed infrastructure already exists.

Due to the nature and substance of the materials stored, the Hazardous Material Storage Facility (P-141) carries with it a potential for drainage-related problems. Should a spill or other damage to the facility occur, the high infiltration rate of the surrounding soil could allow liquid toxins to enter and contaminate the subsoil. Extra care will be taken in construction, maintenance, and operation of this facility to provide shields against pollutant infiltration. In addition, communications at the building will allow for the instant reporting of spills to the appropriate cleanup personnel.

The proposed western Tipalao family housing expansion site is not in any flood or tsunami danger zones, or any other drainage sensitive areas. However, runoff or pollutants have the potential to wash over the cliffs to the west and can impact the Orote Point Ecological Reserve. Therefore, the development will be serviced by an enclosed storm water collection system, and a 4,000-foot buffer zone will be maintained between the proposed development and the ecological reserve. There are steep slopes along the portions of the western boundary of the proposed eastern Tipalao expansion site, where runoff from construction sites presents potential impacts to wetland areas downslope from the site. The use of silt screens, sediment basins, and other BMPs during the construction phase and extension of the existing Tipalao storm drainage system to control runoff will eliminate impacts to these wetland areas.

4.3.2.3 Naval Magazine

The planned sites of the two 9,000-square foot Tomahawk missile magazines lie on rolling lowlands and karst. There are no particular drainage concerns with building in the low-land areas, and there are no concerns with the construction of the 17,000-square-foot Inert Storage Complex.

4.3.2.4 Other Impacts

No new development or construction is planned at Naval Air Station (NAS) Agana, so no impacts to area drainage are anticipated.

4.3.3 Cumulative Impacts

Generally, none of the proposed construction projects or areas of activity increase lie in flood prone or will affect wetlands or other drainage sensitive areas. There are potential impacts associated with construction activities and increasing the amount developed and paved land within the Apra Harbor Complex. This decreases the permeability of the area and causes an increase in urban runoff and non-point source pollution. This impact can be limited through the use of silt screens and sediment basins during the construction phase, and the employment of buffer zones and storm drainage systems in other stages of development.

4.4 TERRESTRIAL BIOTA

4.4.1 Background

Guam's biodiversity has felt the pressures of recent urban and agricultural development and predation by introduced species. As for Guam's plant species, the variety has remained fairly constant. While large parcels of undisturbed forest or native vegetation have become increasingly scarce, very few native Guam plant species are presently in danger of extinction. The same cannot be said for Guam's fauna populations, particularly native forest birds and bats. Due to uncontrolled predation by the introduced brown tree snake (*Boiga irregularis*), only three species of native forest birds are known to remain in the wild on Guam and all three are nearing extinction. Due largely to security restrictions, Navy and Air Force installations, in addition to the private parcels to which the military controls access, have become *de facto* nature preserves that are protected from the levels of human activity and development seen elsewhere on Guam (USFWS, 1992a).

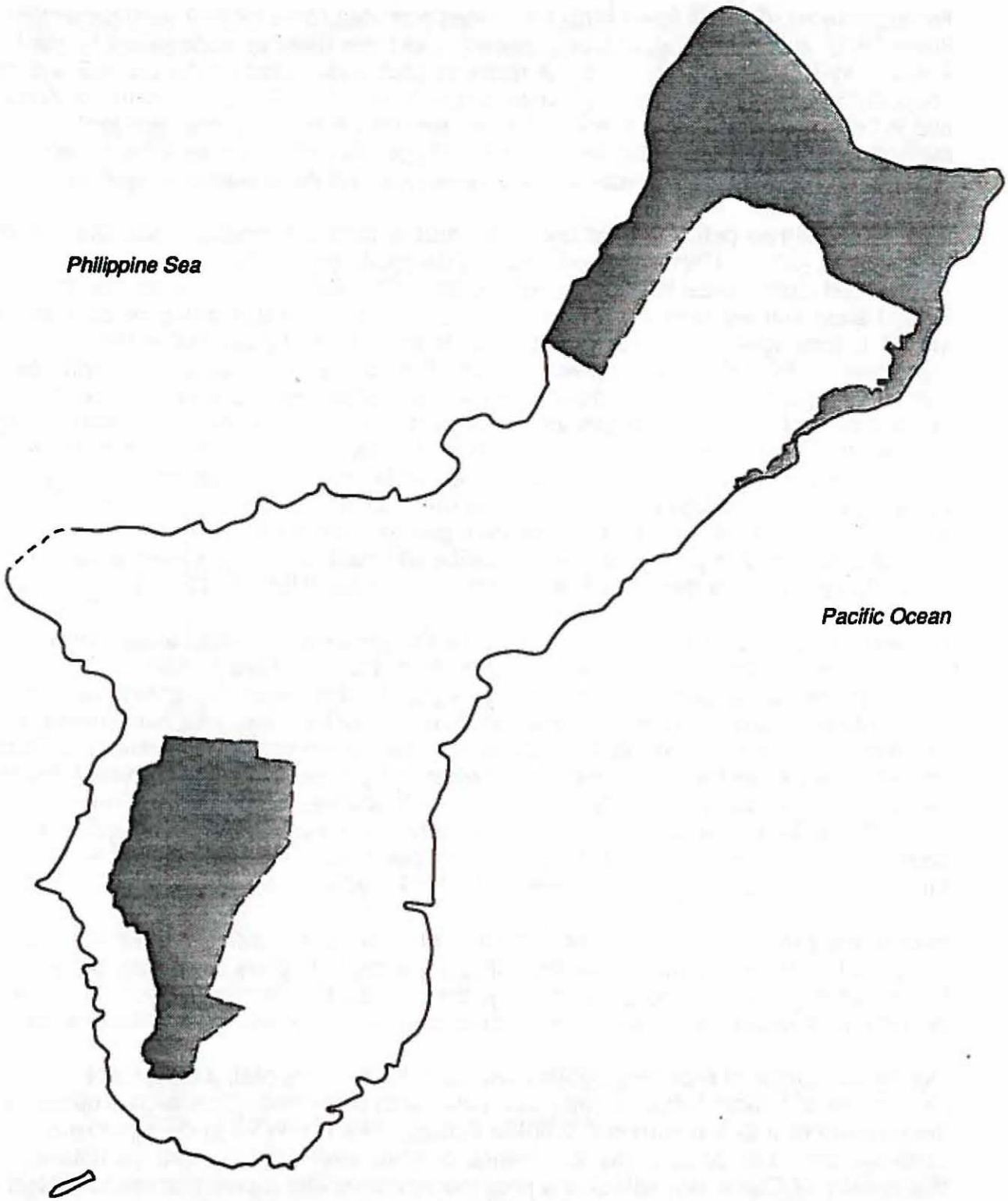
For many years, Guam's forest birds have been provided some form of legal protection. Since 1970, at least ten Guam fauna species have been listed as endangered by the U.S. Fish and Wildlife Service (USFWS). A recovery plan was drafted by the USFWS with the cooperation of the Government of Guam Department of Agriculture Division of Aquatic and Wildlife Resources for a number of these species. A recovery plan sets forth a methodology to prevent extinction of the listed species and to restore them to self-sustaining levels so that they may eventually be taken off the endangered species list.

In response to two petitions filed under the Administrative Procedures Act, the USFWS published in June of 1991 a proposed rule to designate critical habitat for five endangered Guam forest birds and two fruit bats. This federal designation identifies habitat areas that are seen as essential to the conservation of federally-protected species and all federal agencies conducting activities in these areas are advised of the significance. The USFWS has stated in responding to questions regarding this proposal that critical habitat designation does not establish sanctuaries or provide for active management of the habitat or species. However, all federal actions and all projects on private lands which require Federal funds or authorization, which are planned to be taken in areas designated as critical habitat, are to be carried out subject to a mandatory consultation with the USFWS to ensure that the project does not adversely modify designated critical habitat. This consultation process allows the USFWS to evaluate these activities and to provide technical advice and guidance for the purpose of reducing or eliminating risks to threatened or endangered species (USFWS, 1992b).

The areas proposed for critical habitat designation are mostly forested areas comprising 16,980 acres in northern Guam and 7,672 acres in southern Guam. The areas in the north include: those portions north and seaward of a line beginning at Amantes Point and continuing east to Wettengei Junction, north along Highway 3 to Potts Junction, east along Highway 9 to Salisbury Junction, and east to the coast; Government of Guam property from Anao Point to Campanaya Point; and private property at Janum Point (see Figure 4.4.1). Areas in the south include: Naval Magazine; Naval Reservation; area above the 800-foot contour abutting the Naval Magazine and Naval Reservation; area abutting and between the Naval Magazine and Naval Reservation along the Maagas River; and Bolanos Conservation Reserve (USFWS, 1989).

Prior to the proposed rule for critical habitat, there were a number of attempts to agree on special land management provisions through a multiple party Memorandum of Understanding (MOU) among the military, the Service, the Government of Guam, and the Marianas Audubon Society. The attempt to write and agree on the MOU failed.

During the course of receiving public comments on this proposal, a number of alternatives to critical habitat designation have been presented. One such proposal is the creation of a Guam National Wildlife Refuge. The USFWS has characterized refuge establishment as an opportunity to enhance ongoing efforts to conserve the natural biodiversity of Guam as it will offer a progressive conservation commitment to protect the island's wildlife resources, particularly in the area of endangered species recovery (USFWS, 1992a). The concept of a cooperative wildlife refuge which overlays portions of existing military installations is presently under consideration by the USFWS and the affected installations. An overlay refuge is administered by the USFWS as a unit of the National Wildlife Refuge System, but the primary jurisdiction over the underlying land unit would remain with the installation.



Source: *U. S. Fish and Wildlife Service, Notes for Local and Federal Government Agencies on the Proposal to Designate Critical Habitat for Endangered Species on Guam*, June 1989.

LEGEND

Proposed Critical Habitat Areas

North

0 1 2 3

Scale in Miles

Figure 4.4.1
PROPOSED CRITICAL HABITAT AREAS
Guam Development EIS
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As of this writing, no final action has been taken regarding the proposal to designate critical habitat. The USFWS has stated that the final decision on whether or not to designate critical habitat may depend on the outcome of the decision to establish a refuge. No decisions regarding refuge establishment have been made as of this writing.

4.4.2 Existing Conditions

Botanical surveys of selected sites proposed for development were performed by Dr. W. Arthur Whistler in July and December 1992. Sites located in previously developed areas were not surveyed. Faunal surveys of areas with potential for impact were conducted by Philip L. Bruner in July 1992. Copies of these reports are contained in Appendices D and E. (Note: several flora species do not have common names in English or Chamorro.)

4.4.2.1 Andersen Air Force Base

Flora and fauna surveys at Andersen Air Force Base focused primarily on the area around the proposed hangar/apron/washrack site. Projects P-207 and P-209 involve interior renovations only and will have no impact on flora and fauna resources.

Three types of vegetation can be found around the proposed hangar/apron/washrack site at Andersen: managed lands, limestone forest, and a transitional patchy second-growth forest separating the two. The managed lands are comprised of mowed lawns dominated by low, introduced herbaceous species such as *Dichantium bladhii*, *Dichantium caricosum*, and lippia (*Lippia nodiflora*). To the north of this area is the patchy, second-growth scrub forest containing trees such as screwpine or kafu (*Pandanus tectorius*), Indian mulberry or lada (*Morinda citrifolia*), pai-pai (Guamia *mariannae*), and ahgao (*Premna serratifolia*) that separate the managed land from the limestone forest.

The limestone forest is dominated by native species such as beach hibiscus or pago (*Hibiscus tiliaceus*), gapit atayake (*Wikstroemia elliptica*), aplokating (*Psychotria mariana*), and Indian mulberry or lada. Other native species present in smaller quantities include banyan or "lulu" (*Ficus prolixa*), mapunyao (*Aglaia mariannensis*), ahgao, fago (*Neisosperma oppositifolium*), pai-pai, screwpine or kafu, chosga or abas duendes (*Glochidion marianum*), yoga (*Elaeocarpus joga*), and cycad or fadang (*Cycas circinalis*). Introduced species are also present, but only in minor amounts. To the west of this patchy forest lies a relatively undisturbed limestone forest featuring predominantly ahgao, fago, and pai-pai, along with several species also found in the scrub forest. No wetlands are present in the project area.

Endangered or rare animal species do not generally appear in the managed lands or scrub forests around Andersen, although managed lands might harbor the Micronesian starling and other migratory birds during the winter, and endangered bats could be attracted to flowers, gardens, and fruit trees. In the limestone forest areas, however, notable species which inhabit them include the Mariana crow (*Corvus kubaryi*) and the Mariana fruit bat (*Pteropus mariannus*), both endangered. These species prefer habitats in the undisturbed limestone forest and rock outcrops rather than the surrounding scrub forests. Micronesian starlings (*Aplonis opaca*) and black drongos (*Dicrurus macrocercus*) have also been observed in several areas on and around the base. Because of the presence of endangered species, all of Andersen AFB, Northwest Field, and several

additional outlying areas lie within a proposed critical habitat area (see Section 4.4.1). In addition to the Mariana fruit bat, feral mammal observations have included feral cats (*Felis catus*), dogs (*Canis familiaris*), pigs (*Sus scrofa*), Guam deer (*Cervus unicolor mariannus*), black rat (*Rattus rattus*), Polynesian rat (*Rattus exulans*), house mouse (*Mus musculus*), and the musk shrew (*Suncus murinus*). Reptiles of the forest areas include the monitor lizard (*Varanus indicus*), the brown tree snake (*Boigus irregularis*), blue-tailed skinks (*Emoia wemeri*), brown skinks (*Carlia fuscata*), house geckos (*Hemidactylus frenatus*), and the neo-tropical toad (*Bufo marinus*).

4.4.2.2 Apra Harbor Complex

Almost all of the facilities scheduled for development in the Apra Harbor Complex will be placed on previously developed land with very little undisturbed flora and fauna populations and no endangered species. Only the alternative housing sites around Apra Harbor feature undisturbed or relatively undisturbed land. Four alternative sites were surveyed: two parcels adjacent to the Tipalao Family Housing area, one next to the New Apra Heights Family Housing, and Polaris Point. The proposed sites for new family housing are the two parcels located on each side of the existing Tipalao Housing.

Tipalao Housing Expansion Area, Northwest. This site consists of 30 acres of land located to the northwest of the existing Tipalao Family Housing area and extending north along the southern coast of Orote Peninsula towards the Seabee Quarry. The topography consists mostly of rugged karst limestone in the form of jagged ridges and pinnacles. Vegetation grows out of cracks in the limestone and is predominantly limestone forest.

The area north of Haputo Road features the greatest species diversity and the least disturbed landscape on the site. The most common native plant species are banyan or lulu, pisonia or umumu (*Pisonia grandis*), and fago. Less dominant native tree species include gulos (*Cynometra ramiflora*), ifil (*Intsia bijuga*), amahadyan (*Pipturus argenteus*), mapunyao, ahgao, cycad or fadang, pai-pai, pepega (*Polyscias grandifolia*), lalahag (*Pouteria obovata*), aplokating, panao (*Guettarda speciosa*), alom (*Melanolepis multiglandulosa*), screwpine or kafu, and pahong (*Pandanus dubius*). Native epiphytic ferns such as *Phymatosorus scolopendria, Microsorium punctatum, Pyrrosia lanceolata*, as well as the native climbers banago (*Jasminum marianum*) and false ratan or bejuco halum-tano (*Flagellaria indica*), and the native shrubs *Deeringia amaranthoides* and gaogao-uchan (*Phyllanthus marianus*) are present throughout the site. One rare species found in this area, ufa-halomtano (*Heritiera longipetiolata*), is listed as endangered by the Government of Guam. Other rare species found in limited areas of the island, but not officially listed as endangered, are faia (*Tristiriopsis obtusangula Radlk.*) and *Drypetes dolichocarpa*. Introduced trees such as tangantangan (*Leucaena leucocephala*) and limeberry or limon-china (*Triphasia trifolia*), can also be found interspersed among the native species.

The portion of the site south of Haputo Road is generally more disturbed and features a limited variety of plant species. The dominant tree species in this area is tangantangan (*Leucaena leucocephala*), but other species such as cycad or fadang (*Cycas circinalis*), fago (*Neisosperma oppositifolium*), pai-pai (*Guamia mariannae*), ahgao (*Premna serratifolia*), and a'abang (*Eugenia reinwardtiana*) are also common. Canopy tree species such as banyan (*Ficus prolixa*), pisonia (*Pisonia grandis*) faia (*Tristiropsis obtusangula*),

and ifil (*Intsia bijuga*) are fewer in number but maintain a strong physical presence. Native climbers such as banago (*Jasminum marianum*) and false ratan or bejuco halumtano (*Flagellaria indica*) are also found throughout the site, along with the native shrub gaogao-uchan (*Phyllanthus marianus*).

Few animal species currently exist on this parcel. The rugged topography makes habitation difficult, explaining the absence of animals such as the fairly common feral pig (*Sus scrofa*) and Guam deer (*Cervus unicolor*). The most predominant fauna species are black rats (*Rattus rattus*) and house mice (*Mus musculus*) which can be found in limited numbers around buildings. The brown tree snake (*Boigus irregularis*) and the monitor lizard (*Varanus indicus*) were the only reptiles observed in this area; however, geckos and skinks are known to be present. The endangered hawksbill sea turtle (*Eretmochelys imbricata*) and the threatened green sea turtle (*Chelonia Mydas*) are sometimes found nesting on Orote, but it is unlikely that they will be affected by any development. Despite the scarcity of wildlife on the site, the large number of native trees and the high quality of limestone forest represent valuable native habitat areas.

Tipalao Housing Expansion Area, Northeast. Located to the northeast of the existing Tipalao Family Housing, this 70 acre site consists of *Leucaena* scrub thicket and marsh vegetation. The majority of the scrub thicket is dominated by tangantangan (*Leucaena leucocephala*), while the native fern *Phymatosorus scolopendria* appears in the undisturbed areas. Weedy, mostly introduced species commonly appear in the disturbed areas and include Indian pluchea (*Pluchea indica*), beggar's tick (*Bidens alba*), mile-a-minute vine (*Mikania scandens*), love-in-a-mist (*Passiflora foetida*), (*Momordica charantia*), and sword fern (*Nephrolepis hirsutula*). Other introduced species that inhabit a clearing south of the existing baseball field include Mexican creeper (*Antigon leptopus*), spiderlily or lirio (*Hymenocallis littoralis*), and mile-a-minute vine. Ironwood (*Casuarina equisetifolia*) and kamachile (*Pithecellobium dulce*) are larger tree species which inhabit the site in addition to the tangantangan. Nanaso (*Scaevola taccada*), Indian pluchea, and wild sugarcane (*Saccharum spontaneum*) comprise the scrub layer. Several native species, most notably the small shrub gaogao-uchan, and seven out of the eight non-wetland fern species recorded during the survey, are also found on this site. Only three of the native species recorded, aplokating, banago, and pengua (*Macaranga thompsonii*) are endemic to the Marianas, and none of them is rare on Guam.

The marsh vegetation is found in five wetland areas located throughout the parcel. The wetlands comprise approximately 11 acres of land area and are presumed to be part of a drainage sump with no natural surface drainage. The largest wetland area is located in the central portion of the site and is a high quality, relatively undisturbed freshwater marsh dominated by hydrophytic (water-loving) herbaceous species such as California grass (*Brachiaria mutica*), marsh fern (*Cyclosorus interruptus*), swamp fern or langayao (*Acrostichum aureum*), vine fern (*Lygodium microphyllum*), coastal marsh grass (*Paspalum vaginatum*), bulrush (*Scirpus littoralis*), water chestnut (*Eleocharis dulcis*), lodugao (*Clerodendrum inerme*), the climbing fern *Lycodium scandens*, the sedge *Marsicus javanicus*, gasoso (*Colubrina asiatica*), beach hibiscus (*Hibuscus tiliaceus*), and the herb mamaka or mamaca (*Polygonum minus*). Wild sugarcane (*Saccharum spontaneum*), a non-wetland plant species, is also found in this area. The other four wetland areas are much smaller and feature many of the same plant species. All the wetland areas are presumed to be seasonal in nature.

The area features a limited number of animal species. The extent of avifaunal observations included three common shorebirds, all but one of them in non-breeding plumage, that were likely over-summering birds which did not migrate to their Arctic breeding grounds. Other notable species to inhabit the small, marshy wetland area include the native Pacific reef heron (*Egretta sacra*) and the yellow bittern (*Ixobrychus sinensis*). Migratory birds and the protected common moorhen may also use this area. Deer, pigs, cats, and dogs are also occasionally sighted in the area, but no species appear to make the site its place of primary habitation.

New Apra Heights. This alternative site is situated next to the New Apra Heights Family Housing, southeast of the Naval Station's main area. A majority of the parcel is covered by *Leucaena* scrub forest while several areas on the edges of the parcel feature some wetland characteristics. Although wetland plant species are present, the composition of the rest of the vegetation in their respective areas could keep them from qualifying as actual wetland areas (see Appendix D). If this alternative is selected for housing, a wetlands determination will be made.

The fauna populations in this area are minimal as the site and most of the surrounding areas have been heavily developed or disturbed in the past. There is little potential for becoming a significant habitat area.

This site was not chosen as the preferred alternative for new Navy housing for a variety of reasons. Environmentally, certain portions of the site feature slopes exceeding 20 percent, making development of housing units very difficult. In addition, potential wetlands are present in the southwest portion which would preclude all development and require a reconfiguration of the site. Finally, because most of the surrounding areas are developed and experience heavy traffic flow, the additional traffic resulting from new housing units in this area would create major congestion problems (AM Partners, Oct. 1992).

Polaris Point. The proposed housing site on Polaris Point encompasses all the land on the peninsula with the exception of the submarine support area and beach facilities located in the western portion of the site. The whole area is flat, highly disturbed, and comprised mostly of landfill. Despite this seemingly uniform topography, several vegetation types are found on this site: littoral forest, marshes (potential wetlands), swamp forest, mangrove scrub, managed land, and Casuarina forest and woodland (see Appendix D for more information regarding plant species at this site). If this alternative is selected for housing, a wetlands determination must be made.

Because of its diverse vegetative composition, Polaris Point features a wide variety of terrestrial fauna species. Similar to the Northwest Tipalao expansion area, the coastal mangrove and intertidal habitat area of Polaris Point provides nesting areas for native avifauna species such as the Pacific reef heron (*Egretta sacra*) and yellow bittern (*Ixobrychus sinensis*). Feral mammal observations were limited to a few cats; however, dogs, mice, and rats have also been recorded in the area (see Appendix E).

Several factors kept this site from being selected as the preferred housing alternative. First of all, an ESQD arc generated by the submarine support area and ammunition wharves covers the entire southwest corner of Polaris Point and borders the proposed housing area. The site is partially within a security zone which restricts access to the area

when a submarine is in port. Secondly, several potential wetland areas lie to the northeast of the parcel. Finally, an old NSD drum storage area located to the east of the site has been identified as an RCRA Facility Investigation Site (AM Partners, Oct. 1992).

4.4.2.3 Naval Magazine

The proposed Tomahawk missile magazine and inert storehouse will be located on land that has for the most part been heavily disturbed. The site for the Tomahawk missile magazines has been altered over the years by agricultural uses before World War II and fires, while the location of the inert storehouse is currently a parking lot. Despite these seemingly barren surroundings, the sites still contain a wide variety of plant and animal species.

Vegetation around the Tomahawk magazine site consists of an open Pandanus scrub forest dominated by screwpine or kafu and other native trees such as beach hibiscus (*Hibiscus tiliaceus*), gulos, pai-pai, and chosga or abas duendes. The latter two species are endemic to the Marianas. A native climbing member of the screwpine family, fianiti (*Freycinetia reineckei*), is also common on these trees. Introduced species found in this forest include *Vitex parviflora* and bay rum tree (*Pimenta racemosa*). In the areas between trees appear several species of shrubs, most notably nanaso, gapit atayake, *Decaspermum fruticosum*, lodugao (*Clerodendrum inerme*), Indian mulberry or lada, and gafau (*Melastoma malabathricum*). Herbs commonly found on the red soils of the site are mostly a mixture of native and introduced sedges and grasses such as *Scleria polycarpa, Chrysopogon aciculatus*, and *Carex fuirenoides*. No wetlands are present on the site.

The site for the inert storehouse is heavily disturbed and, as a result, most of the vegetation is managed land which has received little maintenance for some time. Weedy species dominate this area and include *Imperata conferta*, false verbana (*Stachytarpheta jamaicensis*), *Eupatorium odoratum*, and wild sugarcane (*Saccharum spontaneum*). A small marginal wetland area lies to the east of the parking lot which features such wetland and dryland species as chaguan lemae (*Kyllinga brevifolia*), *Fimbristylis littoralis*, sensitive plant (*Mimosa pudica*), false daisy (*Eclipta alba*), water hyssop (*Bacopa monnieri*), swamp fern or langayao, and mile-a-minute vine. A small scrub forest is also located to the east and features screwpine or kafu, beach hibiscus or pago, and ironwood (*Casuarina equisetifolia*). Both the marginal wetland and the scrub forest lie outside of the proposed project area.

Very few if any animal species inhabit these sites. Occasionally, rock dove (*Columba livia*) and Eurasian tree sparrow (*Passer montanus saturatus*) will be observed near developed areas, while black drongo (*Dicrurus macrocercus*) and Philippine turtledove (*Streptopelia bitorquata*) sometimes appear around the edges of disturbed forests and open areas. Brown tree snakes (*Boigus irregularis*), monitor lizards (*Varanus indicus*), geckos, and skinks can be found in the forested areas fringing the sites. Mammals such as the Guam deer (*Cervus unicolor*), feral pigs (*Sus scrofa*), and carabao (*Bubalus bubalis*), which predominantly inhabit dense ravine forests, may also be seen. Nevertheless, no endangered species are found in the area and the sites are already so disturbed that they are not likely to serve any sort of purpose for wildlife or native bird habitats.

4.4.2.4 Others

No development is proposed at Nimitz Hill, NAS Agana, or the Naval Hospital, with the exception of interior renovations.

4.4.3 Potential Impacts and Proposed Mitigation Measures

4.4.3.1 Andersen Air Force Base

The proposed hangar/apron/washrack facility (P-203) and fuel storage tank will be constructed on previously developed land, so any adverse impacts to the vegetation of the area resulting from these developments will be minimal. Potential impacts to flora may come about due to the northward relocation of the access road and aboveground fuel line which will be moved to accommodate the construction of the new hangar/apron/washrack facility. The road and fuel line are currently located in managed land and will be moved into second-growth scrub forest areas.

Endangered or protected animal species could inhabit the second-growth scrub forest areas at times. However, any adverse impacts to animal species generated by construction of the hangar/apron/washrack facility and relocation of the access road and aboveground line will be minimal. Less than five acres of land will be displaced for the road alignment, and only about half of this area is forest land. The area to be cleared is not high-value habitat for threatened or endangered species.

Although adverse impacts to animal species on and around the project site will be minimal, new flight operations at Andersen may impact species inhabiting the outlying areas of the northern end of the island. Endangered fauna species such as the Mariana crow and the Mariana fruit bat nest and roost in the mature limestone forests located around Northwest Field and in the steep cliff areas north of the main air field. New operations such as the field-carrier landing practices (FCLPs) performed by the relocated VRC-50 squadron will extend out over these habitat areas. The FCLPs are normal flight practice procedures which attempt to simulate standard Navy aircraft carrier landing patterns. The required elevation for these training practices is 0 to 600 feet above ground level (AGL). The concern with the FCLPs at Andersen is that the low elevation of the exercises could disturb the birds and bats nesting and roosting in the habitat areas located beneath the flight paths (see Section 4.4.1).

The Mariana crow and the Mariana fruit bat were once abundant throughout Guam. However, predation by the introduced brown tree snake and the depletion of forests due to increased urbanization have caused the crow and bat populations to decrease dramatically in recent years. The crow population is down to about 50 individuals, while the bat population is somewhat more stable with approximately 300 to 350 individuals. The forests to the north and west of Andersen represent the last places on Guam where these species nest and roost.

Due to the possible conflict between FCLP operations and crow nesting and bat roosting behavior, the Navy carried out a six-month monitoring program to determine the effect of flight operations on these endangered species. The survey of territories and nesting/roosting sites began in August 1992, and the study of flight impacts on nesting behavior was initiated in December of 1992, the start of the Mariana crow nesting period. This

program was conducted by Navy and U.S. Fish and Wildlife Service biologists, in cooperation with the Guam Division of Aquatic and Wildlife Resources.

Findings of the nesting behavior study were inconclusive, so a two-year study will be funded to obtain the data necessary to make a determination on the impacts of the VRC-50 permanent relocation and operations on the breeding and foraging behavior of the Marina crow and Mariana fruit bat. The study will also seek to determine whether engine run-up noise and airfield lights affect these species. Efforts will be made to reduce low overflights at Andersen Air Force Base during the study period.

During the two-year monitoring program, VRC-50 will fly FCLPs on a controlled basis at Andersen Air Force Base in accordance with the terms and conditions of the Section 7 consultation, and as needed at NAS Agana. If the monitoring finds that flight activity has no significant adverse effects on the endangered species, VRC-50 FCLPs will be performed at Andersen permanently. If significant adverse effects are experienced as a result of the FCLPs, these landing practice exercises may be permanently transferred to NAS Agana. This issue is also covered in the Environmental Assessment for the Relocation of the VRC-50 Squadron to Andersen, prepared by Belt Collins & Associates for the U.S. Navy (Navy, 1992e; USFWS, 1992a).

4.4.3.2 Apra Harbor Complex

Tipalao Expansion Area, Northwest. The construction of housing or any other type of development in this area will modify this presently undisturbed parcel. Housing will be properly sited to avoid adverse impacts to the endangered tree species and limestone forest. No development will occur in the more sensitive area north of Haputo Road. Buffer zones will be established to further protect ecologically sensitive areas which contain a wide variety of native flora species. The Orote Point Ecological Reserve will be a minimum of 4,000 feet from the housing.

Tipalao Expansion Area, Northeast. Housing development in this area will pose no threat to any endangered plant or animal species. Wetlands in this parcel have been delineated to facilitate the construction of housing away from these areas (see Figure 2.3.12). The delineation, as presented in Appendix I, has been approved by the Corps of Engineers.

Although these wetlands are not listed in the *Mariana Common Moorhen Recovery Plan* (U.S. Department of Interior, Fish and Wildlife Service, September 1992) as either a primary or secondary habitat, it is possible that they might be used seasonally by moorhen. The endemic Mariana common moorhen *(Gallinula chloropus guami)* is listed as an endangered species, and habitat loss is considered the prime factor causing its decline in population. Mitigation would include fencing of the wetlands and establishing vegetated buffers of between 50 and 100 feet. These will provide both a physical and visual barrier from humans and potential predators.

4.4.3.3 Naval Magazine

Although the areas around the Tomahawk magazines and inert storehouse feature a wide variety of floral species, development in these areas will not have a significant impact on these species due to the current developed and disturbed state of the actual

sites. Impacts to the wetland area near the inert storehouse are not anticipated as it is located off the proposed construction site.

4.4.4 Cumulative Impacts

- **Construction Impacts.** Construction of new facilities at Andersen AFB, Apra Harbor, and Naval Magazine will further reduce the amount of open space areas on Guam. Although the total area of new construction is relatively small and will take place in previously developed and second growth areas that are less significant for species survival and diversity, any depletion of open space is notable on an island with limited land area such as Guam. Faunal species diversity will not be directly affected by the proposed actions. In an effort to minimize the number of altered habitat areas, careful consideration has been given to the siting of the new facilities so that, with a few exceptions, most of them will be placed on land that had been previously disturbed or used for some other function.

- **Impacts on Mariana Common Moorhen.** Section 4.16.4 of this document addresses the cumulative potable water demand due to the relocation. In its comments on the DEIS, the U.S. Fish and Wildlife Service questioned whether increased water withdrawal from Fena Reservoir may negatively impact endangered Mariana common moorhen. The Mariana Common Moorhen Recovery Plan (U.S. Department of Interior, Fish and Wildlife Service, September 1992) identifies Fena Reservoir as a "primary" habitat for moorhen. Fringes of portions of the reservoir provide good habitat for moorhen, but steep banks and deep water over most of the reservoir limit its habitat potential.

  Potable water demand due to the relocation is estimated to increase by 4.0 percent during the wet season and 4.8 percent during the dry season. In the worst case scenario—complete drought conditions over a seven month period—the new demand would represent an estimated 5.8 percent of capacity. If there is no inflow into Fena Reservoir for one month, water level is estimated to decrease anywhere between three to four inches, depending on conditions. A 3.5-inch monthly drawdown for seven months of the year would result in a decrease in water level of slightly over two feet. Total reservoir drawdown, including rollback demand during drought conditions, is approximately 5 feet per month. The effect on the actual reservoir level varies and is dependent upon the level of the reservoir before drought conditions began. This is expected to have either no impact or a positive impact on moorhen if it provides more shallow water areas that could be used as feeding and nesting habitat. The DAWR biologist who is knowledgeable about moorhen at Fena Reservoir concurs that lower water levels provide better moorhen habitat by exposing flats on the southern end of the reservoir that is used for feeding, nesting, and loafing (personal communication with Tim Sutterfield, Navy Biologist, June 26, 1993).

- **Brown Tree Snake Export.** The increase in military activities on Guam due to the relocation may increase the probability of brown tree snake introductions to other locations. Pacific islands such as Saipan, Tinian, and Hawaii are particularly vulnerable to such incursions. All military aircraft and ocean vessels departing Guam are currently inspected for brown tree snakes by trained military customs personnel. Adequate inspection staff is available to handle the increase in aircraft

and ship traffic associated with the relocation. Funding has been provided to the Department of Agriculture Animal Damage Control unit to assist military customs staff with brown tree snake inspections using dogs trained in snake detection.

- **Introduction of Non-native Species.** There is concern that the relocations activities will result in introduction of non-native species into Guam's terrestrial environment (for example, plants and insects). All aircraft and ships arriving in Guam—both civilian and military—are subject to customs and agricultural regulations and inspection procedures. In cooperation with civilian government officials, the U.S. military provides personnel to inspect incoming military aircraft and vessels. The existing regulations and procedures are adequate to control the introduction of non-native species into Guam's terrestrial environment.

4.5 WATER QUALITY

4.5.1 Existing Conditions, Standards, and Classifications of Guam's Waters

4.5.1.1 Groundwater

Guam, unlike many other areas in the Pacific, has very high quality basal and parabasal groundwater aquifers in the northern region of the island. The extent of these aquifers has already been reasonably defined. Groundwater from these northern aquifers supplies 70 percent of the island's potable water. The Northern Lens Aquifer has been designated as a principal source aquifer under the Federal Safe Drinking Water Act (SDWA). The Guam Environmental Protection Agency (GEPA) has developed a Groundwater Management Program to protect these aquifers. This and other related measures were incorporated into Guam's Groundwater Management Act, which ties together all related legislation that relates to, benefits, or protects groundwater resources (GEPA, 1990).

In 1985, the GEPA completed a three-year comprehensive study of the island's groundwater resources, based on the routine monitoring of Guam's 115 wells. Both quantity and quality were studied. Analysis of well water for 142 priority pollutants showed Guam's groundwater to be remarkably clean. Although the drinking water from the aquifer resources is moderately high in calcium and manganese carbonates, dissolved by rainwater as it percolates through the coral aquifer, it is unusually free from all other contaminants, both organic and inorganic. Some instances of saltwater intrusion continue to occur due to over-pumping near coastal waters (GEPA, 1990). Guam's groundwater contains 0.5 to 2.5 ppm nitrate nitrogen, well below the minimum contaminant levels established by the Safe Drinking Water Act. Every year, half of the wells drawing from the lens are monitored for the constituents identified in the SDWA. Generally, results of this sampling continue to verify that the groundwater is well below recommended Maximum Contaminant Levels (MCLs) established by the SDWA (GEPA, 1990).

In 1989, there was some concern about concentrations of heavy metals such as lead, selenium, cadmium, and mercury in surface impoundments in the Andersen AFB area, but those concentrations have been decreasing since 1990 (GEPA, 1992). GEPA officials expect the concentrations of contaminants in the island's groundwater to continue to decrease over time because most of the contaminants, especially the heavy metals, were introduced to Andersen AFB during and immediately following World War II

when there were no restrictions to their use. With continued enforcement of appropriate regulations, the GEPA expects groundwater sources on Guam to continue to improve.

4.5.1.2 Surface and Marine Waters

In order to maintain compliance with relevant federal and territorial legislation and regulations, the Guam Environmental Protection Agency (GEPA) began systematic sampling and analysis of territorial waters. Since 1978, river and marine complexes have been sampled for physical, chemical, and microbiological determinations. Findings and conclusions from these studies are published bi-annually in the Territory of Guam Water Quality Report 305(b). The 1990 305(b) is the most recently published edition of this report. It is used in this EIS to describe general water quality trends on Guam and provides the basis for the discussion of water quality impacts and proposed mitigation measures.

GEPA implemented a Water Monitoring Strategy for the Territory of Guam in 1978. Through this program, the major river drainage basins, reef flat, and marine reef areas are monitored monthly for 12 chemical and 4 physical measurements, together with weather observations. There are 36 marine, 14 reef flat, and 28 river sampling stations. Many of the stations are measured at multiple depths (GEPA, 1992).

Although significantly reduced at many locations as a result of a sewer construction grant program, bacteriological contamination still remains the major cause of surface water quality violations on Guam. The standard of 200 Colony Forming Units/100 ml (CFU/100 ml) has been established for Guam's recreational waters. This standard is based on the fecal coliform organism which is found in the feces of humans and most warm blooded animals. The public is advised not to fish or swim in waters with fecal counts of 200 CFU/100 ml or greater. High fecal coliform levels are found in many of the streams and storm drain discharges following heavy rains. The problem is caused by on-site sewage disposal overflows and animal wastes being carried into streams or storm drains by runoff. Almost all of the river stations have shown bacteriological violations at some time during 1988 and 1989. In 1988, 73 percent of the public beaches located close to river mouths exceeded the bacteriological standard at least 10 percent of the time. In 1989, 100 percent of the public beaches located close to river mouths exceeded the standard at least 10 percent of the time.

All of the marine and reef flat stations, except those adjacent to river mouths or sewage treatment plant outfalls, are relatively free of any fecal coliform contamination. Marine and reef flat station monitoring indicates that except for an occasional low dissolved oxygen level, all are generally within the limits set by the Water Quality Standards. The waters of Apra Harbor are classified as M-2 (good) and M-3 (fair) by the Guam Water Quality Standards. The quality of the water for many parameters is comparable to pristine marine areas classified as M-1 (excellent).

Non-point source runoff is often indicated by high residue or turbidity values in surface waters and can cause violations of EPA standards. Exceedances of EPA ambient water quality standards on Guam are often a result of heavy silt loads carried by rivers in the south following periods of heavy rain. Although some erosion is natural, a majority is associated with human activities such as development and farming. Another major

factor influencing siltation is the excessive grassland fires which occur in southern Guam. The repeated fires on the southern hillsides, most of them intentionally set, have denuded many areas and exposed them to erosion (GEPA, 1992).

Another pollution problem is the occasional discharge of oil and toxic materials into waters of the territory. These discharges may occur from agricultural runoff, storm drains, industrial discharges, vehicles, and seagoing vessels.

4.5.2 Potential Impacts and Proposed Mitigation Measures

4.5.2.1 Groundwater

Groundwater resource protection is most important in the Northern Lens area. No proposed activity increases or facilities at Andersen will adversely impact aquifer recharge areas. Therefore, there are no foreseeable impacts to the groundwater resources of the Northern Lens Aquifer from increased military activities and construction.

4.5.2.2 Surface and Marine Waters

Potential surface and marine water impacts exist from the construction of new facilities at the Apra Harbor Complex and at the Naval Magazine. The proposed facilities will call for an increase in industrial space, paved areas, and other impermeable surfaces that may increase runoff. This additional runoff has the potential to become contaminated by chemicals, sediments, and other pollutants as it flows over these surfaces and enters streams and other receiving water bodies. This problem will be especially apparent during construction.

As a general practice, storm sewers remain separated from sanitary sewers to avoid storm surge and capacity problems, and storm waters remain untreated. Unchecked urban or agricultural runoff that enters storm sewers may carry sediments and other contaminants that can enter and pollute receiving waters. Apra Harbor is the receiving water body for much of the urban runoff from Orote Point, the site of many proposed construction projects. To mitigate potential impacts to Apra Harbor waters, careful measures will be taken by construction contractors to retain runoff waters onsite. This can be accomplished through the use of filter cloth retention walls, berms, temporary drainage swales, or retention basins around construction sites.

In addition to urban or agricultural runoff, the potential for environmental damage to the harbor waters exists as a result of oil spills and siltation resulting from construction or demolition. The increased use of Apra Harbor by the military and the expansion of the commercial port, with additional support facilities for fishing vessels, tankers, and container ships, will undoubtedly increase the risk of oil and other spills within the harbor. Such spills pose a significant hazard to the marine habitat within the intertidal areas of the harbor, such as mangroves and coral patch reefs. The impacts of spills will be mitigated through the implementation of the Navy's comprehensive Spill Prevention Control and Countermeasure Plan (SPCC).

Sites for facilities at the Naval Magazine will be located within the Tolaeyuus River Watershed. None of the proposed projects at the Naval Magazine include the use or addition of any aboveground storage tanks (ASTs), underground storage tanks (USTs),

underground injection wells, or other facilities or activities that could contaminate ground water resources in the Tolaeyuus Watershed. Runoff is collected and drained into a low lying sump area below the sites, northeast of the Fena Reservoir. Construction runoff will be filtered and handled to prevent any degradation of the wetlands qualities of this sump area. This can be accomplished by utilizing berms, swales, retention basins, and other BMPs during construction. No impacts to the surface waters emptying into the Fena Reservoir system are anticipated.

4.5.3 Cumulative Impacts

The increase in developed area on Orote Point and the increased activity in Apra Harbor and the commercial port resulting from the proposed actions could affect surface water quality in these areas. Methods to control non-point source pollution and storm water runoff will be incorporated in the various projects as they apply. In addition, the proposed actions will be carried out in conference with the Guam Bureau of Planning, which is charged with administering Coastal Management Program Consistency Certification. Measures will be taken to minimize construction runoff and prevent contaminants from newly developed facilities from entering receiving streams and Apra Harbor. In addition, harbor waters at greater risk of contamination from spills because of increased activity will be protected through continued implementation of the Navy's comprehensive SPCC plan.

4.6 MARINE ENVIRONMENT

In May 1992, two consultants conducted studies of the marine waters in and around Apra Harbor to determine the environmental impacts associated with the proposed facilities and activities on Guam. Sea Engineering, Inc. prepared a report entitled *Marine Environmental Impact Evaluation: Relocation of Facilities from Subic Bay Naval Base, Philippines to Apra Harbor, Guam,* and Marine Research Consultants (MRC) prepared *Marine Environmental Assessment in the Vicinity of the U.S. Naval Station, Guam Mariana Islands (Apra Harbor and Tipalao Bay).* Appendix F contains copies of these reports.

Note: When these studies were conducted, maintenance dredging of inner Apra Harbor was included as one of the proposed projects. The project was subsequently deleted from the scope of this EIS.

4.6.1 Existing Conditions at Apra Harbor

4.6.1.1 Physical Makeup

Environmental conditions in outer Apra Harbor range from heavily degraded and dredged areas to well developed coral reef habitats. The eastern side of the outer harbor is the area most heavily influenced by human activity. It consists of two land-filled peninsulas, heavily dredged areas, and various patch reefs. The sand and rubble cover indicates that the reefs experience periods of intense storm wave action capable of physical disruption and resuspension of sediments. Thus, the communities inhabiting the outer harbor are exposed to periodic sediment stress from natural causes (MRC, 1992).

The south side of the outer harbor is bounded by Orote Peninsula and a fringing reef along the entire shoreline, an exception being the land-filled eastern end. There is a steep slope in the outer harbor that levels out onto the harbor floor at a depth of more than 98 feet (30 meters). The deep area is bounded by the Calalan Bank to the west, Luminao Reef to the north, Orote Fringing Reef on the south, and by patch reefs known as Jade Shoals and Western Shoals to the east (see Figure 4.6.1). In general, the inter-tidal regions of outer Apra Harbor are composed of sand, gravel, and rubble, which thinly veneer an underlying reef rock pavement.

The inner harbor is bounded in the east by a narrow alluvial shoreline which supports various forms of vegetation, including mangroves. The western side consists of Naval Station facilities, mostly cement docks and wharves. Much of the inner harbor has been altered by dredging, and bottom composition is a combination of mud, sand, and mud intermixed with coral-mollusc rubble (MRC, 1992).

4.6.1.2 Water Quality and Sediment Composition

In May 1992, Marine Research Consultants conducted a water quality survey of both surface and deep waters at 12 sampling stations throughout inner and outer Apra Harbor. Turbidity values found in Apra Harbor are considered extremely low for harbor waters. In general, chemicals associated with water pollution follow a decreasing concentration gradient from the back of the inner harbor to the mouth of the outer harbor. Also, none of the dissolved nutrients sampled displayed any recognizable pattern with respect to surface and deep samples, suggesting that the water column is well mixed, and that the water column of the harbor is relatively uniform (MRC, 1992).

In addition, Marine Research Consultants conducted harbor sediment analyses at ten different stations throughout the harbor. The largest component of the samples was sand-sized particles larger than 63 micrometers in diameter. These particles comprised from 53 to 90 percent of sediments sampled. Heavy metal concentrations in the samples were considered elevated relative to natural crustal abundances, soils, and deep-sea sediments, and displayed decreasing concentrations moving seaward. However, these concentrations are not particularly elevated in terms of posing a pollution hazard (MRC, 1992).

4.6.1.3 Wind and Waves

The dominant winds affecting Guam are the east-northeast and southeast trades that blow about 70 percent of the time. These winds are strongest and most consistent during the months from January to April with common speeds of 10 to 20 knots. During the main typhoon season from July to October, winds are variable with frequent calms. Guam experiences strong northern winds and heavy rainfalls associated with typhoons approximately 1.1 times a year (Sea Engineering Inc., 1992).

The entrance to Apra Harbor is only exposed to deepwater waves from the west because it is protected from the easterly tradewind-generated waves which generally dominate the rest of Guam. Storm waves generated from the northwest to southwest are the most critical waves affecting the harbor. The commercial port is located at the far east end of the outer harbor and is well sheltered from any deepwater waves. However, it is subject to typhoon waves which may exceed five feet. Typhoon waves can

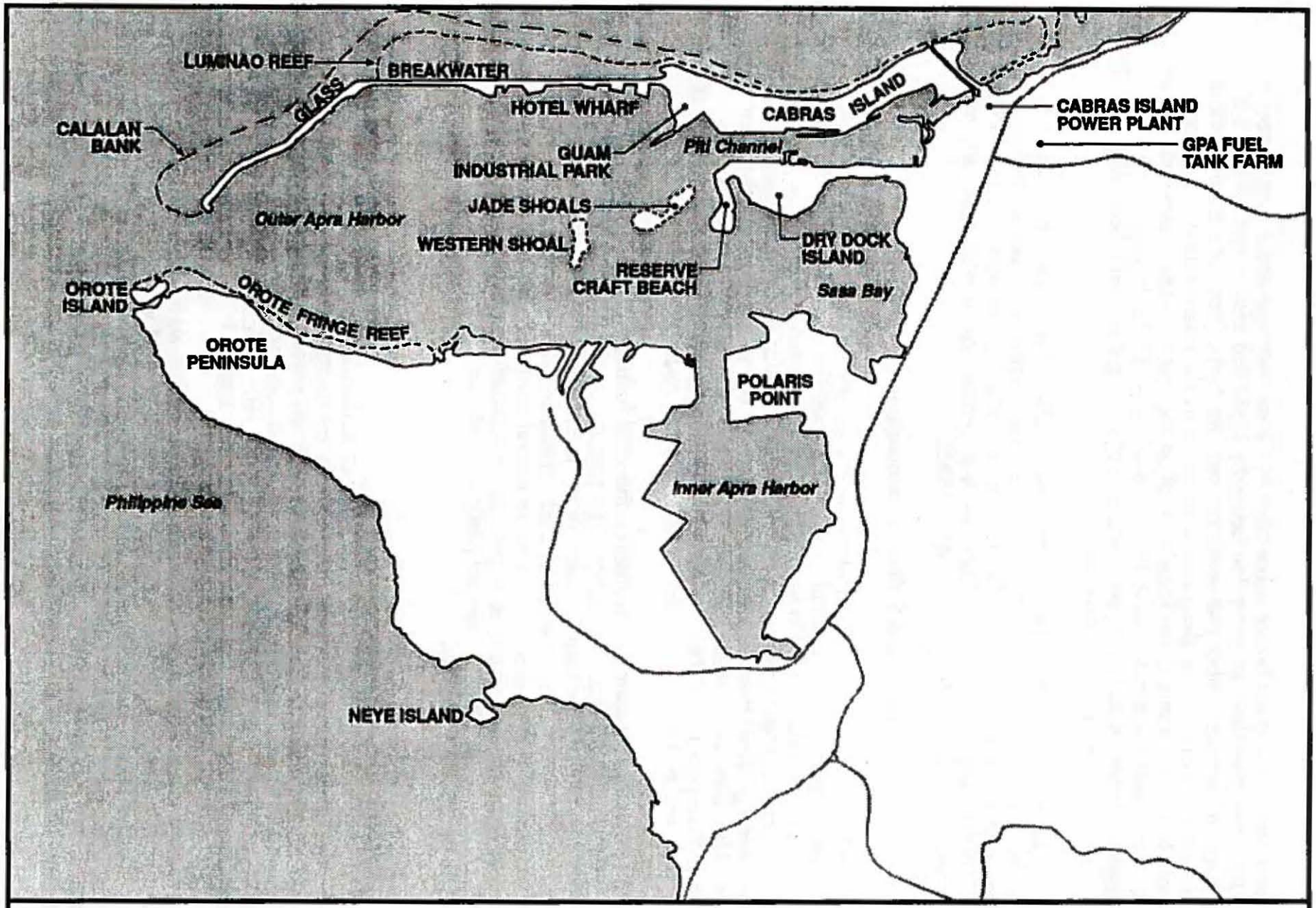

Figure 4.6.1
INNER AND OUTER APRA HARBOR
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have impacts on Apra Harbor even when the storm center is hundreds of miles away (Sea Engineering Inc., 1992).

The entrance channel to inner Apra Harbor is oriented so that most deepwater wave energy is prevented from entering. Waves in inner Apra Harbor are generated within the harbor and are a function of wind velocity. Therefore, strong northerly winds can generate high waves in the inner harbor.

4.6.1.4 Tides and Currents

Tide data shows that the mean tide range is 1.7 feet and the diurnal range is 2.4 feet. The extreme tides observed in Apra Harbor are +3.31 feet and -1.89 feet from the Mean Lower Low Water (MLLW). The tidal currents, tradewinds, and the westward flowing North Equatorial Current are the major factors affecting water circulation patterns around Guam. Within outer Apra Harbor there appears to be little tidal influence, and the majority of water movement appears to follow wind patterns. Water flow at the Commercial Port appears to be more tidal influenced, with currents moving into the port (eastward) during flood tides and moving out (westward) during ebb tides (Sea Engineering Inc., 1992).

A drogue study conducted by Sea Engineering Inc. in inner Apra Harbor indicates that circulation in the inner harbor is primarily controlled by wind, and that tidal currents are only important in the channel between the inner and outer harbor.

4.6.1.5 Marine Biota

The coral patch reefs in Apra Harbor are natural resources that attract many visitors and researchers each year. In addition to providing a habitat for a wide variety of corals and reef fish, the patch reefs in Apra Harbor are commonly covered with a fine layer of sand as well as benthic algae, various motile invertebrates, and a layer of coral rubble fragments. Coral growth and development is also rich along the lagoon slope and on sides of patch reefs. A predominant characteristic of these reefs is a uniform covering of fine sediment on most living and non-living surfaces (MRC, 1992).

Marine biota are also abundant in the Sumay Cove area. According to the 1992 Marine Research Consultants survey of the area, the biological communities inhabiting the bulkhead area consist primarily of two groups, corals and sea urchins. Dense strands of several species of "fire coral" or *Millepora* (*M. dichotoma, M. latifolia, M. platyphylla*) are the most common inhabitants of the vertical wall. In many areas, thickets of the corals are also growing on the sediment comprising the channel floor. Other than corals, the dominant fauna on the bulkhead and the channel floor are the long-spined sea urchins, *Diadema sp.* Numerous urchins were observed on the soft sediment channel floor, often in dense groups of several hundred individuals.

According to Gerald Davis of the Guam Division of Aquatic and Wildlife Resources (DAWR), a hawksbill turtle nest has been found inside Apra Harbor (Interview, April 22, 1992). In addition, both green and hawksbill turtles have been observed in Apra Harbor and Sumay Cove by DAWR biologists.

4.6.2 Potential Impacts and Proposed Mitigation Measures

4.6.2.1 Wastewater Treatment Plant Expansion

The increase in homeported ships and tempo of fleet operations associated with the proposed activities will affect the capacity of the existing sewage collection, treatment, and disposal system. Expansion of the Apra Harbor Sewage Treatment Plant (STP) is necessary to accommodate and ensure proper treatment and disposal of wastewater within the Naval complex. Modifications will consist of a new secondary clarifier, primary clarifier, biotower, waste sludge thickener, solids contactor, and drying beds; modify headworks, influent and effluent pump stations and contact tank; expand existing aeration and grit chamber facilities and secondary facilities building; and upgrade existing chlorination and dechlorination equipment. These changes will increase average capacity by 0.5 mgd. In a separate Government of Guam project, a new offshore diffuser will be constructed to replace the existing structure. The present average sewage discharge is 3.11 mgd (PACNAVENGCOM Code 18 memo 5090.A2, 8 Oct. 92). The increased activities associated with the military relocation is expected to increase the average discharge by 0.4 mgd.

Sewage from the Apra Harbor Complex is currently treated at the Apra Harbor Sewage Treatment Plant and then discharged through the North Tipalao Ocean Outfall, located northwest of Tipalao Bay. At the present time, primary treated effluent flows from the open outfall at the shoreline into the Philippine Sea. Underwater diffusers previously functioned to disperse the effluent offshore, but they have been destroyed by repeated tropical storm and typhoon waves. In 1978, C.E. Maguire, Inc. conducted an engineering evaluation of the existing outfall site and determined that the notch in the cliff where the outfall is currently located is geologically unstable, and that the notch formation magnifies wave energy during storm conditions. Maguire recommended that PUAG relocate the outfall to a point 700 feet to the east, through Tipalao Bay (see Figure 4.6.2). Construction of this new outfall has been accepted by Guam agencies as the best course of action. The ocean portion of the proposed outfall will be a 30-inch-diameter, 1,800-foot-long pipeline, including a 300-foot-long diffuser section. The diffuser will extend from the 90 to 120 foot depth and will be designed for an initial dilution of 100:1 (Sea Engineering, Inc., 1992).

In August of 1987, the U.S. EPA published a review of the proposed Agat and Santa Rita Area IV Wastewater Project, including the joint PUAG/Navy outfall line and diffuser, and found that there will be no significant impacts associated with the project, and that preparation of an Environmental Impact Statement is not necessary (EPA, 1987).

Until the new diffuser is constructed, the increased effluent volume will, at least temporarily, be discharged through the existing system. To understand the effects of existing effluent discharge and to evaluate potential impacts of the proposed wastewater facility, studies of area water quality and oceanographic conditions were conducted by Marine Research Consultants and Sea Engineering, Inc.

The existing discharge from the damaged North Tipalao ocean outfall is not in compliance with Guam water quality standards. However, it is not considered practical to attempt to repair the existing outfall before the new one is completed. Both the

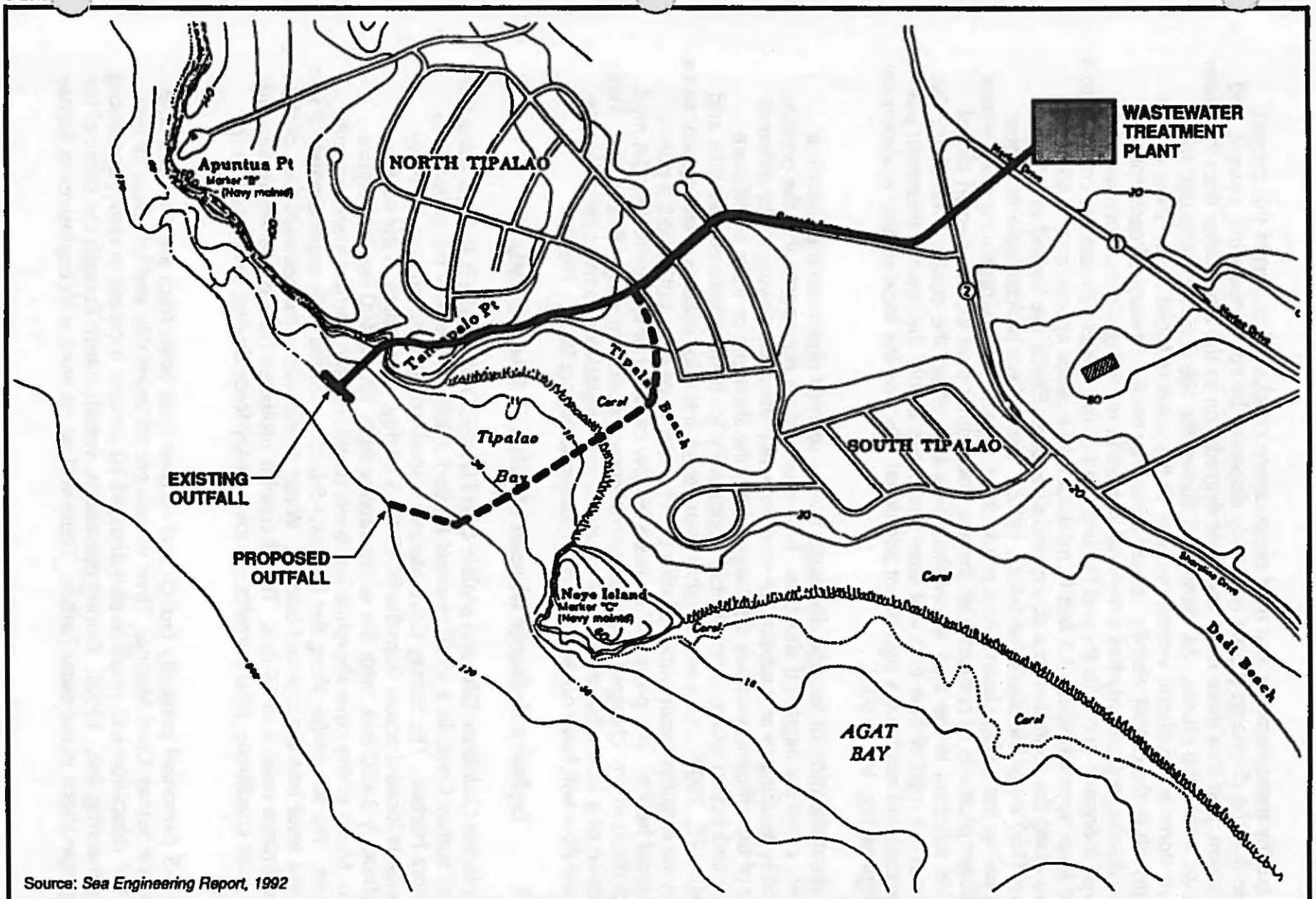

Figure 4.6.2
EXISTING AND PROPOSED OUTFALL LOCATIONS—TIPILAO BAY
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water quality measurements and field observations conducted as part of this project indicate that the discharge plume is quickly dispersed by combined wind, current, and wave action, and that there is no apparent degradation to the area, other than the water condition within the plume. As mentioned above, the site is directly exposed to frequent storm and typhoon waves, and due to the wave induced scour, there is little coral growth in the outfall vicinity. Based on survey results, sewage effluent from the severed discharge pipe only has a minimal impact to receiving waters. Increase in dissolved inorganic nutrients (N and P) contained in the effluent stream are confined to a surface layer approximately 3.3 feet (1 m) thick that extends approximately 492 feet (150 m) along the shoreline in a downwind direction. Effects are limited to within 328 feet (100 m) of the shoreline (MRC, 1992). Little effect is detectable in deeper waters below the surface layer. As a result, there appears to be virtually no areas where the effluent plume is in contact with the sea floor, other than the submerged cliffed shoreline adjacent to the area where the effluent jet enters the ocean. Therefore, the additional 0.4 mgd of flow that will enter the ocean before the sewage treatment plant is expanded will not have a significant additional effect on the local marine environment (Sea Engineering, Inc., 1992).

The present situation of sewage discharge from a severed pipe onto the shoreline definitely creates a degraded situation. However, it does not appear that the present scenario is resulting in any substantial environmental impacts. Owing to the different density of the effluent (whether discharged from the shoreline or from an offshore diffuser) and ocean water, there is little opportunity for contact between benthos and effluent (MRC, 1992). As a result, other than visual and odor impacts, there appear to be virtually no negative environmental effects. The discharge does not impact a public recreational beach. The proposed increase in flow capacity of approximately 0.4 mgd will not result in any change in the situation observed during the May 1992 survey. With completion of a new offshore diffuser structure and upgraded treatment facilities, the increased flow will have no negative environmental impact (MRC, 1992).

4.6.2.2 Explosive Ordnance Disposal Mobile Unit Five (EODMU-5)

The Explosive Ordnance Disposal Mobile Unit Five (EODMU-5) site is located along the banks of Sumay Cove, in a small channel located 3,000 feet west of the entrance to inner Apra Harbor. The Sumay Cove Marina, a small recreational marina for Navy personnel, is located across from the EODMU-5 facility. The length of the cove is approximately 3,000 feet, with the width varying from 125 to 400 feet (see Figure 2.3.11). Much of the cove shoreline has been stabilized with vertical steel sheetpile bulkhead. The sheetpiles along the EODMU-5 facility extend from approximately 8 feet above sea level into the channel bottom. Water depths along the seaward face of the bulkhead range from 5 to 15 feet. The channel is protected from prevailing tradewinds. Under most conditions, tidal currents are the primary force driving circulation in the channel.

EODMU-5 personnel presently launch and recover their boats from the one-lane boat ramp at the Sumay Cove Marina. Their vessels are all trailerable and less than 28 feet long. The relocation will result in an estimated 10 percent increase in vessel operations (Sea Engineering, Inc., 1992). During operations, vessels transit through the channel for training operations in the outer harbor. There will be no work with explosives in Sumay Cove.

The proposed construction consists of repairing or replacing the sheetpile bulkhead. If this is not done, the vertical bank will be considered "unstabilized" and facilities will have to be located a safe distance (50 to 100 feet) inshore (Sea Engineering, Inc., 1992). The repair would involve driving sheet piles in front of the existing sheet piles, filling the space in between with either gravel or concrete, and putting concrete caps on top of the new piles. This will retard further corrosion in the splash zone, which is the most susceptible area. A boat ramp will be provided. In addition, EODMU-5 plans to moor a causeway section along the bulkhead to facilitate operations.

The proposed construction and operational activities related to the EODMU-5 facility do not pose any long-term environmental impacts. Repair or replacement of the bulkhead will generate temporary turbidity, but it will not be extensive, and given the extremely slow currents, most suspended solids will settle in the immediate area (Sea Engineering, Inc., 1992). Based on the visual survey of the bottom of the Sumay Cove channel, it does not appear that any of the biotic components inhabiting the area represent rare or unique resources. During repair, best management practices will be applied as practical to limit the impacts to nearby biotic communities. If they are adversely impacted by restoration of the bulkhead, recolonization will eventually restore the area to its present state (MRC, 1992). Because of the presence of green and hawksbill turtles in the harbor, in-water work on the bulkhead will be prohibited during turtle nesting season (April-September). Dryland work such as backfilling and capping of the new piling will be permitted during this period.

EODMU-5 personnel will conduct Mine Counter Measure (MCM) training operations in outer Apra Harbor up to eight times a year, and each training session will last one week or less. The exercises will consist of raising mines from the area between explosives anchorage No. 701 and Naval Anchorage 'A' No. 951 and towing them along an assigned track to a beaching and disarming site at Reserve Craft Beach on Dry Dock Island (see Figure 4.6.1). The use of explosives in the exercises would be to stabilize the underwater mines (20 lb. charges) or to remove the mooring cables from underwater mines for disarmament (2 lb. charges). Any detonation will be made at depths of 100 to 140 feet, and the exercise scenario at the time of the exercises will determine which of the explosives will be detonated. No actual mines will be detonated during the training (transmittal from CONNAVMAR to PACDIVNAVFACENGCOM, November 5, 1992).

In 1991, similar explosives detonation exercises (without mine beaching) were reviewed by the GEPA, the Division of Aquatic and Wildlife Resources (DAWR) of the Department of Agriculture, the Army Corps of Engineers, and the Guam Historic Preservation Officer. This review followed the submission of an environmental review describing the proposed actions and mitigation measures to be taken to limit impacts to the environment. The explosive anchorage site where the training is proposed is the same as it was in 1991, and is designated as an area for anchorage and explosive anchorage. Naval divers inspected the site and surrounding area to a depth of 140 feet on August 16, 1991. They observed only muddy harbor floor with no coral growth or significant fisheries habitat. Although turtles and other fish species have been observed foraging throughout Apra Harbor, the proposed demolition area is not considered a significant feeding ground or known fisheries habitat. The nearest coral reefs are at a safe distance of 500 yards south of the anchorage area. The nearest historic site in Apra Harbor is the shipwreck *S.M.S. Cormoran* located about 1 nautical mile northwest of the proposed site (Navy, 1991c).

The difference between the 1991 explosives training and the proposed training activities is the towing of mines and beaching them on Dry Dock Island. PWC Guam prepared an updated (April 24, 1992) environmental review dealing with the new mine beaching activities. An underwater survey concentrating on the Dry Dock Island beach area was conducted on March 16, 1992, and it was determined that the beaching site has no obstructions or coral growths. Appropriate mitigation measures will be taken to ensure that the proposed MCM training will have no significant adverse impacts upon the Apra Harbor environment. Consultation with the National Marine Fisheries Service regarding endangered species (turtles) has been carried out.

The Navy realizes the potential impacts that demolition exercises may have upon turtles and other marine species in Apra Harbor, and has gone through a Section 7 consultation with the National Marine Fisheries Service to gain approval for the proposed exercises, as well as any mitigation measures that must be applied. Mitigation measures include notification of GEPA and DAWR at least one week in advance and allowing unrestricted on-site review of the training exercises. Also, a Notice to Mariners will be published by the U.S. Coast Guard prior to the proposed action to ensure safety to boaters and SCUBA divers. On-site spotter boats will be used to provide warnings of hazards and to check for turtles in the hazard area before authorizing detonation. Drag marks from the mine towing and beaching will be smoothed out after the exercise and the beach will be restored to its original condition.

4.6.2.3 Naval Special Warfare Unit One (NSWU-1)

The NSWU-1 marine operations will be based in inner Apra Harbor, along a 780-foot-long section of Wharves V-1 and V-2. There will be an increase in boat moorings and wharf activity associated with the NSWU-1 relocation. Their vessels include several inflatable boats, two 36-foot light landing craft, three 65-foot Riverine Patrol Boats (PBRs), and several smaller vessels in the 24 to 35 foot size range. As part of a separate mission expansion and procurement, two 170 foot coastal patrol boats will be assigned to the unit within the next few years. There will also be two 90-foot floating causeway sections moored to the wharves. During normal conditions, the causeways will be moored to the bulkhead, and the other vessels moored to either the causeway sections or the bulkhead (Sea Engineering, Inc., 1992). The introduction of these causeways will not cause any loss of berthing space for other ships.

During typhoon alerts, the coastal patrol boats, the PBRs, and the causeway sections will be moored to designated typhoon buoys in either the inner or the outer harbor. NSWU-1 has requested that additional typhoon moorings be assigned them to accommodate their requirements. All other vessels will be lifted out of the water and secured on land during typhoons. The only other NSWU-1 activity in outer Apra Harbor, other than the passage to outside destinations, will be dive training operations similar to those conducted by the EODMU-5.

4.6.2.4 Additional Moorings

As a result of the relocation activities, three new typhoon moorings will be placed in the inner harbor in Naval Anchorage Areas A and B. Also, a new typhoon mooring will be placed in the outer harbor, and an existing one will be relocated. The introduction of any new swing moorings will temporarily increase turbidity and could cause severe

damage to corals and other benthic organisms within the drag chain radius. Therefore, they will be designed in accordance to the specifications in Naval Design Manuals DM 26.5 and 26.6, and placed to insure minimal impacts. The moorings to be placed in the inner harbor will be designed and placed according to an Army Corps of Engineers permit filed by PWC Guam. Mooring work in the outer harbor will take place in consultation with the GEPA, who will review mooring placement plans before work begins.

4.6.3 Other Impacts/Cumulative Impacts

In addition to the above mentioned impacts, there is the possibility of further sediment intrusion into marine waters during construction of the proposed facilities. Since many of these projects are in close proximity to one another, and are on or near the shoreline, erosion runoff from construction sites could potentially enter marine waters. However, given the high infiltration rates of the lowlands surrounding Apra Harbor, basic actions can be taken to control erosion. Possible mitigation measures include the use of detention basins, drainage swales, and other best management practices to prevent runoff and sediments from moving offsite.

Guam's marine waters are also susceptible to direct pollution from oil and other spills associated with ship and marina activity around the island. The Ship Repair Facility (SRF), Navy Supply Depot (NSD), and the Public Works Center (PWC) have extensive fuel and oil storage/service systems that service all military craft within Apra Harbor. Any fuel operations have the potential for discharge of contaminants in harmful quantities into navigable waters. A SPCC plan outlines the procedures to prevent spills, and to correct them should they occur. This plan is discussed in more detail in Section 4.21 on Hazardous Waste. Increased prevention measures will be developed, such as additional training of personnel in spill prevention and cleanup, to avoid spills.

There will be an increase in recreational craft activity in Apra Harbor as an increased number of Naval personnel associated with the proposed activities use and launch boats from the Sumay Cove Marina. Currently, there are a limited number of permanent slips and moorings in the cove, which are held by residents and boat rental or charter companies. Since there is no expansion of recreational mooring capacity planned for Sumay Cove, the increase in activity in the marina area will be from increased use of rental or charter vessels or launchings of private vessels from the boat ramp.

Potential impacts to marine biota arise as the number of ships arriving at both the commercial port and Naval Station increases. Any ships entering Guam from foreign ports may carry unwanted pathogens or marine organisms in the form of pelagic larvae, embryos, or eggs in the water in their ballast tanks. Some of these organisms may be considered pests and have the potential to compete with and intrude upon the existing marine organisms in Apra Harbor and other coastal areas. This has the potential to alter the marine community structure around Guam. One of the main ways in which ships can prevent foreign organisms from entering the coastal marine waters of Guam is to pump and exchange ballast water in the ocean, prior to entering an exclusionary zone around the port of entry. There are currently no regulations or policies in place at the national or territorial level to address this issue. Navy vessels represent only a relatively small percentage of the overall ship traffic to Guam. Therefore, initiatives to deal with this potential problem will need to be cooperative and encompass both military and commercial shipping. Individual states and territories have the prerogative to deal with

this issue on a local or regional level. In Hawaii, for example, Governor Waihee is considering convening a task force to seek solutions for the state, and the Navy is funding a research project to provide baseline data on existing organisms in Pearl Harbor.

Anchor chain damage to coral reefs also needs to be prevented, where possible, given the increased number of vessels using the harbor. There has been particular concern about previous damage to Sponge Mound from anchors and chains. Mitigation includes the placement of moorings away from reef areas.

4.7 AIR QUALITY

4.7.1 Air Monitoring

According to the Guam Environmental Protection Agency (GEPA), the Territory of Guam does not have any of the more serious air pollution problems evident in the urban and industrial areas on the Continental United States. This can be attributed to three factors: (1) the small size of the island, (2) the lack of major industrial point source emitters, and (3) the consistent easterly tradewinds. However, there are significant emission sources of particulate matter of less than ten micrograms (μg) in size (PM10) and sulfur dioxide (SO_2), which necessitate an air monitoring program to measure ambient air quality levels and trends (GEPA, 1991).

Major point sources of emissions within the Territory of Guam are the fossil-fuel power generating facilities operated by the Guam Power Authority. These facilities include the base load power plants at Tanguisson, Cabras, and Piti on the western coastline of the island. Assorted smaller power generating units are extensively used in both the military and civilian communities. These diesel powered units contribute as minor sources of less than 100 tons per year of SO_2 emissions.

The GEPA maintains SO_2 monitoring equipment at three locations and PM10 equipment at five sampling stations as part of the State and Local Air Monitoring System (SLAMS). These monitoring stations are intended to be operated on a 24-hour schedule, five times a month, approximately six days apart. However, equipment malfunctions have resulted in data being collected only intermittently (GEPA, 1991).

In addition to the SLAMS network, GEPA operates continuous SO_2 sampling stations in the Piti area and in the Harmon village area near the Tanguisson plant. The Navy also operates SO_2 and PM10 sampling equipment at the Piti Marina for emission level monitoring of the Piti and Cabras plants.

4.7.2 Ambient Air Quality Standards

The U.S. EPA and the Guam EPA have promulgated ambient air quality standards pursuant to the federal Clean Air Act. The National Ambient Air Quality Standards (NAAQS) are divided into primary and secondary standards. Primary standards are intended to protect public health with an adequate margin of safety, while secondary standards are intended to protect public welfare through the prevention of damage to soils, water, vegetation, man-made materials, animals, wildlife, visibility, climate, and economic values. Short-term national standards (eg. one-hour, three-hour, etc.) may be exceeded once per year.

Guam standards are more stringent than the national standards for some categories (annual SO_2 and 1-hour photochemical oxidants), but are less stringent in other categories (annual nitrogen dioxide). A comparison of the national and Guam standards is contained in Table 4.7.1.

Table 4.7.1

Comparison of National and Guam Ambient Air Quality Standards

Pollutant	Averaging Period	Concentrations ($\mu g/m^3$)		
		NAAQS	Class II PSD Increments	Guam
Sulfur Dioxide/Sulfur Oxides	Annual	80	20	60
	24-hour	365	91	365
	4-hour			650
	3-hour	1,300	512	1,300
Particulate Matter < 10 micrograms	Annual	50		60
	24-hour	150		150
	8-hour			360
Total Suspended Particulates	Annual		19	
	24-hour		37	
Nitrogen Dioxide/Nitrogen Oxides	Annual	100	25	160
Carbon Monoxide	8-hour	10,000		10,000
	1-hour	40,000		40,000
Lead	Quarterly	1.5		
Hydrocarbons	3-hour			160

In addition to the ambient air quality standards, new major sources being proposed in attainment or unclassified areas are subject to pre-construction review under the Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act, and thus to ambient air increments for PM10, SO_2, and NO_2. Unless subsequently redesignated, all attainment areas were initially established as Class II areas by the Clean Air Act and are subject to the Class II standards contained in Table 4.7.1. The PSD rules also require one year of pre-construction continuous air monitoring if certain "de minimus" levels are exceeded. These levels are shown in Table 4.7.2.

Table 4.7.2

PSD Pre-Construction Air Monitoring De Minimus Levels

Pollutant	Averaging Period	Concentration ($\mu g/m^3$)
Particulate Matter	24-hour	10
Sulfur Dioxide	24-hour	13
Nitrogen Dioxide	24-hour	14
Carbon Monoxide	8-hour	575
Ozone	see note*	
Lead	3-month	0.1
Mercury	24-hour	0.25
Beryllium	24-hour	0.001
Fluorides	24-hour	0.25
Vinyl Chloride	24-hour	15
Total Reduced Sulfur	24-hour	10
Hydrogen Sulfide	1-hour	0.2
Reduced Sulfur Compounds	1-hour	10

* No ambient concentration specified. If source emits more than 100 tons per year of volatile organic compounds, then air monitoring must be conducted.

4.7.3 Existing Conditions

The nearest monitors for SO_2 and PM10 are over two miles northeast of the Orote plant in the Piti/Cabras area. Recent data from a Navy-operated station near Piti showed no violations of national ambient air quality standards; however, they do indicate violations of the Guam 24-hour particulate standard (Morrow, 1992) There are no air monitoring stations in the immediate vicinity of the Orote Power Plant in the Apra Harbor Complex, site of the proposed 18-MW power plant expansion project. However, since the power plants in the Piti/Cabras area, which are much larger than the Orote plant, show compliance with the NAAQS, it is reasonable to assume that Orote is also in compliance.

Due to past violations of the air quality standards, the U.S. EPA has designated the area within an approximately two-mile radius of the Piti and Cabras power plants as non-attainment for SO_2, and thus subject to stringent emission control requirements. The Orote Power Plant is outside this designated non-attainment area.

4.7.4 Future Conditions

The Navy proposes expand upon the existing Orote Power Plant by installing three additional 6-MW diesel generating units. Due to the necessity to comply with the federal Clean Air Act and local Guam air pollution control requirements, a study of baseline air quality impacts associated with the proposed project was conducted by J.W. Morrow, Environmental Management Consultant (see Appendix G), using preliminary design information. This study assesses potential air quality impacts before

application of raised stacks and other BACT, and then identifies mitigation measures which may be necessary to insure regulatory compliance.

To determine effects upon air quality, dispersion modeling was performed using the EPA's Industrial Source Complex-Short-Term Model. The modeling incorporated existing operating procedures, meteorological conditions, and baseline plant performance parameters, including 43-foot stack height and 1 percent sulfur fuel. A full discussion of the methodology and inputs used for this model are contained in Appendix G.

Estimates of annual emissions from the existing plant and the proposed plant expansion under base line parameters are presented in Table 4.7.3. Also shown are the net emissions should the three new units completely replace the existing plant. These emissions indicate that the proposed plant would be considered a new "major source," because SO_2 and NOx emissions exceed 250 tons per year, or a "major modification" should it replace the old plant because net emissions of CO, SO_2, NOx, and PM are "significant." In either event, it would be subject to PSD review and would require one-year of pre-construction continuous air monitoring.

Table 4.7.4 shows the results from modeling baseline parameters to determine compliance with the air quality standards and the PSD Class II increments. When compared to the standards shown in Table 4.7.1 above, the results show compliance with the NAAQS and the Guam AQS. Due to the prevailing northeasterly winds and the short stacks at Orote, the area of maximum impact would be located approximately 325 feet southwest of the plant site.

Table 4.7.3
Estimates of Annual Emissions for Orote Power Plant
(Tons per Year)

Pollutant	Existing	Expansion	Net
Carbon Monoxide	61	448	388
Nitrogen Oxide	233	1,735	1,492
Sulfur Dioxide	70	517	447
Particulate Matter	23	172	149
Volatile Organic Compounds	6	45	39

Under baseline performance conditions, the plant will be in violation of the PSD Class II increments. Modeling of the proposed new plant with or without the continuation of the existing Orote units showed an anticipated exceedance of the 24-hour PM and SO_2 increments. Since the power plant must comply with increment limitations as part of its PSD permitting process, modifications to baseline performance conditions were modeled to determine mitigations needed to comply with the increment limitations.

Table 4.7.4
Results of Modeling to Determine Compliance with Air Quality Standards

Pollutant	Averaging Period	Second Highest Concentration ($\mu g/m^3$)	
		Air Quality	Class II PSD
Sulfur Dioxide	3-hour	520	632
	24-hour	243	211
	Annual	27	15
Particulate Matter < 10 µg	24-hour	51	70
	Annual	7	5
Nitrogen Dioxide	Annual	6	5

Baseline modeling also showed that the new plant expansion appears capable of "significantly" impacting the Piti non-attainment area during times when winds are blowing from the southwest. It should be noted, however, that under such wind conditions, the emissions from the Cabras and Piti power plants would be blowing away from the modeled impact area and would not be contributing to any cumulative impact. Therefore, it can be concluded that exceedance of ambient air quality standards for non-attainment areas would not occur under "real" conditions.

The redesignation of the area around Piti and Cabras plants from a non-attainment area to an attainment area is an issue that is currently being reviewed by the EPA. In conjunction with this, the Navy and the Guam Power Authority (GPA) have submitted a joint petition requesting a waiver from non-attainment requirements (construction ban, Lowest Achievable Emission Rate, and Offsets) currently in effect for the Cabras-Piti area.

4.7.5 Cumulative Impacts

The proposed expansion of the Orote Power Plant appears capable of complying with the National Ambient Air Quality Standards and the Guam Air Quality Standards. Emissions analysis indicates that the proposed expansion would create a "major source" within an attainment area and would be subject to Prevention of Significant Deterioration (PSD) review. The modeling analysis indicates that the de minimus levels would be exceeded, thus requiring one year of pre-construction continuous air monitoring. A request to waive the one year pre-construction monitoring (but not post-construction) requirement has been submitted to the EPA and is awaiting approval.

Further analysis of the proposed Orote expansion using EPA Industrial Source Complex (ISC) model indicates that PSD Class II SO_2 increment limitations can be met by changing conditions of use of existing Orote units, stack heights of the new units, percent load, and percent sulfur fuel used.

Other possible mitigation includes:

- Implementing enforceable limitations on operating hours of fuel consumption.
- Emission controls that may be installed as BACT to meet PSD requirements.

4.8 NOISE

4.8.1 Andersen Air Force Base

Information on noise conditions and impacts at Andersen Air Force Base is derived from the *Environmental Assessment for the Temporary Relocation of Fleet Logistics Support Squadron Five Zero (VRC-50) to Andersen Air Force Base, Territory of Guam* (Navy, 1992e).

4.8.1.1 Existing Conditions

Prior to 1990, Andersen was the base of operations for conventional B-52 bombers, KC-10s, and KC-135s of the Pacific Tanker Task Force, and transient fighter, bomber, and cargo aircraft. While the B-52s were based at Andersen, the urbanized areas of Dededo, Yigo, Tumon, Naval Communications Housing, and Andersen South were outside the noise contours. Family housing areas fell mostly outside the 65 Day Night Average Sound Level (Ldn) contour and some were located in the 65-70 Ldn contour.

With deactivation of the B-52 squadron in 1990, the average monthly operations at Andersen were cut approximately in half. The projected 1990 noise levels at Andersen after the departure of the B-52s as calculated in the *Final Environmental Assessment Inactivation of the 43rd Bombardment Wing, Andersen Air Force Base, Guam, January 1990* are depicted in Figure 4.8.1. Since then, transient activity has increased by about 30 percent. Therefore, the noise contours slightly underestimate the exposure to aircraft noise of the surrounding lands prior to the relocation of VRC-50 (see Figure 4.8.1). The increase in transient operations in recent years would represent increased noise levels in the northeast and southwest areas of Andersen. Also omitted from the 1990 modeled noise environment are the training operations of aircraft based at NAS Agana, including H-46 helicopters and P-3s, conducted at Andersen. These aircraft primarily conduct left-hand patterns off of Runway 6R/24L and fly a touch and go pattern (T&G) over the ocean and the forested area north of the airfield. Therefore, it is expected that the present noise contours would extend farther to the north than shown by the 1990 noise contours.

4.8.1.2 Potential Impacts and Mitigation

Aircraft Operations. VRC-50's aircraft include three C-130s, nine C-2As, and five US-3As. Flight operations include arrivals, departures, touch and gos, and FCLPs. The majority of the operations consist of training activities, primarily FCLPs performed by the C-2A and US-3A aircraft. These maneuvers attempt to simulate realistic Navy aircraft carrier landing patterns and are part of standard training requirements for pilots supporting aircraft carriers. The standard FCLP consists of flying altitudes between 0 and 600 feet above ground level (AGL). However, Andersen's use as the permanent location for these flight operations will depend on the results of studies to determine effects of FCLPs on the endangered Mariana crow and Mariana fruit bat.

A study was performed by Y. Ebisu & Associates as part of the environmental assessment referenced above (Navy, 1992e) to evaluate potential noise impacts associated with VRC-50 flight operations at Andersen AFB. Noise contours show that VRC-50 flights will not increase the Ldn noise levels northeast, southwest, or south of the airfield from the

1990 levels (see Figure 4.8.2.) Noise sensitive areas south of the airfield's runways will still be located outside the 65 Ldn noise contour with the VRC-50 operations.

As modeled, the noise levels north of the airfield would increase to 65 Ldn. However, the 1990 noise modeled only transient arrivals and departures, exclusive of training activity, so the actual change in noise levels in the forested area north of the airfield is expected to be less than the modeled difference. See Section 4.4 for a discussion of the potential effects of aircraft operations on endangered species that inhabit this area.

Construction Noise. The only other change in noise levels expected as a result of the relocation action will be associated with construction vehicles and equipment at the hangar/apron/washrack site. This will be a temporary localized effect, and there are no noise sensitive areas (e.g., housing) in the vicinity. The housing renovations will involve interior work only. No mitigation is required.

4.8.2 Naval Air Station Agana

Being the only other airfield in the vicinity, NAS Agana is the only practical alternative location for the VRC-50 FCLPs. Andersen is the preferred alternative for these maneuvers.

Unlike Andersen, NAS Agana is located in Guam's urban center. For this reason, in March 1993, Harris Miller Miller & Hanson Inc. (HMMH) prepared a noise survey for NAS Agana. (See Appendix K.) The purpose of the study was to determine the noise impacts attributable to FCLPs conducted by VRC-50, which is based at Andersen.

4.8.2.1 General Description

NAS Agana functions not only as a military air station but also as the islands' civilian airport. Consequently, it serves not only military aircraft but a mix of commercial jet aircraft such as B-747s, DC-10s, and B-727s.

Its runway configuration consists of two parallel runways aligned on magnetic headings of 063° and 243°. The primary runway, 06L/24R, is the northernmost parallel runway, 10,000 feet in length and 150 feet wide. The secondary runway, 06R/24L, is 8,000 feet in length and 150 feet wide, and is separated from the primary runway by 750 feet.

Currently, there is one P-3 squadron (VQ-1), a S-3 squadron (VQ-5), and one H-46 helicopter squadron stationed at NAS Agana. VRC-50, stationed at Andersen, has conducted its FCLPs exclusively at NAS Agana since August 1992.

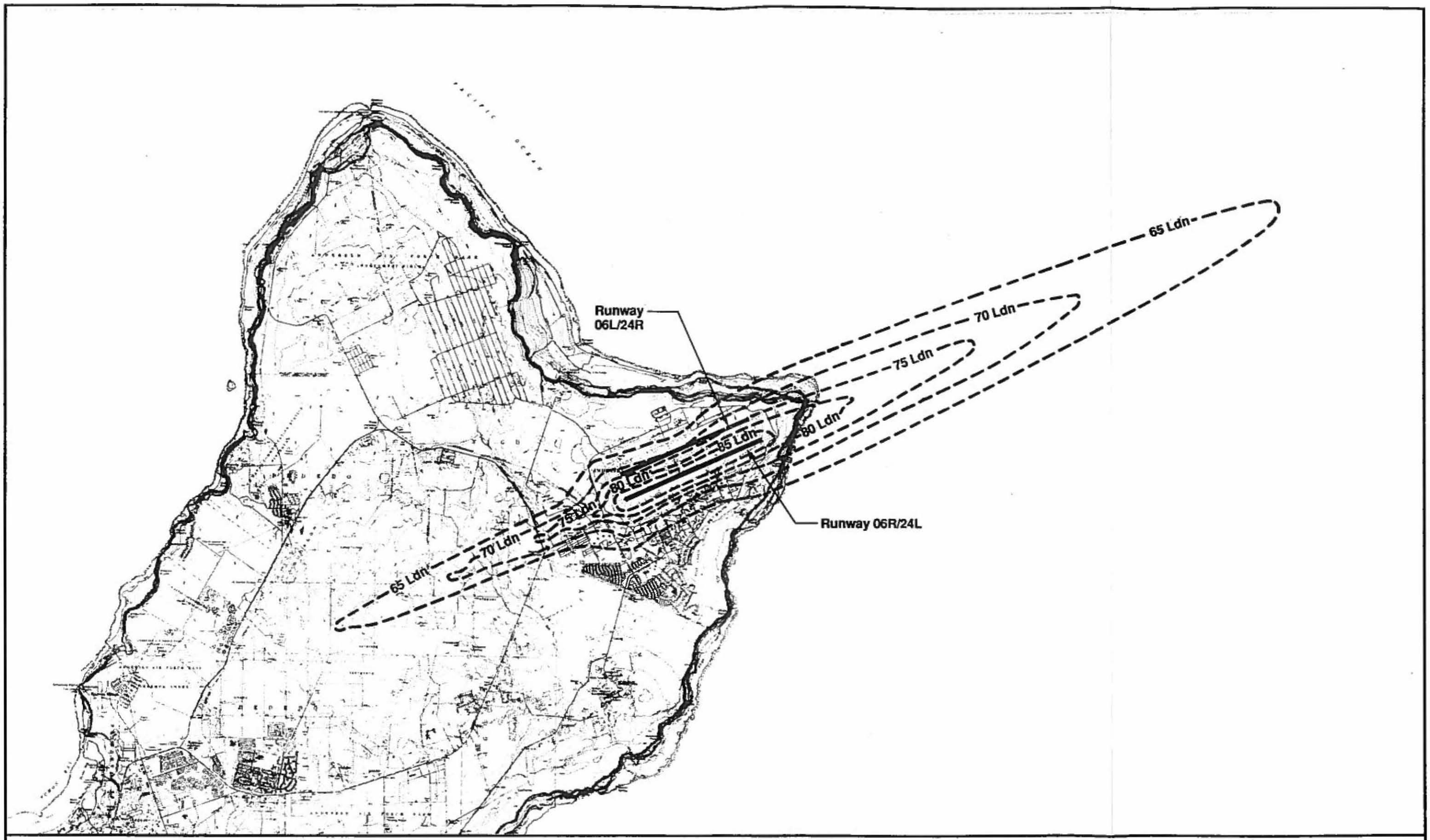

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Figure 4.8.1
1990 Ldn NOISE CONTOURS—
ANDERSEN AIR FORCE BASE
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4.8.2.2 Aircraft Operations

Base Case Annual Operations. Table 4.8.1 presents total annual operations recorded at NAS Agana from August 1991 through July 1992. This 12-month period was determined to be representative of operations typically conducted at NAS Agana prior to the addition of VRC-50 operations. Also, because of several typhoons between August and November of 1992, selection of a later 12-month period would have resulted in abnormally low operation levels.

Table 4.8.1
Base Case Annual Aircraft Operations
(8/91-7/92)

	Military		Civil		Total Operations
	Navy/ Marine Corps	Other Military	Air Carrier	General Aviation	
Annual	34,431	240	22,765	22,280	79,716
Daily	94.332	0.658	62.370	61.040	218.400

Base Case Daily Operations. Table 4.8.2 shows detailed daily operations by Navy and Marine aircraft based at NAS Agana, transient Navy and Marine aircraft, and other military aircraft. This table also shows the base case daily operation levels for civil aircraft, comprised of commercial jet, commuter turboprop, and general aviation aircraft. Regularly scheduled air carrier operations are the dominant noise contributor at NAS Agana.

Table 4.8.2
Base Case Average Daily Operations by Aircraft Type

Aircraft Category	Aircraft Type	Departures	Arrivals	T&Gs*	Total
NAVY/MARINE-BASED (Note: S-3 T&G Patterns includes FCLP Patterns)	P-3	1.710	1.710	46.842	50.262
	S-3	0.920	0.920	10.716	12.556
	H-46	1.424	1.424	19.234	22.082
	Sub-total	4.054	4.054	76.792	84.900
NAVY/MARINE-TRANSIENT	C-130	2.358	2.358	0.000	4.716
	C-12	0.944	0.944	0.000	1.888
	H-1	0.236	0.236	0.000	0.472
	C-9	0.471	0.471	0.000	0.942
	S-3	0.471	0.471	0.000	0.942
	F-14	0.236	0.236	0.000	0.472
	Sub-total	4.716	4.716	0.000	9.432
OTHER MILITARY	P-3	0.198	0.198	0.000	0.396
	C-130	0.131	0.131	0.000	0.262
	Sub-total	0.329	0.329	0.000	0.658
AIR CARRIER/ COMMUTER	B747	3.128	3.152	0.000	6.280
	DC10/L1011	9.351	10.232	0.000	19.583
	B727	15.934	14.518	0.000	30.452
	DC8	0.360	0.334	0.000	0.694
	B737	0.612	0.569	0.000	1.181
	SD330	1.800	2.380	0.000	4.180
	Sub-total	31.185	31.185	0.000	62.370
GENERAL AVIATION	C172	30.520	30.520	0.000	61.040
	Sub-total	30.520	30.520	0.000	61.040
GRAND TOTAL		70.804	70.804	76.792	218.400

(*) T&G operations include one takeoff and one landing for each pattern flown. Divide the number shown by two to get the number of patterns.

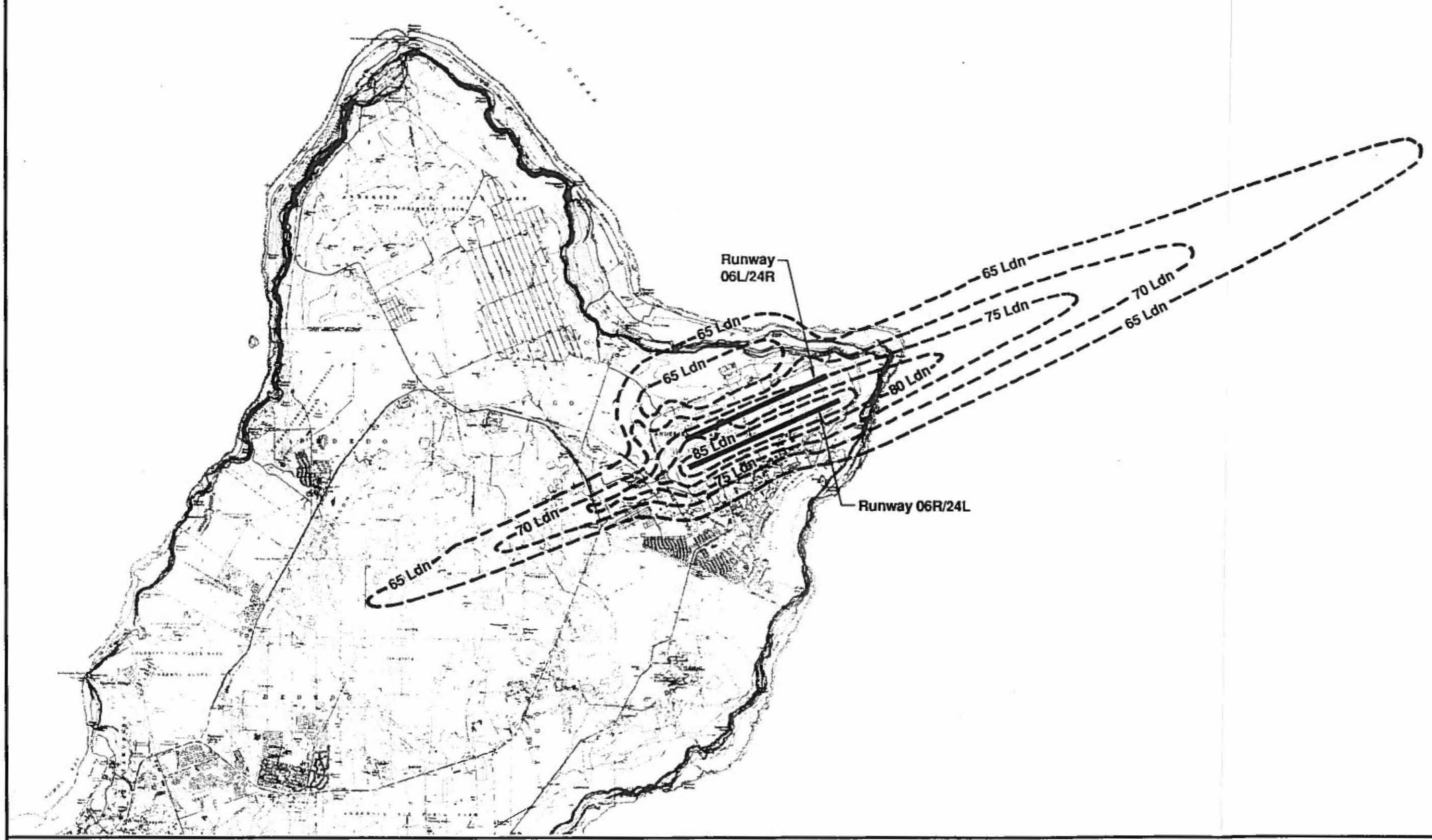

Figure 4.8.2
PROJECTED Ldn NOISE CONTOURS INCLUDING VRC-50 OPERATIONS— ANDERSEN AIR FORCE BASE
Guam Development EIS
April 1993

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Future Daily Operations. For purposes of this noise study, future operations at NAS Agana include the existing base case operations (see Table 4.8.2) and also the FCLP training activity conducted by VRC-50 S-3 and C-2 aircraft. Total daily VRC-50 operations are presented in Table 4.8.3. These numbers are based on estimates of six months of carrier qualifications and six months of minimal or normal FCLP activity. This average daily activity was added to the base case operation levels, resulting in the level of operations for the future case.

4.8.2.3 Noise Contours

Figure 4.8.3 compares the Ldn contours for the base case without the VRC-50 FCLP operations and the future case with the VRC-50 FCLP training activity. A review of Figure 4.8.3 reveals that the air carrier operations would still dominate the noise environment at NAS Agana, even with the addition of VRC-50 FCLP operations. In fact, the impact of VRC-50 FCLP operations are comparable to the impact of other military operations at NAS Agana.

Land uses in areas adjacent to the base consists of residential, apartments, hotel, commercial, and industrial. Typical building construction is characterized by concrete wall construction and air conditioning.

According to the *Federal Agency Review of Selected Airport Noise Analysis Issues, August 1992*, by the Federal Interagency Committee on Noise (FICON), the screening criteria for significance is determined to be a 1.5 dB increase in noise over any noise sensitive area located within the 65 Ldn contour. Figure 4.8.3, which compares the base case without VRC-50 FCLPs and the future case with the VRC-50 FCLP operations, reveals that the VRC-50 activity would cause an insignificant increase in the noise environment. The area of increased noise levels is confined to the area immediately adjacent to the base and results from the small size of the VRC-50 FCLP tracks.

Table 4.8.3

Future Case VRC-50 Average Daily Operations by Aircraft Type

Aircraft Type	Departures	Arrivals	FCLPs	Total
S-3	1.225	1.225	14.696	17.146
C-2	1.027	1.027	12.329	14.383
GRAND TOTAL	2.252	2.252	27.025	31.529

4.9 VISUAL SETTING

4.9.1 Existing Conditions

Guam's visual setting is determined by its natural environment—primarily the surrounding ocean and the island's geology and vegetation—and its built environment. The ocean can be viewed from many vantage points, and large expanses of undeveloped land remain covered with vegetation. The mountains in the central part of the island offer a dramatic backdrop when viewed from coastal areas.

The built environment on Guam ranges from densely populated urban areas such as Agana, Tamuning, Harmon, and Tumon, with busy streets and high-rise buildings, to the sparsely populated southern and northern sections of the island.

The proposed projects will be located at Andersen, Nimitz Hill, Apra Harbor, and Naval Magazine. These four areas are characterized as follows:

- Andersen Air Force Base. Located on a relatively flat plateau, Andersen contains developed sections—including runways and aprons, operational facilities, family and bachelor quarters, and community support facilities—as well as large areas of forest and other open space. Spectacular views of Guam's northern coastline comprise an important visual resource of the area.

  Andersen has an Architectural Compatibility Plan and a Base Landscape Development Plan. The former is intended to establish a cohesive architectural character that will upgrade both the functional and visual quality of the base. The latter outlines a plan of action to enhance the base's landscape appearance (U.S. Air Force, 1992).

- Apra Harbor Complex. Apra Harbor is the most developed of the four locations. The views are dominated by the ocean and various port and industrial facilities. There are also areas of remaining open space. The Apra Harbor Master Plan (Navy, 1986a) provides general guidelines for improving the appearance of the base, particularly in areas with the highest exposure to visitors and personnel and where the greatest positive visual impacts can be achieved. The base appearance program consists of four components: landscape enhancement, base color, outdoor graphics, and area cleanup.

- Naval Magazine. About three-fourths of the NAVMAG land area is unimproved. This includes Fena Reservoir and its watershed, which is generally inaccessible, mountainous terrain. Only the administrative and personnel support area is improved—about 60 acres—while most of the ordnance storage areas are semi-improved with an extensive road network.

  From Mount Lam Lam and along the ridgeline that roughly parallels NAVMAG's southern boundary, there are 360 degree views of the island and surrounding ocean. Other scenic resources include Imong Falls, Fena Reservoir, and the forest/savanna landscape (Navy, 1990c).

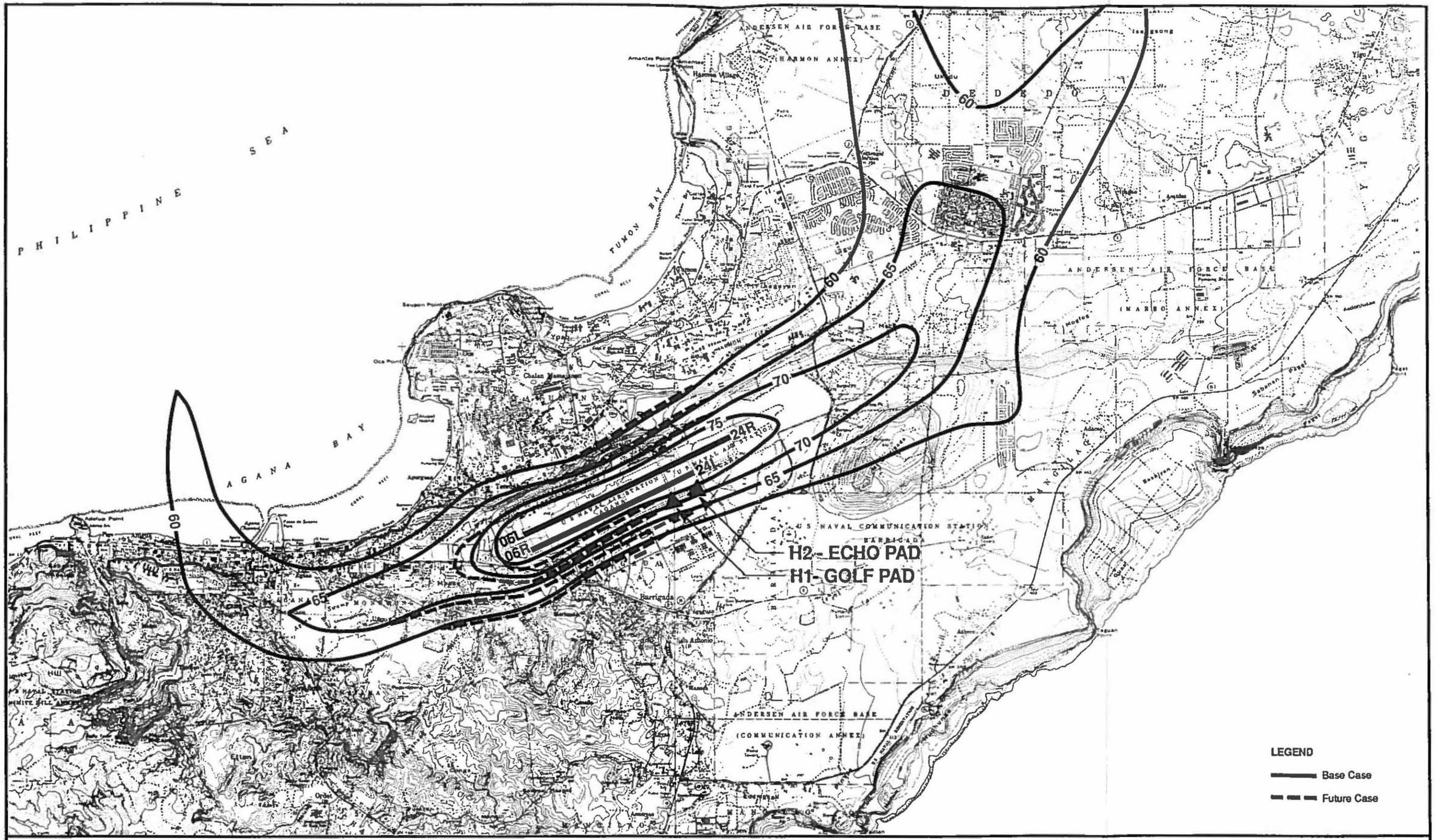

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Figure 4.8.3
COMPARISON OF BASE CASE AND FUTURE CASE Ldn CONTOURS
Guam Development EIS
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- Nimitz Hill. Located at the top of Nimitz Hill, the Commander Navy, Marianas (COMNAVMARIANAS) headquarters building is in a relatively open area together with other Navy facilities.

4.9.2 Potential Impacts and Proposed Mitigation Measures

4.9.2.1 Andersen Air Force Base

None of the proposed facilities will adversely affect the visual setting at Andersen AFB. The proposed hangar, washrack, and apron will be located in an already developed area containing similar facilities. The housing renovations will involve only interior modifications.

4.9.2.2 Nimitz Hill

There will be no visual impacts from the proposed renovation of existing spaces in the Building 200 Annex.

4.9.2.3 Apra Harbor Complex

None of the proposed projects is expected to alter the visual context of the Apra Harbor area. The new buildings will be located in developed areas and will be designed to conform with the appearance of existing facilities and with the base appearance guidelines. No high-rise structures are planned.

Two projects may change the views within the harbor complex but will still be consistent with the present setting. The Orote Power Plant expansion will include 115-foot-high stacks, but will be located adjacent to the existing power plant and stacks. Because of its size, the 300-unit family housing project also has the potential to affect views, depending on the site and the design. The structures will be limited to two stories, thus minimizing visual impacts.

4.9.2.4 Naval Magazine

Neither of the Naval Magazine projects will adversely affect the visual environment. They are consistent with existing uses on the installation.

4.9.3 Cumulative Impacts

No cumulative impacts are anticipated.

4.10 HISTORIC FEATURES

4.10.1 Archaeological Resources

Information in this section is based on archaeological surveys performed by International Archaeological Research Institute, Inc. (IARII) in June, August, and September of 1992. A copy of Part I of the Final Archaeological Report is presented in Appendix H. Part I, Summary of Archaeological Investigations, presents historical background information, describes fieldwork methods, and summarizes field survey findings. It also includes a

report on military historic resources and results of the laboratory analysis, prehistoric pottery analysis, and paleoenvironmental investigations. The conclusion to Part I presents final site significance assessments and recommendations regarding mitigation of impacts. Part II of the final report provides the site locations inventory, including detailed site descriptions and fieldwork results. Copies of the complete report (Parts I and II) have been distributed to the Guam Historic Preservation Office, the Micronesian Area Research Center, and the Nieves Flores Memorial Library.

The entire report has been reviewed by the Guam Historic Preservation Office. Section 106 consultation has been concluded in accordance with the National Historic Preservation Act of 1966 (see Appendix H).

A summary of findings is presented in Table 4.10.1. The table identifies the sites, the actions taken to test and evaluate each site, and based on these evaluations, reports a significance determination for each site. The specific significance criteria for eligibility in the National Register of Historic Places is based on the guidelines stated in 36 CFR 160:

> *The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:*
>
> *(a) That are associated with events that have made a significant contribution to the broad patterns of our history; or*
>
> *(b) That are associated with the lives of persons significant in our past; or*
>
> *(c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or*
>
> *(d) That have yielded, or may be likely to yield, information important in prehistory or history (Parker et al. 1985:5-6)*

4.10.1.1 Andersen Air Force Base

Existing Conditions. Perhaps the most important prehistoric site on Guam, Tarague Beach, is located on the rocky coastal shelf below Andersen AFB. Aside from Tarague, other important sites throughout the northern coastal areas contain remains of prehistoric Chamorro settlements and Spanish villages.

Potential Impacts and Proposed Mitigation. None of the historic sites in northern Guam will be affected by any new activities or construction at Andersen. No archaeological sites have been identified on or around the proposed hangar/apron/washrack facility, so no mitigation measures in the form of further archaeological work are required prior to construction.

Table 4.10.1
Summary of Phase II Findings and Significance

Site (TN) or Potential Site (PS)	Action Taken	Significance
Tomahawk Magazine	Project area surveyed and shovel tested	NE; not a site
Site 1129; Japanese bunker/caves	Shovel and auger tested, mapped, photographed	A, D, MP
TN-1: coral outlines	Shovel tested	NE; not a site
TN-2: coral facing	Photographed; archival research inconclusive	NE
TN-3: bulldozed military debris	No work recommended	NE
TN-4: bulldozed military debris	No work recommended	NE
TN-5: bulldozed military debris, one concrete pad	Shovel tested near concrete pad	NE
TN-6: concrete pads, recent	No work recommended	NE
TN-7: concrete waste dump	No work recommended	NE
TN-8: concrete pads	No work recommended	NE
TN-9: offshore features	Future underwater survey is recommended	Uncertain
TN-10: concrete wall	No work recommended	NE
TN-11: remains of Camp Bright	Phase I recommendations not included in Phase II SOW	A
TN-12: Japanese bunker/cave with prehistoric material	Shovel and auger tested, controlled excavations, mapped, photographed	A, D, MP
TN-13: rockshelter and open deposit	Shovel and auger tested, controlled excavations, mapped, photographed	D
TN-14: Japanese bunker	Auger tested, mapped, photographed	A, C, D, MP
TN-15: drain, bridge	Part of drainage bank shovel faced, shovel tested	NE
TN-16: concrete pads, debris	Backhoe trenching for deep cultural deposits	NE
TN-17: two sherds	Part of earthen bank shovel faced, shovel tested, one controlled excavation	NE
TN-18: fire debris	Phase I recommendations not included in Phase II SOW	NE
PS-1: caves (related to sinkhole structures)	Caves explored, mapped, photographed	D
PS-2: caves (related to sinkhole structures)	Caves explored	D
PS-3a and b: sinkholes	Pick and shovel tests done in two selected solution pits	NE
PS-4: sand embankment	Pick and shovel tests done in two selected solution pits	NE
PS-5: bluff, bulldozing	Vegetation cleared and shovel tested	NE
PS-6: swamp	Coring of sediments	D
PS-7: bluff	Shovel and auger tested	NE
PS-8: low rise	Phase I recommendations not included in Phase II SOW	NE
PS-9: beach deposits at Dadi	Recommend monitoring	(D?)
PS-10: swamp at Dadi	Coring of sediments	NE

Table 4.10.1
(Continued)

The following sites and potential sites were identified during Phase I-B survey:		
Site (TN) or Potential Site (PS)	Action Taken	Significance
TN-19: concrete foundation	Archival research inconclusive	NE
TN-20: water system	Archival research continues	NE
TN-21: stone wall, steps	Archival research continues	A, C, D
TN-22: defensive cave	Mapped and photographed	A, D, MP
TN-23: sewer features	Tested with 10-inch power auger and hand auger	NE
TN-24: structure pads	Archival research inconclusive	NE
TN-25 sewer features	No work recommended	NE
TN-26: defensive cave	Mapped, photographed, shovel tested	A, D, MP
TN-27: defensive cave	No work recommended	A, D, MP
TN-28: defensive cave	No work recommended	A, D, MP
TN-29: defensive cave	No work recommended	A, D, MP
TN-30: defensive cave	Mapped and photographed	A, D, MP
PS-11: hand grenade	Disposed by EOD personnel	NE; isolated artifact
PS-12: Tuparao Village	Backhoe trenches, power and hand auger, controlled tests	C, D
PS-13: rubble filled cave	Surveyed and photographed	A, D, MP
PS-14: gun emplacement?	No work recommended	NE; (MP)
PS-15: old quarry	No work recommended	NE
PS-16: hard stand	Archival research inconclusive	NE
PS-17: lavatory	No work recommended	NE
PS-18: six tie downs	Archival research continues	NE

Notes: NE indicates that the site has no obvious characteristics that meet criteria of eligibility for the National Register. The codes A, B, C, C, and MP are based on criteria stated in 36 CFR 160, which are used to make National Register eligibility determinations (see Appendix H, pg. 17 for further explanation):
A — associated with events that have made a significant contribution to broad patterns of history.
B — associated with the lives of persons significant in the past.
C — associated with distinctive characteristics of construction or artistry, or a significant entity whose components lack individual distinction.
D — has yielded or may yield information about prehistory or history.
MP — multiple property.

4.10.1.2 Apra Harbor Complex

Existing Conditions. Apra Harbor features seven prehistoric sites and one site complex. Six of these sites, including the historic period villages of Sumay, Tuparao, Orote, and Apra, are considered significant but are not listed on the Guam or National Registers (see Figure 4.10.1). The Orote Historic Complex consists of four historic and prehistoric sites and is listed on the Guam and National Registers of Historic Places (see Figure 4.10.2). This complex is one of the few sites on Guam which provides evidence about the possible settlement patterns of the early Chamorro period (Navy, 1992a).

Most new facilities planned for construction in the Apra Harbor Complex will be located on previously or currently developed parcels of land. These parcels feature graded terrain and no cultural materials or deposits to warrant further investigation. The primary project areas surveyed by IARII for potential archaeological significance included the proposed Tipalao housing sites and an alternative housing site at New Apra Heights (see Figure 4.10.3). The Polaris Point alternative was not surveyed since it is comprised primarily of filled land. In addition, certain coastal areas likely to be exposed to indirect impacts such as increased traffic and access were surveyed for archaeological resources.

Tipalao Expansion Area, Northwest. Seven archaeological sites were found in this proposed housing area. The northern portion of the area, characterized by limestone forest and extremely rugged karst topography, provides the context for five of the sites: three sinkholes, a live "pineapple" style hand grenade, and coral outlines. To the northeast is an abandoned quarry which in itself may be considered an archaeological site. The southern portion, featuring a relatively pristine limestone forest, is the location for one archaeological site in the form of a small sinkhole.

Of these seven sites, only one may be eligible for listing on the National Register. This site (PS-1) is located about 1500 feet (470 meters) west of the north-south section of Haputo Road and consists of a large and deep sinkhole and subsidence shaft connected to a massive limestone cave system. The whole site is, on average, approximately 10 meters deep, with the shaft appearing to have formed following the collapse of a large cave. Subsurface archaeological surveys revealed basalt mauls in two locations within the shaft. The caves branching off of the shaft contain remnants of crab shells and charcoal samples, but no other prehistoric artifacts and no material from World War II were found. The significance of this site is derived from criteria regarding its potential to yield important prehistoric and historic information.

Tipalao Expansion Area, Northeast. Ten archaeological sites have been identified on this parcel. The northern portion consists of coralline gravels, dense vegetation, and generally level terrain that appears to have been heavily bulldozed. The eight archaeological sites surveyed in this area include bulldozed piles of coral and various military debris, a swamp, a low limestone bluff, a hard stand, a World War II lavatory, and six concrete tie downs.

The southern portion of this area is for the most part flat and heavily vegetated. The two archaeological sites found in this survey area consist of concrete pads and a concrete waste dump.

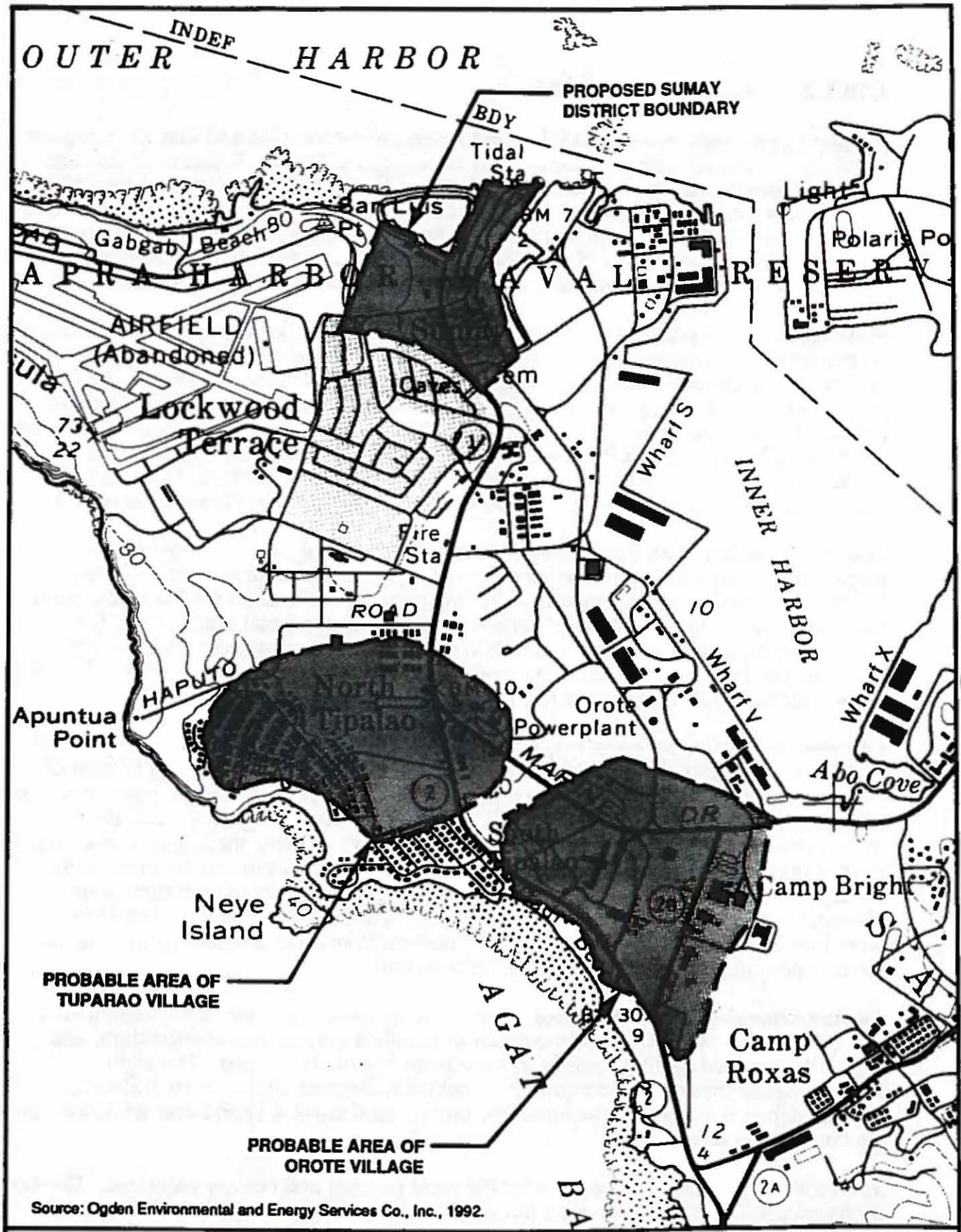
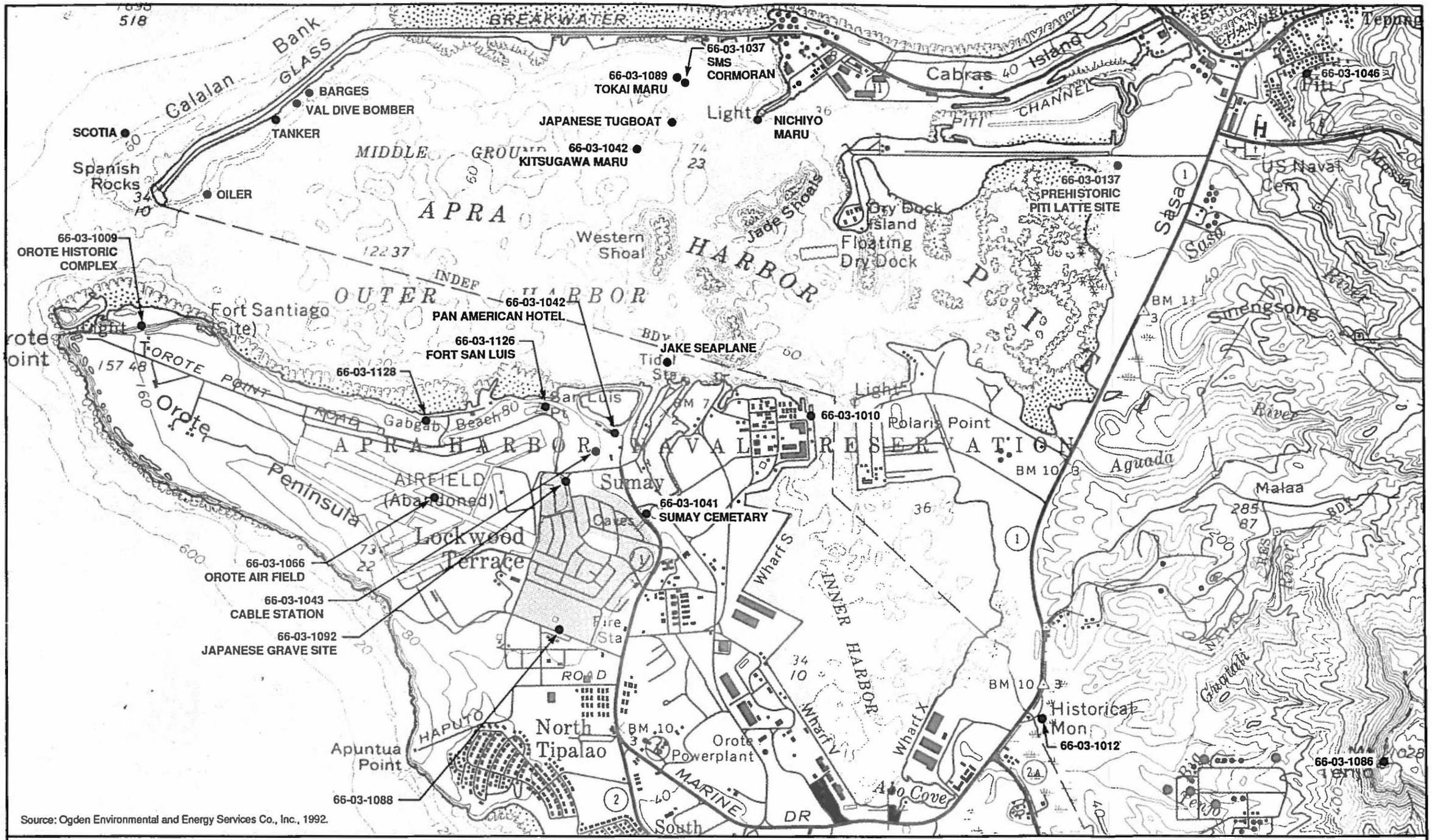


Figure 4.10.1
SUMAY, TUPARAO, AND OROTE VILLAGE LOCATIONS
Guam Development EIS
April 1993



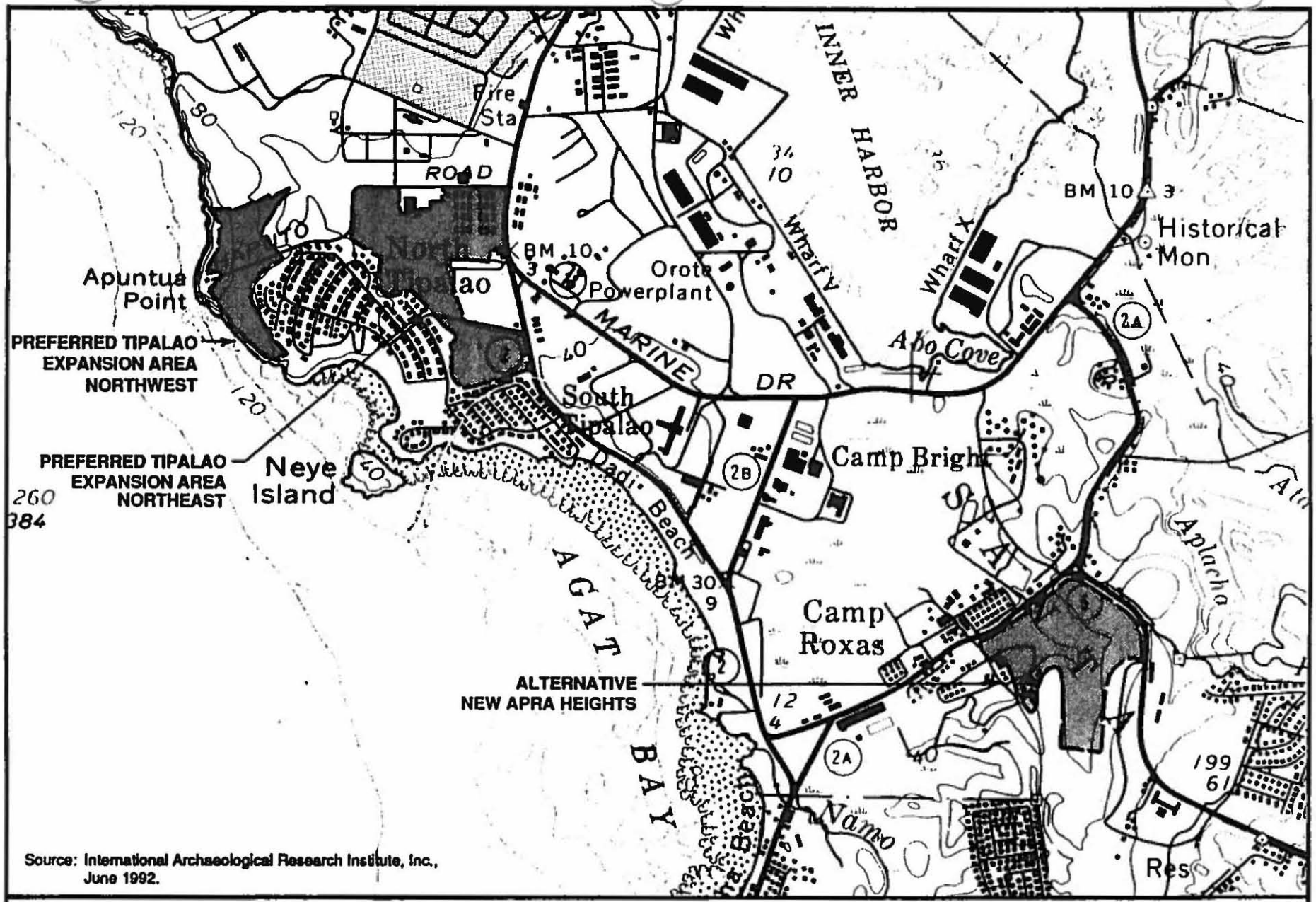
Source: Ogden Environmental and Energy Services Co., Inc., 1992.

North

0 2000 4000 8000

Scale in Feet

Figure 4.10.2
HISTORIC/PREHISTORIC SITE LOCATIONS–
APRA HARBOR COMPLEX
Guam Development EIS
April 1993



Source: International Archaeological Research Institute, Inc., June 1992.

North

0 1000 2000 4000

Scale in Feet

Figure 4.10.3
PROPOSED HOUSING SITES/ ARCHAEOLOGICAL SURVEY AREAS
Guam Development EIS
April 1993

None of the ten identified sites in this parcel exhibit characteristics warranting National Register eligibility or further testing.

Indirect Impact Areas. Additional archaeological surveys were performed by IARII along coastal areas in close proximity to the Tipalao housing sites (see Figure 4.10.4). Although no construction will take place in these areas, they are likely to encounter indirect impacts from increased activity and use resulting from the adjacent developments.

The first survey area is located to the south of the existing Tipalao housing units, covering the northern portion of Tipalao Bay. The five archaeological sites found in this area include a concrete foundation, a water system, sewer features, a Japanese defensive cave, and a series of walls and steps. The Japanese defensive cave and the series of walls and steps may be eligible for listing on the National Register. The Japanese defensive cave (TN-22) may be eligible by virtue of its existence as a component part of a multiple property listing. The series of concrete mortar and coralline rock walls, steps, and paths (TN-21) are associated with two concrete slabs and a set of concrete steps. The area was apparently organized like a garden or observation post. The steps do not appear to lead anywhere, suggesting that a wooden floor may have once connected them to the long foundation. The potential significance of this site is based on its association with World War II, the distinctive characteristics of its design and construction, and its potential to yield important historic and/or prehistoric information.

The central portion of Tipalao Bay comprises another survey area which features two archaeological sites: picnic structure pads and material remains from the Spanish/Chamorro village of Tuparao. The site of Tuparao Village (PS-12) may be eligible for the National Register based on the distinctive characteristics it represents of various cultures and the periods during which it was inhabited. The location of the village is presumed to be on the beach backshore areas where two prehistoric sherds and two historic sherds, either Asian or Spanish in origin, were found in association with the youngest layer of beachrock. Additional surveys may uncover more information about this village and the surrounding areas.

A third survey area encompasses the cliffline of northern Agat Bay, the headland opposite Neye Island, and south Tipalao Bay. This area features eight archaeological sites, five of which are Japanese defensive caves. A rubble-filled cave, sewer features, and a gun emplacement were also discovered in this area. The Japanese defensive caves (TN-26 through 30) and the rubble-filled cave (PS-13) may be eligible for the National Register based on their possible role in the Japanese World War II-era defensive fortifications system. Four of the defensive caves (TN 26 through 29) lie in close proximity to each other, thus supporting the idea that they share some sort of connection, while the other cave (TN-30) features similar characteristics. All of these caves are accorded significance by IARII due to their potential to yield more historic and possibly prehistoric information.

The area surrounding north-central Agat Bay and Dadi Beach comprises the final additional survey area. This densely vegetated coastal strand has been heavily affected by both human activity and natural forces. Human habitation is presumed to date back to the Spanish, yet the period of the most considerable physical alterations occurred during World War II. As a result of this diverse and extensive human presence, 12 archaeological sites were found in this area. They include three Japanese bunker and cave

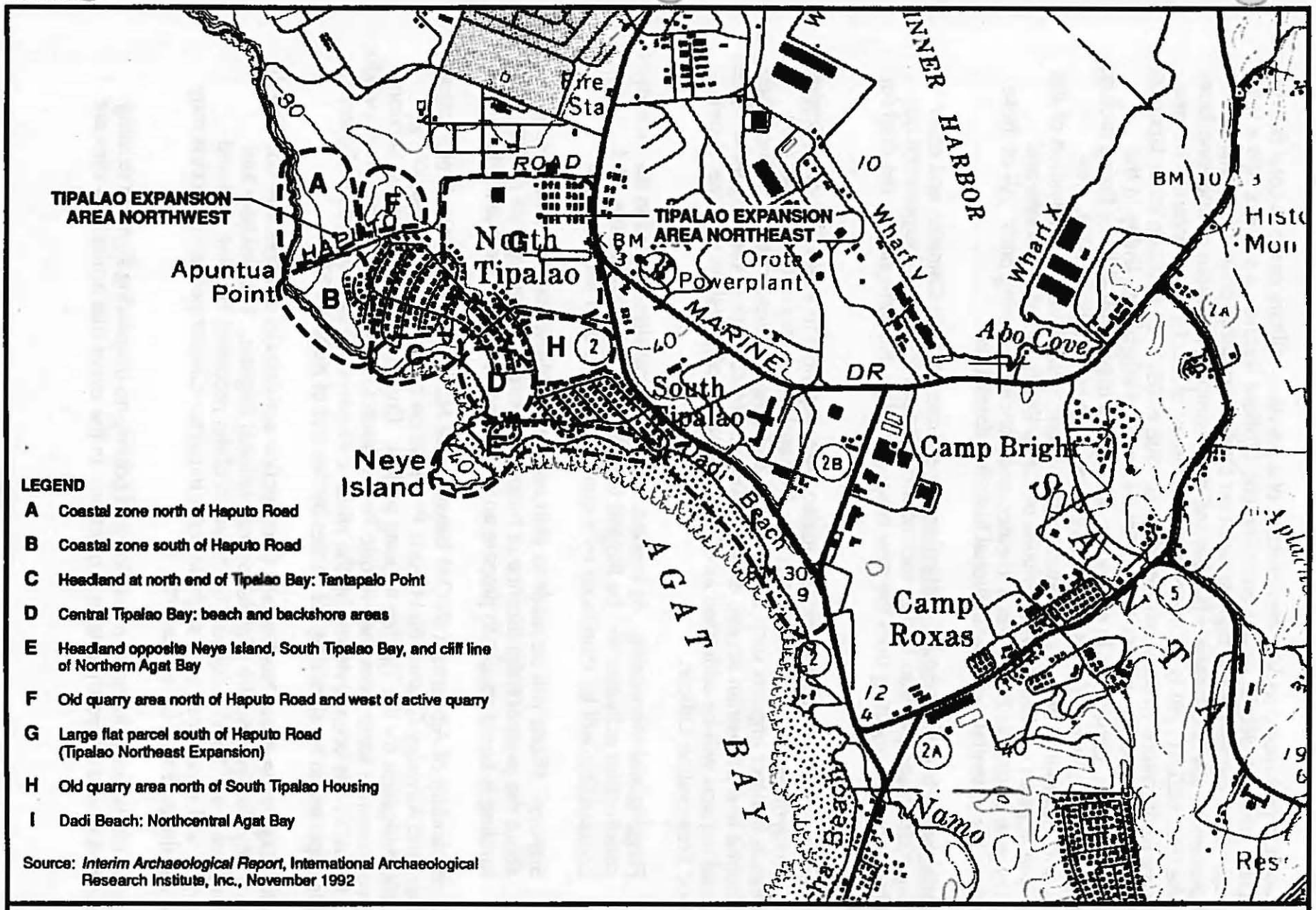


Figure 4.10.4
SURVEY AREAS
Guam Development EIS
April 1993

complexes, a prehistoric rockshelter, remains of a previous military camp, a coral facing, a concrete wall, fire debris, a sand embankment, offshore features, a swamp, and a low rise area which represents the highest point on Dadi's limestone plateau. Perhaps the most prominent site is a Japanese bunker and cave complex built into a limestone face. This site (Site 6603-1129) is an important component of the Japanese World War-era defensive fortifications in the Dadi Beach area. Site 6603-1129 and two other Japanese bunker and cave complexes (TN-12 and TN-14) may be eligible for listing in the National Register. Other sites in the survey area which may be eligible for listing include a prehistoric rockshelter (TN-13) and the remains of Camp Bright (TN-11). The prehistoric rockshelter features undisturbed prehistoric deposits and preservation of the entire site appears excellent. The remains of Camp Bright include concrete and masonry gate posts, the Palm Beach Theater, and concrete housing pads. All of these sites have the potential to yield additional historic information.

Potential Impacts and Proposed Mitigation. The Orote Historic Complex and other existing historic and prehistoric sites located around Apra Harbor will experience no additional impacts resulting from the new Navy activities. No mitigation is required for these areas.

Housing and related improvements at Tipalao are being sited to avoid all archaeological resources identified within the two parcels. Archaeological sites in the vicinity may experience indirect impacts such as vandalism and other disturbances due to increased automobile and pedestrian access, either during construction or in the long term. These potential impacts will be addressed as follows, based on consultation with the Guam Historic Preservation Officer:

- Flagging and Monitoring. As needed, archaeological sites located in the vicinity of construction activities will be flagged to prevent accidental damage, and construction will be monitored by a qualified professional archaeologist.

- Signage. Efforts will be made to alert housing residents and other area users about the presence/significance of historic resources. As a separate project, funding is being sought to prepare an interpretive brochure for Naval Station.

A Memorandum of Agreement (MOA) between the Navy, Guam Historic Preservation Officer, and Advisory Council on Historic Preservation has been drafted stipulating specific mitigation for the Tipalao housing project. Copies of the MOA and a Section 106 concurrence letter from the Historic Preservation Officer are contained in Appendix H. The MOA has been reviewed by the Historic Preservation Officer and the Council and is expected to be signed by all parties by the end of August 1993.

Tipalao Expansion Area, Northwest. Construction activities in this area will not directly impact any sites potentially eligible for the National Register. The sinkhole and subsidence shaft (PS-1) is located to the north of the proposed housing area and therefore will experience only slight indirect impacts. Greater pedestrian access may increase the potential for vandalism.

Flagging off the area during construction and posting no trespassing signs on existing fencelines would afford short-term protection. In the event that artifacts or sites are

uncovered by construction activities, the Guam Historic Preservation Officer will be notified immediately and construction will be postponed until a significance evaluation is completed. Signage and other means to inform area users of the presence of sites will be developed in consultation with the Guam HPO.

Tipalao Expansion Area, Northeast. No sites potentially eligible for the National Register will experience direct or indirect impacts resulting from the housing project in this area.

Indirect Impact Areas. Additional use of the beaches and other recreational features in these coastal areas will increase the potential for vandalism to several archaeological sites which may be eligible for the National Register. Signs will be installed to notify people of the sites' respective significance.

4.10.1.3 Naval Magazine

Existing Conditions. NAVMAG currently has six prehistoric sites listed in the Guam Historic Preservation Office files, none of which is on the Guam or National Registers. Initial archaeological surveys of these sites revealed no evidence warranting eligibility for the National Register. The sites are spread throughout the central portion of the base (see Figure 4.10.5). The prehistoric sites are a clustering of domestic features, including latte structures, which suggest a sizeable late-period Chamorro inland village complex.

Potential Impacts and Proposed Mitigation. None of these sites will experience any effects from construction of the missile magazines or inert storehouse. No further archaeological work is needed.

4.10.1.4 Naval Air Station Agana

Existing Conditions. One historical/prehistorical site exists to the south of NAS Agana near Ungaguan.

Potential Impacts and Proposed Mitigation. No construction is planned for NAS Agana, so this site will not be affected by new Naval operations on Guam.

4.10.2 Historic Structures

Information in this section is derived from a Cultural Resources Management Overview Survey conducted by Ogden Environmental and Energy Services Co., Inc. in March of 1992 (Navy, 1992a).

4.10.2.1 Andersen Air Force Base

Existing Conditions. Andersen AFB's significance stems from the fact that it is the only U.S. Air Force Base from which planes flew combat missions in three wars: World War II, the Korean War, and the Vietnam War. Planes from Northwest Field, as part of the XXI U.S. Bomber Command, played a significant role in the defeat of Japan by launching bombing raids in the spring and summer of 1945. Subsequent bombing raids originating from Andersen targeted South Korea in 1950, and North Vietnam in the 1960s (Guam Department of Parks and Recreation, 1976).

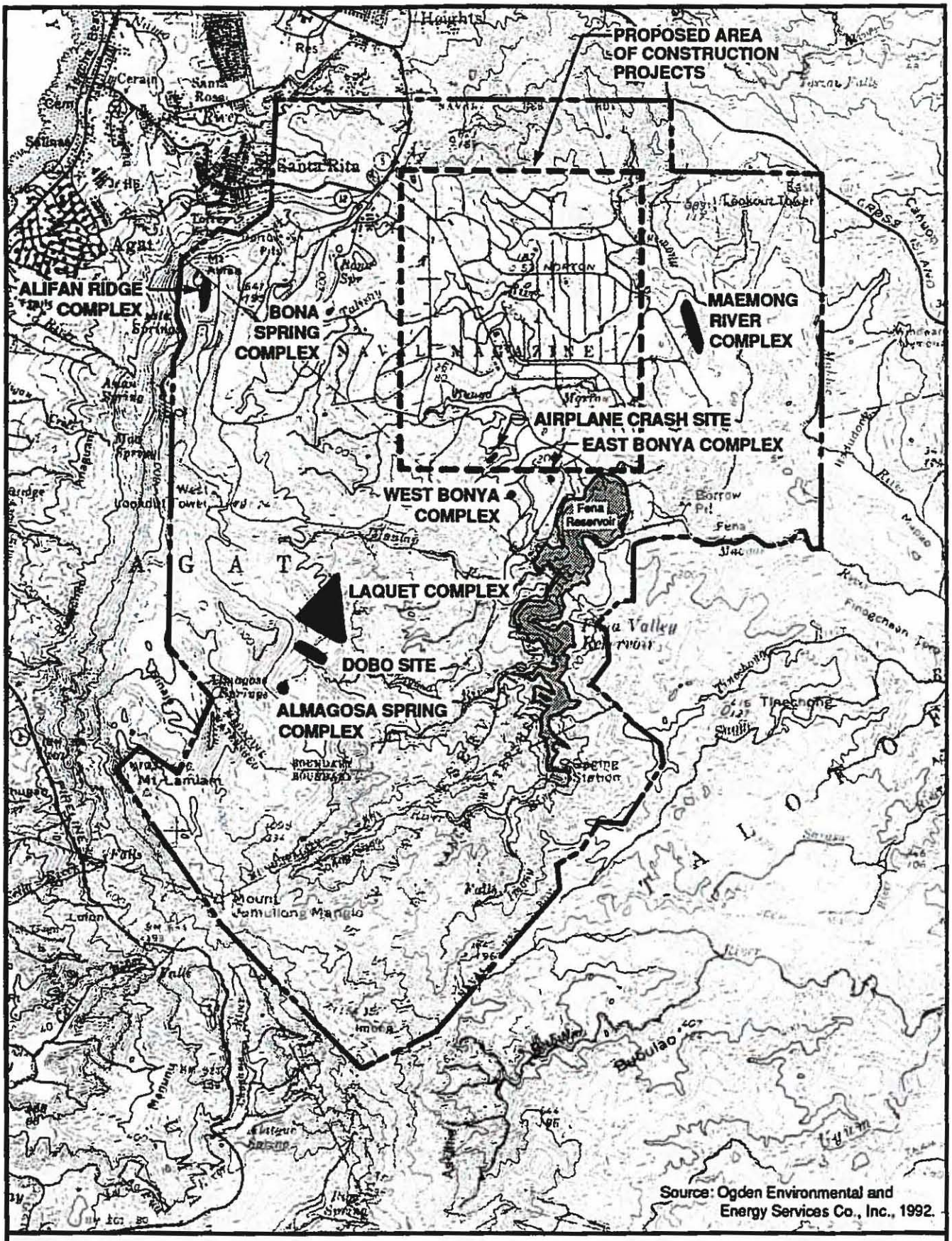


Figure 4.10.5
PREHISTORIC SITES–NAVAL MAGAZINE
Guam Development EIS
April 1993

Potential Impacts and Proposed Mitigation. The proposed construction and activities at Andersen will have no impact on Northwest Field.

4.10.2.2 Apra Harbor Complex

Existing Conditions. Apra Harbor features 53 historic terrestrial sites and 53 historic submerged sites (see Figure 4.10.2). Of the historic terrestrial sites, six are listed on the Guam Register: the Pan American Hotel, Sumay Cemetery, the Japanese Steps, Fonte Plateau, the Last Japanese High Command Post, and the War Crimes Trial Site. Two are listed on the National Register: the Cable Station and Orote Airfield. Sumay Village and Cemetery are part of a complex of sites being nominated as a National Register District. Of the 45 remaining sites, 28 are considered significant, nine are considered not significant, and no information could be found for eight of them (Navy, 1992c).

The 53 submerged sites in and around Apra Harbor include sunken vessels and aircraft and dumped military hardware. One of the vessels, the *S.M.S Cormoran*, is listed on the Guam and National Registers, while the remaining 52 sites require further investigation to determine their significance. The *S.M.S. Cormoran* was a German auxiliary cruiser that had been interned in Apra Harbor in 1914, and then sunk in 1917 after the United States declared war on Germany. It served only a marginal role in the history of Guam, but it represents the only piece of American soil that was touched by World War I (Guam Department of Public Works, 1976).

Potential Impacts and Proposed Mitigation. None of the proposed facilities or activities will affect known submerged historic resources. The only in-water construction project will be associated with the EODMU-5 bulkhead repair, located well away from the submerged resources. EODMU-5 training operations in the harbor, including underwater detonation, will not occur in areas close to the submerged resources.

Increased ship traffic should have little or no impact on these resources. Existing moorings are located a sufficient distance away to prevent adverse effects of anchor chains. Any new moorings in the outer harbor will be placed in consultation with the Guam Environmental Protection Agency.

4.10.2.3 Naval Magazine

Existing Conditions. Ten historic sites, all associated with the early development of the base during World War II, can be found at NAVMAG (see Figure 4.10.6). While the possible eligibility of these sites for the National Register revolves around their contextual relationship to the war, some structures, such as the vehicular bridges and Maemong and Alifan River Complexes, feature a distinctive type of construction.

An historic anchor, flagpole, torpedo, mines, and baseball field are also located at NAVMAG. The torpedo, mines, and anchor exist as signage markers for various facilities on the site, while the flagpole and baseball field remain from World War II.

Potential Impacts and Proposed Mitigation. These sites will not be directly affected by construction of the Tomahawk magazines or the inert storehouse. Increased activity around the historic features may indirectly affect them, but the extent of that will be fairly minor.

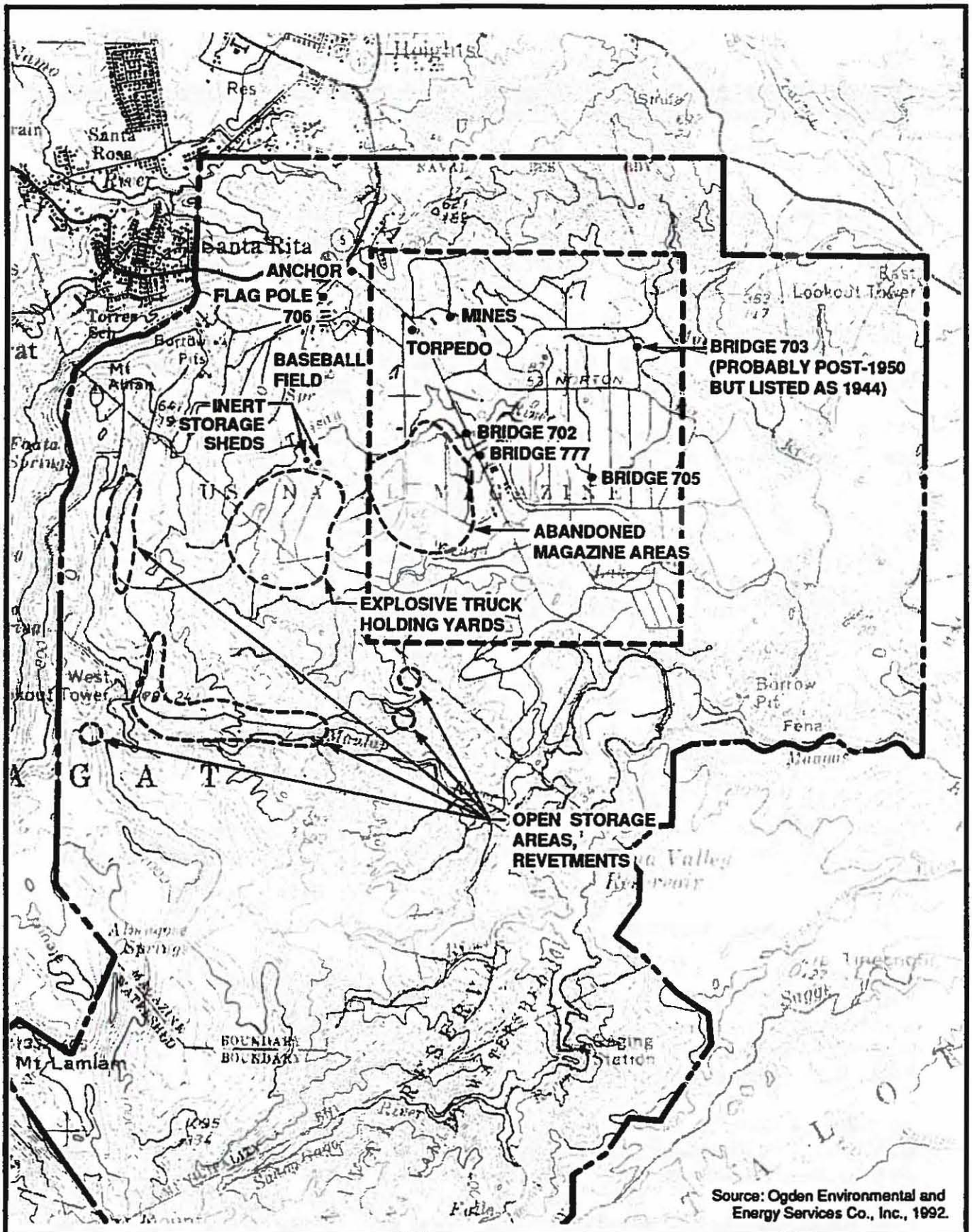


Figure 4.10.6
HISTORIC SITES—NAVAL MAGAZINE
Guam Development EIS
April 1993

242.0101/32

4.10.2.4 Others

There are currently no registered historic structures on or around NAS Agana. Because no development is planned for the air station, no impacts to any historic structures will occur. The Oceanography Building on Nimitz Hill is neither listed nor eligible for listing on the National Register.

4.10.3 Cumulative Impacts

New Navy activities and construction will have only a minor impact on the historic features of Guam. Overall impacts will be mostly indirect as development will generate increased traffic, pollution, and activities around the historic sites.

4.11 SOCIOECONOMICS

In August 1992, Community Resources, Inc. (CRI) of Honolulu completed an analysis of the expected socioeconomic impacts on Guam resulting from the transfer of new activities and personnel (see Appendix I). With a few exceptions, data summarized in this section was obtained before Typhoon Omar struck Guam August 28, 1992.

Note: Since completion of CRI's study, two changes were made to the scope of work which slightly alter some of the figures shown in Appendix I. The conclusions remain substantively the same, in spite of the change in scope, so it was not necessary to revise the report.

One change was deletion of maintenance dredging of inner Apra Harbor from the original list of MILCON projects assessed in this document. The project was deleted because dredging will not be required to accommodate the relocation actions.

The second change was the reduction in number of units for the family housing project, from 308 to 300. This is a relatively insignificant change, in light of the Navy's plans to construct additional housing as a project separate from the relocation action. Preliminary plans are now underway to construct 250 more family housing units in FY 96-97.

In addition, some other projects have been slightly altered (for example, reduction in square footage), but the effect of the change is insignificant.

4.11.1 Existing Conditions

The military owns or controls approximately 30 percent of Guam's total land area, comprised of four major installations and several smaller bases. Due to this presence throughout the island, and Guam's limited land area, the military has a strong influence on the socioeconomic dynamics of the whole island.

4.11.1.1 Population

Guam's population totaled 133,152 people in 1990, a 20.4 percent increase from 1980. The population has increased ten-fold since 1920 with an average annual growth rate of 3.3 percent. The period of greatest growth occurred between 1940 and 1950, when military deployment and construction were at their peak (see Table 4.11.1).

The ethnic composition of Guam's population is 43 percent Chamorro or part-Chamorro, 23 percent Filipino, 14 percent Caucasian, 5 percent other Pacific Islanders, and 15 percent other less prominent ethnic groups. In terms of population percentage, Chamorros have declined the most in recent decades, as they represented over 90 percent of the population about 50 years ago (see Table 4.11.2). Filipinos have shown the steadiest growth over the past 30 years, while the Caucasian population fluctuates depending on the status of military activities on the island. Approximately half of all Guam residents were born on Guam.

The people of Guam are generally young, with nearly 70 percent of the population under the age of 34 in 1990. People over 65 make up only 4 percent of the population, whereas children under 5 comprise almost three times that amount (11 percent). The median age in 1990 was 25.0 years, up from 22.2 years in 1980. Table 4.11.3 shows a comparison of demographic data for Guam residents from the last two census periods.

4.11.1.2 Economy/Employment

The major components of Guam's economy are the government, the military, tourism, and construction. Of these components, the government and the military are the most prominent employers. Approximately one-fifth of the total labor force on Guam is employed by the Territorial government, while the military accounts for an additional 13 percent of the jobs on the island (see Table 4.11.4).

In recent decades, the growing private sector has enabled Guam residents to become less reliant on civil service and the military for employment. Private sector jobs accounted for 58 percent of the total job count and 67 percent of the civilian job count in 1990.

Tourism is Guam's fastest growing industry in the private sector. It attracts hundreds of thousands of visitors each year and provides thousands of jobs. Approximately 7,400 people visit Guam daily, with the majority coming from Japan and the rest coming from other parts of the U.S. and other neighboring areas of the Pacific. To accommodate these people, the number of available hotel rooms in Guam doubled to almost 5,000 between 1980 and 1990. The hotel industry accounted for almost 7 percent of the total civilian jobs and 10 percent of the private sector jobs in 1990.

Unemployment for Guam in March of 1991 was approximately 3.2 percent, relatively low compared to the rest of the United States. In some industries, such as construction, the island experiences such a severe labor shortage that companies must import foreign labor on short-term H-2 visas. While this practice has succeeded in the construction industry, other industries, such as hotels, still struggle to find suitable employees.

The median family income on Guam was approximately $31,000 in 1989. More than one-tenth of island families earned incomes below the poverty line, while approximately 15 percent received Social Security or some other type of public assistance income (see Table 4.11.5). Over half of the military households had 1989 incomes below $25,000 compared to about 35 percent for civilian and mixed households (see Table 4.11.6).

Table 4.11.1
Average Annual Population Growth Rate, 1920-1990
(in percent)

	1920-30	1930-40	1940-50	1950-60	1960-70	1970-80	1980-90
Average Annual Rate	3.4	1.9	10.3	1.2	2.4	2.2	2.3
Ethnicity							
Chamorro/Part Chamorro	3.0	2.1	3.0	2.5	N/A	N/A	1.9
Caucasian	15.7	-4.2	40.1	-1.0	N/A	N/A	8.5
Filipino	-0.8	4.5	29	1.7	N/A	N/A	3.0
Other	3.4	3.5	11.2	3.1	N/A	N/A	-0.4

Note: N/A Data not available.
Sources: U.S. Bureau of the Census, 1992, 1983, 1973, 1963.

Table 4.11.2
Population Trends, 1920-1990

	1920	1930	1940	1950	1960	1970	1980	1990
Total Population	13,275	18,509	22,290	59,498	67,044	84,996	105,979	133,152
Ethnicity								
Chamorro/Part Chamorro	12,216	16,402	20,177	27,124	34,762	N/A	47,845	57,648
Caucasian	280	1,205	785	22,920	20,724	N/A	8,442	19,160
Filipino	396	365	569	7,258	8,580	N/A	22,447	30,043
Other	383	537	759	2,196	2,978	N/A	27,245	26,301

Note: N/A Data not available.
Sources: U.S. Bureau of the Census, 1992, 1983, 1973, 1963.

Table 4.11.3
Demographic Characteristics, 1980 and 1990

	Total Guam	
	1980	1990
TOTAL POPULATION	105,979	133,152
ETHNICITY		
Chamorro/Part Chamorro	46%	43%
Filipino	21%	23%
Caucasian	8%	14%
Other Pacific Islander	2%	5%
Other	23%	15%
AGE		
Less than 5 years	12%	11%
5 to 17 years	29%	24%
18 to 34 years	33%	34%
35 to 64 years	23%	27%
65 or more years	3%	4%
Median age 9 years	22.2%	25.0%
PLACE OF BIRTH (1)		
Guam	49%	48%
Other U.S.-born(2)	24%	23%
Other Pacific Islands	1%	2%
Philippines	16%	18%
Elsewhere	10%	9%
RESIDENCE 5 YEARS PREVIOUS FOR PERSONS AGED 5 AND OVER		
Same house	39%	46%
Same district, different house	14%	9%
Different district	13%	12%
United States (3)	20%	20%
Other Pacific Islands	1%	2%
Philippines	5%	5%
Elsewhere outside Guam	14%	13%
EDUCATION OF PERSONS AGED 25 AND OVER (1)		
High school diploma	N/C	33%
College degree(4)	N/C	23%

Notes:
N/C 1980 and 1990 categories are not comparable.
(1) Based on 15 percent sample; hence, figures represent estimates only.
(2) Includes persons born in U.S. territories and commonwealths, and persons born abroad or at sea to American parents.
(3) Includes U.S. territories and commonwealths.
(4) Includes Associates, Bachelor's, and graduate degrees.

Sources: U.S. Bureau of the Census, 1992, 1984, 1983.

Table 4.11.4
Projected Jobcounts

	1990	1995	2010
Jobcount by Industry			
Hotel	3,920	7,170	17,147
Retail	9,910	13,387	27,241
Construction	9,400	5,500	9,400
Other Private	16,140	19,898	34,604
Federal (Civilian)	6,880	6,880	6,880
Territorial	12,420	13,709	17,140
Military	8,795	8,795	8,795
Total Civilian Jobcount	58,670	66,481	112,413
TOTAL JOBCOUNT	67,465	75,276	121,208

Source: Wilbur Smith and Associates, in association with Duenas & Swavely, Inc., 1991.

4.11.1.3 Housing

As of 1990, there were 35,223 units comprising Guam's total housing stock, 11 percent of which are vacant. Of these vacant units, one percent are for sale, four percent are for rent, and five percent are available through other means. The median value of an owner-occupied home in 1990 was close to $130,000, up from $57,600 in 1980. The islandwide median gross rent in 1990 was about $547, up from $193 in 1980 (see Table 4.11.7).

The high cost of housing on Guam is attributed to the increasing scarcity of units and the steadily growing demand for them. This scarcity is a result of several constraining factors, most notably the lack of available, developable land. As mentioned earlier, the military controls approximately 30 percent of Guam's land area, while the Government of Guam controls another 30 percent. With only 40 percent of the island available for development, and much of that area either privately owned or constrained by environmental, infrastructural, and incompatible land use factors, few areas on Guam are suitable for housing developments.

Another reason for the scarcity of housing on Guam is the overall lack of housing construction. Due to the growing tourist industry and the profitability of resort development, private land owners and development companies have chosen to build hospitality facilities on the available land rather than housing projects. In the event that housing is developed, most of the new units tend to be luxury condominiums with high-scale rents that the majority of Guam residents cannot afford. The influx of high rent units into Guam's housing market is one reason for the 183 percent increase in islandwide median gross rent from 1980 to 1990.

The housing market is further constrained by the unavoidable damaged cause by typhoons. Poorly constructed housing units, which are usually the most affordable for Guam residents, cannot withstand the high winds generated by these storms and are typically destroyed. This wide spread housing destruction drives up insurance premiums which, in turn, force housing prices even higher.

Table 4.11.5
Income Characteristics, 1989[1]

	TOTAL GUAM
HOUSEHOLDS	31,373
INCOME	
Median Income	$30,755
With Social Security income	8%
With public assistance income	7%
HOUSING COSTS AS PERCENTAGE OF HOUSEHOLD INCOME (2)	
Owner costs at 30 percent or more	12%
Renter costs at 30 percent or more	24%
OWNER-OCCUPIED HOUSEHOLDS (2)	
Without a mortgage	38%
With a mortgage	62%
Median monthly costs (3)	$598
FAMILIES	27,313
INCOME	
Below poverty level	13%
Median income	$31,178

Notes: (1) Based on 15 percent sample; hence, figures represent estimates only. Comparable income data for 1979 not available.
(2) For specified households.
(3) Costs include mortgage, real property tax, and utilities.

Source: U.S. Bureau of the Census, 1992.

Table 4.11.6
Military Household Income Distributions, 1989

	All Persons in Military or Military Dependents	Other Households
Less than $15,000	14%	19%
$15,000 to $24,999	38%	17%
$25,000 to $34,999	24%	17%
$35,000 to $49,999	15%	18%
$50,000 too $74,999	7%	17%
$75,000 to $99,999	1%	6%
$100,000 or more	1%	5%

Source: U.S. Bureau of the Census, 1992.

Table 4.11.7
Housing Characteristics, 1980 and 1990

AREA	TOTAL HOUSING UNITS	VACANT UNITS		1989 MEDIAN RENT	
		Total	For Rent	Gross	Contract
TOTAL GUAM	35,223	11%	4%	$547	$493
Agana	416	12%	10%	$448	$393
Agana Heights	1,008	7%	2%	$543	$483
Agat	1,300	13%	2%	$394	$308
Asan	620	9%	2%	$418	$336
Barrigada	2,140	8%	2%	$540	$494
Chalan Pago-Ordot	1,047	9%	3%	$506	$418
Dededo	5,741	8%	2%	$507	$438
Inarajan	553	12%	2%	$322	$248
Mangilao	2,699	10%	5%	$528	$477
Merizo	469	17%	7%	$320	$250
Mongmong-Maite	1,742	10%	4%	$476	$421
Piti	554	13%	2%	$801	$739
Santa Rita	2,343	2%	1%	$446	$420
Sinjana	712	10%	4%	$509	$432
Talofofo	548	5%	1%	$486	$419
Tamuning	6,296	21%	10%	$617	$567
Umatac	188	14%	2%	$246	$185
Yigo	3,686	9%	2%	$591	$534
Yona	1,361	15%	6%	$424	$353

Source: U.S. Bureau of the Census, 1992.

Due to the cost of purchasing a home and the large number of military personnel on Guam who are predominantly short-term residents, 54 percent of the households on Guam choose to rent (see Table 4.11.7). The demand resulting from over half of the households on the island competing for only four percent of the available units has contributed to the dramatic increase of rents. The extremes of the rental market range from $250 in southern Guam to $800 in the northern regions where the majority of Guam residents live. Over one-third of the total housing units are located in the Dededo and Tamuning areas which border the capital city of Agana (see Table 4.11.8). The overall scarcity of units creates a single islandwide rental market. Many tenants are forced by the high prices to find housing wherever they can on the island, rather than the preferred areas near jobs or families.

Households comprised entirely of military personnel and dependents occupy approximately 14 percent of Guam's renter-occupied units. An additional 4.4 percent of total households is comprised of renters with some, but not all, persons in the military. In 1989, 96 percent of military households rented, either on or off-base, with 83 percent paying no cash rents for on-base units (see Exhibit 2-H in Appendix I). Navy studies conducted in 1992 suggest military households on Guam pay approximately $250 more for rent than non-military households. This is due, in part, to the housing allowances received by the military families which are given under the condition that certain housing standards be met. One concern of civilian renters is that landlords will inflate rents in anticipation of these subsidized military families.

Table 4.11.8
Selected Housing Characteristics by District, 1990

	TOTAL GUAM	
	1980	1990
TOTAL HOUSING UNITS	**28,249**	**35,223**
TOTAL VACANT UNITS	12%	11%
Seasonal/recreational	1%	0%
For sale only	1%	1%
For rent	5%	4%
Other vacant	6%	5%
AGE OF STRUCTURE (1)		
1 year	N/A	9%
2 to 10 years	N/A	21%
11 to 20 years	N/A	41%
More than 20 years	N/A	29%
LACKING COMPLETE PLUMBING (2)		
Owner-occupied	N/C	55%
Renter-occupied	N/C	28%
Vacant	N/C	36%
TOTAL OCCUPIED UNITS	**24,834**	**31,373**
TENURE		
Owner-occupied	46%	46%
Renter-occupied	54%	54%
PERSONS IN OCCUPIED UNITS	101,000	124,596
As percent of total population	95%	94%
PERSONS PER UNITS	4.07	3.97
PERSONS PER ROOM		
1.00 to 1.50 (3)	15%	13%
1.51 or more (4)	9%	7%
MEDIAN VALUE (5)	$57,600	$130,000
MEDIAN GROSS RENT	$193	$547
Military households	N/A	$679
Part-military	N/A	$646
Non-military	N/A	$525

Notes:
- N/A Data not available.
- N/C 1980 and 1990 categories are not comparable.
- (1) Based on 15 percent sample; hence, figures represent estimates only.
- (2) 1990 figures based on 15 percent sample; 1980 figures based on full sample.
- (4) Indicates "mildly crowded" conditions.
- (4) Indicates "very crowded" conditions.
- (5) Median values are for owner-occupied non-condominium housing units.

Sources: U.S. Bureau of the Census, 1992, 1983.

4.11.2 Potential Cumulative Impacts

New development on Guam will take place on land already held by the U.S. military. Impacts have been identified in the areas of population, economy and employment, housing, and the social environment. Localized impacts from the relocation of operations and facilities from the Philippines will mostly occur on the military bases, while cumulative impacts will be felt islandwide. In the short-term, the major socioeconomic impacts on Guam will include:

- Transfer to Guam of approximately 2,800 Navy personnel and dependents from the Philippines;
- Separation of families due to the Navy policy that dependents cannot join personnel transferring to other bases until housing is guaranteed;
- A potentially large increase in military demand for housing;
- An imbalance between new demand and the existing supply of public services;
- New equipment and resources shipped to Guam; and
- Temporary demand for workers for the construction of temporary facilities and help to relocate personnel and activities.

Over time, many of the initial impacts associated with the relocation will begin to subside. Military personnel and families living off-base will eventually make their way back on-base as housing becomes available. Over the long-term, several social and economic impacts will occur:

- Additional military and civilian jobs on Guam will provide salaries for residents and subsequently income tax dollars to the island government;
- Additional military personnel and their dependents will add to the labor supply available for civilian jobs and to the overall demand for housing and public services;
- An increase in the numbers of transient civilian mariners and Navy personnel will in turn increase spending on the island; and
- $300 million in new construction will provide direct construction jobs.

4.11.2.1 Population

The proposed actions will bring an additional 1,377 permanent-duty military personnel to Guam accompanied by about 1,455 dependents. As many of these dependents gradually enter the job market, it is anticipated that a net reduction of in-migrant workers will occur. The net effect on Guam's overall population is expected to decline over the long-term as compared to the impact felt immediately after the relocation (see Table 4.11.9). The low numbers of dependents over the short-term reflects the scarce supply of housing units and the Navy's restrictive policy towards allowing dependents of

subsequent duty personnel to come to Guam without family housing. The increase in population due to the relocation represents less than 2 percent of the projected population for 1995.

4.11.2.2 Economy and Employment

The transfer of activities to Guam will bring about islandwide increases in jobs, incomes, and spending. Most of these increases will result from construction of new facilities and new operations on the military bases. Until project related construction is completed, the short-term creation of many new jobs will bring about a greater demand for in-migrant workers. However, in the long term, there will be an eventual reduction in the number of non-military in-migrant workers. This reduction will be due primarily to the presence of more civilian workers among the project's military dependents than new civilian jobs created by the project over the next five years. By comparison, Guam's tourist industry is expected to create thousands of jobs over the next few years which will increase the need for in-migrant workers.

Jobs. New Navy operations on Guam were initiated in 1992 with the arrival of new personnel and equipment and they will continue indefinitely. Direct construction jobs created during this time period will total about 1,800, while indirect and induced jobs resulting from construction-related industries will total over 4,300 (see Table 4.11.10). Approximately 1,377 military billets and 319 direct permanent civilian jobs are being created by the new operations. There will be an average of 150 indirect and induced jobs per year to support operations-related industries during the same time period (see Table 4.11.11). The number of these jobs is expected to decrease after 1996 as military housing approaches completion and personnel subsequently spend less money off-base. Approximately 530 military dependents are expected to seek employment in the civilian or Department of Defense job markets to help offset any labor shortage.

Although additional jobs will have a positive effect on Guam's economy, in the short-term they will tend to aggravate the existing labor shortage problem. Historically, Guam's population has been small enough and its unemployment rate low enough that there have been more jobs than qualified and skilled people. To help deal with this problem, the Navy has had an apprenticeship program in effect for over a decade which provides trained employees for its positions. Because these employment opportunities are very attractive, new recruits to the civilian labor force will need to be found to fill positions created by those workers who leave the private sector for jobs with the Federal government. With the number of skilled workers in the civilian labor force at a relative premium, employers in the private sector will be inconvenienced to find new workers with equal or greater capabilities.

Table 4.11.9
Resident Population Increase Associated with New Navy Activities*

	1993	1994	1995	1996	1997	Long Term
MILITARY & MILITARY DEPENDENTS (1)						
Military	1,377	1,377	1,377	1,377	1,377	1,377
Dependents	1,455	1,455	1,455	1,455	1,455	1,455
IMPACT ON CIVILIAN IN-MIGRATION						
Workers (2)	0	-22	59	-73	-73	-73
Dependents (3)	0	-7	19	-23	-23	-23
TOTAL INCREASE	2,832	2,694	2,564	2,736	2,736	2,736

Notes: * All figures show annual amounts of population increase (or decrease) over pre-project levels. The figures given are, in effect, cumulative. Values in parentheses are negative.
(1) From Exhibit 4-A.
(2) Operations-related workforce, less new military dependent workers brought by Navy.
(3) Estimated from Highway Master Plan: 32 dependents expected to come for every 100 in-migrant.

Sources: Wilbur Smith & Associates, in association with Duenas & Swavely, Inc. 1991.

Table 4.11.10
Employment on Guam Associated with Project Construction(1)

	CONSTRUCTION COULD BEGIN IN THE YEARS:				
	1993	1994	1995	1996	1997
A. Direct Employment (2)					
MILCON Spending (millions of 1992 $s)	$35.6	$150.7	$89.0	$38.6	$4.8
Jobs	200	848	500	217	27
B. Indirect and Induced Employment (3)					
Jobs	480	2,034	1,201	521	65
C. Total Jobs	680	2,882	1,701	738	92

Notes: (1) Construction allocate to year after proposed authorization, except for housing, which was spread over two years.
(2) Direct construction employment on Guam estimated on the assumptions that 90 percent of MILCON funds cover construction costs, total labor cost amounts to 25 percent of construction costs, and 90 percent of construction labor occurs on Guam (the remaining 10 percent would be located in home offices off-island). An average rate of pay of $15/hour was assumed, based on talks with construction experts.
(3) Estimated on the basis of a model of the Guam economy, using data from the Guam Department of Commerce and Labor, and adapting multipliers developed for Hawaii. Construction Type II Multiplier used: .24.

Source: SRI International, 1986.

Table 4.11.11
Direct, Indirect, and Induced Jobs
Supported by New Navy Activities and Personnel on Guam

		TOTAL WAGES & ALLOW-ANCES(1)			
	Jobs	1993	1994	1995	Long Term
A. Direct Jobs(2)					
B. Indirect & Induced Jobs Supported by Continuing New Cash Inputs		1,377	1,377	1,377	1,377
INPUT (Millions of 1992$s)		1,455	1,455	1,455	1,455
Spending by military stationed on Guam and civilian hires (3)					
Spending by transients (4)		0	-22	59	-73
Navy activities, support for personnel (5)		0	-7	19	-23
TOTAL INCREASE		2,832	2,694	2,564	2,736

Notes: (1) Direct jobs do not change over time. Housing allowances and TLAs change depending on availability of housing on Guam. In millions 1992 dollars.
(2) Permanent new Navy jobs, both civilian and military.
(3) Spending in Guam economy estimated as 50 percent of military and military dependent post-tax wages, plus housing allowances and estimated child care costs, and 75 percent of Navy civilian hire's post-tax wages.
(4) Based on population shown in Exhibit 1-B in Appendix H, with daily spending estimated as averaging $50 to $100 per transient.
(5) Estimated as 20 percent of total payroll for activity, from historic relations between military payrolls and non-construction purchases on Guam. Allows for local purchases by commissaries and exchange, as well as new activities.
(6) Derived from CRI model of job distribution in the Guam economy.

Sources: Wilbur Smith & Associates, in association with Duenas & Swavely, Inc. 1991.

This problem presents itself most noticeably in the construction industry. According to Government of Guam forecasts, Guam would have to import approximately 9,450 workers in 1995 without the new Navy construction and operations. The proposed action will cause an increase in the short-term demand for in-migrant civilian workers by about 1,800, mainly to fill construction jobs vacated by Guam residents who move on to work on Navy construction projects. However, by 2010, the need for imported workers will be reduced because construction will have ended and the increased number of military dependents will begin moving into the civilian economy. Nevertheless, with or without the new Navy construction, a deficit of over 34,000 jobs to workers is projected on Guam by 2010 (see Table 4.11.12).

Table 4.11.12
Projected Civilian Employment and Labor Force on Guam, With Versus Without Project

	WITHOUT PROJECT			WITH PROJECT			
	Projected Jobs: Demand	Labor Supply	Difference	Projected Jobs: Demand	Labor Supply	Difference	
A. Year 1995							
Duenas Project (1)							
Demand	66,481			66,481			
Natural Increase		58,368			58,368		
Adjustment due to Non-Project New Military (2)	270	1,129		270	1,129		
New MILCON (3)				500			
New Permanent Navy Civilian Jobs (4)				319			
Indirect & Induced Jobs							
Construction (3)				1,201			
Operations (4)				144			
Military Dependents (5)					530		
Reduction in Percent of Navy Families on Guam (6)				-13	-126		
Unemployment (7)		-2,003			-2,067		(More in-migrants needed)
TOTALS	66,751	57,495	-9,256	68,902	57,834	-11,068	1,812
B. Year 2010							
Duenas Projection (1)							
Demand	112,413			112,413			
Natural Increase		80,279			80,279		
Adjustment due to Non-Project New Military (2)	270	1,129		270	1,129		
New Permanent Navy Civilian Jobs (4)				319			
Indirect & Induced Jobs							
Operations				138			(Fewer in-migrants needed)
Military Dependents (5)					530		
Unemployment (7)		-3,380			-3,394		
TOTALS	112,683	78,028	-34,655	113,140	78,544	-34,596	-59

Notes:
(1) From Highway Master Plan projections, less military billets and personnel. Labor supply projections follow model of population growth given no migration to or from Guam after 1990.
(2) Adjustment for difference of 2,485 millitary billets between Navy estimates and Highway study. Jobs listed are indirect and induced jobs (using a ratio derived from CRI model of impacts of the new Navy activities). Additions to labor force are employed military dependents over 16, based on ratio of military personnel to employed dependents in 1990 Census.
(3) From Table 4.11.10.
(4) From Table 4.11.11.
(5) From Exhibit 1-8 in Appendix H and U.S. Census data on working military dependents in households.
(6) An estimated 148 Navy families who would otherwise transfer to Guam will likely not come, due to Navy policy that dependents can only come when housing is available. Estimate for induced jobs associated with those families from CRI model. Estimate for military dependents' labor force participation from 1990 Census.
(7) Even in Guam's strong economy, some unemployment is likely. A base rate of unemployment is estimated here from forecast jobcounts; the average number unemployed would be about 3 percent of the jobcount.

Sources: U.S. Bureau of Census, 1992; Wilbur Smith & Associates, in association with Duenas & Swavely, Inc., 1992.

Income. Incomes on Guam will receive a boost from the new construction and operations. The average annual direct income generated by construction is projected at about $12.9 million for the five year period between 1993 and 1997. Induced and indirect jobs associated with construction are expected to produce an average annual income totalling $15.7 million during the same time period for a total annual average of $28.6 million (see Table 4.11.13). Annual personal income associated with the new operations amounts to over $40 million from 1993 to 1996 and long term (in 1992 dollars) (see Table 4.11.14), with the majority of that income in direct military and civilian wages and allowances.

Spending. Construction activities are expected to account for almost $314 million in spending between 1993 and 1997, almost half of which will occur in 1994 (see Table 4.11.10). Completion of construction on Guam's military bases is anticipated by 1997.

The projected spending generated by the Navy activities is only a marginal addition to Guam's economy. Tourism still remains the driving force behind the island's future growth, with visitors spending over $750 million in 1990. The military accounted for only about $327 million in spending during the same year. Nevertheless, military spending contributes to the stability of the Guam economy and lowers its dependence on the cyclical tourist industry.

Government Revenue. The Government of Guam will also benefit monetarily from the proposed Navy actions. After the initial increase in revenues due to construction of the proposed facilities, long-term operations and activities will create approximately $8.1 million in revenues between 1998 and 2010 (see Table 4.11.15). These revenues will include:

- Annual federal income taxes paid by Navy personnel, their dependents, and other workers associated with the proposed action, totalling over $5 million;
- Income and gross receipt taxes paid by construction firms;
- Personal income taxes paid by construction workers (calculated at 50 percent of wages to allow for non-residents workers' wages taxed by the Federal government);
- Gross receipt taxes generated through the circulation of cash introduced into the economy by Navy and personal spending;
- A range of smaller taxes, fees, and revenues that would increase along with population growth;
- Federal funds for school lunches that would increase with larger enrollments; and
- Funds from the Department of Defense to the Guam Department of Education that would increase as more military dependents enrolled in the public school system (see Table 4-A in Appendix I).

Table 4.11.13
Income Associated with Project Construction
(In millions of 1992 Dollars)

	FOR PROJECTS BEGINNING IN:					ANNUAL AVERAGE
	1993	1994	1995	1996	1997	
Direct Employment (1)	$7.2	$30.5	$18.0	$7.8	$1.0	$12.9
Indirect & Induced Employment (2)	$8.8	$37.1	$21.9	$9.5	$1.2	$15.7
TOTAL	$16.0	$67.6	$39.9	$17.3	$2.2	$28.6

Notes: (1) Based on estimated construction FTE annual wage of $36,000.
(2) Based on estimated average 1992 wage on Guam ($18,250).

Table 4.11.14
Income Associated with Project Operations
(In millions of 1992 Dollars)

	ANNUAL PERSONAL INCOME, FOR THE YEARS:			
	1993	1994	1995	1996 and Long Term
Direct Employment (1)	$42.5	$41.9	$40.5	$39.2
Indirect & Induced Employment (2)	$2.8	$2.7	$2.6	$2.5
TOTAL	$45.3	$44.6	$43.2	$41.7

Notes: (1) Includes Navy payrolls for military and civilians, and allowances (COLA, subsistence, housing). Military personnel treated as in normal Navy distribution by rank.
(2) Based on estimated average 1992 wage on Guam ($18,250).

Table 4.11.15
Revenues to Government of Guam Associated with New Navy Activities

	1993	1994	1995	1996	1997	1998-2010
Personal Income Taxes						
Direct Operation Wages (Military & Civilian (1)	$5,560,269	$5,560,269	$5,560,269	$5,560,269	$5,560,269	$5,560,269
Project Construction Workers Wages (2)	$687,239	$3,010,665	$1,974,988	$783,098	$97,380	$0
Indirect & Induced Employment Taxable Wages (3)	$1,323,448	$1,262,597	$2,667,075	$1,360,809	$495,551	$372,675
Military Dependent Non-Project Wages (4)	$0	$0	$0	$0	$0	$0
Corporate Income Tax						
Construction (5)	$1,151,750	$5,045,600	$3,309,900	$1,312,400	$163,200	$0
Other Inputs to Local Economy (6)	$365,589					
Gross Receipts Taxes						
Construction (7)	$1,424,000	$6,028,000	$3,560,000	$1,544,000	$192,000	$0
Other Inputs to Local Economy (8)	$1,282,769	$4,425,856	$2,725,630	$1,335,457	$411,378	$279,656
Other Revenues (9)	$912,828	$868,502	$826,477	$881,769	$881,769	$881,769
Federal Grants						
School Lunch Program (10)	$47,916	$44,434	$36,633	$47,916	$47,916	$47,916
DOD/DOE Contract (11)	$722,400	$669,000	$552,300	$722,400	$722,400	$722,400
TOTAL REVENUES	$13,472,568	$31,177,192	$21,990,077	$13,928,723	$8,829,625	$8,141,654

NOTES:

(1) Based on taxable share of wages shown in Table 4.11.14. Average tax rate calculated at 16.23 percent.

(2) Based on indirect and induced workers' incomes, in Tables 4.11.13 and 4.11.14 taxed at 16.23 percent.

(3) Based on indirect and induced workers' incomes, in Tables 4.11.13 and 4.11.14 taxed at 16.23 percent.

(4) Taxes on military dependents' wages, at average Guam pay rates. To avoid possible double count, only the working dependents over the total direct civilian operations workers, indirect and induced operations workers, and indirect and induced construction workers are counted.

(5) MILCON expenditures, taxes at 34 percent.

(6) From cash flows due to project spending. Corporate income tax estimated on the basis of Government of Guam records 28.5 percent gross business receipts tax collected on those cash flows.

(7) Assessed at 4 percent of MILCON.

(8) Estimated using historical gross receipts taxes per person in the labor force adjusted to 1992 dollars using the Guam CPI in 1992 dollars, $2,020 per worker. Total based on indirect and induced workforce, in Tables 4.11.13 and 4.11.14.

(9) Includes Admissions and Excise Tax, Tobacco Tax, Alcoholic Beverage Tax, Fuel Tax, Licenses and Pers, and other charges for public services. Estimated on per capita basis.

(10) National School Lunch Program revenue extrapolated from historical amounts, Project associates revenues allocated on the basis of estimated military dependent school children.

(11) Estimated on assumptions that $4,200 is paid per military dependent pupil, but only 50 percent of pupils complete survey needed for Government of Guam to gain this revenue.

Government of Guam costs associated with the proposed actions are estimated between $4.9 and $5.5 million annually (see Table 4.11.16), yielding a positive cash flow to the Government of Guam of about $26 million in fiscal year 1994. The cumulative balance to the local government is anticipated to be over $63 million through 1997.

Table 4.11.16
Annual Government Cost Associated with the Project Population

	1993	1994	1995	1996	1997	1998-2010
Project-Related Population (1)						
Resident Military and Dependents	2,832	2,724	2,486	2,832	2,832	2,832
Other Civilians	0	-29	78	-96	-96	-96
DOE Students	344	318	262	344	344	344
Military Transients	682	682	682	682	682	682
Costs (2)						
Resident Military and Dependents	$2,463,321	$2,368,963	$2,612,556	$2,463,321	$2,463,321	$2,463,321
Other Civilians	$0	-$70,084	$187,953	-$232,552	-$232,552	-$232,552
DOE Students	$2,220,014	$2,054,885	$1,693,666	$2,220,014	$2,220,014	$2,220,014
Military Transients	$874,368	$874,368	$874,368	$874,368	$874,368	$874,368
TOTAL COSTS	$5,557,703	$5,228,132	$4,918,542	$5,325,151	$5,325,151	$5,325,151
TOTAL REVENUES (3)	$13,472,568	$31,177,192	$21,990,077	$13,928,723	$8,829,625	$8,141,654
ANNUAL BALANCE	$7,919,865	$25,949,060	$17,071,535	$8,603,572	$3,504,474	$3,504,474
CUMULATIVE BALANCE		$33,868,925	$50,940,460	$59,544,032	$63,048,506	Per Year Basis

NOTES:
(1) From Exhibit 1-B in Appendix H and Table 4.11.9.
(2) From Exhibit 5-B in Appendix H.
(3) From Table 4.11.15.

4.11.2.3 Housing

The demand for on-base housing will increase at all military installations that receive new personnel. Andersen will be able to accommodate its additional personnel in existing housing facilities. Off-base housing markets will experience little impact as a result of the increased on-base demand at this installation.

At Apra Harbor Complex, the number of additional personnel will be considerably higher than at the other bases (see Population Projections by Activity in Appendix C), as will the subsequent demand for on-base housing. Unlike Andersen and NAS Agana, on-base housing at Apra Harbor Complex is nearly full and therefore will not be able to accommodate all the new personnel. The short term impact of this on-base housing deficit is the influx of approximately 400 military families into the civilian housing market (see Table 4.11.17). These additional renters will further congest the already crowded housing market, thus, making housing more difficult to find and ultimately more expensive. In the long term, military families will eventually be able to move into on-base housing when it becomes available. As off-base housing prices continue to increase around Guam (and Navy families are subsequently priced out of the market) and the Navy completes its proposed development of 300 housing units at Apra Harbor, the number of off-base Navy families directly associate with the relocation action is expected to decline to approximately 87 by 1996.

Table 4.11.17
Military Demand for Off-Base Housing Attributable to New Navy Activities

A. NUMBER OF MILITARY HOUSEHOLDS ASSOCIATED WITH NEW NAVY ACTIVITIES (1)		
Average Household Size (2)		3.26
Number of Households		645
B. NEW DEMAND FOR OFF-BASE HOUSING (3)		
1. Available Military Family Housing		
1993 to 1995 (4)		250
1996 and Long Term (5)		550
2. Additional Demand for Civilian Housing from Military (A-B1)		
1993 to 1995 (4)		395
1996 and Long Term (5)		95
3. Percentage of Navy Families Able to Afford Market Rents (6)		
	1 Bedroom	2 Bedrooms
1993	99.8%	49.5%
1994	87.7%	29.6%
1995	49.0%	15.1%
1996	48.9%	2.7%
4. Estimated Additional Navy Households in Civilian Housing, Adjusted for Affordability (7)		
1993		395
1994		347
1995		242
1996 and Long Term		95

NOTES: Adapted from Appendix I, Exhibit 4-B.

(1) Based on 1,377 military billets, 1,455 dependents.

(2) From 1990 Census, for households (on- and off-base) composed entirely of members of the armed forces and military dependents.

(3) Assumes all existing Navy family housing is taken.

(4) This includes housing for VRC-50 personnel at Andersen. It does not include military family housing units recently occupied by Navy personnel who are being replaced by civilian mariners.

(5) After construction of 300 housing units, from the 1993 MILCON authorization (updating the number used in Appendix I in light of current plans).

(6) From Navy projections of demand for off-base housing and consultant forecasts of future rents and housing allowances (for Navy Housing Office). That study assumes that rent increases are not dependent on Navy families' ability to pay.

(7) Based on assumed provision of up to 115 leased units at controlled rates, and ability of Navy families not housed in leased units to meet market prices. Average of 1-bedroom and 2-bedroom affordability limits used to estimate rental market capture rate. (The Navy has not yet concluded an agreement for long-term leasing. If this proves impossible, the result would be fewer Navy families in civilian housing, i.e., less impact.) Appendix I states that the Navy will lease units in the Apusento Gardens in Chalan Pago. No lease agreement has been concluded, but it is assumed that the Navy will lease up to 115 units of private housing in the community—either at Apusento Gardens or elsewhere.

SOURCES: U.S. Bureau of the Census, 1992; WESTCO/PAC International, Ltd., 1992.

Navy families who are able to find off-base housing will most likely be dispersed throughout the civilian community. Hence, no long-term change is expected in particular civilian neighborhoods.

4.11.2.4 Social Environment

The members of the Navy community being sent to Guam will experience some serious social effects due to pressures associated with the relocation. Problems of family stress may arise because of difficulties in finding and then paying for housing and living in an expensive society with a limited income. Separation of families may also occur for those families which cannot obtain suitable housing in Guam's tight housing market. For those families which do make it to Guam, the difficulty in finding child care for small children may inhibit spouses from finding well-paying jobs to supplement the low military income.

The new activities and personnel on Guam will boost the level of business for the entertainment districts located in East Agana. The resident and transient personnel will account for an estimated 25 percent increase in military visitors to the area. No expansion of the districts serving these customers is likely.

4.11.3 Proposed Mitigation Measures

The proposed actions described in this document include several steps to mitigate potential socioeconomic impacts related to the relocation. These occur in the construction of housing, child care facilities, and infrastructure. Also, by bringing military dependents to Guam who will contribute to the local labor pool, the project helps to address Guam's problem of labor supply. Possible steps to mitigate the projected socioeconomic impacts of the relocation are listed below. Many of the mitigation measures discussed herein are already planned or being developed by Navy officials.

4.11.3.1 Housing Measures

The Navy has initiated several actions and policies to limit the impact of additional families on a constrained housing market:

- Dependents of Navy personnel being transferred to Guam not as part of the relocation action can only come to Guam when housing has been found for them, on- or off-base. This regulation (a) insures that no sudden increase in demand will change market conditions, and (b) keeps the number of military families on Guam in line with housing resources.

- In the short term, the Navy is attempting to lease units in the private sector to help handle the gradual in-flow of relocated families. These units will be leased only as they become available when vacated by the previous lessee.

- In the long term, the Navy plans to build 250 new family housing units in addition to the proposed action to enable most Navy families living off-base to move onto the installation.

The housing analysis conducted by CRI concluded that even with the additional 250 units of on-base military family housing, demand for off-base housing will continue. Available projections suggest that such housing may be prohibitively expensive by 1996. Estimates of future demands for housing will be monitored and analyzed in light of the future military population on Guam.

4.11.3.2 Economic and Employment Measures

If the recent decline in civilian construction continues, the construction program associated with the new Navy activities could help maintain the prosperity of Guam's construction industry and work force. Guam construction firms' participation in bidding could be maximized by assuring that information about bids and anticipated projects is available on Guam and that some of the construction bids are handled by Guam offices, rather than in Honolulu.

In Guam's tight labor market, any disruption due to hiring for new operations jobs can be minimized by hiring young workers as they enter the job market following graduation. The Navy's apprenticeship program allows such hiring to occur.

Mitigation measures to insure that the Guam Department of Education is able to receive full funding for military dependents can be addressed in several ways:

- Guam authorities need information concerning the number and location of project-related military dependents. The DOE is being informed of plans to house Navy families, as the location of new housing will affect particular schools.

- The DOE's census must be updated to include all military dependents within the school system. This can be achieved by (a) making the census a part of the basic student registration procedures, and (b) by stressing the importance of registering students properly to newly arriving families.

4.11.3.3 Social Environment

Project impacts on some military families could be far-reaching. Those anticipated to be affected more than others include children separated from their Guam-based military parents because housing is not available, and families suffering stress due to relocation, the high cost of living, or difficulties in adjusting to conditions on Guam. Major steps to mitigate family problems include:

- Increased counseling for military families, including programs dealing with relocation assistance, spouse employment, family problems, stress management, intercultural relations, and financial management. Efforts will be made to fully staff family support services.

- Increased efforts to recruit additional childcare-givers to cover the short-term needs before the construction of new child care facilities. Efforts will include workshops on registration, child-proofing family quarters, activities for family caregivers, and the development of a network of family caregivers which could provide support and information among members.

Impacts of the proposed action on Guam's civilian population are expected to be relatively marginal. Civilian and military authorities have often cooperated in the past to assure public safety on Guam. Such cooperation should mitigate potential impacts associated with the project, however, small increases in public safety personnel may be needed. The potential for confrontations between civilians and military personnel can be limited through proactive measures which are largely a continuation or expansion of existing programs. These measures include:

- Programs to control substance abuse (among both the military and young civilians);
- Intercultural awareness briefings for new arrivals; and
- Informing both permanent and transient military personnel of the recreational opportunities to be found on Guam and in the adjacent Mariana islands to allow them to find the recreation they seek in the places where such recreation is gladly provided.

4.12 NATURAL AND MAN-MADE HAZARDS

4.12.1 Natural Hazards

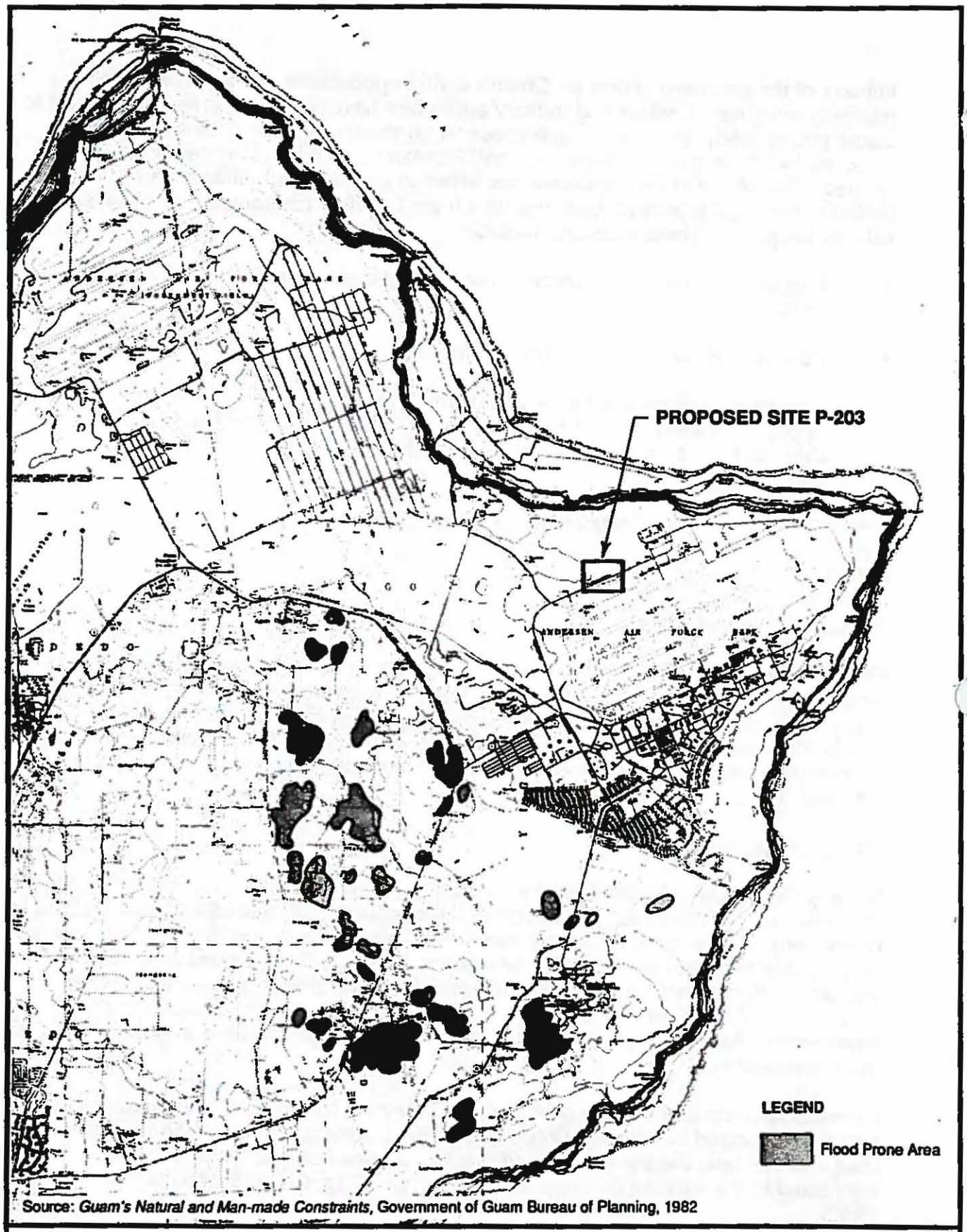
4.12.1.1 Flood Hazard

Flood hazard zones are low lying areas which retain runoff overflow during periods of heavy rainfall. These zones are generally found in level areas which, due to the encroachment of urban development, have already had many of their drainage capabilities hindered. The result of this deterioration of drainage systems has been the increased incidence of erosion and flood-related damage to structures (Guam Bureau of Planning, 1982).

Andersen Air Force Base

Existing Conditions. Located on the flat, porous limestone plateau at the northern end of the island, Andersen rarely experiences flooding or runoff difficulties brought about by heavy rains. The water readily percolates into the subsurface and then into the aquifer, leaving little opportunity for ground saturation. The only flood hazard zones in the area are located to the southwest of the base, away from any kind of activity (see Figure 4.12.1) (U.S. Army Corps of Engineers, 1980). According to the Federal Emergency Management Agency's Flood Insurance Rate Maps, the hangar site is in Zone C (area of minimal flooding).

Potential Impacts and Proposed Mitigation. The new hangar/apron/washrack facilities will not be located in a known flood hazard zone. Except for the location of the new road and fuel line, the site sits on land that has already been developed and, thus, will be connected to the existing drainage system (Navy, 1992g; Guam Bureau of Planning, 1982).



Source: *Guam's Natural and Man-made Constraints*, Government of Guam Bureau of Planning, 1982

North

0 3000 6000 12000

Scale in Feet

Figure 4.12.1
FLOOD-PRONE AREAS—
ANDERSEN AIR FORCE BASE
Guam Development EIS
April 1993

242.010/23

Apra Harbor Complex

Existing Conditions. Located in the south-central part of Guam, the Apra Harbor Naval Complex is unlike the northern region in that its predominantly dense, clay-based soils do not absorb water as readily as porous limestone. Flood hazard areas exist in the northern and southern portions of the base (see Figure 4.12.2). The problem of surface runoff overflow presents itself in times of heavy precipitation, usually during the wet season months between July and December (see Figure 4.12.3). Effects of these overflows are serious surface erosion and occasional floods (U.S. Army Corps of Engineers, 1980). The Federal Emergency Management Agency's Flood Insurance Rate Maps indicate that three of the proposed construction projects in the Apra Harbor Complex are located in Zone A, 100-year flood areas where base flood elevations and flood hazard factors have not been determined. The EODMU-2 facilities and bulkhead (P-393), ship spares storage warehouse (P-168), and Integrated Storage and Handling Facility (P152) are in Zone A. Part of one of the alternative housing sites, New Apra Heights, lies in Zone A, but it is not the preferred alternative. All other construction projects in the Apra Harbor Complex are located in Zone C, areas of minimal flooding.

Potential Impacts and Proposed Mitigation. With the exceptions noted above, no structures are planned for development in flood hazard areas. The waterfront location of the three projects in Zone A will be taken into account in their design and construction. The proposed Tipalao Housing sites have no identified flood prone areas, and drainage or flooding problems are not anticipated at either site. Of the alternative housing sites, Polaris Point presents potential flooding problems due to its poor soil/drainage conditions and relatively low elevation. Approximately one-half of the site has been identified as a flood prone area. The New Apra Heights site has the potential for localized high water in areas beneath steep slopes. The low lying areas of this site exhibit drainage problems and ponding following rains.

Naval Magazine

Existing Conditions. Naval Magazine Guam (NAVMAG) is located in southern Guam and features the same soil types as those found near Apra—dense, clay-based soils overlaying volcanic material. Of the 8,840 acres which comprise NAVMAG, 42 percent of that land area is used as watershed. As a result, NAVMAG experiences similar runoff overflow as Apra and is also characterized by many streams which have the potential to flood in times of heavy rainfall (Navy, 1991b; U.S. Army Corps of Engineers, 1980). The Federal Emergency Management Agency's Flood Insurance Rate Maps show the two proposed NAVMAG projects located in Zone C (area of minimal flooding).

Potential Impacts and Proposed Mitigation. The proposed missile magazines and inert storehouse will be constructed on existing building slabs located in previously developed areas. One large flood hazard areas exist in the eastern portion of the NAVMAG site, far away from the areas proposed for construction (see Figure 4.12.4). Any flood hazard caused by the new buildings will be minimal (Navy, 1992g).

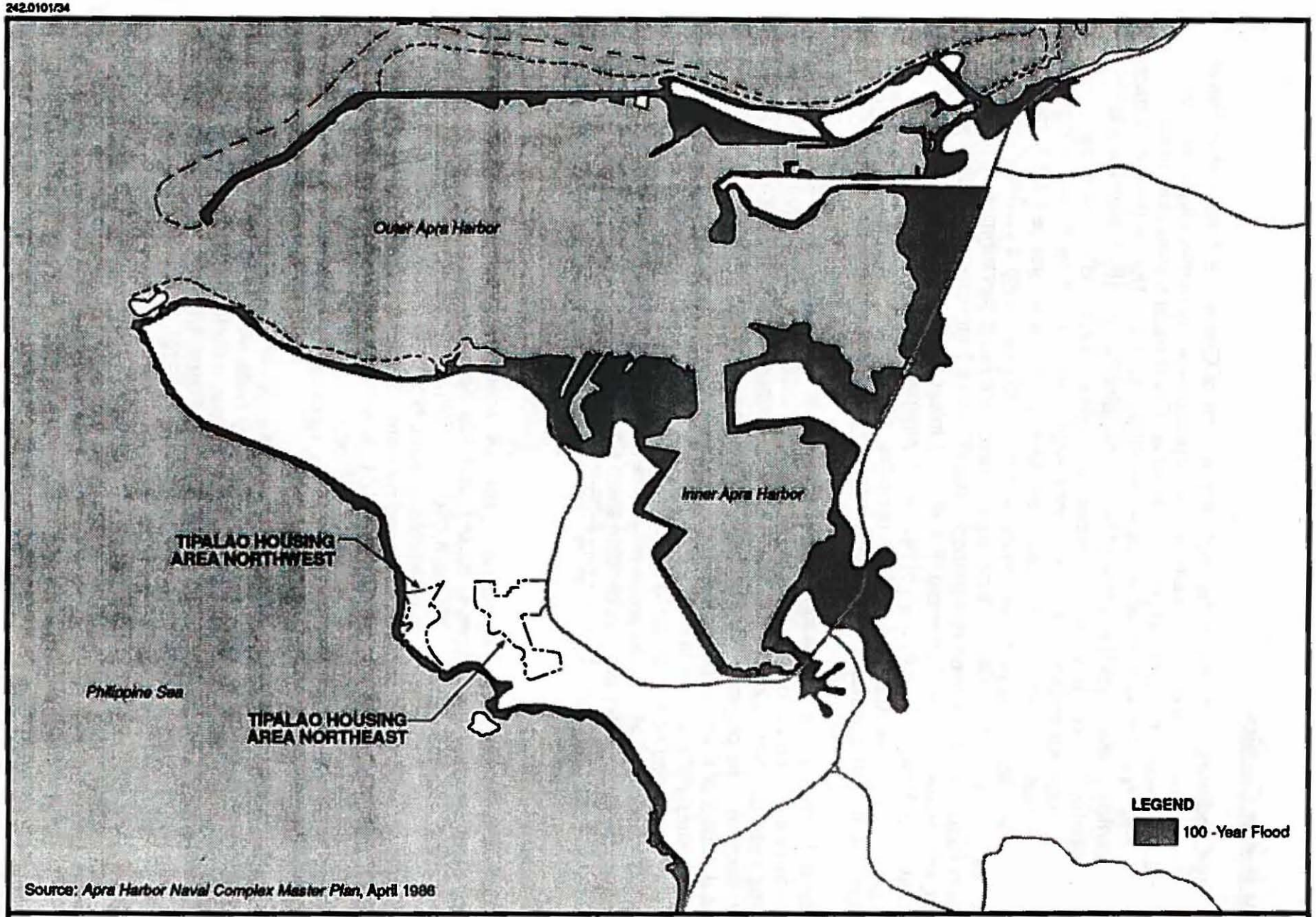


Figure 4.12.2
FLOOD-PRONE AREAS—
APRA HARBOR COMPLEX
Guam Development EIS
/ 1993

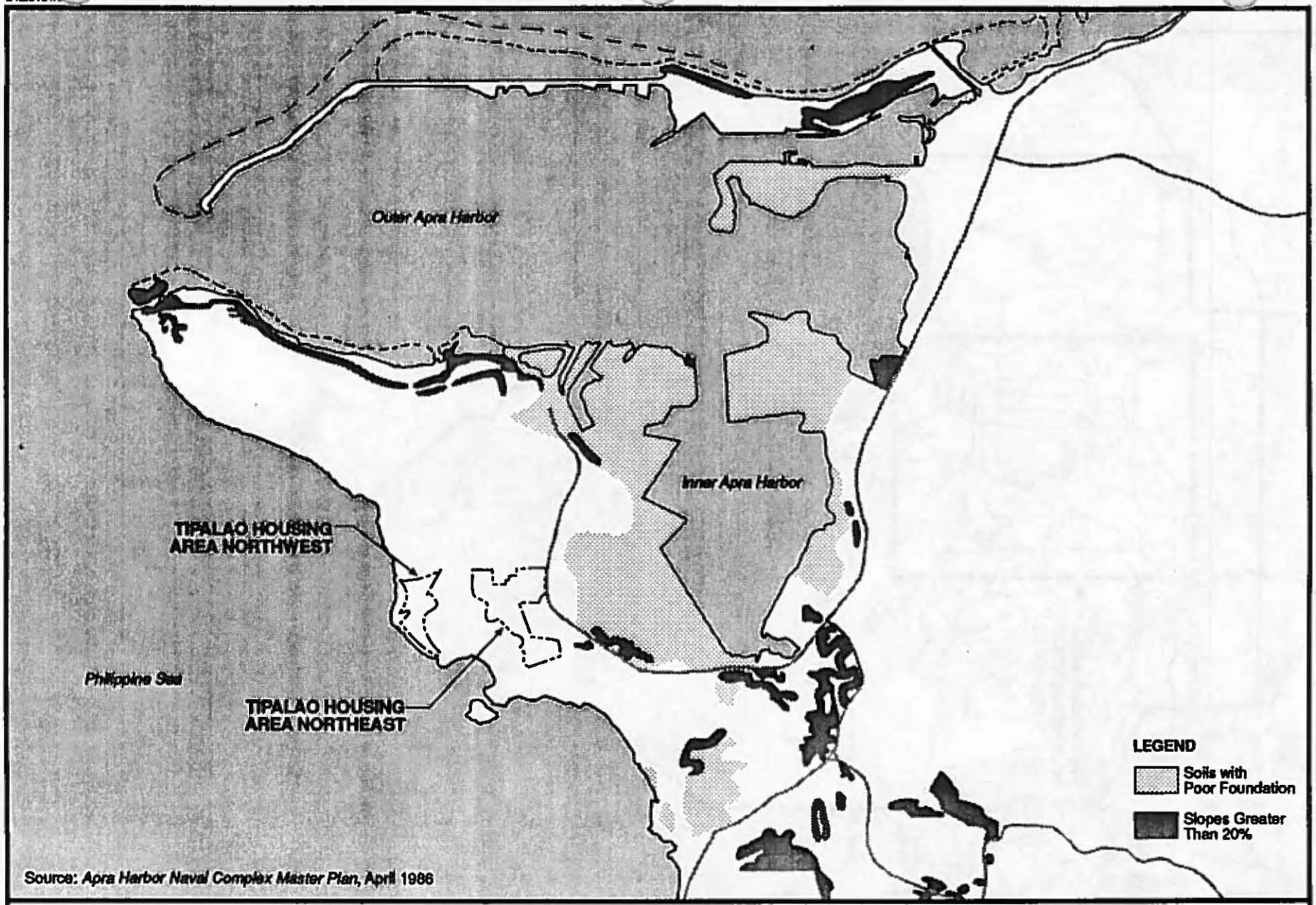


Figure 4.12.3
SLOPE CONSTRAINTS—
APRA HARBOR COMPLEX
Guam Development EIS
April 1993

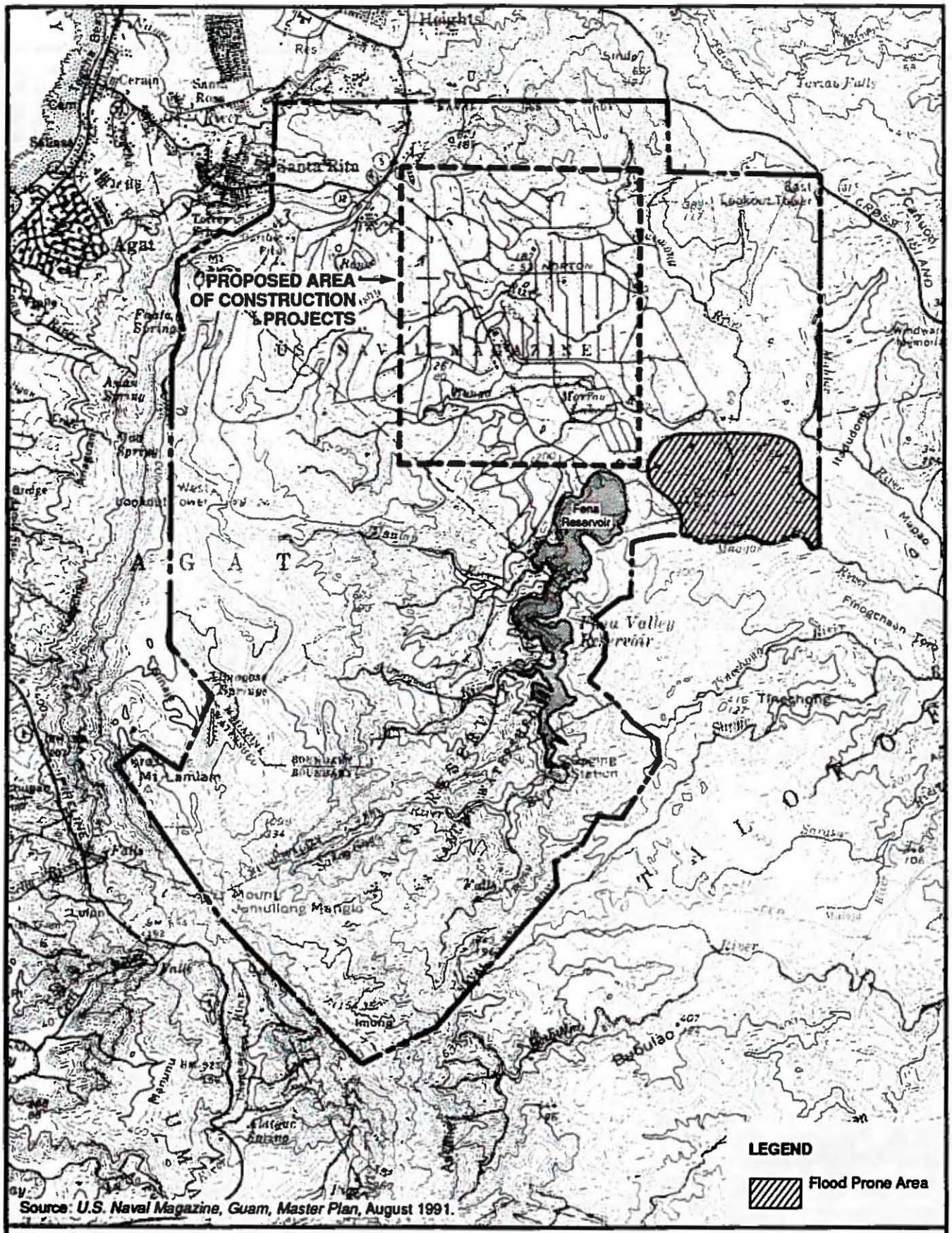


Figure 4.12.4
FLOOD-PRONE AREAS–NAVAL MAGAZINE
Guam Development EIS
April 1993

4.12.1.2 Typhoons

The whole island of Guam lies in a typhoon belt and experiences several typhoons every year, mostly during the wet season months from July to December. Consequently, all structures on Guam are prone to exposure to high winds and rain generated by typhoons (U.S. Army Corps of Engineers, 1980). Wind speeds can exceed 200 miles per hour, as was the case with Typhoon Pamela in 1976.

All new facilities will be constructed to meet regulations pertaining to typhoons. These regulations call for new construction to withstand wind speeds of up to 155 miles per hour.

4.12.1.3 Seismic Activity

Seismic fault zones subdivide the island's geologic structure and pose potential hazards during earthquakes. Guam is located in a seismic probability zone 3 (zone 0 means no damage; zone 4 means major damage) and has experienced a relatively high frequency of strong earthquakes over the last century (Guam Bureau of Planning, 1982). New construction will be designed in accordance with Naval Facilities Handbook P-335 to accommodate probable seismic loads.

Andersen Air Force Base

Existing Conditions. The nearest seismic fault zones lie to the south of the base. Some of these fault lines run from the coast towards the northwest, while others cross them headed in the southwesterly direction (see Figure 4.12.5). The longest fault line is approximately three miles long.

Potential Impacts and Proposed Mitigation. All facilities and structures, including the proposed hangar/apron/washrack facility, are located far enough away from the fault zones that they will not experience any detrimental impacts from seismic activity. Nonetheless, the new structures will be built according to the Navy's buildings codes to withstand quakes of magnitudes equal to or greater than 6.0 on the Richter scale (Navy, 1992g).

Apra Harbor Complex

Existing Conditions. Seismic fault zones lie to the south and west of Apra's inner harbor. The longest fault line is approximately four miles long and passes between Apra Harbor Complex and Naval Magazine in the northeasterly direction (see Figure 4.12.6).

Potential Impacts and Proposed Mitigation. The proposed sites for new development at Apra Harbor Complex are located well away from the fault lines. Navy construction guidelines for withstanding earthquakes measuring 6.0 or greater on the Richter scale will be applied to all new structures.

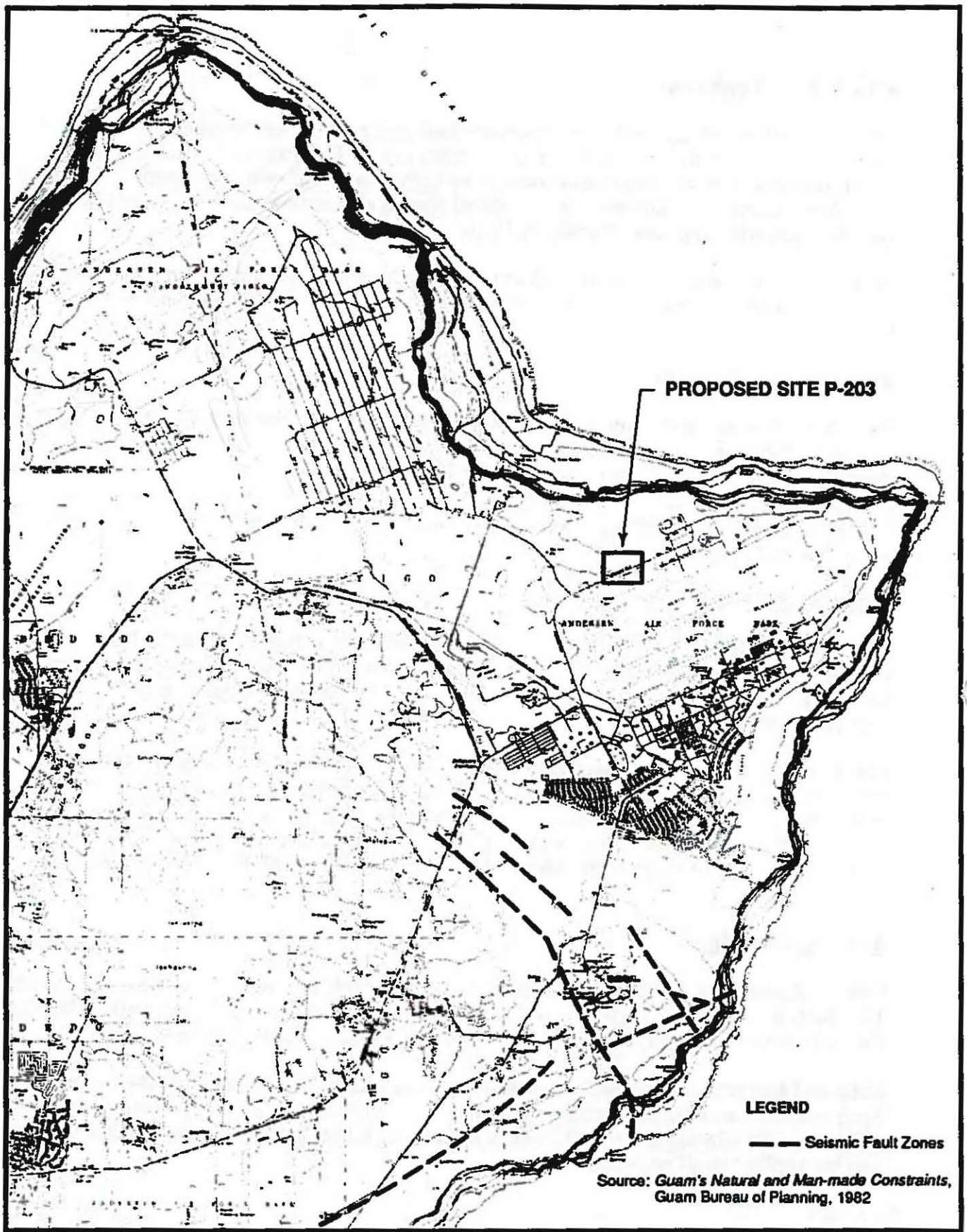


Figure 4.12.5
SEISMIC FAULT ZONES—
ANDERSEN AIR FORCE BASE
Guam Development EIS
April 1993

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Naval Magazine

Existing Conditions. Naval Magazine sits on top of a fault line extending from Talofofo Bay on the eastern side of the island to Santa Rita on the western side (see Figure 4.12.6). Most of the fault line is "concealed" with about a three mile segment "definitely" located on Naval Magazine land (Guam Bureau of Planning, 1982).

Potential Impacts and Proposed Mitigation. The current area proposed for construction lies in close proximity to a hidden seismic fault zone. Munitions stored at Naval Magazine will be configured to reduce potential for damage to stored ordnance. Construction on or near the fault line will take into account the potential for seismic shock and shifting earth.

4.12.1.4 Tsunamis

Although Guam is located in an active seismic zone, earthquake activity in the western Pacific has rarely generated large-scale tsunamis. The only damaging tsunami on record occurred in 1849 (Navy, 1986a). Construction in low-lying coastal areas will only occur if the facilities require water frontage and no other feasible alternative exists.

4.12.2 Man-Made Hazards

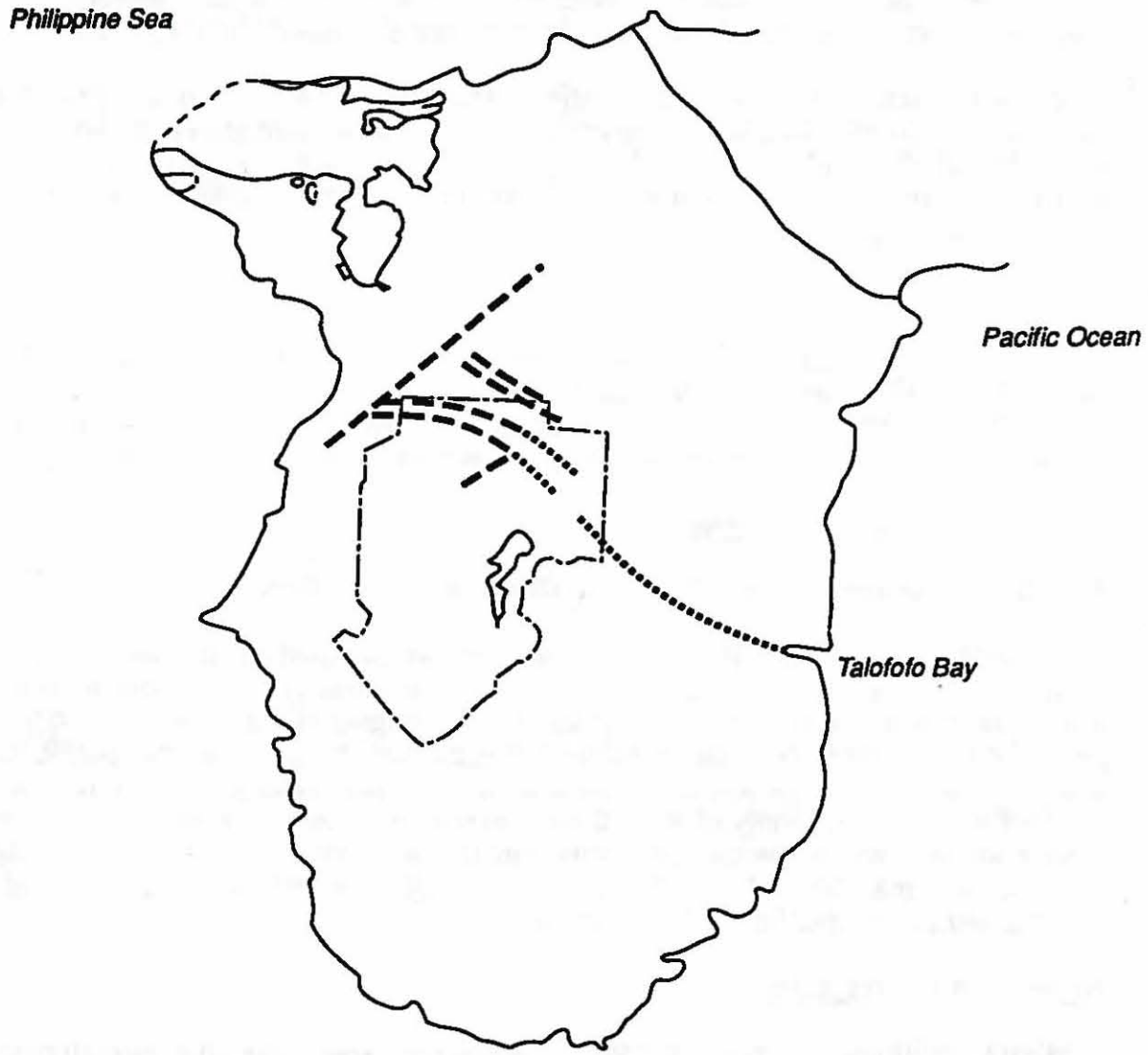
4.12.2.1 Explosive Safety Quantity Distance (ESQD) Arcs

Explosive Safety Quantity Distance requirements are outlined by the Department of Defense for the purpose of separating the potential hazards of certain types of explosives from other functional areas of military bases. The designated hazard zones aim to prescribe minimum safety distances between explosive storage areas and public roads, structures,and residential areas. These distances are proportional to the cube root of the TNT equivalent quantity of explosives stored at any potential explosion site. The areas contained within the arcs generally preclude most kinds of human activity, but the outer portions may be used for military runways, highways, military recreation, and uninhabited storage facilities (Navy, 1991b).

Andersen Air Force Base

Existing Conditions. All munitions storage areas and explosive-loaded aircraft parking areas on Andersen have ESQD arcs surrounding them. The result is a number of overlapping ESQD arcs that encompass the entirety of the main airfield, Northwest Field, and their respective environs. These arcs were devised when Andersen housed B-52 squadrons stationed there in the past. With the departure of the B-52s and the transfer of VRC-50 to Andersen, these ESQD arcs are undergoing review for possible reconfiguration due to the considerable reduction in storage requirement (Navy, 1992e).

Potential Impacts and Proposed Mitigation. VRC-50 acts primarily as a support squadron and does not engage in any combat missions. Any additional munitions will be minimal and no impacts or arc expansions which will affect surrounding areas are anticipated. The proposed hangar is not within an ESQD arc.



LEGEND
Concealed
Definitely Located
NAVMAG Boundary

Source: NAVMAG Master Plan 1991

North

0 1 2 3
Scale in Miles

Figure 4.12.6
SEISMIC FAULT ZONES—
NAVAL MAGAZINE AND APRA HARBOR
Guam Development EIS
April 1993

242.0101/38

Apra Harbor Complex

Existing Conditions. Apra Harbor has two ESQD arcs resulting from the presence of explosives. The first one surrounds Kilo Wharf on Orote Peninsula. Ammunition operations take place in this designated area, which had previously been located across Outer Apra Harbor on Hotel Wharf. The ESQD arc has a maximum radius of 7,210 feet that currently encompasses part of the Sumay/Lockwood Family Housing area. This arc is activated when ammunition ships operate at the wharf with hatches open, or when ammunition is staged at the wharf. The extent of the arc depends on the amount of explosives present. There are standard 115-foot arcs at the base of each pier resulting from the presence of explosives on ships.

The second ESQD arc extends a maximum of 1,565 feet from the ordnance handling facilities at Alpha wharf and 1,250 feet from Bravo wharf located on Polaris Point. Although this ESQD arc is much smaller than the one on Orote, it still covers much of the southeastern part of Polaris Point (see Figure 4.12.7) (Navy, 1986a).

Potential Impacts and Proposed Mitigation. The Navy does not plan to add any new ammunition storage facilities to Apra Harbor. However, although no new ESQD arcs will result from new Navy operations in Apra Harbor, the frequency of their activation may increase, and the presence of munitions may impact several new and existing facilities. The activation of the maximum ESQD arc created by the increased unloading of munitions at Kilo Wharf will cause the closing of Gab Gab Beach for an estimated 32 days each year. Additional beach facilities will be opened to compensate for the closing. The proposed Northwest Tipalao Expansion Area is close but outside of the existing Kilo Wharf ESQD arc.

The Navy plans to build an Explosive Ordnance Disposal (EOD) Unit operations facility in the Apra Harbor Complex area. The EOD facility will act as administrative space, a vehicle storage and maintenance area, and a boat storage area during typhoons. No new munitions will be stored in this facility, nor will any explosive disposal or detonation occur at the site (Navy, 1992g).

Naval Magazine

Existing Conditions. Naval Magazine has approximately twenty ESQD arcs of various sizes and magnitudes extending over about 80 percent of its land area. Some of the arcs spill over into the neighboring civilian areas. The only areas of the base not in an ESQD arc are most of the southern portion and several corners in the northern and western parts. The largest ESQD arc surrounds the ordnance disposal site in the southern part of the base. The arc extends 5,000 feet from the center of the disposal site, in which materials associated with unserviceable and unexploded ordnance are detonated and disposed of (Navy, 1991b). See Figure 4.12.8.

Potential Impacts and Proposed Mitigation. The Navy proposes to build additional missile magazines and inert storehouse at Naval Magazine. The new missile magazines will store Tomahawk cruise missiles as well as other ordnance which will subsequently increase the tonnage at the base by 50 percent. The existing ESQD arcs in the northwest portion will compensate for these additional hazards.

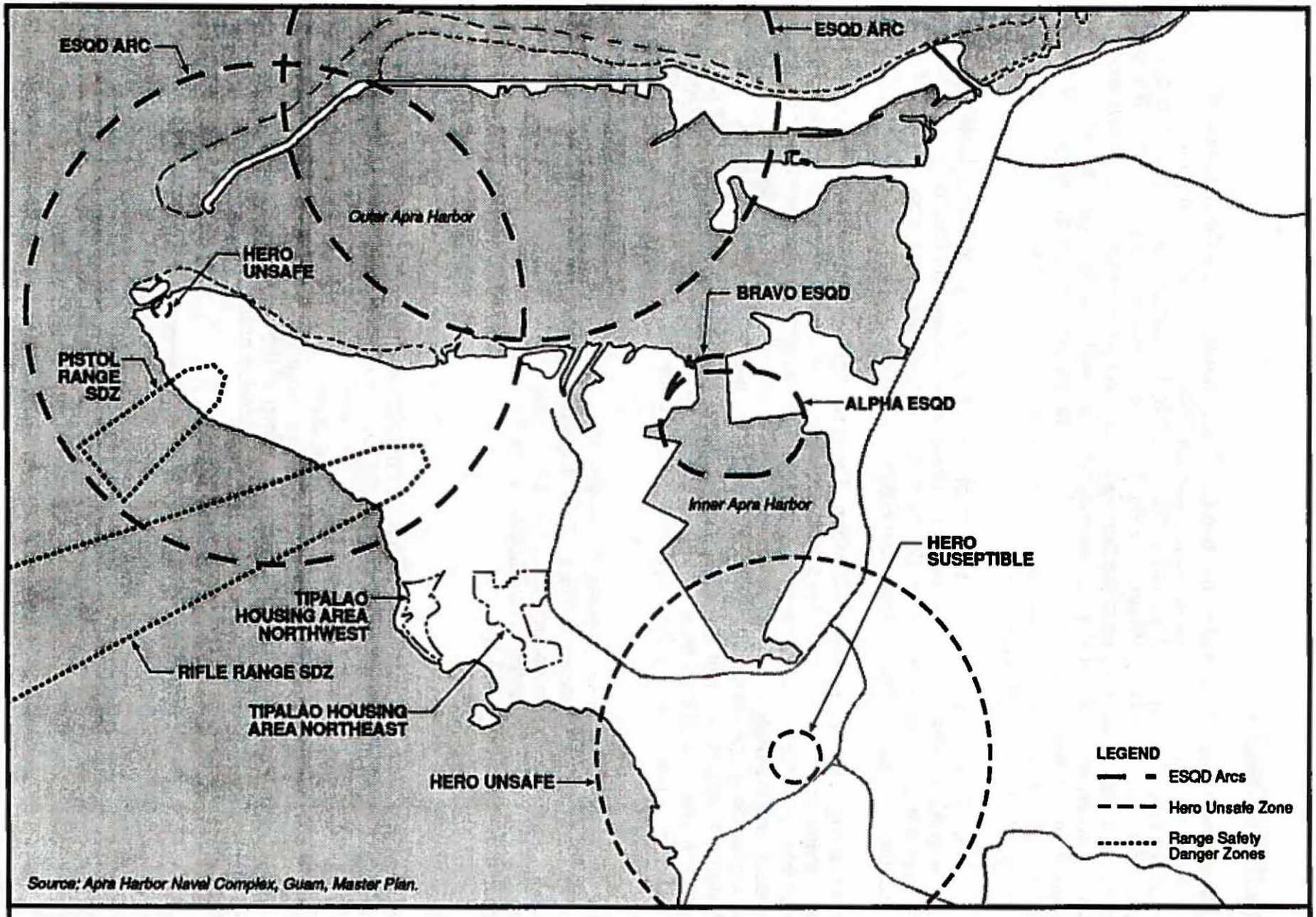


Figure 4.12.7
MANMADE HAZARDS—APRA HARBOR
Guam Development EIS
A[illegible] 1993

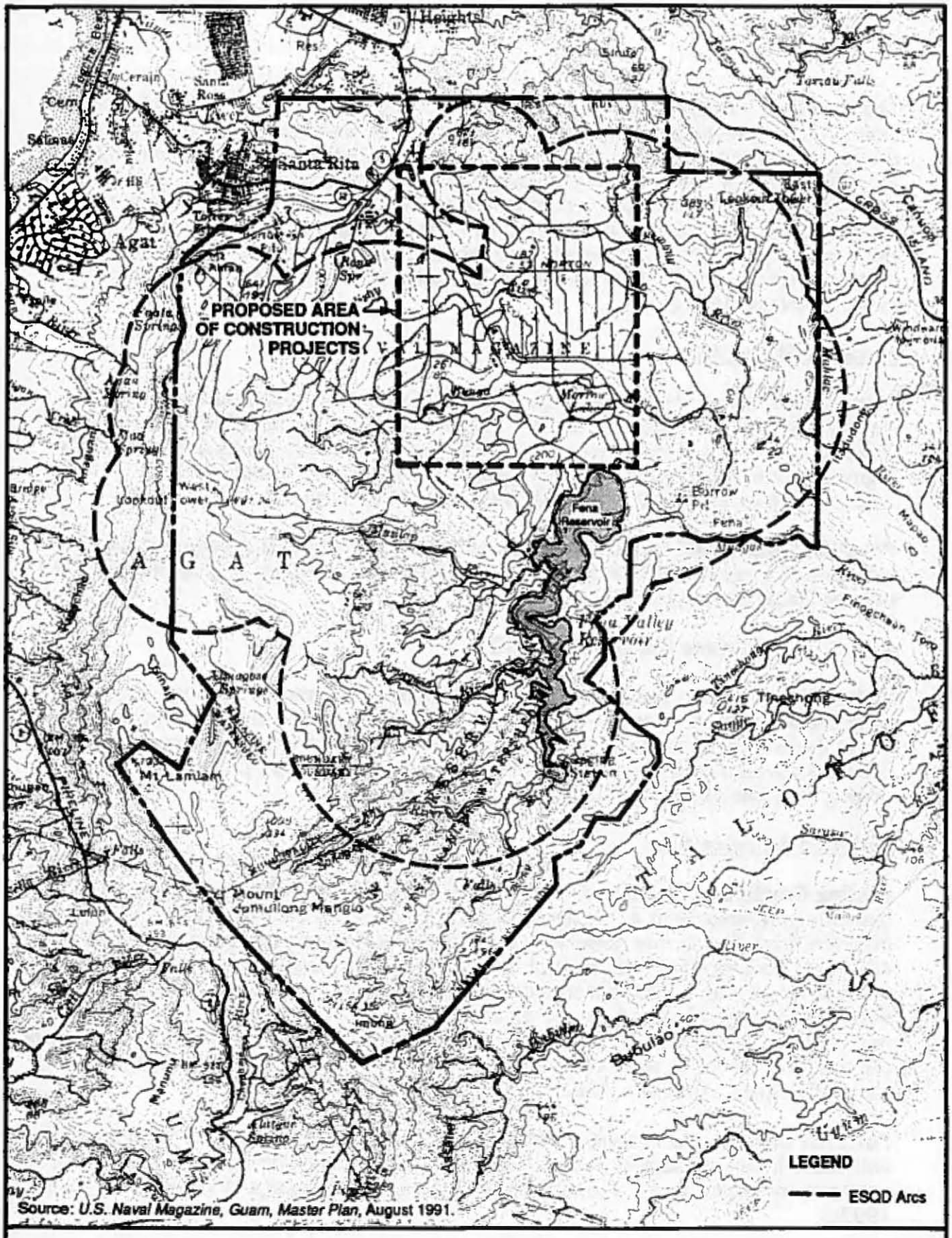


Figure 4.12.8
ESQD ARCS–NAVAL MAGAZINE
Guam Development EIS
April 1993

The increased tonnage at Naval Magazine will not cause the ESQD arcs to further extend into the neighboring civilian landholdings. As it stands, the location of the proposed magazines is in the north central portion of the base, inside an existing ESQD arc. The siting for high explosive storage areas was included in the 1991 master plan for this installation. The land use is compatible for the missile magazines and inert storehouse, but poses a potential hazard to the enlisted dining facility addition as well as to all other buildings in which personnel live and work. These particular buildings lie to the north and west of the new and existing ESQD arcs, so the threat of an explosion is reduced. (Navy, 1992g).

Naval Air Station Agana

Existing Conditions. NAS Agana has several ESQD arcs surrounding the munitions storage and operating facilities located near the northeast corner of the runway area. The arcs cover parts of the runways as well as several off-station areas such as a public highway, some private property, and a portion of the Naval Computers and Telecommunications Area Master Station (NCTAMS), Barrigada (Navy, 1984).

Potential Impacts and Proposed Mitigation. No new munitions storage facilities are scheduled for construction at NAS Agana, and no new buildings will be placed in the existing ESQD arcs (Navy, 1992g).

4.12.2.2 Surface Danger Zones (SDZ)

Surface Danger Zones generally surround areas used for firearms training. The type of zone usually consists of an arc that extends from the firing line at some specified angle out to the end of the range or as a safety radius extending from the center of the facility. Facilities covered by these zones include, but are not limited to, pistol ranges, rifle ranges, machine gun ranges, and hand grenade ranges.

Andersen Air Force Base

Existing Conditions. Andersen's Small Arms Range Complex currently features a machine gun range with a 35 degree surface danger zone extending about 300 yards from the firing line, a rifle range with a 15 degree surface danger zone extending almost 400 yards from its firing line, a pistol range with a 10 degree zone around it, and a hand grenade range with a 200-foot surface danger zone radius extending from its center. All these facilities are clustered closely together to the north of, and well away from, the main base area and aircraft runways. The respective surface danger and safety zones of the machine gun, rifle, and pistol ranges overlap in some areas (Site Plan, Small Arms Range Complex, Andersen AFB).

Potential Impacts and Proposed Mitigation. The personnel from VRC-50 and NSWU-1 will cause increased activity at these facilities; however, the addition of the squadron will not have any effect on the size and shape of the surface danger and safety zones (Navy, 1992g).

Apra Harbor Complex

Existing Conditions. The Apra Harbor Complex features a combined outdoor pistol range and rifle range located on Orote Peninsula. The facility lies within the ESQD arc surrounding the ammunition wharf on Orote Peninsula, and its SDZ extends out over the ocean. This zone also cuts through the Orote Ecological Preserve (Navy, 1986a). See Figure 4.12.7.

Potential Impacts and Proposed Mitigation. While not part of the proposed actions, the Guam Army National Guard proposes to expand the existing rifle range facility. The plan includes a Multi-Purpose Range (MPR) which will feature an M-60 machine gun 10-meter line, a 25-meter line, and 50- meter line for the M-16 rifle and pistol zeroing. The MPR will be located next to the existing Known Distance (KD) Range and will lie within the current SDZ. In addition to the 45-foot high natural backstop, the project will include earth berms and baffles to minimize the surface danger hazards.

The pistol and rifle range will experience an increase in activity due to the arrival of new personnel; however, the SDZ will not require any alterations. No new facilities are proposed in the vicinity of this zone. The proposed ranges will be located to the east or right of the existing firing range facility and will consequently be closer to the Sumay/Lockwood housing area (Army Memorandum for Commander, Naval Station Guam; April, 1992). (See Figure 4.12.7.)

Naval Magazine

Existing Conditions. NAVMAG Guam features no functioning range training facilities and, subsequently, no surface danger zones. EOD training will remain consistent with previous training procedures.

Potential Impacts and Proposed Mitigation. None.

Naval Air Station Agana

Existing Conditions. There are currently no surface danger zones at NAS Agana as no firing ranges of any sort exist on the base.

Potential Impacts and Proposed Mitigation. No new facilities requiring surface danger zones are scheduled for construction.

4.12.2.3 Accident Potential Zones (APZ)

Accident Potential Zones (APZ) result from the need to protect life and property in the event of airplane crashes. They are generally found near the approach-departure zones of airports and delineate the probable impact areas if an accident were to occur. Past experience shows that the probability of an accident is greater on the approach end than on the departure, and that this probability decreases as the aircraft moves farther away from the runway (Navy, 1990e).

Andersen Air Force Base

Existing Conditions. Overall APZs at Andersen AFB are determined by approach-departure zones, the type of aircraft utilizing runways, and where the most accidents have occurred in the past. These zones are broken down into Clear Zones located at the end of each runway and additional APZ delineations (see Figure 4.12.9). APZ I measures 3,500 feet in width and 5,000 in length and appears immediately after the Clear Zone. APZ II is 7,000 feet long and 3,500 feet wide and lies just beyond APZ I. There is no APZ II at the north end of Andersen's runway as this zone is out over the ocean.

The Clear Zones represent the areas of highest risk and are considered too dangerous for any reasonable economic use of land. They have traditionally been acquired by the federal government and are kept clear of obstructions to flight. The APZs have declining levels of risk the farther they get from the runway. Land use regulations restrict population densities in the APZs, yet are still flexible enough to allow for some economic activity (U.S. Air Force, 1992; Guam Bureau of Planning, 1982).

Potential Impacts and Proposed Mitigation. The Clear Zones and the APZs will remain constant after the arrival of VRC-50. The zones were originally delineated for the B-52s and C-5s. No new development is proposed for these areas.

Naval Air Station (NAS) Agana

Existing Conditions. Clear Zones and APZ delineations I and II appear at the end of the runways and extend off the limits of the station.

Potential Impacts and Proposed Mitigation. No new projects are proposed for these areas and their boundaries will remain the same (Navy, 1984). The FCLPs performed by the VRC-50 squadron at NAS Agana have no impact on the existing Clear Zones or APZ delineations.

4.12.2.4 Electromagnetic Radiation (EMR) Zones

Electromagnetic Radiation Zones are generally found around transmitting antennas where high density electromagnetic power intensities may pose a hazard to personnel, explosives, or fuels, or may interfere with non-military electronic equipment. Hazard of Electromagnetic Radiation to Ordnance (HERO) UNSAFE zones extend out from the smaller Electromagnetic Interference (EMI) zones to prevent the location of ordnance storage facilities in these areas (Navy, 1991a).

Andersen Air Force Base

Existing Conditions. The Naval Computers and Telecommunications Area Master Station (NCTAMS WESTPAC) at Finegayan is located to the west of Northwest Field and, as a result, several electromagnetic interference (EMI) zones extend into the Northwest Field area.

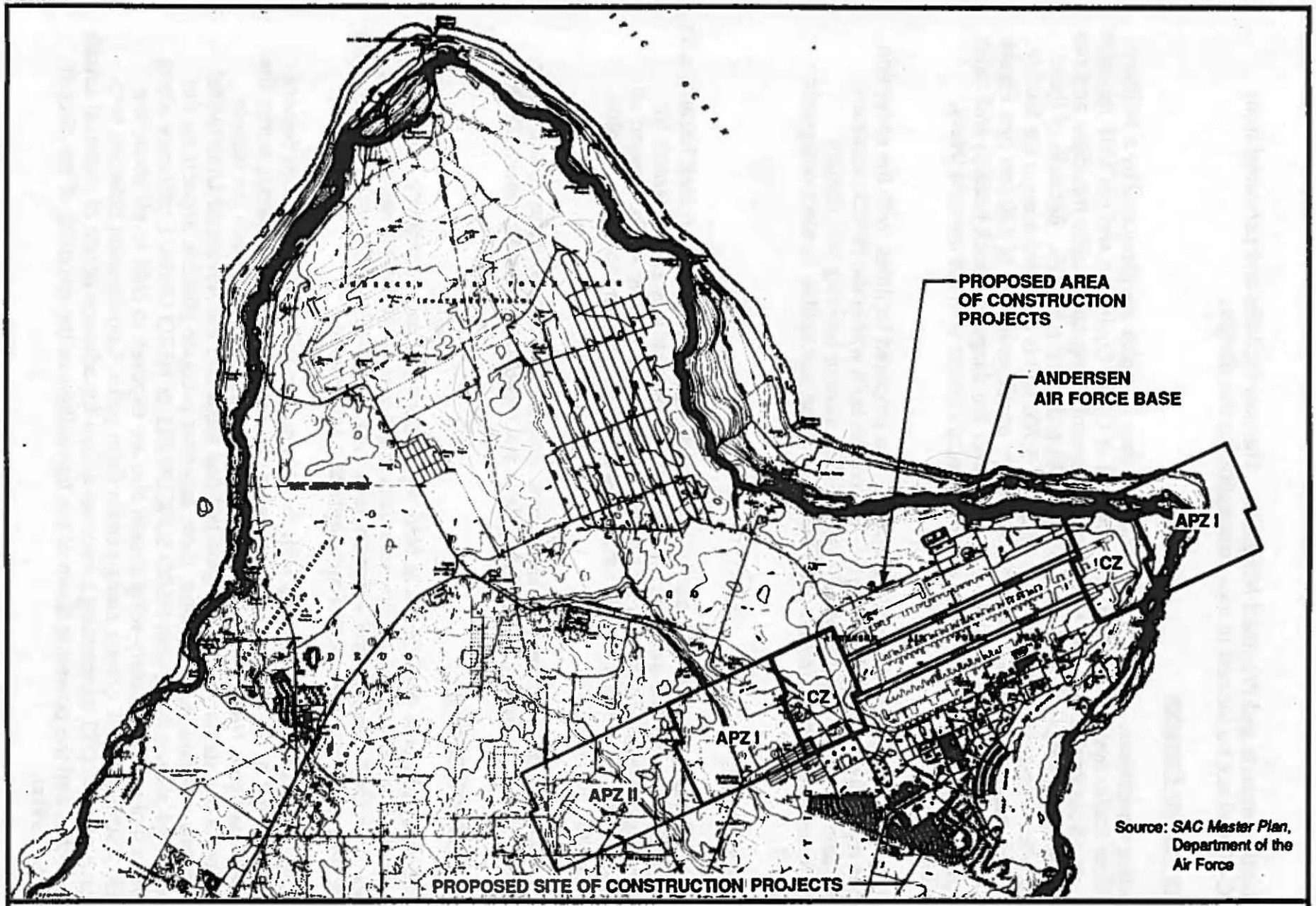


Figure 4.12.9
ACCIDENT POTENTIAL ZONES (APZs)
ANDERSEN AIR FORCE BASE
Guam Development EIS
April 1993

Potential Impacts and Proposed Mitigation. The new facilities and personnel from VRC-50 will not be located in areas susceptible to this danger.

Apra Harbor Complex

Existing Conditions. EMR hazards at Apra Harbor Complex are generated by a Military Affiliate Radio System (MARS) station located at Camp Covington and the VHF repeater site on Orote Peninsula. The MARS station transmits long-range radio messages and can detonate electroexplosive devices contained in ordnance materials. Because of these detonation capabilities, a HERO unsafe arc of 5,700 feet is extended around the facility. The VHF repeater site has a hazard distance for unsafe ordnance of 230 feet (see Figure 4.12.7). Personnel must also take precautions for the danger of shock hazards and radio frequency burns which might occur from physical contact with the antenna (Navy, 1986a).

Potential Impacts and Proposed Mitigation. No proposed facilities, with the exception of the repair shop storage building (P-235), will be built within the HERO unsafe arc generated by the MARS station. The repair shop storage building will contain government vehicle and repair parts that will not be susceptible to electromagnetic hazards.

Naval Magazine

Existing Conditions. Naval Magazine is considered generally safe from EMR hazards with the exception of mobile and hand carried transmitters that may cause hazards for electroexplosive ordnance. For precautionary reasons, a zone of 40 feet around all ordnance has been established in which any transmission from mobile or portable transmitters is prohibited.

Potential Impacts and Proposed Mitigation. Proposed facilities will not generate any electromagnetic radiation, nor will they lie in any HERO unsafe zones (Navy, 1991b).

Naval Air Station Agana

Existing Conditions. EMR zones at NAS Agana surround two emergency transmitters which impose high frequency environments in the vicinity of the ordnance handling sites. The EMR zones extend approximately 1,143 feet from the transmitters but do not reach the ordnance sites located approximately a mile away.

Transmitting antennas associated with the Diplomatic Telecommunications Service (DTS) located at NCTAMS Barrigada produce an EMR zone which extends across the public road onto NAS Agana. HERO UNSAFE conditions exist within the eastern portion of the station near the engine test pad areas and the Advanced Underwater Weapons compound. In addition, these antennas produce possible impacts on the fixed-wing aircraft flying with HERO SUSCEPTIBLE or HERO UNSAFE ordnance along certain flight routes. Rotary-wing aircraft also are exposed to EMR levels above the HERO SUSCEPTIBLE criteria along certain flight paths. Coordination between NAS Agana and the DTS transmitting personnel allows for advance notice of potential unsafe conditions and the powering down of the transmitters or the rerouting of the aircraft (Navy, 1991a).

Potential Impacts and Proposed Mitigation. No new development will occur inside of the EMR zones.

4.12.3 Cumulative Impacts

The cumulative impacts of man-made hazards on Guam will increase only slightly due to new operations and the transfer of munitions or munitions-related activities to the island. Surface danger zones, accident potential zones, and electromagnetic radiation zones will maintain their pre-transfer delineations. ESQD arcs will remain constant at Apra Harbor, NAS Agana, and Andersen AFB. NAVMAG will receive additional ordnance to be stored in areas located primarily within its existing ESQD arcs. Some arcs will be extended in the northwest portion of the base, but none will extend onto neighboring areas as result of the additional tonnage.

4.13 ROADS AND TRAFFIC

4.13.1 Existing Conditions

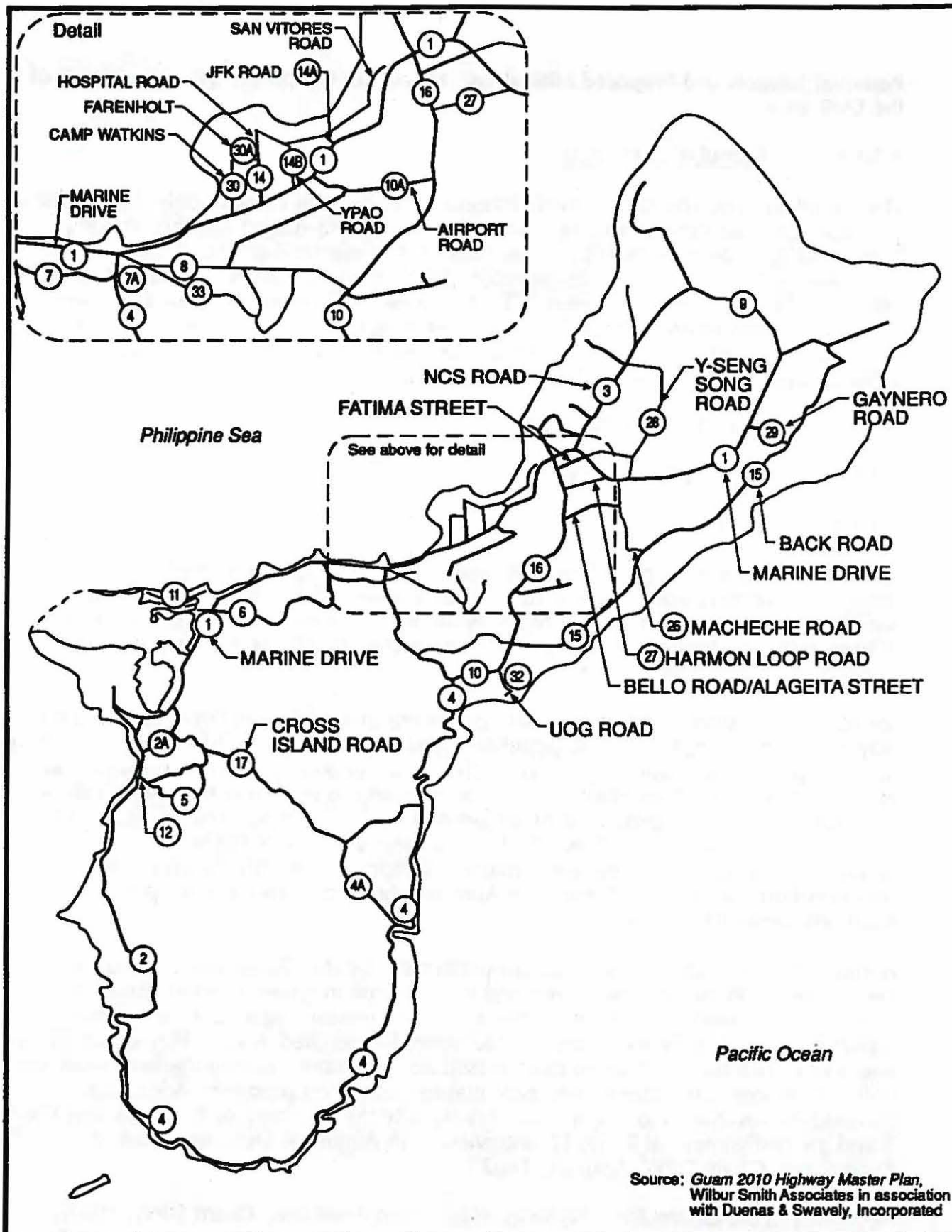
4.13.1.1 Civilian

Roads. The Guam public road network (see Figure 4.13.1) contains over 250 miles of paved roads ranging from two-lane rural roads to a seven-lane urban arterial along Marine Drive. The majority of the highway infrastructure was constructed by the U.S. military following the end of World War II and generally reflects the wartime emphasis on routing efficiency between military posts.

Several arterials provide access to most parts of the island. Marine Drive (Route 1) is the major route servicing the heavily populated western portion of the island and parts of the northern portion, stretching from Yigo in the North, through Tumon and Agana, and ending in the Navy's Apra Harbor Complex. The eastern portion of the island is serviced by Route 15, which extends from Andersen AFB to Chalan Pago. The southern half of the island is accessed by Route 4, which crosses the island from Agana to Yona and continues on to Umatac. Between Umatac and Apra Harbor this stretch of road becomes Route 2. Route 17, between Apra Heights and Baza Gardens, provides additional cross-island access.

A vigorous road improvement program undertaken by the Government of Guam Department of Public Works has resulted in a network in relatively good condition. However, the widespread use of readily available limestone aggregates within the asphaltic concrete surface courses on older roads has resulted in very slippery conditions when wet. This has contributed to increased accident rates. Recent roadway work has utilized surfaces with more friction potential to correct this problem. Additional planned improvements to major roadways include the widening of Route 2A and Route 5 and the realignment of Route 17 (interview with Augustine Dueanas, Chief of Engineering, Guam DPW, April 21, 1992.)

According to the *Guam 2010 Highway Master Plan* (interview, Guam DPW, 1992), traffic flows along the road network are quite heavy in places, with the portion of Route 1 between Route 30 and Route 14A experiencing two-way volumes between 3,500 and 4,700 vehicles per hour during the afternoon peak hour. Most major traffic



Source: *Guam 2010 Highway Master Plan*, Wilbur Smith Associates in association with Duenas & Swavely, Incorporated

Figure 4.13.1
GUAM ROAD NETWORK
Guam Development EIS
April 1993

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congestion occurs along this portion of road within the heavily populated Tamuning area. Other major routes are experiencing afternoon peak two-way volumes below 3,500 vehicles per hour. Traffic growth has been averaging five percent per year.

Mass Transit. Mass transit service is provided by the Guam Mass Transit Authority (GMTA). The GMTA currently operates buses on nine routes, connecting nearly all of the communities of the island. These routes are shown on Figure 4.13.2.

Route service consists of four bi-directional "point-to-point" routes, while the remaining five are configured as one-way loops. The routes are interconnected so that passengers can travel between any two points in the GMTA system. Transfers can take place at the Agana Shopping Center, which services seven routes; Gibson's Shopping Center in Tamuning, which accommodates two routes; and Micronesia Mall, which handles four routes (interview, Guam DPW, 1992).

Service frequencies vary from 30 minutes to two hours with operation provided six days per week, Monday through Saturday. There is no service on Sundays or official holidays. Hours of service generally extend from 6:30 AM to 7:30 PM. Fares range from 35 cents for senior citizens and handicapped to 75 cents for regular fares. Transfer fees are 25 cents.

Transit ridership as reported in the *Guam 2010 Highway Master Plan* was 112,438 passengers for 1991, a nine percent increase from the previous year. This represents a daily ridership of approximately 400 passengers.

The transit fleet currently consists of 20 vehicles, the majority of which are vans with capacities ranging from 7 to 19 passengers. Fourteen of the vans are equipped with wheelchair lifts for the disabled.

Vehicle Ownership. Vehicle ownership in Guam falls into two major classifications: non-government vehicles and government vehicles. In the fiscal year ending September 30, 1990, there were 100,796 non-government vehicles registered in Guam. Of these, approximately 93,500 vehicles were for personal use, an average of 3.0 personal vehicles per household. The average rate of increase in non-government vehicles within the last decade has been 6.6 percent, although the rate since 1988 has been considerably higher (interview, Guam DPW, 1992).

The Government of Guam currently owns 2,273 vehicles, of which 211 are school buses.

4.13.1.2 Military

Andersen Air Force Base. Access to Andersen is via Route 1, which terminates at the Main Gate. From there, primary access to the administration and operational facilities is over Perimeter Road, which services the areas adjacent to both the North and South Runways. Primary roadways to the family housing area consist of Marianas Boulevard, leading to the Main Gate, and Carolines Avenue, connecting with Perimeter Road. Assorted secondary roadways, such as Bonins Boulevard and Chicago Avenue, provide internal links between the administration/operational areas and the housing areas.

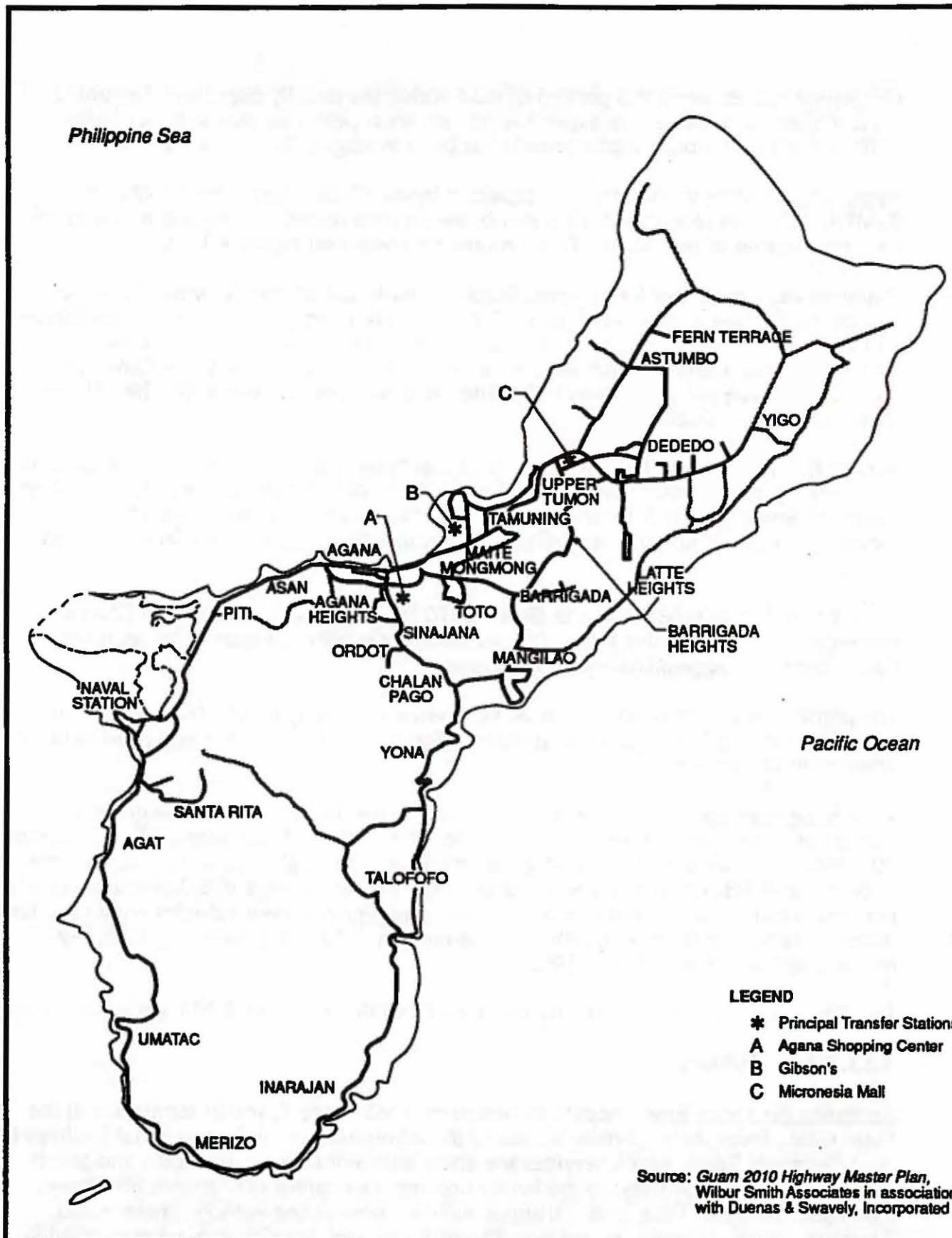

Figure 4.13.2
G.M.T.A. TRANSIT ROUTES
Guam Development EIS
April 1993

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Two-way peak volumes into and out of Andersen taken for the *Guam 2010 Highway Master Plan* show light traffic on the base. Approximately 536 vehicles were observed entering and exiting the Main Gate during the morning rush hour, and 876 vehicles during the evening peak hour. Significantly lower volumes were observed at the back gate leading to Route 15, with 317 vehicles during the morning peak and 212 during the afternoon peak (interview, Guam DPW, 1992).

Apra Harbor Complex. The traffic circulation system in the Apra Harbor complex consists of a hierarchy of military and civilian roadways which provide access to the various activities (see Figure 4.13.3). Marine Drive (Route 1) is the main thoroughfare to Apra Harbor from Agana, NAS Agana, and Guam International Airport. It continues through the complex and terminates at the westernmost tip of Orote Peninsula. Access is provided to the Navy Exchange and Commissary area, Public Works Center transportation facilities, Naval Station administration and community support facilities, and the Lockwood Terrace/Sumay Housing area (Navy, 1986a).

Other primary internal base roadways branching from Marine Drive include Sumay Drive, which provides access to the waterfront operations of Naval Station, Naval Supply Depot, and the Ship Repair Facility, and Shoreline Drive, which provides access to the Tipalao Family Housing area. Smaller secondary roadways connect Sumay Drive and Marine Drive to provide access to various other facilities within the Complex.

The main vehicular control point to the Apra Harbor Complex is located about three-quarters of a mile south of Commissary Junction on Marine Drive. This location leaves a considerable amount of Navy land and facilities outside the Apra Harbor secured area and allows almost unrestricted access to many Navy facilities. A secondary vehicular access gate is provided through the back gate located on Shoreline Drive, which intersects Agat Drive outside the gate. Peak hour two-way volumes at the main gate are approximately 1,100 vehicles entering and exiting in the morning and 1,500 in the afternoon. At the secondary gate, peak two-way volumes are approximately 662 in the morning and 606 in the afternoon (interview, Guam DPW, 1992).

Discussions with officials of the Public Works Center did not indicate the existence of flow problems within the Apra Harbor Complex. However, the Apra Harbor Master Plan did identify two problem areas which continue to exist.

- Egress from Sumay Drive. Peak afternoon traffic entering Marine Drive from Sumay Drive experiences delay due to the large number of civilian workers leaving the Ship Repair Facility. Currently, the left lane of Marine Drive is coned to facilitate the traffic movement onto Marine Drive.

- The five-way intersection in the Naval Supply Depot area. This intersection is poorly designed. Passenger vehicles and heavier industrial trucks converge with no clear directional or stop control indications (see Figure 4.13.4).

Naval Magazine. Naval Magazine Guam contains approximately 65 miles of roads. Privately-owned vehicle traffic is normally confined to the administration and personnel support area where traffic is generally light (Navy, 1991b). Only authorized personnel and vehicles are allowed in the storage and operations area. The main on-base road system is adequate; however, due to high average annual rainfall, the roads are subject

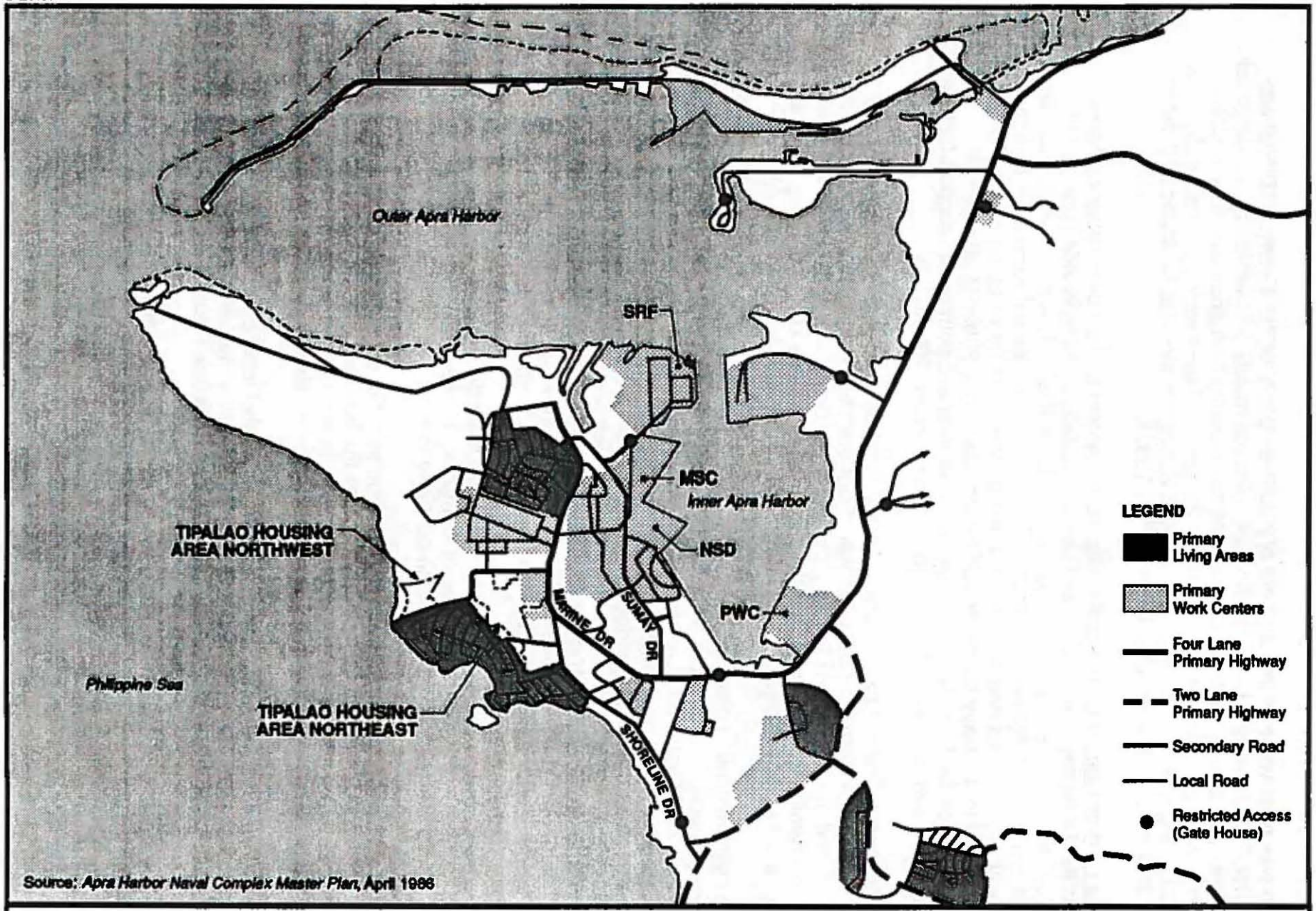

Figure 4.13.3
EXISTING ROAD SYSTEM—
APRA HARBOR COMPLEX
Guam Development EIS
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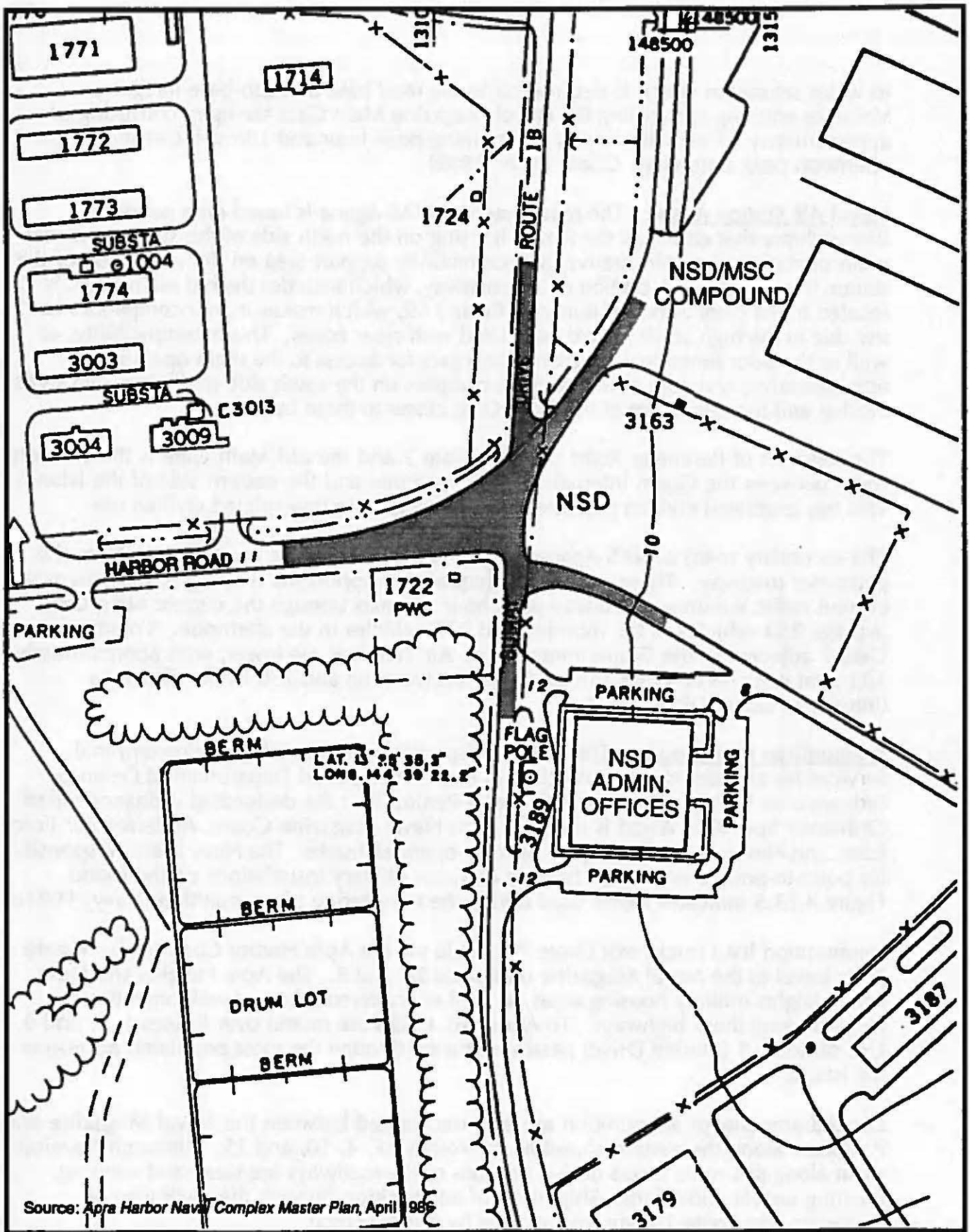

North

0 100 200 400

Scale in Feet

Figure 4.13.4
5-WAY INTERSECTION IN NSD AREA—
APRA HARBOR COMPLEX
Guam Development EIS
April 1993

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to water saturation which is detrimental to the road base and sub-base integrity. Volumes entering and exiting the Naval Magazine Main Gate are light, consisting of approximately 94 vehicles during the morning peak hour and 106 vehicles during the afternoon peak (interview, Guam DPW, 1992).

Naval Air Station Agana. The road system at NAS Agana is based on a perimeter thoroughfare that connects the family housing on the north side of the station with the main operational, administrative, and community support area on the south side of the station (Navy, 1984). A portion of this roadway, which includes the old Main Gate, is located in the clear zones of Runways 6L and 6R, which makes it an incompatible land use due to the high crash hazard associated with clear zones. This incompatibility, as well as the poor functional location of this gate for access to the main operational, administrative, and community support complex on the south side of the base led to its closing and the relocation of the Main Gate closer to these facilities.

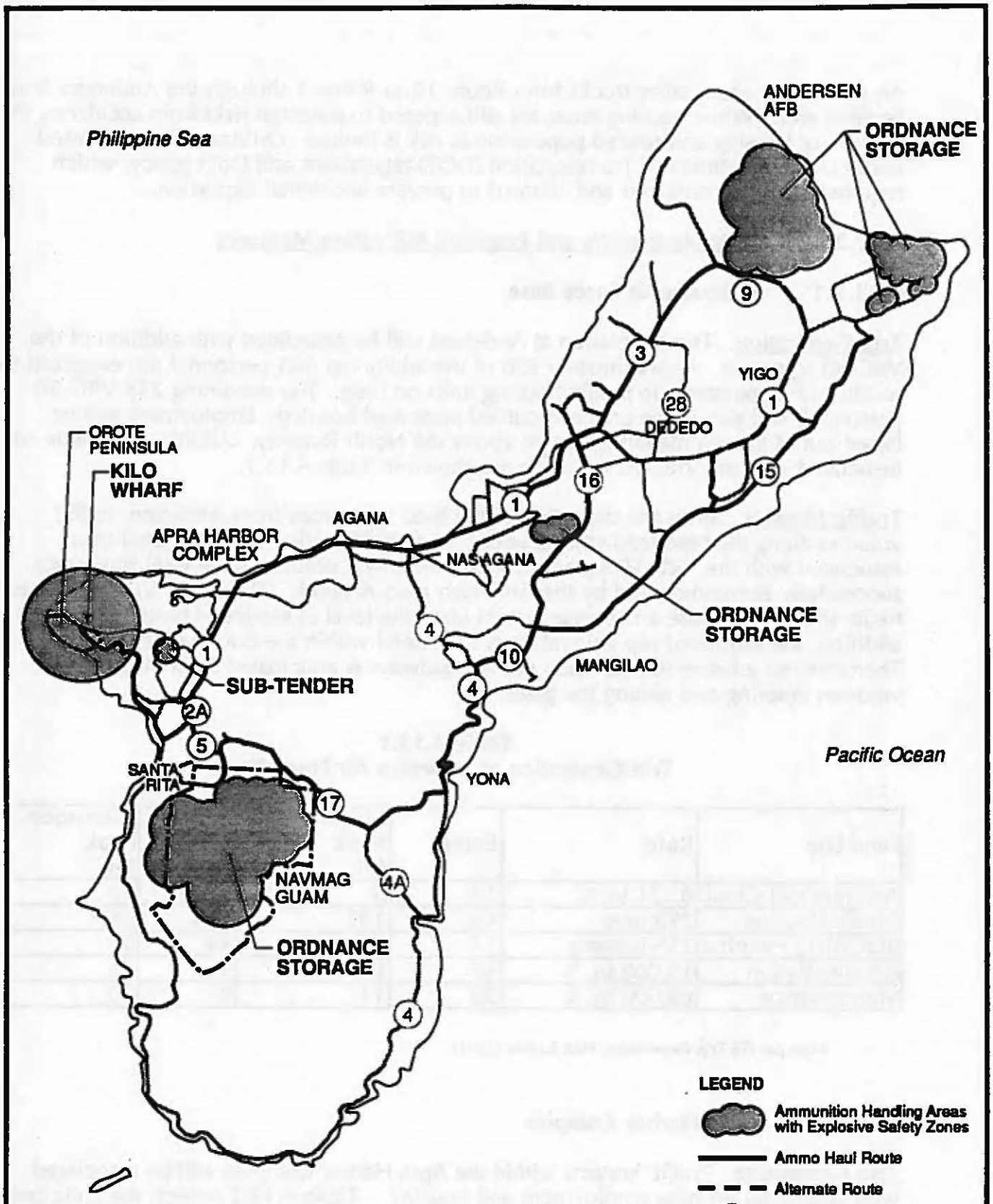
The segment of Perimeter Road between Gate 2 and the old Main Gate is the shortest route between the Guam International Air Terminal and the eastern side of the island. This has generated civilian pressure to open this road to unrestricted civilian use.

The secondary roads at NAS Agana provide access to facilities located away from the perimeter roadway. These roads are adequate to support the existing development and current traffic volumes. Two-way peak hour volumes through the current Main Gate average 250 vehicles in the morning and 275 vehicles in the afternoon. Volumes at Gate 2 adjacent to the Guam International Air Terminal are lower, with approximately 183 total vehicles entering and exiting in the morning and 250 in the afternoon (interview, Guam DPW, 1992).

Ammunition Haul Routes. The Navy is responsible for providing marine terminal services for all loading and unloading of ocean transported Department of Defense ordnance on Guam. Kilo Wharf on Orote Peninsula is the designated ordnance wharf. Ordnance from Kilo Wharf is transported to Naval Magazine Guam, Andersen Air Force Base, and Naval Air Station Agana in Navy operated trucks. The Navy is also responsible for point-to-point ammunition hauling between military installations on the island. Figure 4.13.5 indicates routes used during the transferring of ammunition (Navy, 1991b).

Ammunition haul trucks exit Orote Peninsula via the Apra Harbor Complex back gate. They travel to the Naval Magazine on Routes 2A and 5. The Apra Heights and New Apra Heights military housing areas, as well as scattered private developments are located along these highways. To Andersen, trucks are routed over Routes 1, 3, and 9. Use of Route 1 (Marine Drive) passes ordnance through the most populated portion of the island.

Limited amounts of ammunition are also transported between the Naval Magazine and Andersen along the eastern shoreline on Routes 17, 4, 10, and 15. Although development along this route is less dense, portions of the roadways are steep and winding, creating unsafe conditions. Shipments of ammunition through the back gate of Andersen (via Route 15) are discouraged by the Air Force.



Source: U.S. Naval Magazine, Guam, Master Plan

North

0 1 2 3

Scale in Miles

Figure 4.13.5
AMMUNITION HAUL ROUTES
Guam Development EIS
February 1993

242.0101/46

An alternative route takes trucks from Route 15 to Route 1 through the Andersen South housing area. While housing areas are still exposed to potential risks from accidents, the amount of housing and related population at risk is limited. Ordnance is transported under U.S. Department of Transportation (DOT) regulations and DoD policy, which require that it be contained and shunted to prevent accidental explosion.

4.13.2 Probable Impacts and Proposed Mitigation Measures

4.13.2.1 Andersen Air Force Base

Trip Generation. Trip generation at Andersen will be associated with addition of the VRC-50 squadron. Approximately 250 of the additional 505 personnel are expected to reside with dependents in family housing units on base. The remaining 255 VRC-50 personnel, will stay in the unaccompanied personnel housing. Employment will be based out of the maintenance/hangar above the North Runway. Additional vehicle trips associated with the VRC-50 squadron are shown in Table 4.13.1.

Traffic Impacts. Since the departure of the B-52 squadrons from Andersen, traffic volumes along the base roadways have declined significantly. The additional trips associated with the VRC-50 squadron represent only a portion of the total trips once successfully accommodated by the Andersen road network. Therefore, VRC-50 related traffic should not cause an adverse impact upon the level of service of base roads. In addition, the estimated trip generation is contained within the boundaries of the base. Therefore, no adverse impact upon public roadways is anticipated from increased volumes entering and exiting the gates.

Table 4.13.1
Trip Generation at Andersen Air Force Base

Land Use	Rate	Morning Peak Enter	Morning Peak Exit	Afternoon Peak Enter	Afternoon Peak Exit
Aeromedical Clinic	8,721 sq. ft.	18	5	11	25
Family Housing	250 units	48	137	164	88
BOQ/BEQ Housing	255 persons	12	49	64	33
Administration	18,000 sq. ft.	45	6	9	44
Maintenance	69,000 sq. ft.	53	11	8	60

Rates per ITE Trip Generation, Fifth Edition (1991)

4.13.2.2 Apra Harbor Complex

Trip Generation. Traffic impacts within the Apra Harbor Complex will be associated with additional on-base employment and housing. Table 4.13.2 reflects the anticipated increases in morning and afternoon traffic volumes by traffic generators for the Apra Harbor Complex. Facilities which are open only during regular working hours are assumed to have 100 percent of their employees arriving and leaving during the peak hours. Trip generation from living quarters, family housing, the child development center, and those land uses which include shift work, such as NSD civilians used for

depot work and SRF personnel, were calculated using appropriate land use rates contained within the ITE Trip Generation Manual, Fifth Edition (1991). Civilian employment will represent new volumes entering and exiting the Main Gate, while work-related trips between the Tipalao military housing, the various non-accompanied living quarters, and facilities on base will represent internal base traffic.

Table 4.13.2
AM and PM Peak Hour Trip Generation

		Morning Peak		After-noon Peak	
Land Use	Personnel	Enter	Exit	Enter	Exit
Housing	155	7	38	39	20
Maintenance	155	57	12	8	57

Rates per ITE Trip Generation, Fifth Edition (1991)

Traffic Impacts. Due to the concentration of facilities along the waterfront, Sumay Drive will experience the bulk of additional traffic generated by the proposed actions. Approximately 450 additional personal vehicle trips are anticipated along various portions of this roadway during the morning peak hour as employees commute to the Ship Repair Facility and the Naval Supply Depot compounds. Of these trips, the majority will represent internal base commutes, with origins being in the unaccompanied personnel and family housing areas. This will place an additional burden upon segments of Marine Drive and adjoining connectors to Sumay Drive, especially Harbor Road, which forms one of the five legs of the problem intersection described above. Civilians entering facilities over Sumay Drive from the Main Gate will account for an additional 151 vehicle trips.

During the afternoon peak hour the directional volume reverses itself as employees return to the family housing, bachelor's quarters, or to civilian housing. Approximately 300 additional vehicles are expected to use Sumay Drive and Harbor Road on the return trip to on-base housing facilities. Another additional 160 civilians are estimated to return home over Sumay Drive towards the Main Gate.

Entering and exiting volumes at the Main Gate during the afternoon peak hour are estimated to be approximately 182 vehicles.

Significance of Impacts. The five-way intersection formed by Sumay Drive, Harbor Road, the NSD compound, Route 1b, and the NSD administration building parking lot driveway was identified as a problem in the *Apra Harbor Complex Master Plan* (Navy, 1986a). Additional traffic trips associated with commuters to the new facilities within the waterfront area, as well as those travelling from the expanded Tipalao housing area, are expected to cause increased safety concerns at this intersection. The Navy is currently planning and designing modifications to this intersection to alleviate these traffic concerns. The intersection of Sumay Drive with Marine Drive could also see additional problems during the afternoon peak due to the increased volumes on the left-turn movement. However, current traffic management measures practiced at the intersection are sufficient to accommodate the additional volumes.

Proposed Mitigation. Given the safety concerns with the five-way intersection formed by Harbor Road and Sumay Drive, the present and future traffic volumes along the approaches will be analyzed to aid in the appropriate design of any improvements.

4.13.2.3 Naval Magazine

Trip Generation. Traffic generation at the Naval Magazine will occur as personnel travel to and from the housing area to the dining facility and the maintenance areas. However, given the proximity of the barracks to the dining facility, the lack of available parking, and the restricted nature of the roadways, traffic generation within Naval Magazine will represent only one-third of normally calculated rates. The additional vehicle trips are summarized in Table 4.13.3.

Table 4.13.3
Trip Generation at Naval Magazine Guam

Land Use	Rate	Enter	Morning Peak Exit	Enter	Afternoon Peak Exit
Housing	15	4	18	19	10
Dining	150	12	12	16	13
Maintenance	150	18	3	3	18
Outside Civilians	20	7	2	1	7

Rates per ITE Trip Generation, Fifth Edition (1991)

Traffic Impacts. The low volumes traveling along the internal Naval Magazine road network do not currently create congestion problems. The minimal amount of additional traffic associated with the extra personnel and activities will not create traffic flow or congestion problems that will need to be mitigated. The small number of outside civilians entering the base will not cause an adverse impact upon the level-of-service of the surrounding public road network.

4.13.2.4 Naval Air Station Agana

Trip Generation. Trip generation for Naval Air Station Agana is associated with the additional personnel to be assigned to the base. For purposes of trip generation, these personnel have been assigned to unaccompanied personnel housing areas with employment in the operational/maintenance area. Anticipated morning and afternoon vehicle trips are shown in Table 4.13.4. Given the variability of work shifts and intermediate trips, a one-to-one correspondence between the two land uses cannot be assumed.

Table 4.13.4
Trip Generation at NAS Agana

Land Use	Rate	Morning Peak Enter	Morning Peak Exit	Afternoon Peak Enter	Afternoon Peak Exit
Housing	155	7	38	39	20
Maintenance	155	57	12	8	57

Rates per ITE Trip Generation, Fifth Edition (1991)

Traffic Impacts. The road system at NAS Agana restricts access from the housing support area to the operational/maintenance area to the Perimeter Roadway. Discussions with NAS Agana personnel have not indicated existing traffic flow problems or congestion. The low volumes associated with the additional personnel at NAS Agana should not cause any undue congestion or traffic safety hazards along the internal road network. Inasmuch as the additional work-related trips are within the NAS Agana perimeter, no adverse impact on the adjacent public road system during the peak hours is anticipated.

4.13.2.5 Ammunition Haul Routes

With the closing of Naval Magazine Subic, forward deployment of ammunition within the Western Pacific has become the responsibility of Naval Magazine Guam. An additional Auxiliary Explosives Transport vessel will be forward deployed to Guam, doubling the ammunition shipping capacity.

Ammunition is currently unloaded at Kilo Wharf and transported to the Naval Magazine. From there it is further deployed as needed over the ammunition haul routes shown in Figure 4.13.5. Although there will be an increase in the overall amount of ammunition on Guam from current levels, the majority of the ammunition will remain within the Apra Harbor/Naval Magazine area for use on Naval vessels. Routes between these two stations are not heavily populated; however, the route does pass next to the existing Apra Heights family housing area.

A small increase in ammunition transportation from Naval Magazine Guam to Andersen is expected to support VRC-50 activities. However, this increase will be minimal, and in no way will it approach the large volumes or types transported as a result of the recent war in the Persian Gulf.

Ammunition is always transported under U.S. Department of Transportation regulations and Navy policy which mandates that it be configured in a HERO SAFE condition. This can include foil wrapping, electronic shunting, or defusing.

4.13.3 Cumulative Impacts

Possible cumulative impacts are associated with the proposed actions and to the construction of related facilities not covered by this document. Inasmuch as traffic impacts are generated by additional persons and by the demand represented by a specific land

use, they will be felt immediately upon the completion of personnel transfers to Guam. Future modifications to directional distribution and network assignment are anticipated as temporary structures are replaced with permanent facilities in other areas and as the family housing units replace living situations in the private sector.

4.14 HARBORS

4.14.1 Existing Facilities

The commercial port of Guam is located in Apra Harbor, which has been upgraded by the construction of Glass Breakwater on top of Lumino Reef and Calalan Bank. This provides a sheltered anchorage 4 miles long and 1.5 miles wide. The average water depth in the outer harbor and the middle ground is over 100 feet. Within this area, there are four anchorages for commercial vessels and three reserved for the Navy. To the south is inner Apra Harbor, which is entirely owned by the Navy. The north side of the outer harbor is bounded by Glass Breakwater, and in the northeast is Cabras Island where the Commercial Port is located (see Figure 4.14.1).

Commercial activity at the Port of Guam is managed by the Port Authority of Guam (PAG). Except for military weapons, ammunition, and heavy equipment, all goods shipped to Guam are received and handled at the commercial port. This includes all Naval Supply Depot (NSD) materials, as well as commercial goods, food supplies, and construction and raw materials. In fiscal year 1991, NSD handled 6,593 inbound containers (20- and 40-foot vans). Currently, much of the material that goes through the commercial port is for use at the increasing number of tourist facilities on Guam. Military materials present a relatively small burden upon the commercial port facilities. Following a recent expansion, the commercial port contains approximately 26.5 acres of container storage space. Under the current Master Plan for the Commercial Port of Guam, this storage space is slated to expand by 33 to 36 acres by the year 2000 (PAG, 1992).

4.14.2 Potential Impacts and Mitigation Measures

As a result of the increased Naval activities, the number of NSD containers coming through the commercial port will increase by approximately 150 a month. There will be no adverse impacts upon the commercial port resulting from this increased activity. According to the Port Authority General Manager, there will be no container storage or handling problems at the commercial port associated with the increase in NSD shipping volume (Interview with David Tydingco, Port Authority of Guam, April 23, 1992).

One potential problem raised by the PAG are the long delays which could develop in the Navy's removal of NSD materials due to insufficient equipment. Currently, containers may remain tariff-free for 10 aggregate days. Phased reductions over the next year will lower this time to 5 aggregate days (Interview with David Tydingco, Port Authority of Guam, April 23, 1992). However, the proposed Integrated Storage and Handling Facility (P-152) is designed to alleviate such delays and prevent subsequent demurrage charges to the Navy.

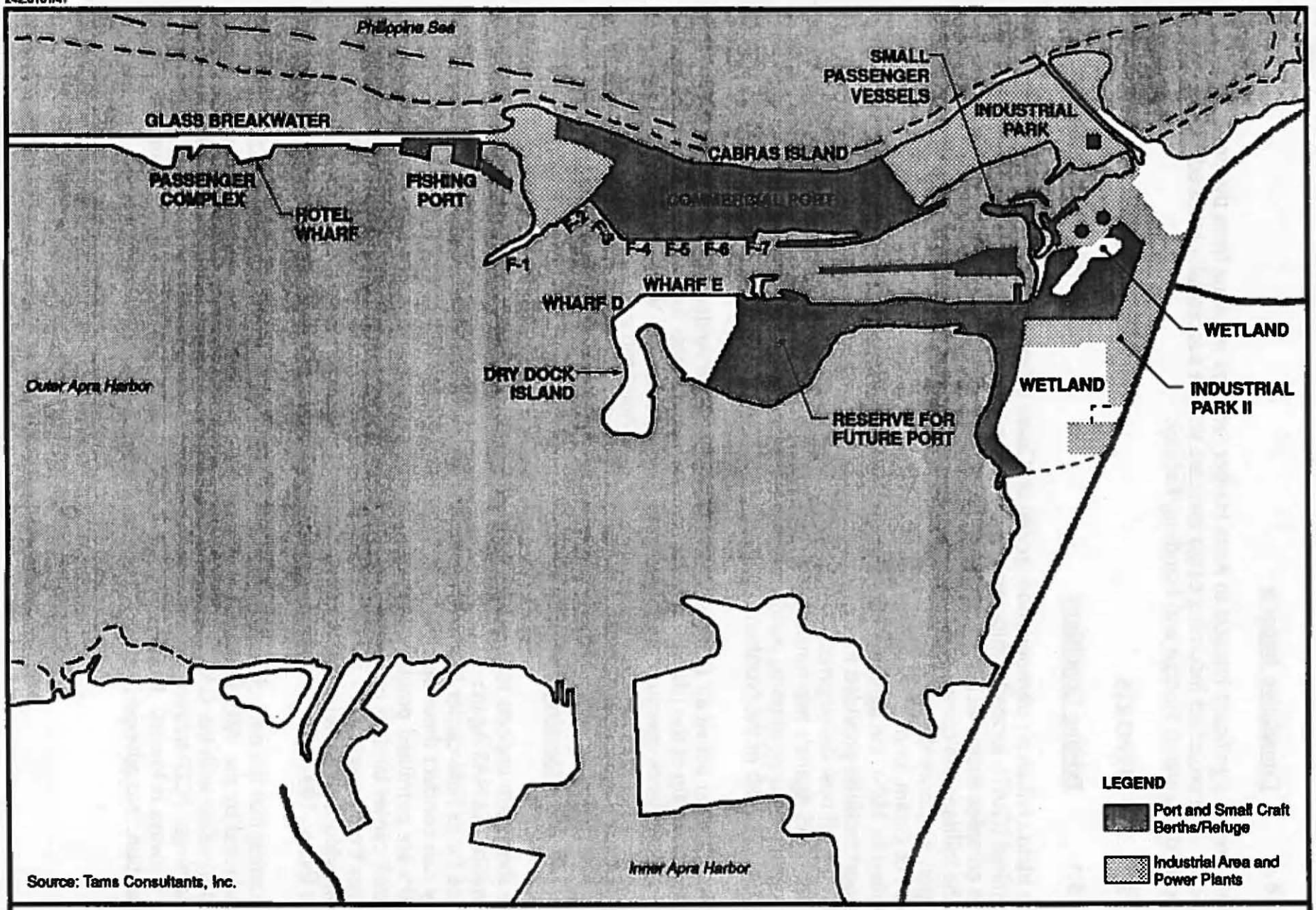


Figure 4.14.1
COMMERCIAL PORT PLAN
Guam Development EIS
April 1993

4.14.3 Cumulative Impacts

There are no significant impacts to Apra Harbor facilities resulting from the proposed actions. The projected incoming cargo increase will be successfully handled through the proposed Integrated Storage and Handling Facility.

4.15 AIRPORTS

4.15.1 Existing Conditions

The main civilian air transportation facility on Guam is the Guam International Air Terminal (GIAT), located approximately six miles northeast of the capital city of Agana. This complex shares facilities with Naval Air Station (NAS) Agana and handles nearly all of the military and commercial flights into and out of Guam. GIAT is run by the Guam Airport Authority (GAA), a public corporation and autonomous agency of the Government of Guam, under the terms of its Joint Use Agreement with the United States Navy. Drafted in 1974, the agreement holds that GIAT may use NAS Agana's runways and support facilities provided that GAA conduct operations, maintain its facilities, and conform all new development to U.S. Navy criteria (Navy, 1989a). In addition to military flights, NAS Agana's two runways are used by eight major airlines which link Guam to several other large airports, making it the hub of air transportation for Micronesia, the Commonwealth of the Northern Mariana Islands, and the Western Pacific.

The only other active air field on Guam can be found at Andersen, located on the northeastern tip of the island. Air Mobility Command flights for military personnel and their dependents operate out of Andersen in addition to the VRC-50 squadron. Commercial aircraft may occasionally fly through Andersen's airspace, but only with permission from Andersen Control Tower (Air Force, 1992; Navy, 1985).

4.15.2 Potential Impacts and Proposed Mitigation

The short term impacts to the GIAT will focus on the presence of the VRC-50 squadron operations at NAS Agana. VRC-50 will use NAS Agana's facilities, runways, and air space for its field-carrier landing practices (FCLPs) until such time as it is determined that they can conduct these operations at Andersen without adverse impacts to wildlife. The FCLPs are permitted practice procedures which attempt to simulate standard Navy aircraft carrier landing patterns. The required elevation for these training practices ranges from ground level at takeoff to 600 feet above ground level (AGL) during the downwind leg parallel to the runway. Approximately 7,000 FCLPs are anticipated per year (Navy, 1992e).

Assuming that the only change in aircraft activity at NAS Agana will be the FCLPs conducted by the VRC-50 squadron, the long-term effects to GIAT will be minimal. Coordination with the GAA occurs to prevent disruptions to the civilian arrivals and departures. FCLP training occurs only during periods when commercial carrier use of the runways is lowest. No new permanent facilities are planned for development at the air station. No adverse impacts to civilian air operations are anticipated.

4.15.3 Cumulative Impacts

No airport-related cumulative impacts are anticipated from the proposed actions.

4.16 POTABLE WATER

4.16.1 General Existing Conditions

4.16.1.1 Government of Guam Water System

The Public Utility Agency of Guam (PUAG) operates an integrated islandwide water distribution system with a capacity of 30 million gallons per day (mgd). This water gets piped to all of the civilian facilities across the island (see Figure 4.16.1). According to PUAG, the breakdown for current water demand is:

- 3.48 mgd for the Northern region (Dededo, Tamuning, and Yigo).
- 11.03 mgd for the Central region (Agana Heights, Asan, Barrigada, Chalan Pago, Ordot, Mangilao, Maite, Piti, and Sinajana).
- 1.52 mgd for the Agana/Apra region.
- 1.97 mgd for the Southern region (Agat, Inarajan, Merizo, Santa Rita, Talofofo, Umatac, and Yona).

Total daily demand from the PUAG system is 18 mgd leaving approximately 12 mgd in excess capacity (PUAG, 1992b). Major PUAG sources of water are wells in the northern plateau that tap into in vast limestone aquifers. This Northern Lens Aquifer has an estimated sustainable yield of up to 60 mgd and provides 70 percent of the island's potable water.

Current groundwater production from the aquifer is 25 mgd (PUAG, 1992b). One hundred fifteen (115) wells are being used to pump water from the aquifer for distribution to Guam's residents. PUAG operates 92 of these wells and produces about 15 mgd. PUAG uses these waters as well as an additional 5.0 mgd of water that it purchases from the Navy's Fena system. In addition, the U.S. Air Force and U.S. Navy operate 10 and 5 wells respectively to provide for or supplement their needs. There are also 8 private wells which produce approximately 4 mgd (GEPA, 1990).

A recent PUAG project has created a new source of freshwater in southern Guam. The Ugum River Project redirects approximately 2 mgd of the river flow to a newly constructed reservoir where it is treated and pumped from a new pump station through PUAG lines to residents from Talofofo to Umatac (Pacific Daily News, Oct. 6, 1992). The capacity of the treatment plant is 6 mgd, but the reservoir capacity is only 2 mgd, so all of the reservoir capacity will be used each day as it is replaced by the river water. The project was set up as an independent service to all elevations in the southern part of Guam. However, it is tied in to the PUAG system and could pump water north if necessary. The PUAG system relies on direct well-to-consumer service with only a bare minimum of storage. Consequently, any power outages greatly hinder the water producing capabilities of the PUAG system (Navy, 1985).

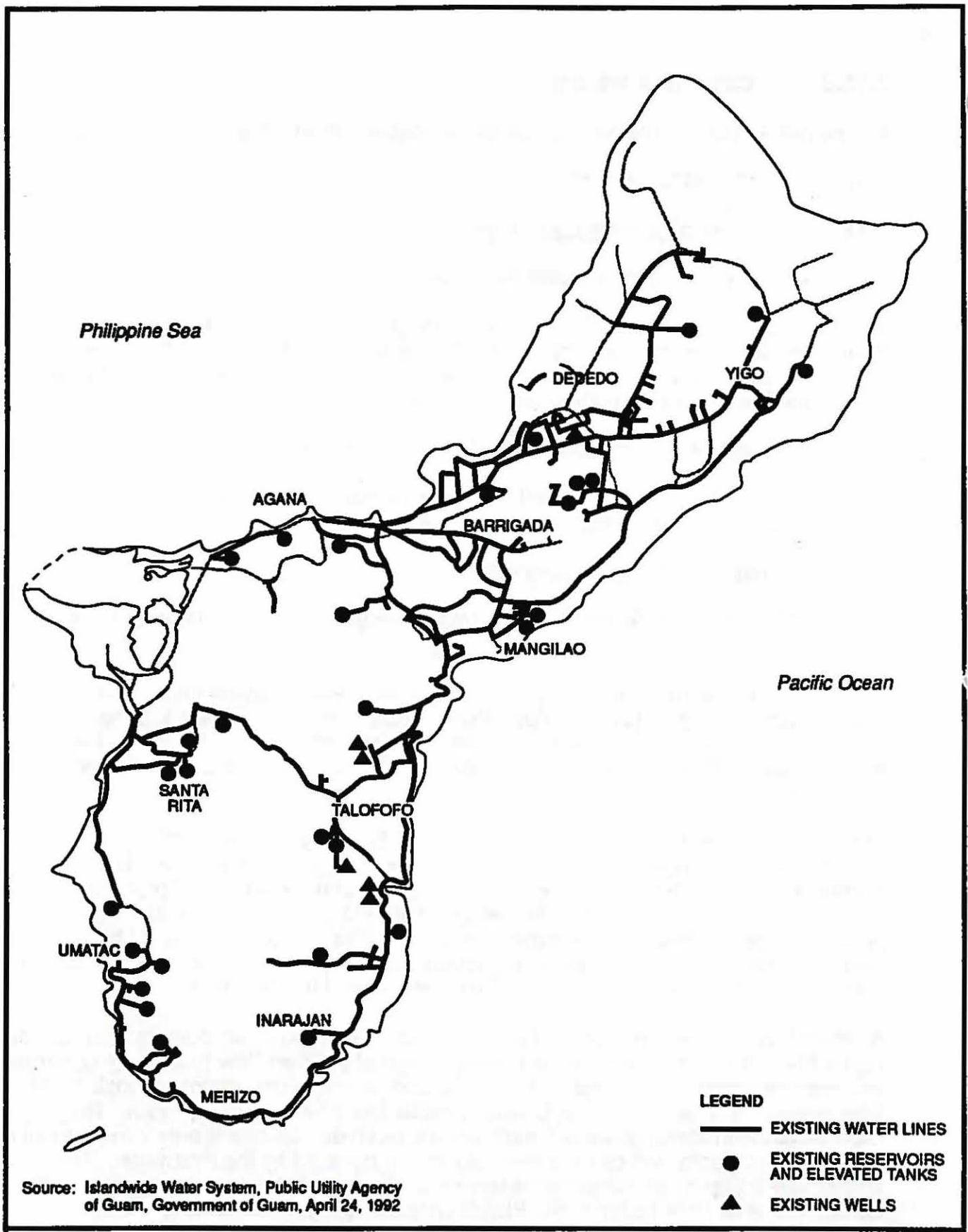


Figure 4.16.1
PUAG ISLANDWIDE WATER DISTRIBUTION SYSTEM
Guam Development EIS
April 1993

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4.16.1.2 Naval Water System

The Navy's Fena system provides water to most of the military facilities as well as some civilian facilities on Guam. This system utilizes three primary sources in the southern region of the island: Almagosa Spring, Bona Spring, and the Fena Watershed and reservoir. The total yield from the two springs varies from 0.5 mgd in the dry season to 3.0 mgd during the rainy season. In addition, the Navy has three wells at NCTCAMS WESTPAC Finegayan on standby for general distribution during dry periods. The Fena Reservoir has a useable storage capacity of 2.1 billion gallons (Navy, 1991b). The overall production capability of Fena system sources is 16.0 mgd during the rainy season and 12.2 mgd during the dry season (PWC Guam, 1992).

Treatment of reservoir waters takes place at the Fena Treatment Plant, which has a treatment capacity of 13.5 mgd. An additional one mgd could be treated if the plant is operated at maximum capacity. Current production varies between 10.5 and 12.5 mgd in the dry and wet seasons, respectively. The water distribution system also has in excess of 20 million gallons of storage for treated water which forms an emergency reserve and in some cases provides a pressure head through elevation. The majority of storage is in the immediate vicinity of the treatment plant at the locations shown in Table 4.16.1. The Navy system is diagrammed and represented schematically in Figures 4.16.2 and 4.16.3.

Table 4.16.1
Naval Water System

Major water storage areas:	
• Tupo Reservoir	5,000,000 gal
• Apra Reservoir	5,000,000 gal
• Naval Magazine Reservoir	700,000 gal
• Treatment Plant Clearwell	1,000,000 gal
• Maanot	500,000 gal
Other reservoirs on the system:	
• Adelup Reservoir	3,000,000 gal
• Naval Regional Medical Ctr. Res.	1,000,000 gal
• Nimitz Reservoir	1,000,000 gal
• Barrigada Reservoir	3,000,000 gal
• NCS Finegayan Reservoir	200,000 gal
• NCS Finegayan (elevated)	250,000 gal
• So. Finegayan Housing (ground)	120,000 gal
• So. Finegayan Housing (elevated)	250,000 gal

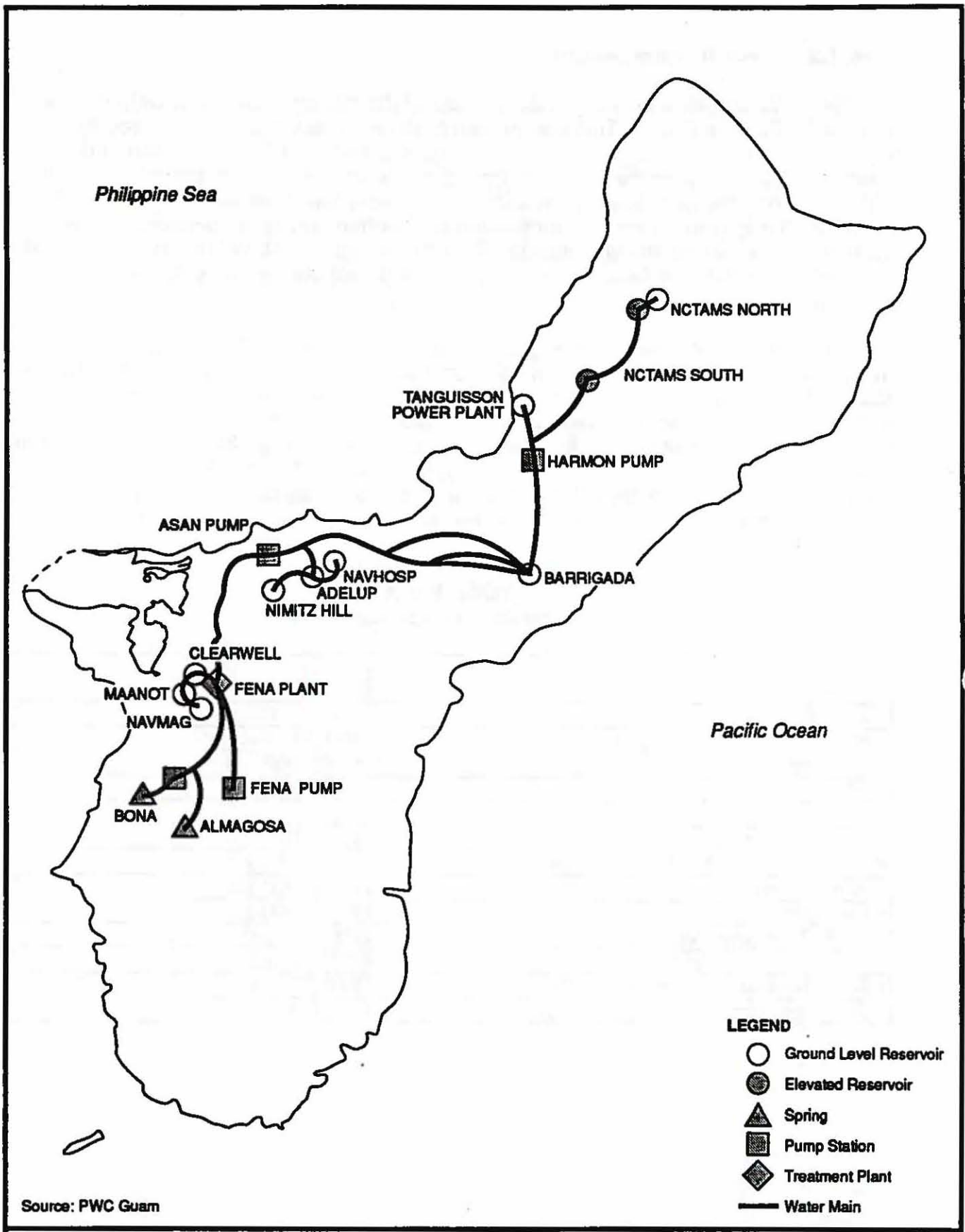

Figure 4.16.2
NAVY POTABLE WATER SYSTEM
Guam Development EIS
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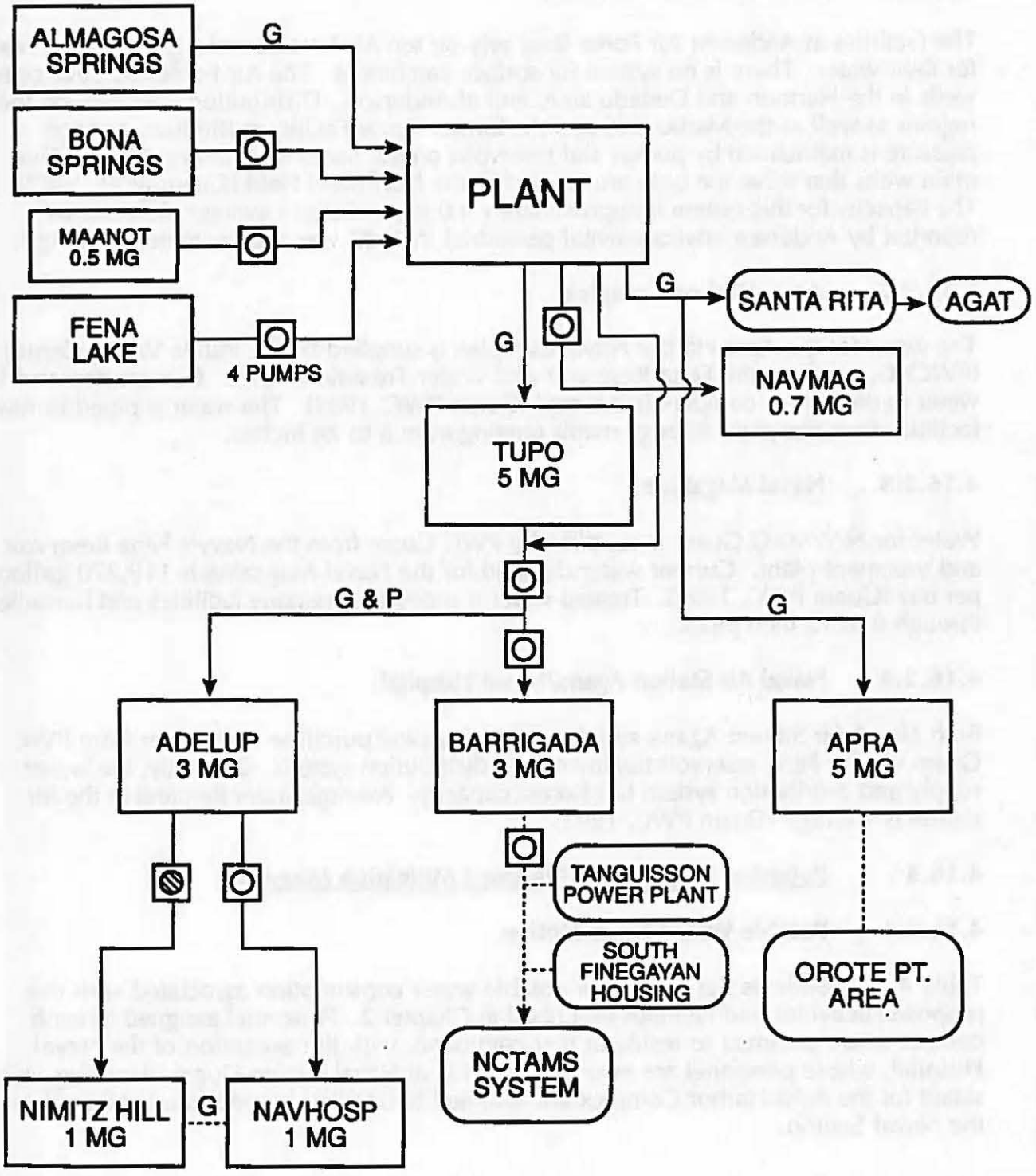
NAVY WATER SYSTEM SCHEMATIC



Source: PWC Guam

LEGEND

- Existing Pump
- Existing Pump Capacity Being Increased
- G Gravity

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Figure 4.16.3
NAVY WATER SYSTEM SCHEMATIC
Guam Development EIS
April 1993

4.16.2 Existing Conditions at Military Facilities

4.16.2.1 Anderson Air Force Base

The facilities at Andersen Air Force Base rely on ten Air Force-owned groundwater wells for their water. There is no system for surface catchment. The Air Force has developed wells in the Harmon and Dededo area, and at Anderson. Distribution lines service these regions as well as the Marbo area and the former Naval Facility at Ritidian. Service pressure is maintained by pumps and reservoirs on Mt. Santa Rosa (Navy, 1985). The main wells that serve the base are located in the Northwest Field (Guam BOP, 1982). The capacity for this system is approximately 4.0 mgd. Current average daily use as reported by Andersen environmental personnel in 1992 was approximately 3.0 mgd.

4.16.2.2 Apra Harbor Complex

The water for the Apra Harbor Naval Complex is supplied by the Public Works Center (PWC) Guam from the Fena Reservoir and Water Treatment Plant. Current demand for water in the harbor complex is 2.8 mgd (Guam PWC, 1992). The water is piped to naval facilities from the plant through mains ranging from 6 to 24 inches.

4.16.2.3 Naval Magazine

Water for NAVMAG Guam is supplied by PWC Guam from the Navy's Fena Reservoir and treatment plant. Current water demand for the Naval Magazine is 119,270 gallons per day (Guam PWC, 1992). Treated water is piped to magazine facilities and barracks through 8 to 12 inch pipes.

4.16.2.4 Naval Air Station Agana/Naval Hospital

Both Naval Air Station Agana and the Naval Hospital purchase their water from PWC Guam via the Fena reservoir treatment and distribution system. Currently, the water supply and distribution system has excess capacity. Average water demand at the air station is 1.8 mgd (Guam PWC, 1992).

4.16.3 Potential Impacts and Proposed Mitigation Measures

4.16.3.1 Potable Water Consumption

Table 4.16.2 outlines the additional potable water consumption associated with the proposed activities and facilities described in Chapter 2. Personnel assigned to each command are assumed to reside at that command, with the exception of the Naval Hospital, whose personnel are assumed to reside at Naval Station Guam. Housing units slated for the Apra Harbor Complex are assumed to be filled by personnel assigned to the Naval Station.

Table 4.16.2
Additional Potable Water Demand

Facility	Perm. Duty	Depen-dent	Temp. Duty	Total Persons	Total SQFT	Rate (gal/unit)	Totals (gpd)
NORTHERN LENS AQUIFER							
Andersen AFB							
Bachelor's Quarters	255			255		150	38,250
Family Housing	250	580		830		200	166,000
Squadron Admin. Off.					2,000	0.1235	247
Aeromedical Facility					8,721	0.1235	1,077
Hangar (Maintenance)					53,625	0.251	13,460
Hangar (Administration)					17,875	0.1235	2,208
Apron/Washrack					15,478	0.251	3,885
NORTHERN LENS DEMAND							225,127
FENA SYSTEM							
NAS/NAVHOSP/Nimitz Hill							
NAS Maintenance Employment	145		10	155		50	7,750
NAS Bachelor's Quarters	145		10	155		150	23,250
NAVHOSP Employment	70			70		200	14,000
Oceanographic Facil. (Nimitz)	12			12		20	240
Total Area Demand							45,240
Naval Station							
MSC Administration	48			48		20	960
Hazardous Material Storage				6		50	300
Integrated Storage & Handling				25		50	1,250
General Warehouse				10		50	500
Pers. Prop. & Flt. Logist.				61		20	1,220
Cold Storage				10		50	500
Supply Systems Support Bldg.				50		20	1,000
SRF (from added man-days)				55		580	31,900
AFDL Support Facility					2,000	0.1235	247
NSWU-1 (personnel)				36		20	720
NSWU-1 (facility)					29,500	0.251	7,405
Child Development Center				264		15	3,960
EOD (personnel)	47			47		20	940
EOD (facility)					19,730	0.251	4,952
Bachelor's Quarters	269		266	535		150	80,250
Bachelors Quarters (NAVHOSP)	70			70		150	10,500
Family Housing	300	852		1,152		200	230,400
Visiting ships				1		20,000	20,000
T-AE Kilauea				1		20,000	20,000
T-AFS Sioux				1		40,000	40,000
T-AFT Spica				1		5,000	5,000
Total Apra Harbor Demand							462,004
Naval Magazine							
Maintenance Employment	170			170		50	8,500
Bachelor's Quarters	150			150		135	22,250
Total Naval Magazine Demand							31,000
FENA SYSTEM DEMAND							538,244

Andersen Air Force Base. As a result of the loss of the B-52 squadrons, on base water facilities on Andersen are not expected to be overburdened by the proposed activities. The arrival of the VRC-50 squadron will bring 73 officers, 432 enlisted personnel, and 580 dependents, (Navy, 1992e). It is estimated that these new residents will create an additional demand of 220,000 gpd on the freshwater aquifers. In addition, minor amounts of water are to be used for aircraft washing and maintenance at the proposed hangar/apron/washrack facility 20,000 gpd, at the new Squadron Administration Office (247 gpd), and at the aeromedical facility (1,077 gpd). Total additional demand on the Northern Lens Aquifer as a result of activities associated with the relocation is anticipated to be approximately 0.23 mgd.

Apra Harbor Complex. The largest increase in water demand on Guam due to the proposed activities will come as a result of the new facilities and activities in the Apra Harbor Naval Complex. The additional 300 units of family housing will have the greatest permanent impact on the water system, demanding approximately 230,400 gpd. Unaccompanied personnel housing (Bachelors Quarters) will demand another 90,750 gpd. Next to housing, the greatest use of water will be the three additional Military Sealift Command vessels being deployed to Guam. The worst case scenario of their being berthed at the same time, along with one additional visiting ship, will create a demand of 86,000 gpd. Another large demand will be from the added man-days at the Ship Repair Facility, which will require an additional 32,000 gpd. In addition, several smaller facilities and activities that will have a water demand of approximately 56,300 gpd. The total additional demand of water resulting from new facilities and activities in the Apra Harbor Naval Complex will be approximately 0.5 mgd.

Naval Magazine. The major increase in water use on the Naval Magazine will result from increased personnel to the installation. A Naval Airborne Weapons Maintenance Unit and a Mobile Mine Assembly Unit will add 170 personnel who will require 8,500 gpd. The facilities needed to house and feed the additional personnel at the Naval Magazine will increase water use by 22,500 gpd. However, this impact will not be severely felt because of the recent disestablishment of the Marine security detachment from the Naval Magazine. As a result of their removal, the approximately 140 enlisted Marines living at the Naval Magazine will no longer use facilities there.

The Inert Storehouse and Tomahawk Missile Magazine will not require potable water supplies. Therefore, they have not been included in the demand calculations. The total increase in water demand at the Naval Magazine will be approximately 31,000 gpd.

Naval Air Station Agana/Naval Hospital/Nimitz Hill. Additional water consumption at these facilities will be a result of additional activities at the air station and hospital, and a new facility on Nimitz Hill. The Air Station will receive 155 personnel who will live and work on base and consume approximately 31,000 gpd. The hospital will experience a personnel increase of 20 officers and 50 enlisted people to handle the required increase in hospital services. There will be an increased water demand of 14,000 gpd. No additional beds will be added to the hospital. On Nimitz Hill, the new Naval Oceanographic facility will employ 12 people and require 240 gpd. The total additional demand on the Fena Reservoir system as a result of new facilities and activities in this region will be approximately 0.05 mgd.

4.16.4 Cumulative Impacts

A Utility Technical Survey is being conducted for the Navy's treatment, storage, and distribution system. This study will recommend improvements as needed. Islandwide civilian water consumption increases for 1995 were projected as follows based upon population, enrollment, visitor, and employment projections contained within the Guam 2010 Highway Master Plan:

Table 4.16.3
1995 Water Consumption Increases

Generator	GPD
Households	2,653,815
School enrollment	61,469
Retail Employment	340,899
Hotel/Visitors	89,325
Other Employment	42,815
Total	3,188,323

This 3.2 mgd demand increase from the civilian sectors of Guam will affect the PUAG system and its draw upon the Northern Aquifer. As mentioned above, PUAG currently has 12 mgd of excess capacity; therefore there will be no problems meeting this future demand. As a result of increases in both civilian and military water consumption on Guam, the 1995 Northern Aquifer draw will be approximately 3.44 mgd more than the present draw of 25 mgd. Since the sustainable yield of the Northern Lens is estimated to be 60 mgd, this increased demand will be insignificant.

As a result of increased military facilities and activities, demand on the Andersen potable water system will increase from 3 mgd to approximately 3.23 mgd. The capacity for the system is 4.0 mgd, so there will be adequate resources to meet this increased demand.

The demand on the Navy's Fena system will increase from 10.5 to an estimated 11.0 mgd during the dry season and from 12.5 to approximately 13 mgd during the wet season. There are potential problems associated with this Navy increase because there will only be a buffer of about 0.5 mgd between wet season demand and the treatment design capacity of 13.5 mgd. Wet season demands that surpass this daily treatment capacity could effectively be met by increasing treatment to peak capacity (14.5 mgd), or by using part of the 20 million gallon reservoir supply. However, relying upon these reserve waters or treating at peak capacity will not become a long-term practice. Future expansion of the Fena Treatment Plant or reservoir system capacity will be investigated as a possible means to alleviate this problem.

A problem also arises with the increased Navy system demand during the dry season. Dry season system demand will expand to 11.0 mgd, while production can be as low as 10.5 mgd. Again this problem could be dealt with by using reservoir waters, but over the long run, it will decrease the length of reservoir supply life, affect distribution to other facilities, and require increased applications of the PWC Guam Water Storage Management and Response Plan.

One method of countering this problem would be to expand the treated reservoir system capacity. Another alternative is to develop near-reservoir wells to capture losses to groundwater. During wet season water surpluses, excess treated waters could be directed and stored for use during dry season shortages. An additional long term alternative for meeting both wet and dry season water demands would be for the Navy to construct additional water wells in the northern aquifer, which would reduce the need for the Navy to pump water all the way to the NCTAMS from Fena. A short term solution would be for the Navy to purchase or trade water with PUAG. PUAG has excess capacity but still buys 4.5 mgd of water from the Navy to serve southern and mid-island customers.

Additional actions to maintain adequate supply would be the adaptation and implementation of a more conservative Water Storage Management and Response Plan, as well as the installation of water conservation features in the new facilities. The installation of modern water saving faucets, shower heads and toilets, along with air conditioning units that use less water in the all of the proposed facilities and housing units is a practical approach to saving consistent amounts of water.

In addition to the above long-term impacts, there will be impacts associated with the many temporary facilities that have been constructed on the military bases to meet the immediate requirements of relocated personnel and activities. Generally, these temporary facilities will be replaced by permanent military construction projects described in this document. Since the rates for water consumption in Table 4.16.2 are based upon employment in the individual facilities, water impacts associated with the immediate relocation of personnel to these facilities will not differ from those listed for the Andersen, NAS Agana, or Naval Hospital areas.

However, the lack of permanent family housing in the Apra Harbor Complex will cause these people to enter the civilian housing market and create immediate water supply impacts outside the Naval system. Families qualifying for Navy housing will be required to find units wherever they can. It is assumed that they will find housing in the central region and create temporary impacts on the PUAG system serving the region.

4.17 ENERGY USE

4.17.1 Existing Conditions

4.17.1.1 Government of Guam Facilities

The Guam Power Authority (GPA) is responsible for planning and providing for power supply needs on the island of Guam. Electricity is provided to the various users primarily from the base load steam-electric generating stations at Cabras and Tanguisson (see Figure 4.17.1). Prior to the construction of GPA units between 1968 to 1975, the Navy provided electrical power generation for the entire island of Guam. In October 1972, the Navy and the GPA entered into a power pool agreement that provided for the joint use of separately owned power generation, transmission, and distribution facilities. Under the terms of the agreement, the Navy and GPA equitably shared in the responsibilities and costs of operating the Island-Wide Power System (IWPS). However, as of August 1992, a new Customer Service Agreement went into effect, making the Navy a customer of the GPA. Annual revenues of $4 million are expected by GPA with

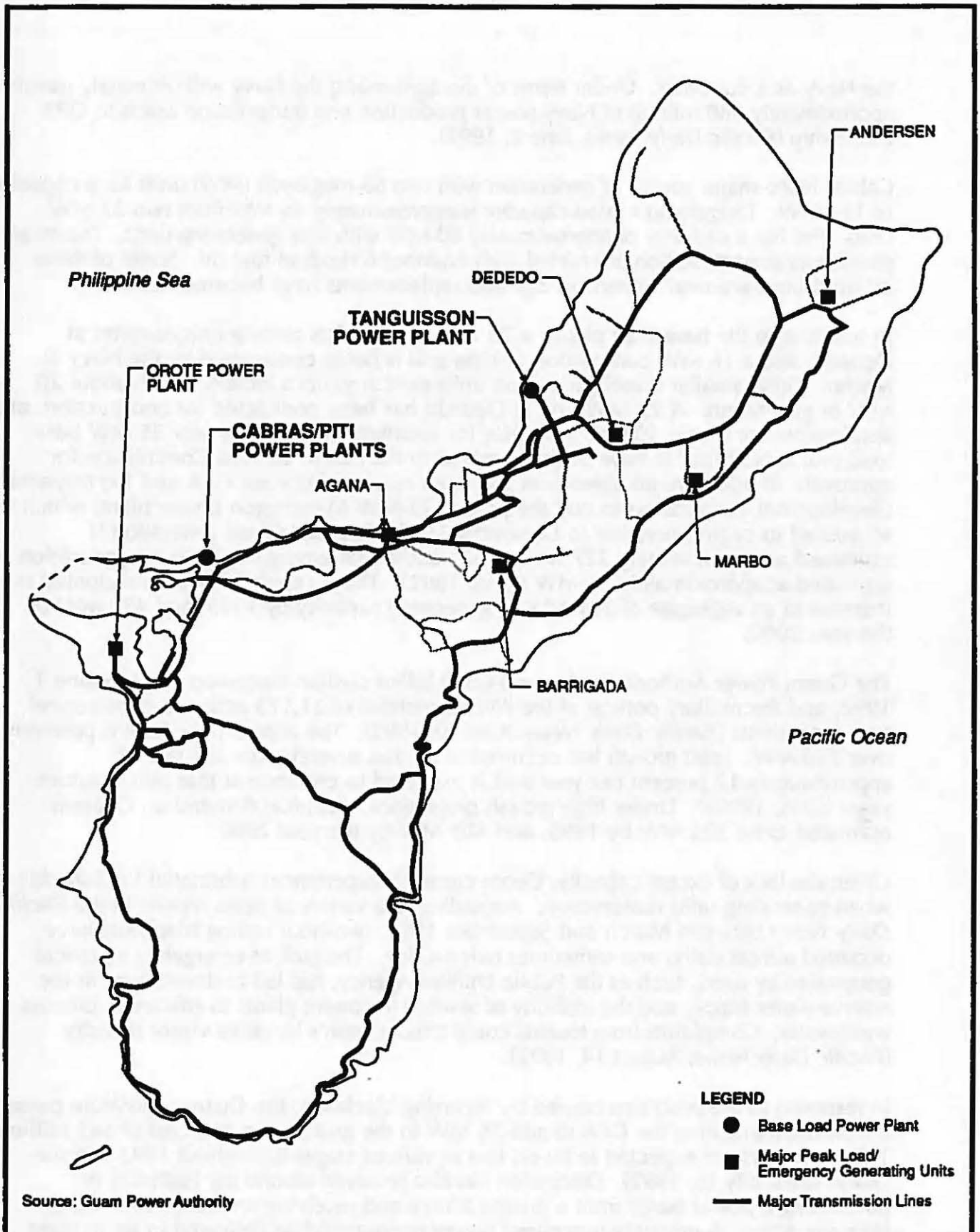

Figure 4.17.1
MAJOR ELECTRICAL DISTRIBUTION LINES
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the Navy as a customer. Under terms of the agreement, the Navy will ultimately transfer approximately $60 million of Navy power production and transmission assets to GPA ownership (*Pacific Daily News,* June 2, 1992).

Cabras is the major source of generation with two 66-megawatt (MW) units for a capacity of 132 MW. Tanguisson's rated capacity is approximately 46 MW from two 23 MW units. Piti has a capacity of approximately 60 MW with four generating units. The steam generators at each station are fueled with Number 6 residual fuel oil. Some of these oil-fired units are near retirement age and replacements have become necessary.

In addition to the base-load plants, a 23 MW combustion turbine unit operates at Dededo, and a 16 MW combustion turbine unit is being constructed by the Navy at Marbo. Other smaller diesel generation units exist at various locations with about 20 MW of generation. A 23 MW unit at Dededo has been contracted for construction, and applications for a new 30 MW generator for southern Guam and a new 35 MW base-load unit for Cabras/Piti have been submitted to the Public Utilities Commission for approval. In addition, an agreement has been reached between GPA and the Miyama Development Corporation to buy the private 23-MW Manenggon power plant, which is scheduled to begin operation in December 1993. Available base generation is estimated at approximately 227 MW, while additional emergency/peaking generation is estimated at approximately 59 MW (GPA, 1992). These capabilities are anticipated to increase to an aggregate of 361 MW of generating capacity by 1995, and 431 MW by the year 2000.

The Guam Power Authority had over 34,880 billed civilian customers prior to June 1, 1992, and the military portion of the IWPS consisted of 21,173 active duty personnel and dependents (*Pacific Daily News,* June 10, 1992). The annual peak load is presently over 230 MW. Load growth has occurred in the last several years at a rate of approximately 12 percent per year and is expected to continue at that rate in future years (GPA, 1990a). Under high growth projections, electrical demand on Guam is estimated to be 325 MW by 1995, and 403 MW by the year 2000.

Given the lack of excess capacity, Guam currently experiences substantial load-shedding when generating units malfunction. According to a variety of news reports in the *Pacific Daily News* between March and September 1992, two-hour rolling blackouts have occurred almost daily, and sometimes twice a day. The lack of emergency electrical generation by users, such as the Public Utilities Agency, has led to drawdowns in the reserve water supply and the inability of sewage treatment plants to efficiently process wastewater. Complaints from tourists could affect Guam's lucrative visitor industry (*Pacific Daily News,* August 14, 1992).

In response to the problems caused by recurring blackouts, the Guam Legislature passed a measure mandating the GPA to add 76 MW to the grid system at a cost of $45 million. The generators are expected to be on line at various stages throughout 1993 (*Pacific Daily News,* July 16, 1992). Discussion has also revolved around the feasibility of purchasing a power barge from a private source and receiving an older power barge from the Army. A privately-purchased power barge could be delivered in six to eight months and generate up to 30 MW of electricity (*Pacific Daily News,* May 30, 1992). A 16 MW Army power barge is being leased to GPA for emergency power purposes.

4.17.1.2 Navy Facilities

In accordance with the Customer Service Agreement described above, the Navy will continue to operate and maintain the baseload generating units at Piti, the combustion turbine at Marbo, the Navy's portion of the island's transmission system, and the baseload Unit No. 1 at Tanguisson while GPA establishes compliance with certain performance criteria. Once this compliance is established, ownership and operation of these assets, except for Tanguisson No. 1, will be transferred to GPA. Although GPA will take over its operation, Tanguisson No. 1 will continue to be owned by the Navy. The Navy will retain facilities for emergency power and peak power generation under the control of the Public Works Center within the base compounds at NAS Agana (4 MW), Apra Harbor Complex (4-6 MW), Barrigada (5 MW), Finegayan (4.5 MW), and Andersen Air Force Base (9 MW) (GPA, 1992). Although designed for operations only during the peak demand hours, due to the general lack of generating capability from the base load plants, many of these units have been operating between 12 to 18 hours a day.

Andersen Air Force Base. Andersen AFB receives power from the IWPS, which is stepped down at the Andersen Substation for distribution within the base. Backup power is provided by a 9 MW power plant composed of six 1.5 MW diesel generators.

Apra Harbor Complex. The electrical system for the Apra Harbor Complex distributes power from the Piti/Cabras and Orote Power plants, as well as from four 2 MW mobile utility support equipment (MUSE) units, to the various activities through the substations listed below (Navy, 1986a):

- Naval Station Guam receives 13.8 Kilovolt (KV) and 4.16 KV power from the Orote Substation. The Orote Substation steps down the 34.5 KV power received from the IWPS.
- Camp Covington receives 13.8 KV from the Apra Heights Substation with alternate power from the Navy Cold Storage Substation.
- The Ship Repair Facility receives power from the SRF Substation, which steps down the 13.8 KV received from the Orote Substation to 4.16 KV.
- Naval Supply Depot receives 13.8 KV power from the Orote Substation.
- Public Works Center administration buildings receive 13.8 KV power from the Cold Storage or Apra Substations.

Naval Magazine Guam. Naval Magazine Guam receives commercial power at 13.8 KV from the Apra Heights Substation. Power is distributed by a 1.25 MVA transformer. In the event the substation's transformer is out of service, 13.8 KV can be obtained from the Cold Storage Substation. In addition, NAVMAG Guam has emergency generators to supply backup power in the event of a commercial power outage (Navy, 1991b).

Naval Air Station Agana. Power service to NAS Agana is provided by the IWPS through substations at Agana and RTF Barrigada. Power is normally distributed at 13.8 KV to the NAS Agana substation from Agana, with RTF Barrigada available as an alternate source.

An alternate 13.8 KV feeder to NAS Agana from RTF Barrigada exists. On-station power distribution is at 13.8 KV and 4.16 KV (Navy, 1984).

4.17.2 Potential Impacts and Proposed Mitigation Measures

4.17.2.1 Electrical Supply

Table 4.17.1 shows the electrical demand upon the IWPS as a result of the various projects. Projects that have been reviewed separately and are not part of the proposed actions have been included in the analysis when they would add to the overall cumulative demand. Rates for electrical consumption were obtained from *NAVFAC P-80, Facility Planning Criteria for Navy and Marine Corps Shore Installations* (Navy, 1982).

Approximately 8 megawatts of additional demand are anticipated as a result of the proposed actions. Total demand upon the IWPS by 1995 is estimated to be approximately 325 MW under high-growth scenarios, while generating capacity is expected to grow to 361 MW (GPA, 1992). Given these projections, as well as the recent legislative funding for an immediate supply of 76 MW of power, the additional loads represented by the proposed actions are not likely to have an adverse effect upon the electrical generation capacity of the island at that time.

As a part of the proposed actions, two electrical projects are planned for the Apra Harbor area: the installation an additional 18 MW of electrical generating capacity and two 20/25 MVA transformers. The three 6 MW (18 MW total) diesel generators for the Orote Power Plant expansion have been designated for peak load/emergency generation and represent a 10 to 12 MW net increase to the IWPS during their use.

In the near term, immediate impacts will be felt from the influx of personnel transferring to Guam. Given the state of the current generating facilities, the additional demand will be difficult to absorb until such time as more power units are installed, or until such time as the current systems are adequately repaired and maintained. While 1993 should definitely see an improvement over 1992's rate of rolling blackouts and load shedding, the potential for further power interruptions will remain until such time as an adequate supply of emergency back-up power generation is available. Implementation of the measures authorized by the Guam legislature and signed by the Governor to purchase and install an additional 76 MW of power generation will help. Modern energy conservation active and passive features will be pursued for major military construction projects. Energy cost and consumption will be one of the evaluation factors used during technical review of the proposals to construct 300 houses. Natural gas was considered and rejected as a means of reducing load because of the limited island infrastructure for distributing natural gas and ensuring its reliability.

Table 4.17.1
Additional Daily Electrical Demand

Facility	Quantity	Unit	Rate (Watts)	Demand (MW)	Consumption (MWh/Yr)
Andersen Air Force Base					
Bachelor's Quarters	255	Persons	500	0.173	558
Family Housing	250	Families	6,000	1.500	6,570
Hangar Maintenance	53,625	Square Feet	7.5	0.402	840
Hangar Administration	17,875	Square Feet	6	0.107	224
Apron/Washrack	15,478	Square Feet	7.5	0.116	242
Aeromedical Facility	8,721	Square Feet	8	0.070	146
Shops Storage	2,000	Square Feet	2	0.004	8
Squadron Administration Office	2,000	Square Feet	6	0.012	25
Andersen Air Force Base Sub-Total				2.384	8,613
NAS/NAVHOSP/Nimitz Hill					
Bachelor's Quarters (NAS)	155	Persons	500	0.078	339
Oceanographic Facility (Nimitz Hill)	11,800	Square Feet	6	0.071	148
NAS/NAVHOSP/Nimitz Hill Sub-Total				0.148	487
Apra Harbor Complex					
MSC Administration	6,300	Square Feet	6	0.038	79
Hazardous Material Storage	55,000	Square Feet	2	0.110	230
Integrated Storage & Handling	125,000	Square Feet	2	0.250	522
Gas Bottle Storage	10,000	Square Feet	2	0.020	42
General Warehouse	60,000	Square Feet	2	0.120	251
Personal Property & Fleet Logistics	9,000	Square Feet	6	0.054	113
Cold Storage	41,000	Square Feet	2	0.082	171
Supply Systems Support Building	11,000	Square Feet	6	0.066	138
SRF (additional work-load)	55	Persons	5182	0.285	595
Ship Spares Storage Warehouse	26,300	Square Feet	2	0.053	110
AFDL Support Facility	2,000	Square Feet	6	0.012	25
NSWU-1 Maintenance/Storage	29,500	Square Feet	7.5	0.221	462
NSWU-1 Unit Building	41,400	Square Feet	6	0.248	519
Child Development Center	10,350	Square Feet	7	0.072	151
EOD Operations Facility	19,730	Square Feet	7.5	0.148	309
Bachelor's Quarters	605	Persons	500	0.303	1,325
WWTP Expansion	0.50	MGD	200,000	0.100	438
Family Housing	300	Families	6,000	1.800	7,883
T-AE Kilauea	1	Ship	317,000	0.317	1,388
T-AFS Sioux	1	Ship	288,000	0.288	1,261
T-ATF Spica	1	Ship	149,000	0.149	653
Average Ship Visits Per Day	1	Ship	288,000	0.288	1,261
Apra Harbor Complex Sub-Total				5.024	17,926
Naval Magazine					
Missile Magazine	18,000	Square Feet	2	0.036	75
Inert Storehouse	17,000	Square Feet	7.5	0.128	266
Battery Recharging Facility	1,800	Square Feet	2	0.004	8
Ordnance Office Addition	2,100	Square Feet	6	0.013	26
Security Office	1,800	Square Feet	6	0.011	23
Enlisted Dining	1,535	Square Feet	6	0.009	19
Bachelor's Quarters	150	Persons	500	0.075	329
Naval Magazine Sub-Total				0.275	745
TOTAL IWPS ELECTRICAL DEMAND				7.831	27,969

4.17.2.2 Energy Use

In addition to electricity, activities at the various military stations directly consume refined, liquid fossil fuel, primarily gasoline and diesel fuel. Other types of fuels, such as natural gas, are not used in significant quantities and are not included in this discussion. Energy will be consumed during construction activities, but this consumption will be a short-term impact. Several of the activities (such as the EODMU-5 and NSWU-1) will have additional energy requirements due to specific training or operational characteristics. However, due to the varied scope of these activities, it is not possible to quantify their amount of energy use.

In this discussion, energy demand is examined from four sources: additional electrical consumption, additional vehicle miles traveled, additional ship requirements, and additional flight operations of VRC-50. For comparison purposes, all energy use is reduced to equivalent barrels (bbl) of crude oil required to produce the end product energy consumed. It should be noted that this energy use may not necessarily represent additional demands upon the global oil reserves, as these projects are relocations of existing activities. However, the proposed actions do represent a shift in the management of global resources, and the increased activity level on Guam will require shipments of energy supplies to the island, which will have an impact on fuel importing and storage systems.

Electrical Consumption. Electrical consumption for the various facilities is shown in Table 4.17.1 in terms of megawatts per hour per year (MWh/yr). This amount is determined by estimating the number of hours per day and days per year of operation for each facility type. Additional electrical consumption as a result of the proposed actions is estimated at 27,969 MWh/yr. The largest component of consumption is the housing and barracks facilities, which are expected to consume approximately 22,000 MWh/yr.

One barrel of oil has a thermal equivalency of 1,698 kilowatt hours (kWh). However, when used to generate electricity, approximately 65 percent of this equivalency is lost due to conversion and transmission. Using 35 percent of the 1,698 kWh per barrel rate yields approximately 40,000 bbl of additional fuel oil consumed for electrical generation which will need to be imported to Guam.

Vehicle Miles. Energy use by vehicles is determined by the amount of fuel used per vehicle mile. Vehicle miles for this discussion reflect the average travel distance between housing locations and the central on-base support facilities. Average weekday (261 days/yr) and average weekend (104 days/yr) two-way trip volumes were calculated for each housing and barracks area from rates included in the *Trip Generation Manual, Fifth Edition* (ITE, 1991). A two-way trip represents one vehicle making one round-trip. Table 4.17.2 shows average vehicle miles traveled per year.

Table 4.17.2
Average Vehicle Miles Per Year

Source	Weekday	Avg. Daily Two-Way Volumes Weekend	Avg. Miles (One-Way)	Avg. Yearly Vehicle Miles
Tipalao Housing	2,941	3,139	3.0	3,282,171.0
Apra BEO/BOQ	880	869	3.0	960,168.0
NAVHOSP BEO	229	226	7.0	582,911.0
NAS BOQ/BEO	507	501	1.5	276,646.5
NAVMAG BEO	164	162	1.0	59,652.0
Andersen BOQ/BEO	834	824	1.5	455,055.0
Andersen Housing	2,388	2,548	1.5	1,332,390.0
Total				6,948,993.5

Energy requirements for these vehicle miles can be determined on the basis of an average mile per gallon (mpg) rate of 19.6 mpg (Navy, 1990b). Approximately 354,540 gallons of gasoline will be consumed annually to travel the additional vehicle miles shown in Table 4.17.2. As Guam has no refining capacity, this gasoline represents a net increase in automotive fuel imports to the island. With one barrel of crude oil able to produce 32 gallons of gasoline, it is calculated that 11,079 bbl of crude oil will be required from the global reserves each year to produce gasoline.

Ship Requirements. No significant increase in ship fuel use in Guam due to the proposed activities is anticipated (CINCPACFLT, Code 415 Memo, 20 Nov 92).

Flight Operations. Although VRC-50 squadron operations represent a transfer of existing operations from the Philippines, the remoteness of Guam will result in more training and flight operations than occurred previously. Flight operations, consisting of arrivals, departures, touch and goes, and fleet carrier landing practice (FCLP), are estimated to increase approximately 26 percent in Guam from levels experienced in the Philippines. Without factoring in differences for flight patterns or distances between air stations, this will translate into approximately 474,240 gallons of additional jet fuel consumed by VRC-50 over its prior consumption due to the increased flight activity. This new demand in fuel represents a net increase in required jet fuel imports to Guam. With residual fuels comprising approximately 32 percent of a barrel of crude oil, calculated additional petroleum consumption is approximately 26,945 bbl per year from global reserves.

4.17.3 Cumulative Impacts

The increase in activities resulting from proposed actions on Guam will require the importation of approximately 80,000 bbl of additional fuel oil per year. However, only about 27,000 bbl of this represents a net increase in use of global reserves. The rest will be the result of relocated activities, and represents a shift in management of global resources.

The proposed activities will also result in an increase in daily electrical demand on Guam of approximately 8 MW. This equates to 27,969 MWh/yr, with the largest component of this demand coming from the housing and barracks facilities that will consume

approximately 22,000 MWh/yr. Total demand on the IWPS by 1995 is estimated to be 325 MW under high growth scenarios, while generating capacity is expected to grow to 361 MW. Given these projections, as well as the recent legislative funding for an immediate supply of 76 MW of power, the additional loads resulting from the proposed actions are not likely to have a long term adverse effect upon the electrical generation capacity of Guam. However, there will be short term or immediate impacts felt from the influx of personnel and activities transferring to Guam. Until an adequate supply of emergency back-up power is made available, power interruptions, load shedding, and rolling blackouts will continue.

4.18 TELECOMMUNICATIONS

4.18.1 Existing Conditions

All military bases on Guam operate independent telephone networks integrated with the Guam Telephone Authority (GTA) system. These networks allow personnel to place official calls throughout their respective bases without having to obtain access to the public system. The military system is operated by Public Works Center (PWC) Guam and provides telephone service to all official areas owned by the U.S. Department of Defense. PWC Guam operates and maintains four telephone exchanges and four EPABX/PABX buildings. For the most part, the telephone system consists of an underground fiber optics system providing multiple line capacity.

Island-wide telephone service is also provided by the Guam Telephone Authority (GTA), an autonomous agency of the Government of Guam. The interconnection with this civilian system allows access to public telephone lines all over the island.

Overseas telephone communication for both military and civilian services is handled by RCA Global Communications, Inc. and ITE, Inc. FTS service to the continental U.S. (CONUS) is provided under DoD contract for federal agencies.

4.18.2 Potential Impacts and Possible Mitigation Measures

4.18.2.1 Andersen Air Force Base

The additional military activities and personnel at Andersen Air Force Base will cause an increased use of the existing telephone system. The VRC-50 squadron is comprised of 17 aircraft and approximately 1,200 people including officers, enlisted personnel, transient personnel, and dependents. These additional people will be housed in previously unused and newly-renovated quarters that will require new telephone extensions. The aircraft will be maintained at a new hangar/apron/washrack facility that will also need to be connected to the civilian and base telephone systems through additional lines (Navy, 1992g).

Although Andersen will experience a substantial influx of new personnel, the resulting population will be smaller than when the base serviced B-52 squadrons. Therefore, the capacity of the telephone system will be able to accommodate the new activities. Any other impacts to the telephone system resulting from the relocation will be minimal.

4.18.2.2 Apra Harbor Complex

Apra Harbor will receive over the next few years approximately 1,700 new people including officers, enlisted personnel, civilian workers, transient workers, and dependents (see Appendix D). Many of these people will live and work in new facilities which will require additional phone lines and connections to the existing telephone systems. As a result, the overall volume of calls will increase. To accommodate the increased demand on telecommunications services over the next few years, the Navy will upgrade its system as appropriate.

4.18.2.3 Naval Air Station (NAS) Agana

An additional 138 personnel will be transferred to NAS Agana. No new buildings are planned. More calls will be made on the military and civilian telephone systems, but the increase will not be enough to cause any problems to the current phone network.

4.18.2.4 Naval Magazine Guam

Naval Magazine will receive new units totalling approximately 150 personnel. As the new personnel will be housed in existing structures, the only new phone lines will be those connecting the new storage facilities to the base and civilian phone systems. The base and civilian phone systems for the Naval Magazine will be able to handle the additional calls.

4.18.3 Cumulative Impacts

The increase in personnel and facilities resulting from the proposed actions will require a number of new phone hookups to the civilian (GTA) and base telephone systems of Guam. However, these new hookups and increased use of the systems do not represent a significant increase to the islandwide or base networks, and will have no adverse impact on the islands telecommunications systems.

4.19 SEWAGE

4.19.1 Existing Conditions

4.19.1.1 Government of Guam Facilities

The civilian wastewater collection system in Guam is operated and maintained by the Public Utilities Agency of Guam (PUAG). A separate wastewater collection and treatment system serves the Navy Apra Harbor Complex.

The PUAG-operated system is divided into three regions, two of which contain Department of Defense commands. One additional region is formed by the Navy owned and operated Apra Harbor collection system. These sewage districts are described below and shown in Figures 4.19.1 and 4.19.2 (PUAG, 1992b).

Northern Sewage District. This district the portion of the village of Dededo north of Marine Drive, Andersen Air Force Base, Northwest Field, Andersen South (Marbo), the NCTAMS WESTPAC at Finegayan, and the Navy family housing at South Finegayan.

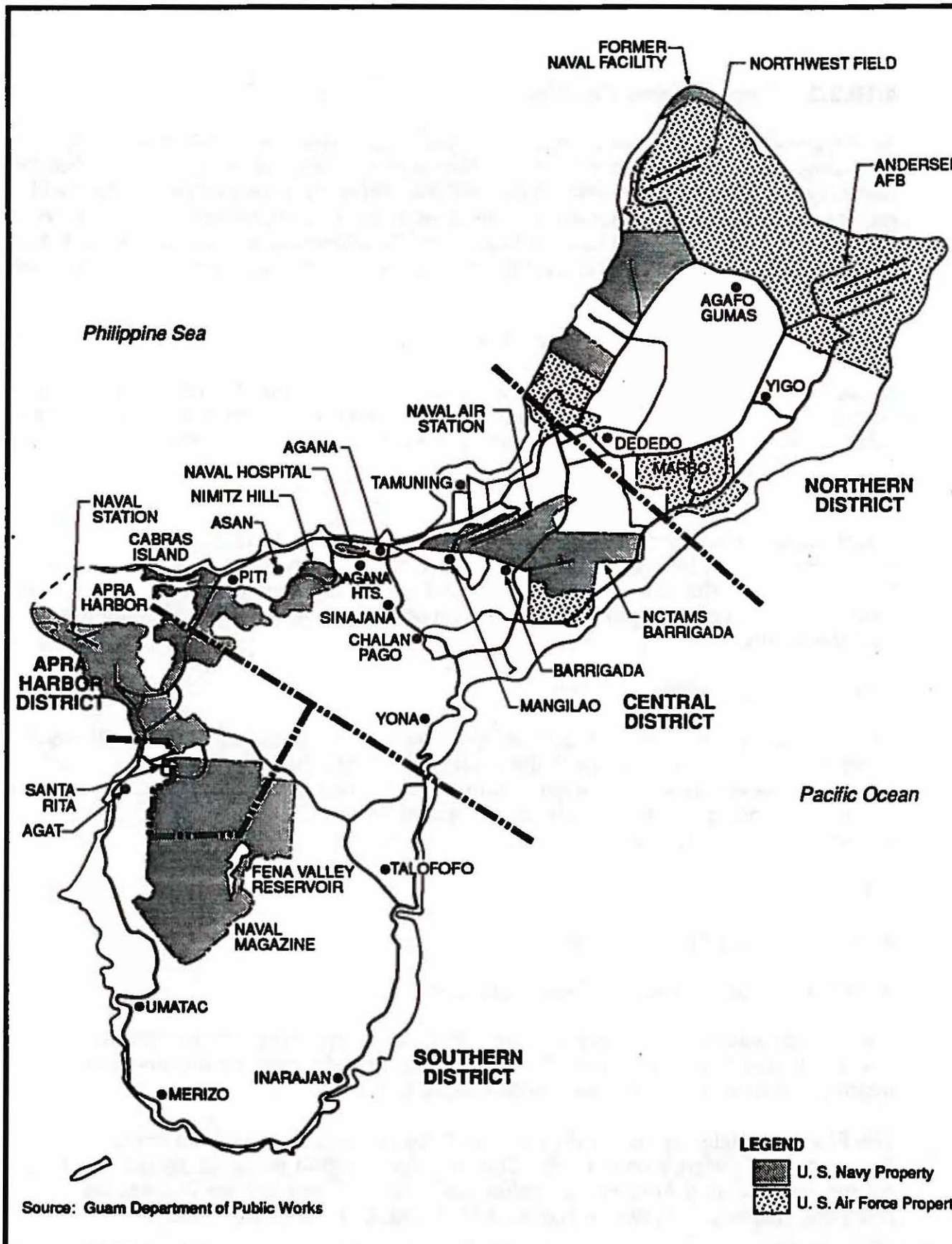

Figure 4.19.1
INTEGRATED SEWERAGE SYSTEM
SEWERAGE DISTRICTS
Guam Development EIS
April 1993

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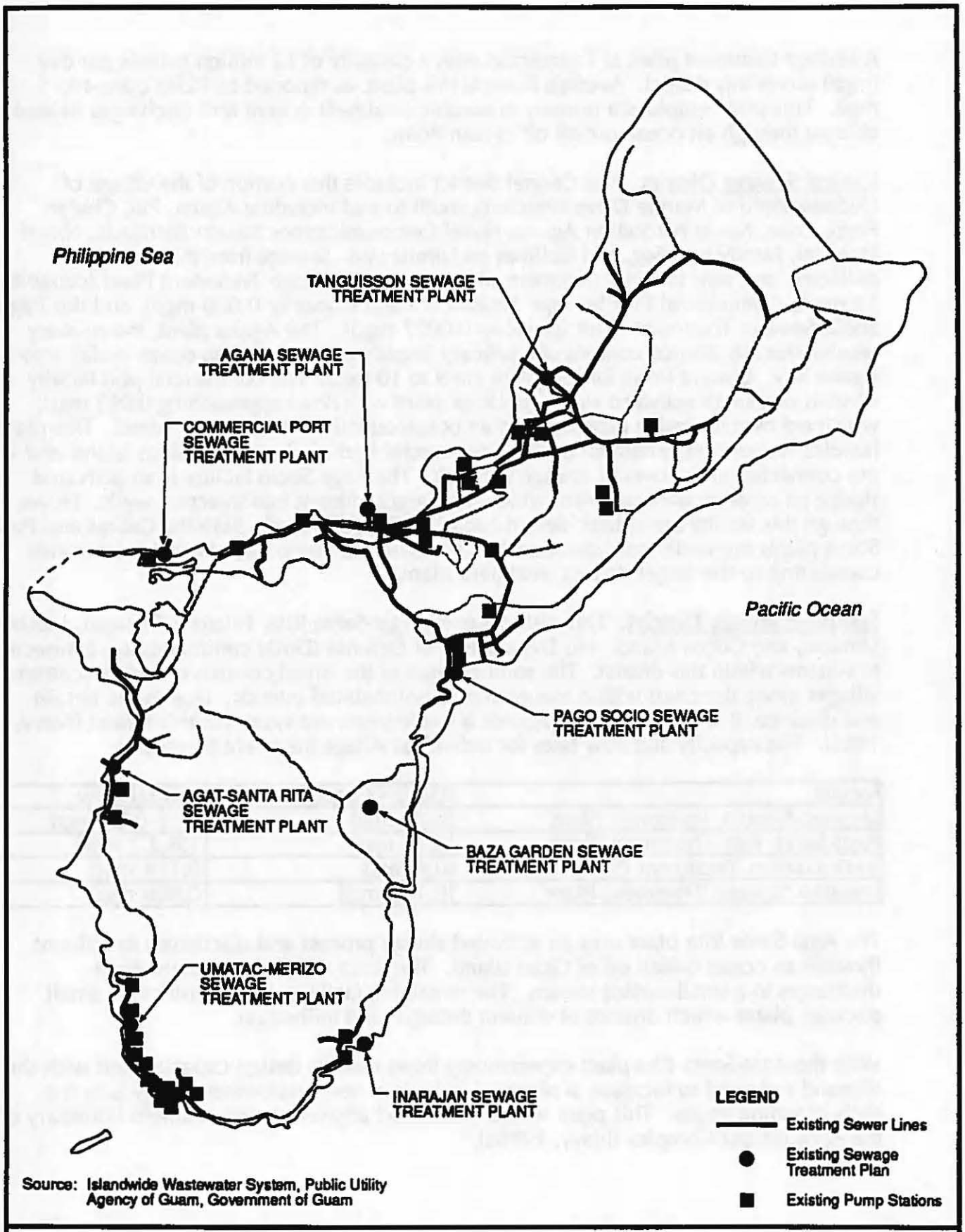

Source: Islandwide Wastewater System, Public Utility Agency of Guam, Government of Guam

North

0 1 2 3

Scale in Miles

Figure 4.19.2
PUAG ISLANDWIDE WASTEWATER SYSTEM
Guam Development EIS
April 1993

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A sewage treatment plant at Tanguisson with a capacity of 12 million gallons per day (mgd) serves this district. Average flows at this plant, as reported by PUAG, are 4 to 5 mgd. This plant employs a primary anaerobic treatment system and discharges treated effluent through an ocean outfall off Hilaan Point.

Central Sewage District. The Central district includes that portion of the village of Dededo south of Marine Drive stretching south to and including Agana, Piti, Chalan Pago, Yona, Naval Air Station Agana, Naval Communications Station Barrigada, Naval Hospital, Family Housing, and facilities on Nimitz Hill. Sewage from this district is collected and sent to three treatment plants: Agana Sewage Treatment Plant (capacity 12 mgd), Commercial Port Sewage Treatment Plant (capacity 0.020 mgd), and the Pago Socio Sewage Treatment Plant (capacity 0.0077 mgd). The Agana plant, the primary receiver for this district, consists of a primary aerobic process with an ocean outfall into Agana Bay. Current flows for this plant are 9 to 10 mgd. The commercial port facility consists of a small activated sludge package plant with flows approaching 0.063 mgd, which are over its design capacity, and an ocean outfall north of Cabras Island. This plant handles wastewater generated by the Commercial Port of Guam on Cabras Island and is not connected to the overall sewage network. The Pago Socio facility is an activated sludge jet aeration package plant which discharges effluent into injection wells. Flows through this facility are at their design capacity of 0.0077 mgd. Both the Cabras and Pao Socio plants are under consideration for conversion to pump stations and force mains connecting to the larger district treatment plant.

Southern Sewage District. This district covers Agat-Santa Rita, Talafofo, Inarajan, Merizo, Umatac, and Cocos Island. No Department of Defense (DoD) commands are connected to systems within this district. The southern part of the island consists of widely scattered villages along the coast with a mountainous, uninhabited interior. Due to the terrain and distance, it is not feasible to provide a single treatment system to this district (Navy, 1985). The capacity and flow rates for individual village treatment plants are:

Facility	Design Capacity	Actual Flow
Umatac-Merizo Treatment Plant	0.25 mgd	0.22-0.31 mgd
Agat-Santa Rita Treatment Plant	0.75 mgd	1.8-2.7 mgd
Baza Garden Treatment Plant	0.6 mgd	0.114 mgd
Inarajan Sewage Treatment Plant	0.191 mgd	0.066 mgd

The Agat-Santa Rita plant uses an activated sludge process and discharges its effluent through an ocean outfall off of Gaan Island. The Baza Garden Treatment Plant discharges to a small surface stream. The remaining facilities in this district are small package plants which dispose of effluent through land infiltration.

With the Agat-Santa Rita plant experiencing flows over its design capacity, and with the demand expected to increase, a proposal to build a new wastewater facility is in the early planning stages. This plant would be located adjacent to the southern boundary of the Apra Harbor Complex (Navy, 1986a).

4.19.1.2 Department of Defense Facilities

Andersen Air Force Base. The sewage collection system for Andersen AFB consists of 6- and 8-inch gravity lines connected to a 20-inch force main. This force main deposits sewage collected on base into the PUAG system, where it is treated at the Tanguisson facility. The sewage system services the housing and administration areas located south of the South Runway. Areas along the North Runway and above are serviced by individual septic systems. Approximately 2 mgd is pumped from Andersen into the PUAG system (Navy, 1992e).

Apra Harbor. The Apra Harbor collection area is made up of all Navy activities on and around Orote Point, including the Naval Magazine and the Apra Heights housing. Sewage from Naval operations, including the Navy wharves, is routed to the Apra Harbor Sewage Treatment Plant (see Figure 4.19.3). The collection system along the wharves consists of a combination of 4- and 6-inch diameter force mains and 6-, 8-, 10-, and 12-inch diameter gravity lines. The system was completed in 1976 (Navy, 1986a). The Apra Harbor plant is currently being upgraded to secondary treatment. Existing design capacities are 3.2 mgd average and 6 mgd peak; planned improvements will add 0.5 mgd capacity to the plant (fax dated Feb. 23, 1993 from PWC to Environmental Services Dept., U.S. Navy PWC Guam). Current average flows are between 2.5 and 3 mgd (Navy, 1992h). Effluent from this plant is directed to a broken ocean outfall and into the nearshore waters of Tipalao Bay.

This outfall is currently in disrepair, resulting in the discharge of effluent near the shoreline. A Memorandum of Agreement has been signed between the Navy and PUAG over the joint use of the ocean outfall connected to PUAG's proposed Agat-Santa Rita facility to correct this situation. PUAG is proceeding with design and environmental assessment work. A separate military construction project (P-142), not part of the proposed actions, has been proposed to pay the Navy's share of correcting the PUAG outfall.

Naval Magazine Guam. The sewage collection system for NAVMAG Guam consists of a series of 6- and 8-inch lines which connects the administration and personnel support areas with a force main and gravity lines that takes the waste to the Apra Harbor Wastewater Treatment Facility. Outlying maintenance and ordnance handling facilities are connected to separate sewer lines which lead to septic tanks and leaching fields (Navy, 1991b).

Naval Air Station Agana. The NAS Agana sewer system is composed of two major interceptors serving the northern and southern areas. The 10-inch and 18-inch interceptors are connected to the PUAG sewer system. Connections to these interceptors are through a series of 6-, 8-, 10-, and 12-inch gravity lines (Navy, 1984).

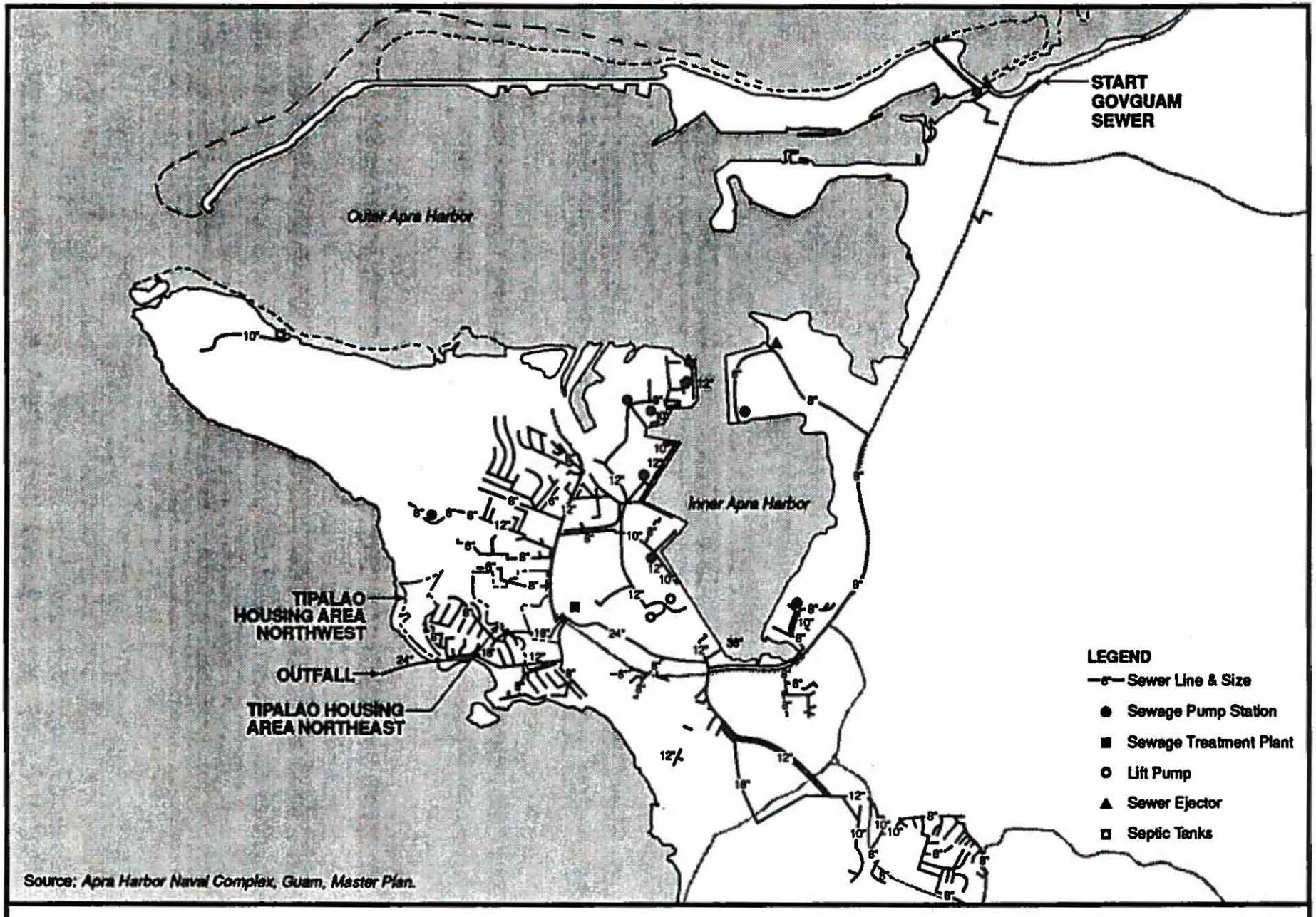

Figure 4.19.3
APRA HARBOR
DISTRICT COLLECTION AREA
Guam Development EIS
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4.19.2 Potential Impacts and Proposed Mitigation Measures

4.19.2.1 Sewage Generation

Table 4.19.1 shows the additional sewage generated by the proposed projects described in Chapter 2. In cases where specific wastewater generation rates for Naval facilities were not available, generation was calculated as 80 percent of potable water consumption. Personnel assigned to each command were assumed to reside at that command, with the exception of the Naval Hospital, whose personnel were assumed to reside at the Naval Station. Housing units slated for the Apra Harbor Complex were assumed to be filled by personnel assigned to the Naval Station. Background levels of wastewater flow resulting from future population growth in Guam were derived from population, school enrollment, employment, and visitor projections for each municipal district contained in the *Guam 2010 Highway Master Plan, Working Paper No. 3* (Guam DPW, 1991a).

4.19.2.2 Impacts on Northern Sewage District

Increased personnel and dependents living on or around Andersen AFB as a result of the relocation of the VRC-50 squadron will be responsible for approximately 92 percent of the additional DoD wastewater generation in the Northern Sewage District (174,200 gallons per day). Facilities associated with the squadron, as well as administrative employment, are estimated to produce approximately 15,800 gallons per day (gpd). Due to the lack of sewage hook-ups above the South Runway, construction of approximately 13,000 lineal feet of sewer pipe will be required to link the VRC-50 facilities with the Andersen system. Wastewater generated by maintenance activities will be required to pass through an EPA-approved oil-water separator before entering the sewage system. Total additional wastewater generation from Andersen is estimated to be 0.20 mgd.

Because of the sufficient system capacity at Andersen, on-base sewage facilities are not likely to be adversely affected by the additional VRC-50 personnel and dependents. General population increases within the Northern Sewage District will create an additional 0.87 mgd of wastewater flow on top of the current 4 to 5 mgd flowing to the Wastewater Treatment Plant at Tanguisson. The additional 0.20 mgd produced by activities associated with the proposed actions will create a projected 1995 flow of between 5.07 to 6.07 mgd at the plant. With the current capacity of the Tanguisson plant at 12 mgd, this small amount of additional flow is not expected to have an adverse impact upon the Northern District sewage system.

4.19.2.3 Impacts on Central Sewage District

Additional sewage generation for the Central Sewage District will result from increased activities at Naval Air Station Agana, Nimitz Hill, and the Naval Hospital. New and augmented personnel and maintenance work at NAS Agana will generate approximately 25,000 gpd. Additional employment at the Naval Hospital is estimated to produce 11,200 gpd. Current internal collection systems at both sites are adequate to handle these small increases.

Table 4.19.1
Additional Daily Sewage Generation

Facility	Perm Duty	Depen-dents	Temp Duty	Total Persons	Total SQFT	Rate (gpd)	Total (gpd)
NORTHERN SEWAGE DISTRICT							
Andersen Air Force Base							
Bachelor's Quarters	255			255		120	30,600
Family Housing	250	580		830		160	132,800
Hangar Maintenance					53,625	0.20	10,725
Hangar Administration					17,875	0.10	1,788
Apron/Washrack					15,478	0.20	3,096
Squadron Admin. Offices					2,000	0.10	200
Aeromedical Facility					8,721	0.10	872
NORTHERN DISTRICT TOTAL							180,081
CENTRAL SEWAGE DISTRICT							
NAS/NAVHOSP/Nimitz Hill							
Maintenance Employment (NAS)	145		10	155		40	6,200
Bachelor's Quarters (NAS)	145		10	155		120	18,600
Hospital Employment (NAVHOSP)	70			70		160	11,200
Oceanographic Facility (Nimitz)	12			12		16	192
CENTRAL DISTRICT TOTAL							36,192
APRA HARBOR SEWAGE DISTRICT							
Naval Station							
MSC Administration	48			48		16	768
Hazardous Material Storage				6		40	240
Integrated Storage & Handling				25		40	1,000
General Warehouse				10		40	400
Pers. Prop. & Flt Logistics				61		16	976
Cold Storage				10		40	400
Supply Systems Support Building				50		16	800
SRF (from additional man-days)				55		404	22,220
AFDL Support Facility					2,000	0.20	400
NSWU-1 (personnel)				36		16	576
NSWU-1 (facility)					29,500	0.20	5,900
Child Development Center				264		12	3,168
EOD (personnel)	47			47		16	752
EOD (facility)					19,730	0.20	3,962
Bachelor's Quarters	269		266	535		120	64,200
Bachelor's Quarters (NAVHOSP)	70			70		120	8,400
Family Housing	300	852		1,152		160	184,320
T-AE Kilauea				1		16,000	16,000
T-AFS Sioux				1		32,000	32,000
T-AFT Spica				1		4,000	4,000
Average Ship Visits Per Day				1		16,000	16,000
Naval Station Sub-Total							366,482
Naval Magazine							
Maintenance Employment	170			170		40	6,800
Enlisted Dining	150			150		24	3,600
Bachelor's Quarters/wo Dining	150			150		96	14,400
Naval Magazine Sub-Total							24,800
APRA HARBOR DISTRICT TOTAL							391,282

The current capacity of the Agana Sewage Treatment Plant is 12 mgd. In 1995, baseline flows through the plant are projected to be 10.4 to 11.4 mgd. With the eventual conversion of the Pago Socio and commercial port plants to pump stations and the diversion of their wastewater flows to the Agana plant, baseline flows could increase to between 10.47 to 11.47 mgd. The additional 0.036 mgd from the proposed activities represents a small incremental increase. In order to accommodate future private development requirements over the next two years, PUAG may need to consider expanding the capacity of the Agana plant or diverting flows elsewhere.

4.19.2.4 Impacts on Southern Sewage District

No DoD activities or facilities are planned for areas within the Southern Sewage District. However, cumulative impacts resulting from any increased tourism due to the additional military personnel on Guam could result in localized increases in sewage. These increases, however, would be so slight as to be insignificant at this time.

4.19.2.5 Impacts on Apra Harbor Sewage District

The area serviced by the Navy's Apra Harbor Sewage Treatment Plant will experience the highest increase in wastewater generation as a result of the proposed activities. The additional 300 units of family housing will have the greatest impact, producing approximately 185,000 gallons per day (gpd). Unaccompanied housing (bachelor's quarters) account for another 72,600 gpd. Next to housing, the second largest generators of wastewater are the three Military Sealift Command vessels being forward-deployed to Guam. The worst-case scenario of their being in port together, along with at least one other visiting ship, would increase wastewater flow by 68,000 gpd. In total, approximately 366,000 gpd of additional wastewater will be generated by activities and facilities on Naval Station Guam.

Wastewater generators on Naval Magazine Guam consist of the proposed maintenance facilities and personnel loading. The 150 persons newly assigned to Naval Magazine will generate an estimated 18,000 gpd of wastewater in their homes. An additional 6,800 gpd is anticipated from new employment in operational facilities. All sewage generated as a result of the proposed activities will be directed to the sanitary sewer system leading to Apra Harbor.

Total additional wastewater generated by the proposed activities is approximately 0.4 mgd. With an average flow capacity of 3.2 mgd at the Apra Harbor STP following completion of the secondary treatment modification, and current average flows at 2.5 to 3 mgd, future average flow rates will be between 2.9 and 3.4 mgd. To accommodate this future flow, the Navy proposes a new chlorine contact tank, a new solids aerator tank, and additional aeration piping to the solids contactor bypass channel (P-239). However, while these modifications will sufficiently augment the Apra Harbor facility to handle the additional flows caused by the proposed actions, future growth will require more sewage treatment capacity at the plant.

In addition to the increase in influent to the treatment plant, a corresponding increase in effluent through the ocean outfall will occur. The conversion of the Apra Harbor facility from a primary treatment system to a secondary treatment system will greatly improve the quality of the effluent being discharged. The minor amount of additional

effluent being discharged is not likely to cause any exceedance of the current National Pollutant Discharge Elimination Permit.

4.19.3 Cumulative Impacts

Cumulative impacts are associated with the many temporary projects constructed to accommodate the immediate requirements of personnel and activities transferring to Guam. These temporary facilities will, for the most part, be replaced by the permanent military construction projects described in Chapter 2. However, the addition of personnel to the various commands will have an immediate impact on the amount of sewage generation in the sewage districts. As the rates used for sewage generation in Table 4.19.1 reflect employment in these facilities, either temporary or permanent, immediate additional sewage impacts are not expected to differ from those discussed for Andersen AFB, NAS Agana, or Naval Hospital. However, the initial amount of wastewater flowing into the Apra Harbor treatment plant will be reduced until the 300 family housing units are occupied. This approximately 0.2 mgd reduction should keep influent flows within the current design capacity of the plant until such time as the 0.5 mgd expansion can occur.

The shortage of available family housing in the Apra Harbor Complex will force families into the local housing market. As a temporary measure, the Navy will lease apartment units to accommodate some of these families, while other families will be required to find units wherever they can. It is assumed that families would most likely find housing in the Central Sewage District, so there would be a short-term cumulative impact on the Central District's Agana facility attributable to these families.

4.20 SOLID WASTE

4.20.1 Existing Conditions

4.20.1.1 Civilian Facilities

Municipal refuse on Guam is collected by the Department of Public Works and private haulers and transported to the Ordot Sanitary Landfill (see Figure 4.20.1). No tipping fee is collected, and individuals are allowed to use the landfill for private refuse disposal. Approximately 150 to 200 tons of municipal solid waste are disposed of at the site daily. Estimates derived from population projections indicate that by 1995, the amount of solid waste dumped into the Ordot Landfill will be between 230 and 280 tons per day.

The 47-acre landfill has no effective excess capacity at this time. In 1982, it was recognized as one of 418 sites labeled as the nation's worst toxic waste dumps targeted for cleanup. Two years later, the landfill made the list of 28 sites eligible for priority action under the U.S. Environmental Protection Agency Superfund program. Discharges of pollutants from the landfill into the Lonfit River were observed from July 1985 to June 1990 (*Pacific Daily News*, April 22, 1992).

No effective recycling program exists on Guam, and the Ordot Landfill continues as the only legal disposal area for municipal solid wastes. A solid waste management plan adopted by the Territorial Legislature in 1984 called for the purchase of 52 acres for landfill expansion, as well as the institution of user fees. However, lack of funding

appropriations prevented the implementation of this plan. As a result, recent federal auditors reports have warned the Government of Guam that it may lose $2.7 million in federal money for the implementation of future solid waste plans (*Pacific Daily News*, April 22, 1992).

Government of Guam officials report that a solid waste management program currently being formulated will include recycling and waste reduction, the use of a municipal solid waste resource recovery incinerator, and a 13-acre expansion of the present landfill. In addition, proposals have been made in the Legislature to ban the dumping of green wastes (yard clippings, tree branches, leaves, etc.) in the landfill. These items would instead go to village public composting sites, thus cutting the flow of debris to the Ordot Landfill by about 30 percent (*Pacific Daily News*, August 19, 1992).

4.20.1.2 Military Facilities

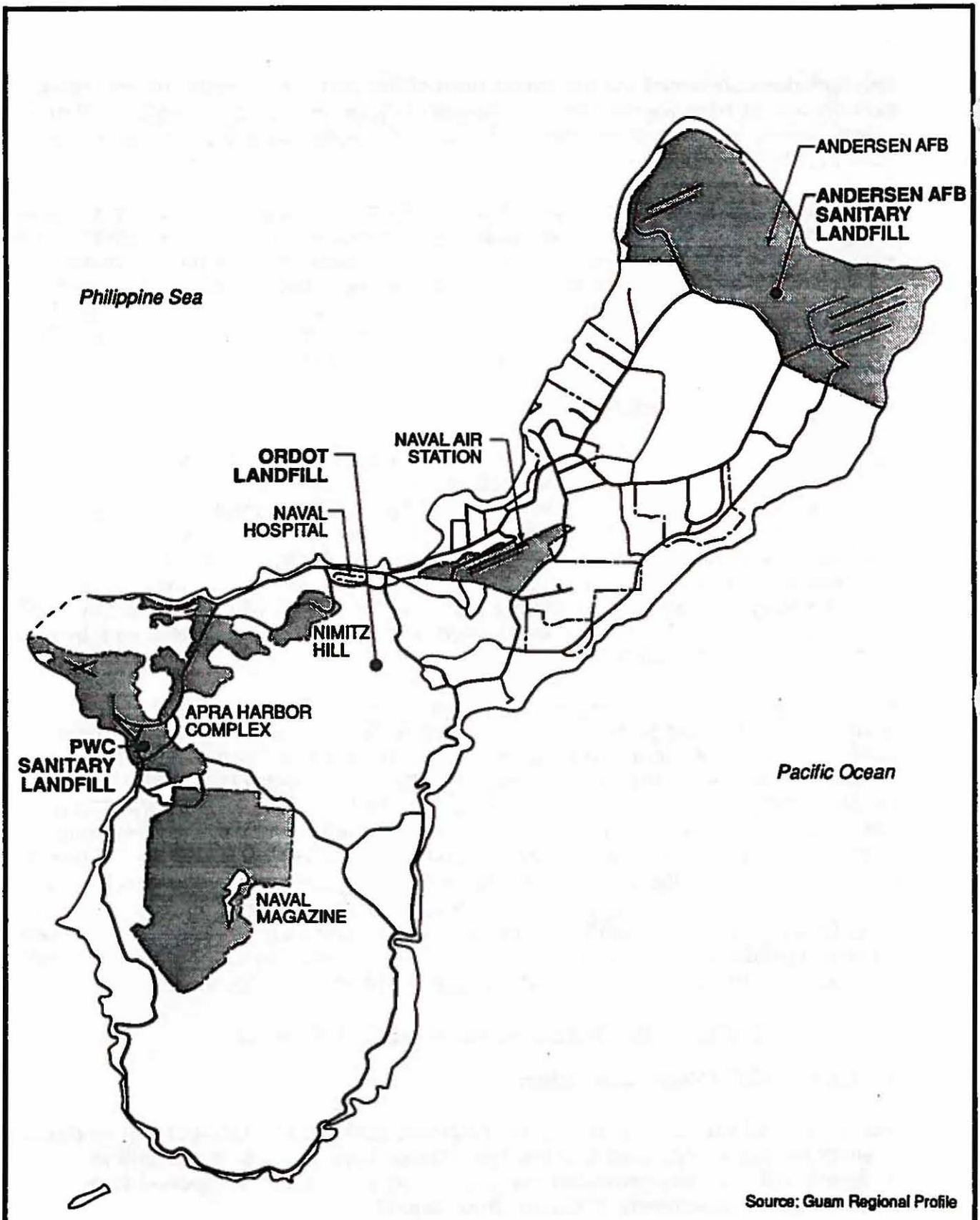
Navy Facilities. Disposal of Navy-generated municipal solid waste from the various stations and activities on Guam is handled by the Navy Public Works Center. Trash is transported to the Navy's sanitary landfill at the Apra Harbor Complex (see Figure 4.20.1). This 93-acre landfill is located adjacent to Shoreline Drive, south of the Navy Exchange (Navy, 1985). In fiscal year 1991, approximately 48,225 tons of solid waste were deposited in the landfill, or approximately 132 tons per day. At these tippage rates, the Navy PWC estimates that the capacity of the landfill will be reached by 1997 (PWC interview, May 1, 1992). A breakdown of the current solid waste stream by type of refuse is shown in Table 4.20.1.

Air Force Facilities. Air Force-generated waste is collected by the Air Force Environmental Support Section, Refuse Collection Division, and transported to the sanitary landfill on Andersen (see Figure 4.20.1). The Andersen Sanitary Landfill covers 41 acres and has an estimated refuse loading of 22.5 tons per day (Navy, 1992e). In October 1992, the site was finalized for listing on the federal National Priority List of hazardous waste sites and is under consideration for closure around 1996 (transmittal from HQ PACAF/DEV to PACDIVNAVFACENGCOM, November 11, 1992). Given the estimated life span of the landfill, under present loading conditions it will reach capacity in about two years (Navy, 1985). Options for future solid waste disposal include locating a site for a replacement landfill on Andersen or using any future Government of Guam municipal solid waste resource recovery incinerator. In addition to solid waste disposal, the Andersen landfill is equipped and approved to handle asbestos disposal.

4.20.2 Potential Impacts and Possible Mitigation Measures

4.20.2.1 Solid Waste Generation

Municipal solid wastes generated by the proposed activities and facilities will be directed to either the Navy PWC landfill at the Apra Harbor Complex or to the landfill at Andersen AFB. Military-generated municipal solid waste is not transported to or disposed at the Government of Guam Ordot landfill.



North

0 1 2 3

Scale in Miles

Figure 4.20.1
SANITARY LANDFILL SITES
Guam Development EIS
April 1993

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Table 4.20.1
Breakdown of FY 1991 Navy Municipal Solid Waste

Type	Cubic Yards	Tons	Tons/Day Basis
Foreign Refuse	1,596	159.6	0.437
Industrial Refuse	346,096	34,609.6	94.8
Housing Refuse	118,668	11,866.8	32.5
Other Refuse	15,892	1,589.2	4.4
Total	**482,252**	**48,225.2**	**132.1**

Source: PWC Guam

The amount of additional daily municipal solid waste projected for the PWC landfill has been estimated using rates supplied in *NAVFAC Design Manual 5.10, Civil Engineering, Solid Waste Disposal* (Navy, 1979) (see Table 4.20.2). Housing activities represent the largest producer of solid waste for both the Andersen and Apra Harbor Landfills (7.14 tons/day), while industrial/maintenance generated wastes comprise the second largest category (see Table 4.20.3). Foreign refuse, or solid waste brought in by ships, is only a small component of the overall waste stream.

4.20.3 Cumulative Impacts

Andersen Landfill. Approximately 3.39 tons of additional solid waste per day are anticipated at the Andersen Landfill as a result of the relocation of the VRC-50 squadron to Andersen AFB. This represents a 15 percent increase in the present solid waste disposal rate to approximately 25.89 tons per day. Given this loading, the landfill is expected to reach its capacity by mid-1994. Plans for the eventual closure of the landfill and alternative sites or disposal methods will be formulated to accommodate solid waste generated after 1995. As a part of a separate Air Force project (Project 5109), a new solid waste management facility is being planned for Andersen. In addition, a recent initiative by the Navy, COMNAVMARIANAS Instruction 5090.5, Regional Solid Waste Management Plan for Navy Activities, establishes management policies and goals for reducing the volumes of non-hazardous wastes generated by Navy facilities on Guam, including VRC-50.

Apra Harbor Landfill. Approximately 7.18 tons per day of additional solid waste are estimated for the Apra Harbor Landfill as a result of the proposed actions. Total tippage into the landfill will be approximately 140 tons per day. At that rate of disposal, the landfill will be at capacity by mid-1997. Methods to extend the life of the landfill include more aggressive recycling efforts, composting of waste, and incineration at any future Government of Guam resource recovery unit. Planning has begun for the site selection of a replacement landfill for Navy solid wastes.

Cumulative Impacts. As the disposal of military-generated solid waste takes place within military facilities, no spill-over effect is anticipated in the civilian sector. However, some impact to the Ordot Landfill is expected from those military personnel living off-base, especially in the short-term. Since this landfill is currently beyond capacity, additional wastes from further development become problematic. Although private recycling efforts have been difficult due to the economies of scale, there appears to be sufficient compostable solid waste to warrant a marketable composting facility for the disposal of solid wastes and sewage sludge.

Table 4.20.2
Additional Solid Waste Generation

Facility	Quantity	Unit	Rate (lbs/day)	Total (tons/day)
Andersen Air Force Base				
Bachelor's Quarters	255	Persons	3.5	0.45
Family Housing	250	Families	11.82	1.48
Additional Base Facilities Loading	505	Persons	5.11	1.29
Aeromedical Facility	8,721	Square Feet	0.0048	0.02
ADDITIONAL ANDERSEN TIPPAGE				**3.24**
NAS/NAVHOSP/Nimitz Hill				
Bachelor's Quarters (NAS)	155	Persons	3.5	0.27
NAS Maintenance Employment	155	Persons	2.2	0.17
Naval Hospital Employment	70	Persons	3.5	0.12
Oceanographic Facility (Nimitz Hill)	11800	Square Feet	0.0048	0.03
NAS/NAVHOSP/Nimitz Hill Sub-Total				**0.59**
Naval Station				
MSC Administration	6300	Square Feet	0.0048	0.02
Hazardous Material Storage	55000	Square Feet	0.003	0.08
Integrated Storage & Handling	120000	Square Feet	0.00236	0.15
Gas Bottle Storage	10000	Square Feet	0.003	0.02
General Warehouse	60000	Square Feet	0.00236	0.07
Personal Property & Fleet Logistics	9000	Square Feet	0.0048	0.02
Cold Storage	41000	Square Feet	0.00236	0.05
Supply Systems Support Building	11000	Square Feet	0.0048	0.03
SRF (additional work-load)	55	Persons	3	0.08
Ship Spares Storage Warehouse	26300	Square Feet	0.00236	0.03
AFDL Support Facility	2000	Square Feet	0.0048	0.00
NSWU-1 Maintenance/Storage	29500	Square Feet	0.003	0.04
NSWU-1 Unit Building	41400	Square Feet	0.0048	0.10
Child Development Center	10350	Square Feet	0.125	0.65
EOD Operations Facility	19730	Square Feet	0.0048	0.05
Bachelor's Quarters	605	Persons	3.5	1.06
Family Housing	308	Families	20.3	2.61
T-AE Kilauea	41	Persons	3.5	0.07
T-AFS Sioux	49	Persons	3.5	0.09
T-ATF Spica	4	Persons	3.5	0.01
Average Ship Visits Per Day	Total Foreign	Refuse	437.3	0.22
Average Ship Visits Per Day (Personnel)	300	Persons	3.5	0.53
Naval Station Sub-Total				**5.97**
Naval Magazine				
Bachelor's Quarters	150	Persons	3.5	0.26
Enlisted Dining	450	Meals	0.75	0.17
Additional Maintenance Employment	170	Persons	2.2	0.19
Naval Magazine Sub-Total				**0.62**
ADDITIONAL APRA HARBOR TIPPAGE				**7.18**

Table 4.20.3
Additional Solid Waste Generation by Category

	Tons Per Day	
Category	Andersen	Apra Harbor
Industrial/Maintenance/Storage Refuse	1.29	0.91
Other/Administration Refuse	0.02	0.98
Housing	2.08	5.06
Foreign Refuse		0.22
Total	3.39	7.18

4.21 HAZARDOUS WASTE

4.21.1 Existing Conditions

4.21.1.1 Hazardous Waste and Materials Handling and Disposal

Hazardous waste and materials consist of those items which cannot be disposed of in normal landfill operations due to their potential toxicity. Such materials include, but are not limited to, varnish, paints, latex, asphalt, solvents, acids, oils, and chemicals such as mercury, nitrates, and freon. In addition, hazardous materials may include such items that can be reprocessed or recycled for later use, such as engine parts, scrap metal, or packing materials. The federal Resource Conservation and Recovery Act (RCRA) regulations define hazardous waste as exhibiting certain characteristics of ignitability, corosivity, reactivity, or toxicity; as being placed upon specified lists; or as a mixture of a hazardous and non-hazardous waste.

The cataloguing and storage of hazardous waste and materials for military installations is the responsibility of the Defense Reutilization and Marketing Office (DRMO). This office receives the waste and materials, stores it and packs it as necessary, and arranges for its eventual disposal or recycling. DRMO Guam is also responsible for the disposal of hazardous wastes and materials from DoD activities off island such as Yap, Chuuk, Saipan, and Diego Garcia. Approximately 25 persons are employed at the DRMO facility, including two scrap metal processors, two hazardous waste processors, and two environmental specialists.

The packing and transporting of hazardous wastes and materials from most Navy activities to the DRMO is the responsibility of the Navy PWC. NSD Guam packages its own hazardous waste. Generally, the PWC will go to the activity storage facility, load the material, and return to the PWC hazardous waste and material storage area, where they further pack the materials. The waste and materials are then turned over to the DRMO for inventory control and storage until removal from Guam by an independent disposal contractor using MSC vessels. Hazardous wastes and materials are shipped through the commercial port of Guam to disposal sites in the continental U.S.

Hazardous waste and materials generated by the Air Force are stored and packaged at Andersen AFB and transported by Air Force personnel to the DRMO facility. Currently, the Andersen storage area is exceeding its capacity. This 90-day storage facility is being expanded. This expanded facility will accommodate all of AAFB's 90-day requirement,

including waste generated by VRC-50. Approximately 55,000 lbs. of Air Force-generated hazardous materials and waste are transported to the DRMO facility per year (interview with 633rd CEF/DEV, Andersen AFB, 20 Aug. 1992).

Current DRMO facilities and operations are split between the administration and surplus materials yard area and the hazardous and flammable yard area. These two areas are located some distance away from each other. The hazardous and flammable yard consists of three quonset huts: one for corrosives, one for PCBs, and one for flammables. Additional flammables are stored under tents, in truck containers, or outside and unprotected. Construction of an integrated DRMO facility to replace the current hazardous and flammable storage area has been approved as a separate project from the proposed actions.

The Navy Public Works Center generates approximately 45 percent of all waste turned in to DRMO. Ships generate at least 10 percent of all hazardous waste turned in to DRMO. In the 1991 calendar year, DRMO accepted 638,419 pounds of Navy generated RCRA regulated waste and 156,379 pounds of non-RCRA Navy waste. Of this, 358,153 pounds was shipped off island for disposal. The reasons for turn-in included: excess purchase, shelf-life restrictions, mission realignment, contamination by hazardous waste, unused residual and spent material or solvents, laboratory waste, and disposal of cleanup debris (Navy, 1991b).

Approximately 500 line items of hazardous property are generally present in the DRMO storage yard. Each line item represents a delivery of a hazardous waste or material and may contain several units (drums, boxes, cartons, etc.) of the material. Several line items for the same chemical, compound, or other waste may be present in the yard.

Civilian-generated hazardous waste on Guam must be handled by private operators. The Commercial Port of Guam will store small amounts of materials until shipment; however, large generators must pack and ship directly without storage at the port. A study is currently being conducted by the Guam EPA to identify the types and amounts of hazardous wastes created and stored on Guam. This data will help Guam comply with federal regulations requiring states and territories to have the capability to dispose of hazardous materials created within their borders. Guam has agreed to send its hazardous wastes off island, (*Pacific Daily News*, August 25, 1992).

4.21.1.2 Installation Restoration Sites

Navy Facilities. The U.S. Navy, Pacific Division, Naval Facilities Engineering Command, is investigating the need for remedial environmental action at a number of sites under its jurisdiction as part of the Navy's Installation Restoration (IR) program. The purpose of the Navy's IR program is to identify, assess, and clean up or control contamination from past hazardous waste disposal operations and hazardous material spills at Navy and Marine Corps stations. Currently, 16 sites have been identified at Navy stations on Guam for possible remedial action. These sites (shown on Figure 4.21.1) include:

Naval Air Station Agana

- Sanitary Landfill
- Drainage Basin Holding Pond

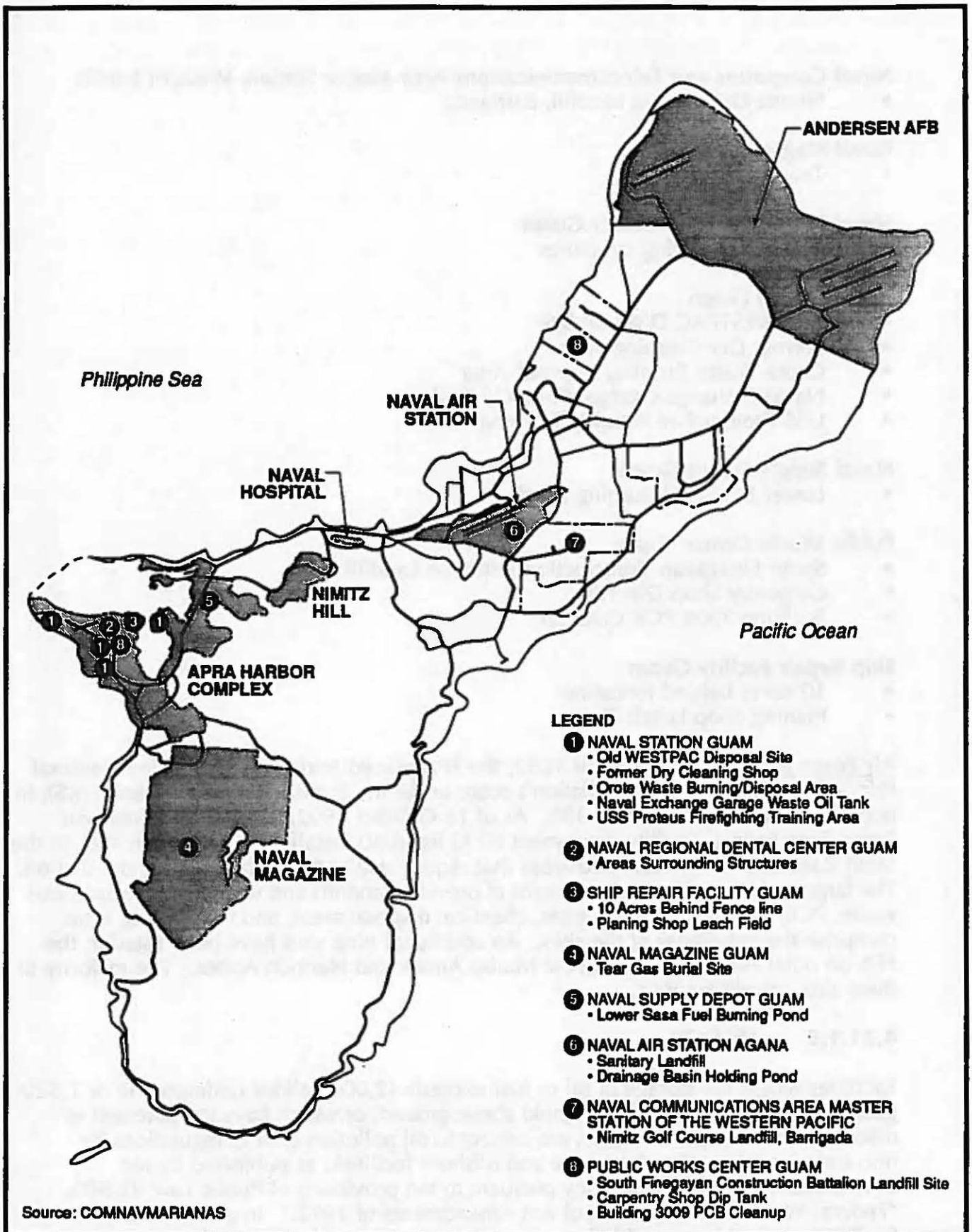

Figure 4.21.1
NAVY INSTALLATION RESTORATON SITES
Guam Development EIS
April 1993

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Naval Computers and Telecommunications Area Master Station, Western Pacific
- Nimitz Golf Course Landfill, Barrigada

Naval Magazine Guam
- Tear Gas Burial Site

Naval Regional Dental Center Guam
- Areas surrounding structures

Naval Station Guam
- Old WESTPAC Disposal Site
- Former Dry Cleaning Shop
- Orote Waste Burning/Disposal Area
- Naval Exchange Garage Waste Oil Tank
- USS Proteus Fire Fighting Training Area

Naval Supply Depot Guam
- Lower Sasa Fuel Burning Pond

Public Works Center Guam
- South Finegayan Construction Battalion Landfill Site
- Carpentry Shop Dip Tank
- Building 3009 PCB Cleanup

Ship Repair Facility Guam
- 10 acres behind fenceline
- Planing Shop Leach Field

Air Force Facilities. In October 1992, the EPA placed Andersen AFB on the National Priority List based on the installation's score under the Hazard Ranking System (HRS), in accordance with 40 CFR, Part 300. As of 16 October 1992, the draft Andersen Air Force Base Federal Facility Agreement (FFA) listed 30 installation restoration sites in the Main Base and Northwest Field areas that require evaluation and possible remediation. The large majority of these sites consist of previous landfills and waste piles. Hazardous waste, PCB, and drum storage areas, chemical disposal areas, and fire training areas comprise the remainder of the sites. An additional nine sites have been listed in the FFA on other Air Force lands at the Marbo Annex and Harmon Annex. The majority of these sites are old landfills.

4.21.1.3 Oil Spills

Facilities where the storage of oil or fuel exceeds 42,000 gallons underground or 1,320 gallons (660 gallons for any one tank) above ground, or which have the potential to discharge into navigable waters, are subject to oil pollution control regulations for non-transportation related onshore and offshore facilities, as published by the Environmental Protection Agency pursuant to the provisions of Public Law 92-500, "Federal Water Pollution Control Act Amendments of 1972." In addition, any new facility that would reasonably be expected to discharge oil in harmful quantities must have a SPCC plan.

Several Navy activities are required to have SPCC plans, chief among them the Naval Supply Depot and the Ship Repair Facility. Most prevention control consists of berms surrounding above-ground tanks to contain any accidental spills. Potential spills from tank trucks supplying the tanks are handled by bringing the truck as close as possible to the berm and by using safe operating procedures. No major spills were recorded at the Naval Supply Depot or at the Ship Repair Facility's SPCC designated storage tanks between 1973 and 1990.

Once a spill occurs, the source is secured and either the Naval Supply Depot Environmental Team or the Navy Public Works Center Guam Hazardous Material Response Team is contacted. Floating spills are contained by booms and consolidated. The spill is removed by skimming. Land based spills are contained and the spill picked up by pumps or buckets and loaded into tanks or tank trucks for delivery to the Navy Supply Depot Fuel Farm. Once the oil-contaminated earth is determined to be a non-hazardous waste, it is removed by hand shovels or construction equipment and loaded into dump trucks for burial at the NSD Solid Oily Waste Disposal Site. Oil-contaminated soil determined to be hazardous waste is packaged, labeled, and disposed through the DRMO. Oil on contaminated shorelines is picked up by sopping it with cuttings of green tangantangan or absorbent materials.

Andersen's SPCC plan is similar to the Navy's plan; however, the emphasis is upon fuel spills occurring during flight operations. The base Fire Department is the first contact in the event of a spill. The VRC-50 squadron introduces a new component to the Andersen SPCC plan. VRC-50 will use the existing JP-8 pump houses on the north ramp to refuel their aircraft. However, certain aircraft operated by the VRC-50 squadron are not capable of connecting to the high-pressure fuel system and must be fueled by truck.

4.21.2 Potential Impacts and Proposed Mitigation Measures

4.21.2.1 DRMO Operations

The DRMO will increase its level of service as a result of the closure of DRMO Subic and as it handles wastes from other relocated activities. Various activities, such as the Ship Repair Facility and the Naval Magazine, are expected to generate 10 to 15 percent more wastes due to proposed activities. The VRC-50 squadron at Andersen will also add to the overall hazardous stream.

In addition to handling wastes from Guam activities, DRMO has assumed responsibility for handling hazardous waste and material disposal for the Naval base at Diego Garcia, a function previously assigned to DRMO Subic. It is estimated that this will bring an additional 2 to 3 containers of hazardous materials per month to DRMO Guam.

An internal reorganization for the entire DRMO is planned, including updating the environmental section to a separate branch. The addition of the new DRMO facility will provide much needed storage space, and staff increases will handle the expected workload.

The situation at Andersen is expected to be the same as at the Apra Harbor Complex. Hazardous waste generated by the VRC-50 squadron will be packed and transported by the Navy PWC. The expansion of the 90-day storage facility at Andersen will help accommodate this increase.

The storage of hazardous wastes and materials is constrained along the processing chain. Activities lack sufficient space, as do the PWC and the DRMO. However, the DRMO is now utilizing MSC and has regular shipments of waste off-island that generally create adequate space for new generations. The new contractor, NorthWest EnviroService, Inc., is performing services in an excellent manner on-site and on-call. The construction of the Hazardous Material Storage Facility (P-141) will help reduce the amount of hazardous materials that become hazardous waste because of improper storage and handling.

The overall hazardous waste generation is not expected to increase as a result of the relocated activities. In fact, a comparison of 1992 hazardous waste disposal statistics from DRMO showed that a 34 percent decrease in Navy generated RCRA waste was turned into DRMO from 1991 levels. Non-RCRA waste went up 111 percent over 1991 levels. Post-relocation conditions existed for approximately 8 months of 1992 (COMNAVMAR, June 2, 1993).

The decrease in generation of hazardous waste is a result of Navy hazardous waste minimization efforts coinciding with the increased workloads. The bulk of past RCRA wastes resulted from expired shelf life materials. The Navy has been addressing this procurement at a policy level, and the Fleet Industrial Supply Center (FISC) is currently establishing a shelf life extension program. In addition, the implementation of a formal HAZMIN plan by DRMO and PWC is a condition of the Part B RCRA permit. Such a plan will describe every waste reduction activity in place and the standard operating procedures that apply. In addition, the plan shall include projected waste minimization activities and goals for hazardous waste reduction. An approved plan will be necessary before the new treatment storage and disposal facility (TSDF) begins operation in 1995. The Air Force has implemented similar programs called the Pollution Prevention Action Plan and the Hazardous Waste Management Plan for Andersen Air Force Base which establish goals and policies for reducing the amount of hazardous waste generated at Andersen facilities.

4.21.2.2 Oil Spills

As a result of the incresed ship and marina activity around the island associated with the proposed activities, Guam's marine waters are also more susceptible to direct pollution from oil and other fuel spills. The Ship Repair Facility (SRF), Navy Supply Depot (NSD), and the Public Works Center (PWC) have extensive fuel and oil storage/service systems that service all military craft within Apra Harbor. Any fuel operations have the potential for discharge of contaminants in harmful quantities into navigable waters.

The Navy's Environmental and Natural Resources Protection Manual, OPNAVINST 5090.1, directs that each Navy Area Coordinator develop an Area Oil and Hazardous Substance Pollution Contingency Plan in support of the National Oil and Hazardous Substance Pollution Contingency Plan. This contingency plan provides guidelines and specifies responsibilities for the control and cleanup of oil and hazardous substance spills

in any medium: air, land surface water, or groundwater. Local Oil and Hazardous Substance Pollution Contigency Plans, which support the area-wide plan, are required for individual Navy activities that generate or store significant amounts of hazardous material. Navy On-Scene Commanders are responsible for developing local contingency plans for the activities in their areas and for establishing permanent On-Scene Operations Teams. These teams are available on a 24-hour-per-day basis, providing equipment, materials, expertise, and labor for rapid response to oil and hazardous substance spills.

On Guam, the Coast Guard is responsible for initial responding to oil and fuel spills. They are the first responders, but the oil companies or facilities are responsible for clean-up. Response capability includes bouy tenders outfitted as oil skimmers and trailerable booms/skiffs. All of this equipment is available on Guam. According to officials at the U.S. Coast Guard Marine Safety Office in Honolulu, the Navy has significant assets (equipment and manpower) to handle oil spill emergencies on Guam. In addition, a Spill Prevention Control and Countermeasure (SPCC) Plan outlines the procedures to prevent spills, and to correct them should they occur.

4.21.2.3 Polychlorinated Biphenols and Asbestos Hazards

The Navy, as required by OPNAVINST 5090.1A, keeps an inventory of all activities which generate, use, treat, store, and/or dispose of PCBs. The only potential PCB removal or disturbance due to proposed relocation activities might come from the transformer work required as part of the proposed family housing project, the power plant project, or the renovations to the bachelors quarters at Andersen AFB. The Toxic Substance Control Act (TSCA) and 40 CFR Part 61 govern the use, storage, and disposal of PCBs and PCB-contaminated equipment and substances. PCB equipment is identified in bid documents for each of the individual projects where it applies, and the work will be completed by the contractor.

Due to the age of some of the facilities at Andersen AFB and at the Apra Harbor Complex, there is potential for asbestos materials to be present in some of the buildings scheduled for renovation or demolition. Asbestos surveys will be performed prior to any renovation or demolition work, and any asbestos-related work will be in compliance with 40 CFR Part 61, Subpart M, the Asbestos National Emission Standards for Hazardous Pollutants (NESHAP). These requirements will be included in the contractor bid documents.

4.21.3 Cumulative Impacts

None of the proposed activities or facilities will occur or be located on any identified Installation Restoration sites, and there will be no impact on operation or remediation activities in any of these areas. However, the proposed actions will cause an increase in the amount of hazardous waste generated on Guam, as well as an increase in the potential for hazardous spills to occur in Apra Harbor.

Overall, the DRMO does not expect an increase in the volume of hazardous materials that it handles. The Ship Repair Facility expects to generate 10 to 15 percent more hazardous waste due to proposed activities. Hazardous waste generated by the military activities is handled, stored, and disposed by the military, DRMO, and their contractors,

and does not enter the waste stream of the rest of the island. Civilian-generated hazardous waste on Guam is handled by private contractors whose facilities will not be affected by increased DRMO activities. The generation of hazardous materials by military activities will be mitigated by the addition of the new DRMO Facility, Hazardous Materials Storage Building (P-141), and implementation of the Guam Hazardous Waste Minimization Plan.

The increased potential for discharges or spills of hazardous materials in Guam's marine waters because of increased military activities will add to the cumulative risk associated with the increasing tourist and civilian activity in and around Guam's waters. The Coast Guard is responsible for responding to any spills or discharges into marine waters, and the GEPA has jurisdiction over spills on land. After initial response, the companies or generating facilities are responsible for the clean up. The Navy has a significant amount of equipment and manpower assigned to preventing and handling hazardous spills. The maintenance of these assets along with continued training in accordance with the SPCC plan will effectively mitigate the military's share of the cumulative potential impacts to Guam's marine waters.

4.22 SCHOOLS

4.22.1 Existing Conditions

Public education on Guam is provided solely by the Guam Department of Education. The public school system is currently comprised of 24 elementary schools, 6 middle schools, and 5 high schools with a combined total enrollment (as of September 1992) of 29,186 students (*Pacific Daily News*, November 6, 1992). Nearly half of these students attend the elementary schools, while approximately one quarter attend the middle schools and high schools, respectively. Guam also has 19 private schools serving 5,336 students throughout the island.

Enrollments during the 1980s remained fairly constant in central and southern Guam, while northern Guam experienced an 11 percent increase in the elementary schools and a 31 percent increase in its middle and high schools. Despite this growth, no new school has been built on Guam since 1974, leading to numerous problems associated with overcrowding. Preliminary projections indicate that the islandwide public school population will grow by 20 percent during the 1990s. Data contained in this section regarding Guam's public schools was compiled by Community Resources, Inc. (see Appendix I).

4.22.1.1 Andersen Air Force Base

The public schools around Andersen are found in the neighboring districts of Dededo and Yigo. There are two elementary schools, Upi Elementary (enrollment of about 850 students) and Yigo Elementary (950 students); one middle school, Leon Guerrero Middle School (950 students); and one high school, Simon Sanchez (1,700 students).

4.22.1.2 Apra Harbor Complex

Schools around Apra Harbor are located in several of the surrounding districts. Santa Rita has two elementary schools: Torres Elementary and Truman Elementary, which

have a combined capacity of about 1,000 students. Piti has one middle school with an enrollment of around 750 students; it serves primarily Apra Harbor, Naval Magazine, and Nimitz Hill. The next closest middle school, located in Inarajan, has about 400 students. Also servicing military students from Apra Harbor are an elementary school with 900 students and a middle school with about 300 students, both located in Agat. The only high school in the area—Oceanview High, with an enrollment of approximately 1,000 students—is also found in Agat. This high school services Apra Harbor, Naval Magazine, and Nimitz Hill, as well as the neighboring villages from Asan to Umatac.

4.22.1.3 Naval Magazine

Children of military personnel stationed at Naval Magazine attend the public schools in Santa Rita, Piti, and Agat, which also provide services for the children from Apra Harbor. No schools, public or private, are located in close proximity to NAVMAG.

4.22.1.4 Others

Schools located around NAS Agana, Naval Hospital, and Nimitz Hill include the Lujan, Ordot, and Agana Heights elementary schools, Johnston and Untalan middle schools, and George Washington and Kennedy high schools.

4.22.2 Potential Impacts and Proposed Mitigation

According to the Guam Department of Education, most schools are at or near full capacity, but new students can be accommodated in existing and soon-to-be-built facilities as long as they do not all arrive at the same time (Guam DOE, 1992). The Government of Guam plans to construct 223 additional permanent classrooms around the island. Sixty-six of them were completed in November of 1992 to help ease the initial impacts of the new students. An additional 108 are in various stages of bidding and design, 71 of which are tentatively scheduled for completion by August of 1993. The remaining 49 classrooms are on hold until they receive funding from the legislature.

To prepare for the influx of new students, the Navy has informed the DOE that approximately 600 military children are expected to enter the public schools over the 1992-93 and 1993-94 school years. For their own planning purposes, the DOE uses an estimate of 800. (Since dependents are not allowed to accompany military personnel unless sufficient housing is available, this number is also subject to the effects of the relocation on the current housing market. An estimated 50 families in 1994 and 150 in 1995 are expected not to move to Guam for this reason.)

According to Community Resources, Inc. (CRI), the 1990 census proportions of children per military household show a much lower estimate of 410 children for the 1,377 personnel associated with the project. Of these potential students, 343 are projected to enroll in public schools. This figure represents 1 percent of recent DOE enrollments and 6 percent of the total increase in enrollments projected for the 1990s. The findings presented here are based on the CRI assessment.

4.22.2.1 Andersen Air Force Base

Approximately 250 additional families relocated to Andersen in the fall of 1992. These families were expected to generate 41 percent of the new students on the island, all of which would use the existing schools in Dededo and Yigo.

Because the new classrooms are located throughout the island, new students at Andersen may have to commute to other areas if the schools nearby exceed capacity. The Government of Guam will then have to revise its busing program, and perhaps purchase more buses, to compensate for the students traveling away from their home districts.

4.22.2.2 Apra Harbor Complex

Another 280 families are expected to settled in and around Apra Harbor by the fall of 1992, regardless of whether housing can be found on or off-base. An additional 41 percent of the new students on Guam will be housed around Apra Harbor and central Guam until the proposed family housing project is completed. At that time, over half of the new students will live in Piti and Santa Rita. New students are expected to attend the existing schools in Santa Rita, Piti, and Agat. The additional 66 classrooms completed in November of 1992, and the 157 to be finished by August of 1993, will help accommodate the increased number of new students in the short term.

In the long term, a new high school for approximately 2,000 students will be constructed in Santa Rita, and a new 400-student elementary school is planned for Piti. Construction of the schools should begin by the fall of 1994 and should take about three years to complete.

4.22.2.3 Naval Magazine

Any new students living in the NAVMAG area will be accommodated by the new facilities scheduled for construction around Apra Harbor.

4.22.2.4 Others

School-age dependents accompanying personnel transferred to NAS Agana, Naval Hospital, and Nimitz Hill will attend the public schools around their respective areas. Any overcrowding will be mitigated in the short-term by the recently built classrooms and in the long-term by the new schools planned around the Apra Harbor area.

4.22.3 Cumulative Impacts

The cumulative effect of new Navy activities on Guam will be an islandwide distribution of new personnel and their families. Nearly all school districts in the northern and central portions of the island will experience some impacts, since students will attend schools in the district where their families find housing. When the Navy completes its proposed housing project in 1996, and these personnel and families become concentrated around Apra Harbor, then the impacts on schools in Santa Rita, Piti, and Agat will be more pronounced.

4.23 PARKS AND RECREATION

Information on parks and recreation facilities was provided by Community Resources, Inc. (see Appendix I).

4.23.1 Existing Conditions

Both the military and the Government of Guam maintain extensive recreational facilities on Guam. These areas include, but are not limited to, beaches, playing fields, pools, youth centers, and passive parks. Andersen features a patrolled swimming area with picnic facilities at Tarague Beach. At Apra Harbor, Gab Gab Beach, Polaris Point Beach, USO Beach, Old Wives Beach, and Sumay Cove Marina are used by active duty military and civilian Department of Defense personnel. Snorkeling and diving sites are readily accessible from all these beaches, while boat rentals and docking facilities are available at Sumay Cove. The Navy and Air Force both have golf courses and other on-base recreation resources such as swimming pools, tennis courts, gyms, bowling alleys, crafts shops, clubs, restaurants, and movie theaters. Hunting is also allowed on parts of Andersen with a permit.

4.23.2 Potential Impacts and Proposed Mitigation

The increased population resulting from personnel relocation to Guam is considered relatively small, so the impact on any one public facility will not be great. Civilian parks and recreation facilities in general will not experience any significant increase in use because sufficient facilities are provided on the military bases.

At Andersen, the resulting population will roughly equal the population total of two years ago, before departure of the B-52 squadrons. Recreational facilities at Andersen will, therefore, have no problem handling the additional personnel and their families.

Military recreation facilities on Guam will not experience any major effects due to the relocation. The increased military population on Guam is equivalent to only about 26 percent of the current patron count at Navy recreational facilities on the island. The percentage increase of users will most likely be much less than this amount due to the fact that one-third of the relocated military population will be stationed at Andersen, and almost two-thirds of the Navy families will live off-base for the first few years. Moderate impacts to facilities will occur only in the cases of Gab Gab Beach and the weight rooms. Gab Gab Beach will have to close for approximately 32 days each year due to its proximity to the explosive loading and unloading areas at Kilo Wharf. Weight room patrons may experience limited access to such facilities due to an immediate increase in user demand.

To mitigate the weight room problem, Navy officials responsible for Morale, Welfare, and Recreation (MWR) have requested additional funds to provide extra facilities and staff. In the case of the part-time loss of Gab Gab Beach, the Navy will improve access to other beaches.

4.23.3 Cumulative Impacts

The cumulative impacts to Guam's parks and recreation facilities will be minimal. Use of facilities will increase by a small percentage and the use of others may be slightly constrained due to new operations, but the overall availability of parks and recreation facilities will remain basically unchanged.

4.24 HEALTH CARE

Information in this section is provided by Community Resources Inc. (see Appendix I).

4.24.1 General Services

4.24.1.1 Existing Conditions

The only civilian hospital on Guam for general medical care is the 200-bed Guam Memorial Hospital in Tamuning. Regional clinics near the areas designated for the proposed actions are located in Dededo and Santa Rita. Small Government of Guam health care clinics are located in various areas throughout the island.

The 45-bed Naval Hospital (NAVHOSP) provides services primarily for active duty personnel, but it will treat emergency civilian cases when necessary. Health care positions at NAVHOSP will increase by 20 officers and 50 enlisted personnel transferring from Subic. The hospital will also undergo renovations in the next few years. Four branch clinics of NAVHOSP are located at NAS Agana, Naval Station, and Naval Magazine.

4.24.1.2 Potential Impacts and Proposed Mitigation

According to the Chief Public Health Officer for the Department of Public Health and Social Services, only a slight impact on islandwide health services will result from the new personnel and activities. Most military personnel will be adequately handled by existing military facilities located on or near the various bases, so increased demand on civilian services is not likely.

4.24.2 Mental Health

4.24.2.1 Existing Conditions

The only civilian mental health unit is located in Tamuning. The military provides most of its own mental health services at NAVHOSP and the on-base clinics. The Mental Health Clinic at Andersen has psychiatric and social work professionals.

4.24.2.2 Potential Impacts and Proposed Mitigation

No direct impacts are expected on the Tamuning civilian unit as a result of the proposed action. The psychiatric units at NAVHOSP and the Mental Health Clinic will most likely experience an increase in mental health care and substance abuse cases. However, the additional personnel to NAVHOSP will be able to accommodate the projected increases.

4.24.3 Cumulative Impacts

The cumulative impacts on Guam's health care facilities will be minimal. These facilities will experience a slight increase in demand for general and mental health care services, but none which the additional hospital personnel will not able to handle.

4.25 POLICE AND FIRE PROTECTION

An analysis of the police and fire protection capabilities on Guam was performed by Community Resources, Inc. (see Appendix I).

4.25.1 Police

4.25.1.1 Existing Conditions

Civilian. The Guam Police Department maintains regional stations in Agana, Dededo, and Agat. With 2.5 officers per 1,000 people on Guam, the department has a larger staff than many U.S. cities of comparable size.

The volume of crime on Guam is relatively low in comparison to similar U.S. locales. The annual rate of offenses in 1990 was 107.5 per 1,000 people, up from 85 per 1,000 in 1980. The number of offenses involving military personnel reached a high of 40 per 1,000 people in 1988, but decreased to around 21 per 1,000 by 1991. If arrested, members of the military were most likely to be charged with drunk driving. Crimes committed against military personnel were usually larceny-theft, disorderly conduct, and vandalism.

Military. Each military installation operates its own police force. Andersen AFB has approximately 200 military police, 75 percent of which are in law enforcement and the rest are security. Apra Harbor Complex maintains a force of 32 civilians and 44 military police to cover the entire complex as well as Nimitz Hill and Naval Hospital. NAS Agana has 40 military and 10 civilian officers. NCTAMS employs 63 military billets and 10 civilian billets to provide security to the surrounding bases and military housing areas.

The volume of crime on all military installations is generally lower than in the civilian areas of Guam. The most commonly reported crimes are domestic disturbances and larcenies of personal and government property.

Military police jurisdiction is limited to military property. Concurrent civilian/military jurisdiction exists with respect to military personnel; military police will generally detain apprehended civilian personnel for turnover to the Guam Police Department (CRI, 1992).

4.25.1.2 Potential Impacts and Proposed Mitigation

According to the Chief of the Guam Police Department, the population increase resulting from the proposed actions on Guam will have little effect on police operations and public safety. Up to seven additional police officers and two civilian employees will be needed to maintain the current ratio of police personnel to resident population. Because the military has shown less propensity for being involved in criminal offenses,

and many of the new personnel will live on-base, the additional manpower needed will probably be even lower. The number of military police is not expected to increase. The additional sailors on liberty will not create any serious problems as long as the police department is warned in advance of major visits. On-base programs will attempt to counteract any increase in drunk-driving offenses involving military personnel.

4.25.2 Fire Protection

4.25.2.1 Existing Conditions

Guam has approximately 300 full-time professional civilian firefighters operating eight civilian fire stations. These stations are located in Yigo (one tanker, one fire truck, one ambulance); Dededo (one tanker, one fire truck, one ambulance); Piti (one tanker); Agat (one fire truck, one ambulance, one rescue unit); Umatac (one tanker, one fire truck, one ambulance); as well as Inarajan and Tamuning.

A consolidated Federal Fire Department on Guam covers all naval bases and activities. Under a mutual aid agreement with the Government of Guam fire department, either civilian or military fire fighters may respond to emergencies as necessary. The Navy operates seven fire stations: a crash/structural station at NAS Agana, and structural stations at NCTAMS Finegayan, NCTAMS Barrigada, Naval Hospital, Nimitz Hill, Apra Harbor Complex, and Naval Magazine. Each station has one engine company, with the exception of Apra Harbor Complex which has two, and each company has a minimum of four firefighters on duty at all times. All the companies have one pumper truck, except for the crash/structural station at NAS Agana which utilizes an additional three crash/rescue trucks. A total of 145 civilian personnel are employed by the department, with all but 13 of them being qualified firefighters.

Andersen operates three fire stations: two crash/structural stations on the flight line, and one structural station located in the southern portion of the base. These stations utilize three engines and six crash/rescue trucks. A total of 79 military and civilian personnel operate the stations, with all but three of them being qualified firefighters. Andersen also has a mutual aid agreement the Government of Guam fire department as well as an interservice support agreement with the Navy.

Although response to potential spills of hazardous materials is provided by the Navy, Air Force, and civilian fire departments, no hazardous material response vehicles are currently found on Guam (CRI, 1992).

4.25.2.2 Potential Impacts and Proposed Mitigation

According to the Guam Fire Department, with the 60 additional firefighters that were recruited in 1992, existing civilian fire protection facilities will be more than adequate to accommodate increased demand on fire services associated with the proposed actions. The only expected impact on fire services is a slight increase in the number of motor vehicle accidents. All proposed housing areas are within existing fire response distances of the respective fire station providing services.

Because most of the new facilities will be constructed within existing military compounds, the Navy and Air Force fire stations anticipate additional demand for fire protection, but have not planned any increases in their existing service.

A hazardous material response vehicle is scheduled for arrival within the current fiscal year. This vehicle, which will be stationed at NAS Agana, will be fully equipped for safely containing spills and fires resulting from and involving hazardous materials. The proposed hazardous material storage building for Apra Harbor Complex will not require extensive coverage from this vehicle as the building will be equipped with sprinklers and located in an isolated area so as to avoid adverse fire conditions.

4.25.3 Cumulative Impacts

Cumulative impacts to police and fire protection services associated with the proposed actions will primarily be in the form of increased demand. Aside from the slightly increased incidence of fires, motor vehicle accidents, and certain crimes such as larceny and drunk-driving, no other impacts on these services are anticipated.

4.26 SUMMARY

4.26.1 Direct and Indirect Effects and Their Significance

Three kinds of impacts are discussed in this environmental impact statement: direct, indirect, and cumulative impacts. Direct and indirect effects are summarized in this section. Cumulative impacts are discussed in Section 4.26.8.

Many of the direct impacts are those associated with facilities construction—for example, noise, dust, and erosion. Other examples include the direct effects of clearing and grading on vegetation, or the direct effect that a facility may have on local traffic conditions at certain hours.

For the most part, direct impacts can be mitigated, and they are usually insignificant when considered on a project by project basis. The large majority of the projects will be constructed on already disturbed land with little loss of vegetation or habitat. The exception to this is the planned construction of the 300 housing units. The site selected for this project contains natural habitat, and the units will have to be carefully sited to help mitigate potential losses. There is the direct cumulative impact of grading and clearing, resulting in silt bearing urban runoff entering the marine waters of Apra Harbor. Although the potential is low, and the construction duration short, proper construction techniques, such as the use of berms, will be used to avoid degradation of the receiving waters.

One project carries the potential for significant direct impacts: the use of Andersen for VRC-50 flight training operations. The VRC-50 operations have the potential to disturb endangered bird and bat species. This potential is being studied, and flight operations will not commence on a permanent basis at Andersen until such time as the issue has been addressed by the U.S. Fish and Wildlife Service, Guam authorities, and the U.S. Navy. Mitigation will be carried out in accordance with the terms and conditions of the Section 7 consultation with the U.S. Fish and Wildlife Service.

Potential impacts on endangered sea turtles due to demolition exercises in Apra Harbor and bulkhead construction will be mitigated by implementing the terms and conditions of the Section 7 consultation with the National Marine Fisheries Service.

Indirect impacts are those not directly caused by the proposed actions but which, nonetheless, may have been induced as a result of the actions. For example, there will most likely be an increase in government revenues from taxes on income earned by businesses that cater to activities such as the Naval Supply Depot, Ship Repair Facility, etc. Another example is the indirect effect that expansion of activities at Naval Magazine can have on recreational areas when the ESQD surrounding Kilo Wharf is in effect. Gab Gab Beach is closed during these periods, and this may have an indirect effect on other beaches which experience increased use as a result of beachgoers seeking alternatives to Gab Gab Beach.

There will be indirect impacts from the proposed activities on the job and housing markets. Indirect and induced jobs from the additional activity will increase during the time period between 1994 and 1997. Over 1,800 direct, indirect, and induced long-term jobs will be created as a result of the increased Navy activities on Guam. Long-term incomes are expected to rise, and the housing market is expected to tighten further. Construction of Navy housing will help alleviate the situation in the long-term. However, short-term impacts will be noticeable in the form of higher rents for substandard units.

4.26.2 Environmental Effects of Alternatives

Table 4.26.1 presents a summary of the potential impacts associated with each of the proposed actions. It also lists the proposed mitigation measures, if such measures are required or appropriate. Table 1.7.1 in Chapter 1 summarizes the level of significance of the environmental impacts expected as a result of the various alternatives for each proposed action.

4.26.3 Energy Requirements and Energy Potential

Alternatives for the various construction projects include no action, use of alternative sites, and the use of existing facilities or sites either on base, at other bases, or off base. Alternatives may be available for certain activities, for example, training operations. Although taking no action may provide temporary short-term energy savings, this alternative has not been considered in this analysis.

Energy requirements for the remaining alternatives do not vary in great degree from one another. No variations in electrical consumption would occur due to the location of the facilities. As the preferred sites were selected due to their proximity to surrounding similar uses, they represent the most feasible locations to avoid excessive travel and fuel consumption. If sites are located on different military stations, personnel will have to drive the extra distances between their homes and their places of employment.

The proposed site for the 300 family housing units provides the least travel distance to employment centers, compared to the alternative sites, thus representing the greatest energy savings.

Within the context of energy requirements and conservation potential of the alternatives, the preferred alternatives provide the lowest energy requirements and greatest conservation potential.

4.26.4 Irreversible and Irretrievable Commitments of Resources

Construction of the various facilities will involve the irretrievable loss of certain environmental and fiscal resources, as well as an irreversible use of labor, materials, and energy resources. With the exception of the family housing project, which will involve a relatively irreversible change in land use, most of the facilities will be located in already developed areas. There will be an irreversible commitment to supplying water to the new residences and facilities, and a greater demand on the current water allocation would be created. Additional energy demands will also occur.

4.26.5 Short-term Use and Long-term Productivity

The proposed action will involve a few minor trade-offs between short-term gains and long-term losses, such as the long-term loss of open space at the Tipalao family housing site. Short-term losses will occur due to air quality, noise, erosion, and traffic impacts during building construction.

The proposed developments will not foreclose any potentially beneficial long-term use of land and facilities. For example, no new permanent facilities are planned at NAS Agana, which the Government of Guam would like to have transferred to expand GIAT. Likewise, none of the designated excess lands are affected by the proposed actions.

4.26.6 Urban Quality, Historic/Cultural Resources, and Design of the Built Environment

The proposed actions will result in further development of already developed areas. The urban quality of the affected installations or Guam as a whole will not be significantly affected. Design of new and renovated structures would be consistent with the appearance of existing buildings.

The impact of the proposed developments on historic and cultural resources is discussed in Chapter 4. None of the buildings slated for modification has any historic significance. Pending the results of subsurface testing, it appears that the proposed construction projects can be accomplished with minimal impact on archaeological resources. There may be indirect impacts on archaeological resources due to increased levels of activity in the Apra Harbor Complex, but these impacts can be mitigated.

4.26.7 Means of Mitigating Potentially Adverse Effects

Potentially adverse effects have been identified in connection to Field Carrier Landing Practice (FCLP) and other operations of the VRC-50 squadron at Andersen. These operations will occur near the identified nesting areas of the endangered Mariana crow and roosting areas of the Mariana fruit bat. A program to monitor the effects of VRC-50 operations on these species will be continued.

In order to mitigate potential impacts to sea turtles in and around Apra Harbor, in-water construction at the EOD bulkhead facility will not occur during the months of the turtle nesting season (April-September). Also, at least one week's notice will be given to the GEPA and DAWR before EOD demolition exercises begin in Apra Harbor. These agencies will be given unrestricted on-site review of the training activities. On-site spotter boats will also be used to provide warning of hazards and to check for turtles in the hazard area before authorizing detonation.

The construction of 300 housing units carries the potential for adverse effects. The Tipalao Northwest site contains native habitat, which will be avoided. A buffer will be created between housing on this site and the Orote Ecological Reserve. Wetlands on the Tipalao Northeast site will be avoided through proper site planning. Proper siting to avoid the steeper areas of the Tipalao Northwest site can prevent drainage and erosion problems.

Short-term adverse impacts are likely within the civilian rental housing market due to increased demand. Higher prices for substandard units and more families per unit can be expected in the short-term. To mitigate this problem, the Navy is planning 300 housing units for accompanied personnel. In addition, renovations to unaccompanied personnel housing will further expand the number of available accommodations. However, further increases in the number of housing units on Guam may be needed to meet anticipated military demand after 1996.

There is a potential for short-term construction-related impacts from erosion, fugitive dust, noise, and the movement of construction equipment. However, the use of proper construction techniques and an erosion control plan can minimize these impacts.

Potential impacts and proposed mitigation measures are summarized in Table 4.26.1.

4.26.7.1 Pollution Prevention

Pollution resulting from the net increase in activities and use of facilities on Guam has the potential to increase and cause long-term cumulative impacts to the environment. As a means for limiting these impacts, certain pollution preventing mitigations and programs have been incorporated into the facilities and activities plans.

The proposed Hazardous Materials Storage Facility (P-141) will incorporate the space and design requirements to facilitate the proper handling and storage of hazardous materials. Since improperly stored hazardous materials become classified as hazardous waste, this facility will help reduce the amounts of those types of wastes generated and the pollution associated with them. The bulk of past RCRA wastes resulted from expired shelf life materials. The Navy has been addressing this procurement at a policy level, and the Fleet Industrial Supply Center (FISC) is currently establishing a shelf life extension program. In addition, the implementation of a formal HAZMIN plan by DRMO and PWC is a condition of the Part B RCRA permit.

Non-point source pollution impacts associated with soil erosion and construction site runoff will be mitigated through individual erosion control plans and the implementation of best management practices during construction of the facilities. Point sources of pollution such as oil, fuel, or other hazardous substance spills will be prevented and

mitigated through the implementation and use of spill prevention and control plans as identified in the National Oil and Hazardous Substance Pollution Contingency Plan (40 CFR Section 300). The Navy's Environmental and Natural Resources Protection Manual, OPNAVINST 5090.1 directs that each Navy Area Coordinator develop an Area Oil and Hazardous Substance Pollution Contingency Plan in support of the national plan. This plan is discussed further in Section 4.21.2.1.

In order to prevent pollution impacts from the projected increase in wastewater generated within the Naval Complex, the Apra Harbor Sewage Treatment plant will be upgraded to ensure proper treatment and disposal. The Apra Harbor Sewage Treatment Plant as a primary and secondary treatment facility will remove solids and organic material from the sewage and treat it to produce a non-toxic and organically safe effluent that will not harm or pollute receiving waters off of Orote Point.

4.26.8 Cumulative Impacts

Although the proposed actions themselves may be independent of each other, there are a variety of interactions among the projects covered in this document. Some impacts, such as electricity and water consumption or sewage and solid waste generation, have little meaning when considered on a project by project basis, and are significant only when they are considered together as regional or even island-wide cumulative impacts.

There are 25 military construction (MILCON) projects covered in this EIS. Several other construction and/or renovation projects, due to their limited size and scope and lack of environmental impacts, are excluded from detailed consideration in this document. However, these projects, together with the MILCON projects, will have cumulative impacts upon infrastructure and services on Guam. These impacts are addressed below.

4.26.8.1 Energy Use

Energy use consists of (1) the amount of additional electricity used, (2) the amount of fuel consumed by the additional vehicle miles on roadways, (3) the amount of fuel consumed due to additional ship travel, and (4) the amount of fuel consumed by the additional flight operations of the VRC-50 squadron. Electrical use is estimated to consume approximately 40,000 barrels (bbl) of oil annually. Additional vehicle miles traveled are estimated to consume 11,079 bbl per year. Flight operations are anticipated to consume an additional 26,945 bbl per year. Total additional long-term energy use is expected to be approximately 82,000 bbl per year. Although these barrels of oil represent an additional draw upon the global oil reserves, in real terms to Guam, the additional energy use represents an increase in the amount of refined fuels which must be imported and stored on the island. As such, it will be necessary to import yearly an additional 40,000 barrels of low-sulfur fuel oil for electrical generation, 354,540 gallons of gasoline for automotive use, and 470,240 gallons of jet fuel for the VRC-50 squadron. No significant increase in ship fuel use in Guam due to the proposed activities is anticipated (CINCPACFLT, Code 415 Memo, 20 Nov 92).

4.26.8.2 Electricity

Cumulative maximum electrical demand from all projects will total approximately 8 megawatts (MW). This represents an increase of between 2 to 2.5 percent over the projected 1995 baseline demand of 325 MW. By 1995, Guam Power Authority (GPA) generating capacity is projected to grow to 361 MW. The expansion of the Orote Power Plant will supply 18 MW of peak-hour and emergency-load generation in addition to the projected GPA capacity, and is thus seen as a positive cumulative impact upon the electrical supply system. However, given the nature of power supply on Guam, a vigorous conservation program will be implemented to help mitigate any short-term problems.

4.26.8.3 Water

The approximate demand on the Navy's Fena system will increase from 10.5 to 11.0 million gallons per day (mgd) during the dry season and from 12.5 to 13 mgd during the wet season. There are potential problems associated with this Navy increase because there will be only an estimated 0.5 mgd buffer between wet season demand and the treatment plant design capacity of 13.5 mgd. Wet season demands that surpass this daily treatment capacity could effectively be met by increasing treatment to peak capacity (14.5) or by utilizing part of the 20-million-gallon reservoir supply. Dry season demand may exceed production during times of severe drought. More vigorous conservation measures and the expansion of reservoir supplies could help to alleviate dry season drawdowns. A long term alternative for meeting both wet and dry season water demands would be for the Navy to construct additional water wells in the northern aquifer, which would reduce the need for the Navy to pump water all the way to the NCTAMS from Fena. A short term solution would be for the Navy to purchase or trade water with PUAG. PUAG has excess capacity but still buys 4.5 mgd of water from the Navy to serve southern and mid-island customers. Designing buildings with water conservation features, as well as studying methods for using wells to recover subsurface reservoir losses, will further improve water use efficiency.

Demand upon the Northern Lens Aquifer is anticipated to be approximately 238,000 gpd as a result of additional activities at Andersen. The 1995 Northern Lens Aquifer draw will be approximately 28.44 mgd. Since the sustainable yield of the Northern Lens is estimated to be 60 mgd, this increased demand will not be a significant impact.

4.26.8.4 Sewage

Cumulative impacts upon Guam's sewage system will occur in the various Sewage Districts. Additional base loading at Andersen will add approximately 0.20 million gallons per day (mgd) to the Northern Sewage District treatment plant at Tanguisson. Projected 1995 background flows for the 12-mgd-capacity plant are estimated to be approximately 5 to 6 mgd.

Sewage flows in the Central Sewage District will increase from Naval Air Station Agana, Nimitz Hill, and the Naval Hospital. The increase at the 12-mgd-capacity Agana Sewage Treatment Plant will be approximately 0.036 mgd. Projected 1995 background flows for the district are approximately 10.47 to 11.47 mgd. Short-term housing arrangements for Navy personnel in the private sector will slightly increase immediate

flows to the plant, but the effect will diminish upon completion of the family housing project.

The Navy's Apra Harbor Sewage Collection Area will experience an increase in flows of approximately 0.4 mgd. This additional flow will create future average flow rates at the facility of between 2.9 and 3.4 mgd. The capacity of the Apra Harbor Sewage Treatment Plant following its conversion to secondary treatment and the proposed modifications will be sufficient to process these projected flows.

4.26.8.5 Solid Waste

The proposed actions will impact the sanitary landfills at Andersen and at the Apra Harbor Complex. A small amount of solid waste will be sent to the Government of Guam's Ordot Landfill as a result of the short-term use of civilian housing.

Additional solid waste loading will be approximately 3.39 tons per day at the Andersen facility, for a total daily tippage of 25,89 tons per day. At this rate of disposal, the landfill will reach capacity by mid-1994. The Public Works Center Landfill in the Apra Harbor Complex will receive an additional 7.18 tons per day as a result of proposed activities. Total tippage into the landfill will be approximately 140 tons per day, and the estimated life span of the landfill will extend until 1997.

4.26.8.6 Hazardous Waste

Various activities, such as the Ship Repair Facility and the Naval Magazine, are expected to generate 10 to 15 percent more wastes. The VRC-50 squadron at Andersen will add to the overall hazardous waste stream. However, due to the Navy's hazardous waste minimization initiatives and the completion of the Hazardous Materials Storage Facility, it is not anticipated that DRMO will experience an increase in the amount of RCRA Hazardous Waste handled on Guam.

4.26.8.7 Traffic

Traffic on Guam's roads will increase, but because housing and employment centers are concentrated on the military installations, peak hour commuter trips will have little impact on the public road networks. Off-peak travel on local roadways will increase slightly due to additional shopping-, school-, or tourist-generated trips.

4.26.8.8 Schools

Relocated families will increase the number of students in the elementary, junior high, and high schools. Approximately 343 new students are projected to attend public schools, with 41 percent attending schools servicing Andersen and another 41 percent attending schools servicing the Apra Harbor region. The remaining 18 percent will be scattered in the central region around Agana. Additional childcare facilities are proposed to accommodate the number of children requiring such care. Proper registration of military dependents in the Guam public school system will be improved to insure the complete availability of federal support funds.

4.26.8.9 Socioeconomic

The transfer of activities to Guam will bring approximately 1,380 military personnel and 1,450 dependents to the island. Islandwide increases in spending and jobs are expected as a result of new construction and operations at the bases. New jobs created by the Navy will employ additional personnel from the civilian sector. Construction associated with the relocation will account for almost $320 million in spending between 1993 and 1997. Direct construction jobs created during this time period will total about 1,800, while indirect and induced jobs will total over 4,300. New operations will create approximately 1,700 direct jobs and account for $164 million in spending between 1993 and 1996. Nearly 600 indirect and induced jobs will be created by operations- or support-related industries. Incomes on Guam will receive a modest boost. The increased construction activities will also aggravate an already existing shortage of construction laborers, causing Guam to import additional workers to fill job openings. The increased personnel loading will also exert more pressure on Guam's tight housing supply and could cause short-term rental increases across the island.

Government of Guam revenues associated with the proposed actions are estimated to peak at over $31 million (1992 dollars) in 1994, and to stabilize at over $8 million as of 1998. Additional government costs will be about $5 million annually. The cumulative balance of revenues over costs is estimated to be $70 million by the year 2000, and nearly $110 million by 2010.

4.26.8.10 Increased Training Activities

There will be an increase in the use of the various military training facilities on Guam as a result of the proposed actions. This will be the result of the activities of relocated detachments as well as increases in regularly scheduled visiting groups. Visiting groups such as the 31st Marine Expeditionary Unit and the amphibious assault (COMPHIBRON 11) group, will visit once or twice a year for 4 to 7 days, and require use of Naval Station ship support facilities, as well as firing ranges, and other training grounds. Since these increased activities are occurring at already existing facilities, the cumulative impacts of these activities will not be significant.

4.26.8.11 Global Warming

A significant body of opinion exists within the scientific community that high temperatures recorded in recent years may be part of a long-term phenomenon of global warming that is caused by the "greenhouse effect." Gases, primarily carbon dioxide (CO_2), are released into the atmosphere by combustion of fossil fuels and other organic materials. These gases reflect infrared radiation back to the earth's surface, thus preventing some of the heat caused by sunlight from being released into the upper atmosphere.

The proposed actions on Guam will contribute in a minor way to this greenhouse effect, either through direct use of fossil fuel driven vehicles, or through indirect use via electricity generated by burning fossil fuels. Many of these vehicles and activities that use fossil fuels were already being used and will only be relocating to Guam from other regions of the world, so the proposed actions will not cause a net contribution of carbon dioxide to the atmosphere. However, with the expansion of fossil fuel burning power

plants to support the increases in housing and other new facilities, there will be a net increase in these gases.

4.26.9 Unavoidable Adverse Impacts/Unresolved Issues

No permanent unavoidable adverse impacts have been identified. The relocation will have a short-term adverse effect upon the civilian rental housing market, with higher rents and more families per unit anticipated. Renovation of unaccompanied personnel housing and the planned construction of 300 family housing units will help to mitigate this situation.

The issue of impacts to the Mariana crow and the Mariana fruit bat from VRC-50 flight training operations remains unresolved at this time. Currently, the VRC-50 squadron is using NAS Agana for Field Carrier Landing Practices (FCLPs) to avoid disturbance of the animals. A study will be conducted for two years to obtain the data necessary to make a determination on the impacts of FCLPs and other VRC-50 air operations on these species.

TABLE 4.26.1

SUMMARY OF ENVIRONMENTAL IMPACTS AND PROPOSED MITIGATION MEASURES

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
ACTIVITIES		
ANDERSEN AIR FORCE BASE		
1. Permanent Relocation of Fleet Logistics Support Squadron (VRC-50)	**Geology/Soils/Drainage:** *None*	
	Water Resources: *None*	
	Terrestrial Biota: *Potential adverse impacts of FCLPs on endangered Marianas crow and fruit bat.*	*Two-year program to monitor effect of FCLPs and other VRC-50 air operations on crows and bats, in accordance with the terms and conditions of Section 7 consultation.*
	Marine Environment: *None*	
	Water Quality/Air Quality/Noise: *Potential minimal increase of Ldn noise levels in areas adjacent to NAS Agana.*	*Same as above.*
	Visual Setting/Aesthetics: *None*	
	Historic Features: *None*	
	Socio-Economics: *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.*	*Renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.*
	Infrastructure/Utilities: *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting. Implementation of New Andersen AFB Solid Waste Management Plan.* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO. Expansion of Andersen 90-day Storage Facility.*
	Public Services: *Cumulative impacts on schools.*	*Coordination with DOE; busing of students to other districts, as required.*
	Hazards: *None*	

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 1. Naval Station (NAVSTA) 2. Military Sealift Command (MSC) 3. Naval Supply Depot (NSD) 4. Ship Repair Facility (SRF)	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *Cumulative impact of introduced species on terrestrial biota.* **Marine Environment:** *Increased risk of oil spills; potential for introduction of unwanted pathogens or marine organisms in ballast water; anchor chain damage.* **Water Quality/Air Quality/Noise:** *Potential impact on marine water quality if industrial runoff is not properly handled; air quality impacts from sand blasting at SRF.* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *Cumulative impacts on schools.* **Hazards:** *None*	*Continued implementation of existing procedures.* *Implement Spill Prevention Control and Countermeasure Plans; place moorings away from reef areas.* *Comply with 1990 Clear Air Act amendments.* *Construction of 300 family housing units and renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO. Implementation of Naval Hazardous Waste Minimization programs.* *Coordination with DOE; busing of students to other districts, as required.*
5. Navy Special Warfare Unit One (NSWU-1)	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *Potential impact from training activities.*	*Notify GEPA and DAWR in advance and allow on-site review; publish Notice to Mariners; have spotter boats provide warnings and check for turtles.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 5. Navy Special Warfare Unit One (NSWU-1) (cont'd)	**Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *Cumulative impacts on schools.* **Hazards:** *None.*	*Construction of 300 family housing units and renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.* *Coordination with DOE; busing of students to other districts, as required.*
6. Explosive Ordnance Disposal Mobile Unit Five (EODMU-5)	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *Potential impact from training activities and bulkhead in-water work.* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.*	*Notify GEPA and DAWR in advance and allow on-site review; publish Notice to Mariners; have spotter boats provide warnings and check for turtles. Prohibit in-water work on bulkhead during turtle nesting season.* *Construction of 300 family housing units and renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 6. Explosive Ordnance Disposal Mobile Unit Five (EODMU-5) (cont'd)	**Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *Cumulative impacts on schools.* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.* *Coordination with DOE; busing of students to other districts, as required.*
NAVAL MAGAZINE 1. Naval Magazine (NAVMAG)	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *Cumulative impacts on schools; closing of Gab Gab Beach 32 days/year.* **Hazards:** *None*	*Construction of 300 family housing units and renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.* *Coordination with DOE; busing of students to other districts, as required; provide alternative beach recreation opportunities.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
OTHER		
1. Naval Air Station (NAS) Agana	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *Cumulative impacts on schools.* **Hazards:** *None*	*Construction of 300 family housing units and renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.* *Coordination with DOE; busing of students to other districts, as required.*
2. Naval Hospital	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None*	

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
OTHER 2. Naval Hospital (cont'd)	**Socio-economics:** *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *Cumulative impacts on schools.* **Hazards:** *None*	*Construction of 300 family housing units and renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.* *Coordination with DOE; busing of students to other districts, as required.*
3. Naval Oceanography Center/Joint Typhoon Warning Center	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Cumulative impacts on rental housing market; increase in government revenues, employment income, and spending; social impacts on newly arrived personnel and families.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.*	*Construction of 300 family housing units and renovation of unaccompanied personnel housing; ongoing support programs for military personnel and dependents.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO. Implementation of Naval Hazardous Waste Minimization programs.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
OTHER 3. Naval Oceanography Center/Joint Typhoon Warning Center (cont'd)	**Public Services:** *Cumulative impacts on schools.* **Hazards:** *None*	Coordination with DOE; busing of students to other districts, as required.
MILITARY CONSTRUCTION PROJECTS **ANDERSEN AFB** 1. P-203 VRC-50 Hangar, Apron, Washrack	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *Temporary construction impacts: dust, noise, runoff.* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use;,water consumption, solid waste, and hazardous waste generation.* **Public Services:** *None* **Hazards:** *None*	*Erosion control and other appropriate measures, such as oil/water separator, reuse of washrack water.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
ANDERSEN AFB 2. P-207 Renovation of SNCO 3. P-209 Renovation of BOQ	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, and solid waste generation.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Solid Waste: Planning for new landfill sites, recycling, and composting. Implementation of Naval Hazardous Waste Minimization programs.*
APRA HARBOR COMPLEX 1. Naval Station: P-391/392 Additions and Alterations to Child Development Center	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *Temporary construction impacts (dust, noise, runoff).* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenues, income, and spending.*	*Erosion control and other appropriate measures.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 1. Naval Station: P-391/392 Additions and Alterations to Child Development Center (cont'd)	**Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, and solid waste generation.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting*
2. Military Sealift Command: P-160 Operations Building	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *Temporary construction impacts (dust, noise, runoff).* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *None* **Hazards:** *None*	*Erosion control and other appropriate measures.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX		
3. Naval Supply Depot: P-141 Hazardous Material Storage Building	**Geology/Soils/Drainage:** *Potential for hazardous spills to infiltrate and contaminate the soil.*	*Provide secondary containment against pollutant infiltration and good management practices.*
	Hydrology/Water Resources: *None*	
	Terrestrial Biota: *None*	
	Marine Environment: *Potential for hazardous spills to adversely affect water quality.*	*Employ proper safety measures to reduce risk of leakage and proper handling of leaks.*
	Water Quality/Air Quality/Noise: *Potential for hazardous spills to adversely affect water quality. Temporary construction impacts (dust, noise, runoff).*	*Employ proper safety measures to reduce risk of leakage and proper handling of leaks. Erosion control and other appropriate measures. Special floor drains.*
	Visual Setting/Aesthetics: *None*	
	Historic Features: *None*	
	Socio-economics: *Positive impacts during construction: jobs, government revenue, income, and spending.*	
	Infrastructure/Utilities: *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.*
	Public Services: *None*	
	Hazards: *None*	
4. Naval Supply Depot: P-152 Integrated Storage and Handling Facility 5. Naval Supply Depot: P-153 General Warehouse 6. Naval Supply Depot: P-156 Gantry Crane and Rails 7. Naval Supply Depot: P-157 Cold Storage Warehouse 8. Naval Supply Depot: P-158 Supply Systems Storage Building	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *Temporary impacts during construction: dust, noise, runoff.*	*Erosion control and other appropriate measures.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 4. Naval Supply Depot: P-152 Integrated Storage and Handling Facility 5. Naval Supply Depot: P-153 General Warehouse 6. Naval Supply Depot: P-156 Gantry Crane and Rails 7. Naval Supply Depot: P-157 Cold Storage Warehouse 8. Naval Supply Depot: P-158 Supply Systems Storage Building	**Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use; water consumption; sewage, solid waste, and hazardous waste generation.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.*
9. Ship Repair Facility: P-168 Ship Spares Storage Warehouse	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *Temporary impacts during construction: dust, noise, runoff.* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, and solid waste.*	*Erosion control and other appropriate measures.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 9. Ship Repair Facility: P-168 Ship Spares Storage Warehouse (cont'd)	**Public Services:** *None* **Hazards:** *None*	
Naval Special Warfare Unit One (NSWU - 1): 10. P-394 Maintenance/Storage Building 11. P-395 Naval Special Warfare Unit Building	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *Temporary impacts during construction: dust, noise, runoff.* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *None* **Hazards:** *None*	*Erosion control and other appropriate measures.* *Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.*
12. Explosive Ordnance Disposal Mobile Unit Five: P-393 EOD Operations Facility	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *Some turbidity during construction. Potential impacts to turtles during bulkhead repair.* **Water Quality/Air Quality/Noise:** *Temporary impacts during construction: dust, noise, runoff.*	*Will not conduct in-water bulkhead work during turtle nesting season.* *Erosion control and other appropriate measures.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 12. Explosive Ordnance Disposal Mobile Unit Five: P-393 EOD Operations Facility (cont'd)	**Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, solid waste, and hazardous waste generation.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting* *Hazardous Waste: Construction of hazardous materials storage building; increased staffing of DRMO; construction of DRMO facility. Implementation of Naval Hazardous Waste Minimization programs.*
13. Public Works Center: P-234 Orote Power Plant Expansion	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *Temporary impacts during construction (dust, noise runoff); exceedance of air quality standards.* **Visual Setting/Aesthetics:** *Second stack adjacent to existing plant/stack.* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Positive impact - increased peak load/emergency generation.* **Public Services:** *None* **Hazards:** *None*	*Construction Impacts: Erosion control and other appropriate measures.* *Air Quality: Limit fuel sulfur content; raise stack heights; limit operating hours; install emission controls in accordance with EPA permit.* *None required.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX		
14. Public Works Center: P-235 Repair Shop Storage	**Geology/Soils/Drainage:** *None*	
	Hydrology/Water Resources: *None*	
	Terrestrial Biota: *None*	
	Water Quality/Air Quality/Noise: *Temporary construction impacts: dust, noise, runoff.*	*Erosion control and other appropriate measures.*
	Visual Setting/Aesthetics: *None*	
	Historic Features: *None*	
	Socio-economics: *Positive impacts during construction: jobs, government revenue, income, and spending.*	
	Infrastructure/Utilities: *Cumulative impacts on electricity use, water consumption, sewage, and solid waste.*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting*
	Public Services: *None*	
	Hazards: *None*	
15. Public Works Center: P-237 Waterfront Utilities	**Geology/Soils/Drainage:** *None*	
	Hydrology/Water Resources: *None*	
	Terrestrial Biota: *None*	
	Marine Environment: *Positive impacts due to ship sanitary waste handling facility.*	
	Water Quality/Air Quality/Noise: *Temporary construction impacts: dust, noise, runoff.*	*Erosion control and other best management practices.*
	Visual Setting/Aesthetics: *None*	
	Historic Features: *None*	

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX 15. Public Works Center: P-237 Waterfront Utilities (cont'd)	**Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, and sewage.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications*
16. Public Works Center: P-239 Modifications to the Apra Harbor Sewage Treatment Plan	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *Positive impacts due to improved treatment.* **Water Quality/Air Quality/Noise:** *Temporary construction impacts: dust, noise, runoff.* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impacts during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Positive impact - will accommodate projected flow due to proposed actions.* **Public Services:** *None* **Hazards:** *None*	*Erosion control and other appropriate measures.*

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX		
17. Public Works Center: P-236 Family Housing Tipalao Expansion Area Northwest	**Geology/Soils/Drainage:** *Potential for runoff on Orote Point Ecological Reserve.*	*Best management plan and erosion control plan. Provide buffer between housing and Ecological Reserve.*
	Hydrology/Water Resources: *None*	
	Terrestrial Biota: *Potential impacts on native flora, limestone forest, an endangered tree species, and nearby Orote Peninsula Ecological Reserve.*	*Site housing to avoid sensitive areas and minimize impacts on potential habitat.*
	Marine Environment: *None*	
	Water Quality/Air Quality/Noise: *Temporary construction impacts: dust, noise, runoff.*	*Erosion control and other appropriate measures.*
	Visual Setting/Aesthetics: *Change in visual setting due to size of project.*	*Consider visual factors in siting and design.*
	Historic Features: *Potential indirect impact on archaeological sites in and around the area.*	*Locate housing to avoid sites; flagging during construction; signage to inform users of sites' significance.*
	Socio-economics: *Positive impact during construction: jobs, government revenue, income, and spending; will help mitigate housing shortage.*	
	Infrastructure/Utilities: *Cumulative impacts on electricity use, water consumption, and sewage.*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications*
	Public Services: *Increased demand on Navy-provided public services in immediate area; increased enrollment in nearby schools.*	*Consider expansion of services to accommodate increased demand; coordinate with DOE to mitigate impact on schools.*
	Hazards: *None*	

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
APRA HARBOR COMPLEX		
18. Construction Projects: P-236 Family Housing Tipalao Expansion Area Northeast	**Geology/Soils/Drainage:** *Potential impact on wetlands from runoff during construction.*	*Best management practice and erosion control plan.*
	Hydrology/Water Resources: *Potential impact on wetlands.*	*Site housing to avoid wetlands.*
	Terrestrial Biota: *Development might affect use of wetland and other areas as wildlife habitat (e.g., Mariana common moorhen).*	*Site housing to avoid wetlands and minimize impacts on potential habitat, fence wetland areas, and establish vegetated buffers.*
	Marine Environment: *None*	
	Water Quality/Air Quality/Noise: *Temporary construction impacts: dust, noise, runoff.*	*Erosion control and other appropriate measures.*
	Visual Setting/Aesthetics: *Change in visual setting due to size of project.*	*Consider visual factors in siting and design.*
	Historic Features: *Potential indirect impact on archaeological sites in and around the area.*	*Locate housing to avoid sites; flagging and signage.*
	Socio-economics: *Positive impact during construction: jobs, government revenue, income, and spending; will help mitigate housing shortage.*	
	Infrastructure/Utilities: *Cumulative impacts on electricity use, water consumption, and sewage.*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications*
	Public Services: *Increased demand on Navy-provided public services in immediate area; increased enrollment in nearby schools.*	*Consider expansion of services to accommodate increased demand; coordinate with DOE to mitigate impact on schools.*
	Hazards: *None*	

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
NAVAL MAGAZINE		
1. P-829 Missile Magazines	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impact during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, and solid waste.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Solid Waste: Planning for new landfill sites, recycling, and composting*
2. P-830 Inert Storehouse	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None*	

PROPOSED ACTIONS	IMPACTS	MITIGATION MEASURES
NAVAL MAGAZINE 2. P-830 Inert Storehouse (cont'd)	**Socio-economics:** *Positive impact during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, sewage, and solid waste.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features* *Sewage: Apra Harbor STP modifications* *Solid Waste: Planning for new landfill sites, recycling, and composting*
OTHER 1. U.S. Naval Oceanography Command Center/Joint Typhoon Warning Center: P-001 Renovation of Oceanography Building	**Geology/Soils/Drainage:** *None* **Hydrology/Water Resources:** *None* **Terrestrial Biota:** *None* **Marine Environment:** *None* **Water Quality/Air Quality/Noise:** *None* **Visual Setting/Aesthetics:** *None* **Historic Features:** *None* **Socio-economics:** *Positive impact during construction: jobs, government revenue, income, and spending.* **Infrastructure/Utilities:** *Cumulative impacts on electricity use, water consumption, and sewage.* **Public Services:** *None* **Hazards:** *None*	*Electricity: Orote power plant expansion; energy conservation measures* *Water: Water conservation measures and design features*

Chapter 5

Consistency with Land Use Plans, Policies, and Controls

CHAPTER 5

CONSISTENCY WITH LAND USE PLANS, POLICIES, AND CONTROLS

5.1 FEDERAL GOVERNMENT

5.1.1 National Environmental Policy Act of 1972

This document has been prepared in compliance with the National Environmental Policy Act (NEPA) of 1969, as amended in 1972, and the Council on Environmental Quality Regulations, 40 CFR 1500-1508.

5.1.2 Coastal Zone Management Act of 1972

A Guam Coastal Management Program Consistency Certification is being filed in compliance with the National Coastal Zone Management Act of 1972 (P.L. 92-583), as amended (P.L. 94-370). This law requires Federal agencies to conduct their planning, management, development, and regulatory activities in a manner consistent with the Government of Guam's Coastal Management Program. The "coastal zone" includes all non-federal property within the Territory, including offshore islands and submerged lands and waters extending seaward for a distance of three nautical miles. The Guam Bureau of Planning is the lead agency responsible for conducting the consistency review.

Although all of the proposed actions will be located on federal land, spillover effects on non-federal lands are anticipated. The completed assessment concludes that the proposed actions are consistent with the objectives and policies of the Guam Coastal Management Program. The Guam Bureau of Planning has concurred with this assessment. Copies of the assessment form and concurrence letter are in Appendix L.

5.1.3 Endangered Species Act of 1973

The Endangered Species Act of 1973 requires that federal actions taken do not jeopardize the continued existence of endangered and threatened species. The U.S. Fish and Wildlife Service (USFWS) has jurisdiction over endangered and threatened terrestrial flora, terrestrial fauna, and birds. The National Marine Fisheries Service (NMFS) has jurisdiction over marine mammals. The two agencies USFWS and NMFS, share responsibility for listed sea turtles. Under Section 7 of the Act, these agencies must be consulted when proposed actions may affect species under their jurisdiction that are listed as endangered species, or likely cause jeopardy to the continued existence of species proposed to be added to the list. Section 7 consultation has been conducted as part of the EIS process.

5.1.4 National Historic Preservation Act

This project is being carried out in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, and 36 CFR 800 (implementing regulations). Section 106 requires Federal agencies to consider the effects of their actions on historic properties. The review process is designed to identify and evaluate historic properties and to assess the effects of the proposed action on the properties. If it is determined that

there is an effect, consultation with the Territorial Historic Preservation Officer is required to determine means to avoid, reduce, or mitigate the effect. Section 106 applies not only to those properties listed in the National Register of Historic Places, but also to properties that meet specified eligibility criteria. Section 106 review has been concluded with the Guam Historic Preservation Officer in the Department of Parks and Recreation.

The Guam Historic Preservation Officer has determined that there is a potential for adverse effect due to the Tipalao family housing project. A Memorandum of Agreement has been drafted to stipulate specific mitigation measures. See Appendix H.

5.1.5 U.S. Army Corps of Engineers

Under Section 404, Clean Water Act (CWA) (33 U.S.C. 1344), the Corps of Engineers (COE) is responsible for regulating activities in wetlands. Any placement of dredged or fill material into a wetland, including clearing of wetlands with mechanical equipment, is subject to Section 404 jurisdiction. The wetlands in the Tipalao Family Housing project area have been delineated in cooperation with the COE to insure that the housing avoids them.

Other laws may also affect the processing of applications for Corps of Engineers permits, including those listed in the above sections. These include the Fish and Wildlife Coordination Act, which requires the Corps of Engineers to coordinate permit applications with State and Federal wildlife agencies, and the Clean Water Act of 1977. Pursuant to Section 401 of the CWA, a water quality certification is required by any applicant for a federal permit to conduct an activity in U.S. waters that may result in any discharge. The Guam Environmental Protection Agency (GEPA) is responsible for Section 401 water quality certifications.

5.1.6 Base Master Plans and Resource Management Plans

Several planning documents were reviewed to assess the proposed actions' consistency with these plans, including master plans for Andersen Air Force Base, Apra Harbor, Naval Magazine, and Naval Air Station Agana, and the Natural Resources Management Plan for Naval Magazine. While the preferred alternatives are consistent with base master plans, some alternatives for housing are not. See Chapter 7 for a listing of these references.

5.1.7 Explosive Safety Regulations

NAVSEA OP 5, Volume 1, and Army Regulation 385-64, Ammunition and Explosive Safety Standards, provide guidelines for explosive arc determinations for military facilities. The criteria described in these regulations concern ship unit separation distance in wharf and pier operations, as well as traffic safety issues. The regulations also provide guidelines for munitions storage relative to inhabited buildings and public highways. The proposed actions are consistent with military guidelines for explosive arc regulations.

5.1.8 Military Housing Guidelines

NAVFAC DM-35, Family Housing (1971) sets out design criteria for housing facilities. Density, basic design considerations, unit and room planning, site selection, plan arrangement, and construction are discussed. These criteria are being used in the site selection, planning, and design process for the 300-unit family housing project at the Naval Station.

5.1.9 Water Pollution Control

Discharges of pollutants into surface waters of the United States are controlled under the National Pollutant Discharge Elimination System (NPDES) program, pursuant to Section 402 of the Clean Water Act. The NPDES program requires a permit for any discharge of pollutants from a point source into waters of the United States. The proposed actions and expansion of the Apra Harbor Sewage Treatment Plant will increase the amount of effluent discharged and thus may require a permit modification. NPDES permits issued by the Guam EPA specify limitations on effluent volume and chemical characteristics to assure that water quality standards will be met in receiving waters. Increases in effluent volume above the existing 3.2 mgd permit limit will require modification of the existing permit issued 29 September 1988. Technology-based treatment requirements under section 301(b) of the Clean Water Act represent the minimum level of control that must be imposed in an NPDES permit (40 CFR 125.3). In order to comply with this standard, the Apra Harbor Sewage Treatment Plant is undergoing modifications to upgrade to secondary treatment. If technology-based effluent limitations are insufficient to assure that water quality standards will be met in the receiving water, the NPDES permit may contain additional or more stringent water quality-based limitations.

5.1.10 Air Quality Regulation

The 1990 Clean Air Act Amendments (CAAA) required the EPA to promulgate stricter air quality regulations. A major addition is the identification of 189 hazardous air pollutants (HAPs) to be regulated under National Emission Standards for Hazardous Air Pollutants (NESHAPS). These chemicals will be regulated in terms of emission limitations, control technology, and prevention of accidental releases.

A second major addition is the establishment of an all-encompassing permit system and a whole new series of permitting requirements and programs. Almost all air emissions sources will require a "federally enforceable operating permit." These permits will not only regulate the emissions coming from the facility, but will directly or indirectly affect the operation of the manufacturing or processing operations that are the sources of the emissions. Programs will in most cases be state run, with the requirement that states obtain program approval from the EPA. The 1990 amendments stipulate that permitting requirements must include submittal of a compliance plan describing how the source will comply with applicable requirements under the Clean Air Act. A schedule of compliance and a schedule for submitting progress reports at least every six months will also be required.

The two existing programs for new sources, new source review (NSR) in non-attainment areas and prevention of significant deterioration (PSD) in attainment areas, will remain essentially the same. However, a new type of new source review added by the

amendments is an air toxics review program designed to ensure that new sources of HAPs will be controlled to an efficiency described as the maximum achievable control technology (MACT).

EPA must regulate major sources according to a 10 year schedule and establish emissions standards from routine releases. Emissions will initially be based upon MACT for major sources and generally achievable control technology (GACT) for other sources

The U.S. EPA and the Guam EPA have promulgated ambient air quality standards pursuant to the federal Clean Air Act. The National Ambient Air Quality Standards (NAAQS) are divided into primary and secondary standards. Primary Standards are intended to protect public health with an adequate margin of safety, while secondary standards are intended to protect public welfare through the prevention of damage to soils, water, vegetation, man-made materials, animals, visibility, climate, and economic values. In addition to the ambient air quality standards, new major sources being proposed in attainment or unclassified areas are subject to pre-construction review under the PSD provisions. The PSD rules also require one year of pre-construction continuous monitoring if certain de minimus levels are exceeded.

Estimates of annual emissions from the existing plant and the proposed plant expansion adjacent to the Orote Power plant indicate that the proposed plant would be considered a new major source because SO_2 and NO_x emissions exceed 250 tons per year, or a major modification should it replace the old plant because net emissions of CO, SO_2, NO_x, and PM are significant. Under either classification it would be subject to PSD review and would require one-year of pre-construction continuous air monitoring. The Orote Point power plant is not within the non-attainment area established within a 2 mile radius of the Piti/Cabras site. However, under normal tradewind conditions, the Orote stack plume will not affect the non-attainment area. During southeasterly winds, when the Orote plume will affect this area, the Piti/Orote emissions will be blowing away from the non-attainment area.

5.1.11 Federal Hazardous Waste Regulation

The 1976 Resource Conservation and Recovery Act (RCRA) and the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are two federal laws which gave the U.S. EPA responsibility for regulating the generation, handling, disposal, and clean up of hazardous waste.

Following RCRA guidelines, the EPA has established a program to regulate industrial hazardous waste from the point of generation to the point of disposal. This program, commonly referred to as cradle to grave legislation is found in 40 CFR 261. A manifest system has been established to track the waste and control the handling and disposal of these hazardous substances by the responsible parties. Through this legislation, EPA defines which chemical wastes are hazardous to the environment based on: (1) a compilation of lists of various chemicals and/or their generation process and (2) their characteristic properties such as ignitability, corrosivity, reactivity, and toxicity. The proposed actions will increase the generation of these regulated solid wastes.

CERCLA was passed to establish a legal and financial means of curbing the dangers to human health posed by the thousands of abandoned hazardous waste sites in the U.S. Funds set aside to the Superfund are used to clean up those abandoned sites where the pollutants pose a hazard to the health of surrounding communities and the environment. This law is comprehensive and applies to air, groundwater, surface water, and land contamination. If the responsible parties fail to act, the EPA can proceed with the clean-up and collect costs later through litigation. Punitive damages of up to three times the remediation costs to the Superfund may be imposed through the courts for failure to clean up a hazardous waste site.

The Superfund Amendments and Reauthorization Act of 1986 (SARA) established a series of programs for the cleanup of hazardous waste disposal and spill sites nationwide. One of those programs, the Defense Environmental Restoration Program (DERP), is codified in SARA Section 211 (10 USC 2701). The Navy Installation Restoration (IR) Program is a DoD program and a component of DERP. The purpose of the IR Program is to identify, assess, and clean up or control contamination from past hazardous waste disposal operations and hazardous material spills at Navy and Marine Corps activities. The Navy has been engaged in this program since 1980. The program is intended to clean up hazardous substances on sites currently owned or leased by the Navy, and which are in the United States, its territories, or its possessions (Navy Installation Restoration Manual, 1988). The IR program addresses sites both on and off the National Priority List (NPL) developed by the EPA. Currently, 16 sites have been identified within Navy stations on Guam for possible remedial action. These sites are shown on Figure 4.21.1 and discussed further in Section 4.21.1.2.

5.2 GOVERNMENT OF GUAM

Several Territorial agencies are charged with administering Federal programs, including the following:

- Guam Environmental Protection Agency (GEPA): Section 401 Water Quality Certification
- Bureau of Planning: Coastal Management Program Consistency Certification
- Department of Parks and Recreation, Division of Historic Resources: Section 106 Consultation

The proposed actions will be carried out in conformance with the applicable requirements of these agencies. For example, as part of the Section 106 consultation, the items listed in the Division of Historic Resources Archaeological Survey Reports Evaluation Checklist will be addressed.

In addition, other Government of Guam agencies have been consulted during the scoping and EIS preparation process. A complete list of these agencies is presented in Section 1.6 of this document.

Chapter 6

List of Preparers

CHAPTER 6

LIST OF PREPARERS

This Final Environmental Impact Statement (FEIS) was prepared for the Department of the Navy, Pacific Division, Naval Facilities Engineering Command, by Belt Collins & Associates, with information provided by the Navy, the Air Force, consulted agencies, and subconsultants. The following were involved in preparation of this document.

Belt Collins & Associates:

John Goody	Planner with master's degrees in planning and general management; contract manager; contributed to the organization and content of all sections.
Susan Rutka	Planner with master's degree in political science; project manager; contributed to the organization and content of all sections.
Jeff Hutchinson	Planner with bachelor's degree in environmental systems technology; wrote the sections on hydrology/water resources, drainage, marine environment, water quality, harbors, and water (utilities); contributed to the organization and content of all sections.
John Cheever	Planner with bachelor's degree in urban and regional studies; wrote Chapter 3 and the sections on terrestrial biota, historic features, socioeconomics, natural and manmade hazards, geology/soils, and public services.
Mark Willey	Planner with master's degree in urban and regional planning; wrote the sections on roads/traffic, energy use, sewage, solid waste, hazardous/toxic waste, air quality, and cumulative impacts.
Lisa Williams	Planner with bachelor's degrees in mechanical engineering and architecture; contributed to the organization and content of all sections.
Mara Soloway	Editor with bachelor's degree in communication studies; responsible for editing and production.
Diane Yamamoto	Graphic Designer with bachelor's degree in fine arts; responsible for preparation of maps and other figures.
William Byrd	Manager of Guam office; assisted with agency coordination.

Subconsultants:

Phillip L. Bruner	Faunal (bird and mammal) survey
Community Resources, Inc.	Socioeconomic impact assessment
Harris Miller Miller & Hanson	Noise study
International Archaeological Research Institute, Inc.	Archaeological inventory survey
Marine Research Consultants	Marine environmental assessment
J.M. Morrow	Air quality impact report
Sea Engineering, Inc.	Marine environmental impact evaluation
Dr. W. Arthur Whistler	Botanical survey

Chapter 7
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CHAPTER 7

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Appendix A

Impacts, Issues, and Concerns Identified During the Scoping Process

IMPACTS, ISSUES, AND CONCERNS IDENTIFIED DURING THE SCOPING PROCESS

IMPACTS	IDENTIFIED BY
ıcrease in generation of hazardous materials and waste at all bases.	DRMO
ımpact on air and water quality by sandblasting at SRF.	SRF
Increased number of Gab Gab Beach closures due to ammunition loading at Kilo Wharf (32 days/yr)	NAVMAG
Socioeconomic and cultural issues; land ownership rather than lifestyle	COMNAVMAR
Expanded Tipalao housing site: need to evaluate wetlands and effects of quarry blasting operations; also slope, infrastructure, and archaeological analysis.	PWC/PacDiv
Old Orote Village housing site: conservation district, coastal zone, recreation, tsunami, flora, and archaeological concerns; land use conflicts.	PWC/PacDiv
New Apra Heights housing site: slope, drainage, wetland, flora, fauna, infrstructure concerns	PWC/PacDiv
Polaris Point housing site: partially in tsunami inundation zone; possible land use conflicts; wetland concerns.	PWC/PacDiv
Endangered Marianas Crow and fruitbat at Andersen AFB	AAFB staff
Need to be aware of the Critical Habitat and refuge overlay	AAFB staff
Asbestos, solvents, and cleaners may be issues in Andersen housing renovations	AAFB staff
Hazardous waste concerns: DRMO is full and not accepting waste; RCRA 90-day requirement is not being met; Navy will be using some stuff AF doesn't normally handle (e.g., hydorzene); NSD doesn't allow synthetic oils in recycling system.	AAFB staff
Effects of dredging mangrove swamps, coral reefs, and other natural submerged resources; potential for silt/sediments to cause irreversible damage to reefs and marine life. Also impacts on water quality of the harbor.	National Park Service
Effect of dredging on historically significant shipwrecks; effects on coral growing ın wrecks which offer protection to the wrecks.	National Park Service
Need to reduce sediment loads to Apra Harbor and lagoon areas abutting lands to be developed; assess potential damage to aquatic habitat.	Soil Conservation Service
Impact to wildlife protection zone on AAFB; presence of endangered species	SCS
Site specific traffic concerns (rather than regional).	Dept. of Public Works
Impact of anticipated growth on demand for electrical power currently not being met.	Guam Power Auth.
Long delays in removing NSD materials due to insufficient Navy equipment.	Port Auth. of Guam
Problems in meeting water demand during periods of extended drought and during blackouts.	Public Utilities Agency of Guam
Possible problems in meeting water/sewage demand over the short-term when Subic personnel find housing served by PUAG system; overloading of system if personnel are concentrated in one area.	PUAG
Concerned about traffic/transportation. Need to indicate how many Subic personnel will have cars. There may be need for more school buses.	Bureau of Planning, Coastal Mgt Program
Other major concerns: housing and schools.	BOP, CMP
Other concerns: fragile areas, e.g., wetlands	BOP, CMP
Need to look at potential impact of Subic rollback on NAS Agana and how actions would affect transfer of NAS Agana to GovGuam.	Bureau of Planning
Why does Navy need new hangar/washrack/apron at Andersen? Why not use existing facilities? Have the Navy/AF done studies on availability of space?	Bureau of Planning
Need to clearly define military mission and enhanced military role on Guam, in order to analyze cumulative impacts.	Bureau of Planning
ıvestigate all alternatives to enable consolidation of Navy and AF facilities.	Bureau of Planning

IMPACTS, ISSUES, AND CONCERNS IDENTIFIED DURING THE SCOPING PROCESS

IMPACTS	IDENTIFIED BY
Address impacts of assignment of 138 additional personnel to and expansion of activities at NAS Agana relative to transfer to NAS to GovGuam, including relocation costs of NAS activities to AAFB.	Bureau of Planning
Address methods by which impacts of Subic relocation are to be minimized relative to infrastructure: water, power, schools, etc.	Bureau of Planning
EA for flight operations of VRC 50 should not be separate from EIS	Bureau of Planning
Discuss the numbers and skills of employees needed that cannot be obtained locally, to assess impact on local labor force. Discuss nature of positions (temporary or permanent).	Bureau of Planning
Impact of training on existing training areas/operations.	Bureau of Planning
Concern about increase in flight operations at NAS Agana due to VRC 50; need to analyze alternatives such as relocating operations to AAFB.	Bureau of Planning
Impact of transport of munitions from Apra Harbor to NAVMAG and AAFB; will ESQD arcs extend further onto civilian landholdings?	Bureau of Planning
Need to evaluate other housing alternatives such as participation in private rental market.	Bureau of Planning
Increase in solid waste generation; consider participating w/GovGuam in Resource Recovery Program spearheded by Guam Economic Development Authority.	Bureau of Planning
Concern about growth of ESQD areas and potential for harm to natural and human environment; concern about storage of nuclear weapons.	Bureau of Planning
Concern about EOD Unit Five: Is it necessary? Does it duplicate existing EOD unit on Guam or expand area served? Will it result in increases in ordnance exploded on Guam?	Bureau of Planning
Use of excess lands	Terr. Planning Coun
Traffic and infrastructure	TPC
Major concerns at Andersen AFB: Tarague Beach and Northwest Field.	Historic Preservation
Concern that security and base access will be affected by the rollback	Historic Preservation
Impacts on submerged cultural resources in the outer harbor	Historic Preservation
Impacts on archaeological resources at NAVMAG	Historic Preservation
Some concerns about increased use of public parks and historic parks	Historic Preservation
Impacts on recreational resources	Parks & Recreation
Impacts on archaeological resources	Parks & Recreation
Concern primarily with the large projects: acute impacts during housing construction, e.g., erosion.	Guam Env. Protection Agency
Hazardous waste	GEPA
Emissions/pollution from power plant	GEPA
Impacts on the northern lens water quality	GEPA
Impacts of dredging operations	GEPA
Noise impacts	GEPA
Impacts on endangered species, critical habitats, wetlands	GEPA
Hawksbill turtle nest has been found inside Apra Harbor	Div. of Aquatic & Wildlife Resources
Green sea turtles along Andersen AFB shoreline	DAWR
Marianas Crows nesting along cliffline at Andersen; concern about flight operations	DAWR
Fruitbat colony along the Andersen cliffline	DAWR

IMPACTS, ISSUES, AND CONCERNS IDENTIFIED DURING THE SCOPING PROCESS

IMPACTS	IDENTIFIED BY
Issues: traffic, crime, schools, housing	Land Mgt
Breaking down of extended family ties	Land Mgt
Identity crisis (e.g., Chamorro Language Commission)	Land Mgt
Need to look at design; e.g., landscaping plans should emphasize use of local flora	Land Mgt
Impact on coral reef habitats in Apra Harbor from anchors.	UOG Marine Lab
Introduced alien species from ship ballast water and encrusting fauna found on ships and drydocks.	UOG Marine Lab
Navy Seals exercises in Apra Harbor that involve moving a dummy mine across a reef area and beach: impact on beach users, scuba tours, etc.	Butch Irish
Damage to Sponge Mound from anchors and chains; damage to coral reef ecosystems; impact on people/businesses that depend on ocean for livelihood	Butch Irish
Impact on private property rights; need to balance environmental protection and property rights.	Tony Artero
Concern about waste	Tony Artero
Need to fully examine the change in U.S. military mission on Guam as a result of Subic rollback; assess total impact of this increased mission on Guam.	Commission on Self Determination
Disagreement with the position on no action: concern that Guam is not the optimum site, lands are available in CNMI and FSM; failure to consider views of the people of Guam in use of land by the U.S. govt; possibility of other funding options.	Comm on Self Det
Need to examine impacts of each individual project or activity, not just cumulative impacts.	Comm on Self Det
Concern that impacts will occur prior to completion of the EIS.	Comm on Self Det
Concern that the total number of personnel necessary to carry out the mission is being understated; need to identify all functions and support personnel needed.	Comm on Self Det
Need to clarify issue of separate EA for initial relocation of VRC 50	Comm on Self Det
Request for more information/clarification on various actitivites/facilities	Comm on Self Det
Request for more information on personnel changes	Comm on Self Det
Potential for significant social and economic impacts	Comm on Self Det
Clarify number of "sailor days" from port calls, including foreign vessels	Comm on Self Det
Concern about "liberty" for sailors, massage parlors, etc.	Comm on Self Det
Need to examine relationship of increased number of container shipments and capacity of commercial port; need to define what the increase is attributed to.	Comm on Self Det
Provide size of MSC vessels and number of personnel assigned to each.	Comm on Self Det
Increase in personnel requirements at SRF should be fully satisfied by local hires or transfer of former SRF employees or former Guam residents; if alien laborers are required on interim basis, they should be systematically replaced by local workers.	Comm on Self Det
Encourage hiring of senior management positions from within ranks of SRF employees rather than from off-island.	Comm on Self Det
Navy Seals should be in an isolated geographic location; need to assess the potential social impact of the Seals unit.	Comm on Self Det
Explain how and where ordnance handled by EOD unit will be disposed of.	Comm on Self Det
Examine increased risk factor associated with increased tonnage at NAVMAG	Comm on Self Det
If Wharves at Polaris A and B are to be used for NAVMAG activities, assess possible restrictions on use of property at the Reserve Craft Beach area.	Comm on Self Det

IMPACTS, ISSUES, AND CONCERNS IDENTIFIED DURING THE SCOPING PROCESS

IMPACTS	IDENTIFIED BY
Assess potential negative economic impact of possible use of Hotel Wharf (Commercial Port of Guam) for munitions loading/unloading, given problems DOD has experienced in using Kilo Wharf under certain surf conditions.	Comm on Self Det
Impacts on housing availability and rental rates (short and long term).	Comm on Self Det
Impact on schools (education delivery services and facilities)	Comm on Self Det
Address issue of commissaries and exchanges competing with private sector.	Comm on Self Det
Address problems of military-civilian interaction (e.g., crime).	Comm on Self Det
Economic impact of construction.	Comm on Self Det
Potential designation of all U.S. military property as wildlife refuge.	Comm on Self Det
Clarify types of material to be stored in hazardous waste storage building and length of storage.	Comm on Self Det
Identify types of gas to be stored in gas bottle storage building.	Comm on Self Det
Review environmental effects of all proposed maintenance facilities due to probability of hazardous materials storage.	Comm on Self Det
Assess environmental effects of missile magazines.	Comm on Self Det
Assess environmental effects of all utility projects.	Comm on Self Det
Assess environmental effects of the battery recharge facility.	Comm on Self Det
Impacts on sole source northern aquifer	US EPA
Assess hazardous substances contamination at AAFB and other bases; e.g., identify solid waste management units in need of corrective action, asbestos removals, underground storage tank cleanups, etc.	US EPA
Assess compatibility of proposed actions (especially housing and schools) with past land use practices (contamination)	US EPA
Recommend implementation of a full range of pollution prevention measures at the receiving facilities: water and energy conservation measures, solid waste recycling hazardous waste minimization. Incorporate these measures into proposed projects whenever feasible.	US EPA
Recommend preparation of a sediment sampling plan for all dredging operations.	US EPA
Discuss whether actions will require placement of fill material into waters of the U.S.; avoid or minimize adverse impacts to aquatic ecosystems.	US EPA
Avoid violation of water quality standards.	US EPA
Avoid jeopardizing existence of threatened/endangered species or harm to critical habitat of listed species.	US EPA
Identify flora and fauna and potential impacts to biological resources.	US EPA
Assess how various alternatives may affect basic infrastructure of Guam, including wastewater treatment and disposal, wastewater and drainage outfalls, solid waste disposal, electric power, drinking water, roads, and community services (both existing and projected infrastructure improvements—those already planned that didn't calculate Subic-related requirements).	US EPA
Impacts to planned land transfer actions to GovGuam.	US EPA

Appendix B

EIS Distribution and Review

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DRAFT EIS DISTRIBUTION LIST

GOV. OF GUAM OFFICIALS AND AGENCIES

Governor Joseph Ada
U.S. Territory of Guam
P.O. Box 2950
Agana, Guam 96910

Lt. Gov. Frank F. Blas
Executive Chambers
P.O. Box 2950
Agana, Guam 96910

The Honorable George Bamba
Senator
Twenty-Second Legislature
155 Hesler Street
Agana, Guam 96910

The Honorable Marilyn Manibusan
Senator
Twenty-Second Legislature
155 Hesler Street
Agana, Guam 96910

The Honorable David Shimizu, Chairman
Twenty-Second Legislature
Committee on Health, Ecology & Welfare
155 Hesler Street
Agana, Guam 96910

The Honorable Joe T. San Agustin
Speaker
Twenty-Second Guam Legislature
155 Hesler Street
Agana, Guam 96910

The Honorable Francisco Santos, Chairman
Committee on Federal & Foreign Affairs
Twenty-Second Legislature
155 Hesler Street
Agana, Guam 96910

The Honorable Madeleine Z. Bordallo
Chairperson, Committee on Education
Twenty-Second Legislature
155 Hesler Street
Agana, Guam 96910

The Honorable Carl T.C. Gutierrez, Chairman
Twenty-Second Legislature
Committee on Ways and Means
155 Hesler Street
Agana, Guam 96910

The Honorable Eddie C. Artero
Mayor of Yigo
Mayor's Council
P.O. Box 786
Agana, Guam 96910

The Honorable Isabel Haggard
Mayor of Piti
Mayor's Council
P.O. Box 786
Agana, Guam 96910

The Honorable Benny L. San Nicolas
Mayor of Asan-Maina
P.O. Box 786
Agana, Guam 96910

The Honorable Jose A. Rivera
Mayor of Dededo
Mayor's Council
P.O. Box 786
Agana, Guam 96910

The Honorable Antonio Babauta
Mayor of Agat
Mayor's Council
P.O. Box 786
Agana, Guam 96910

The Honorable Greg Borja
Mayor of Santa Rita
Mayor's Council
P.O. Box 786
Agana, Guam 96910

The Honorable Raymond Laguana
President, Mayors' Council
P.O. Box 786
Agana, Guam 96910

Mr. Peter R. Barcinas, Director
Department of Commerce
590 S. Marine Drive, Suite 601
Tamuning, Guam 96911

Ms. Lourdes T. Pangelinan
Special Assistant
Office of the Governor
P.O. Box 2950
Agana, Guam 96910

Atty. Gen. Elizabeth Barrett/Anderson
237 O'Hara Street
Agana, Guam 96910

Mr. Joaquin Blaz, Director
Department of Revenue & Taxation
855 W. Marine Drive
Agana, Guam 96910

GOV. OF GUAM OFFICIALS AND AGENCIES (cont'd)

Mr. Charles Crisostomo, Administrator
Guam Economic Development Authority
ITC Building, Suite 911
590 S. Marine Drive
Tamuning, Guam 96911

Mr. Anthony C. Leon Guerrero
Executive Sec.
Guam Contractors Licensing Board
P.O. Box 20339
GMF, Guam 96921

Mr. Edward A. Guerrero, Director
Department of Labor
ITC Building
P.O. Box 9970
Tamuning, Guam 96911

Mr. Fred Santos, General Manager
Guam Mass Transit Authority
P.O. Box 24383
GMF, Guam 96921

Mr. John Benavente
General Manager
Guam Power Authority
P.O. Box 2977
Agana, Guam 96910

Mr. Joe Mesa, Chief Officer
Public Utility Agency of Guam
P.O. Box 3010
Agana, Guam 96910

Mr. Benigno Palomo, Director
Department of Public Works
P.O. Box 2950
Agana, Guam 96910

Mr. Joseph Ducnas, Chairman
Public Utilities Commission
P.O. Box 2950
Agana, Guam 96910

Mr. Jesus Q. Torres
General Manager
Guam Airport Authority
P.O. Box 8770
Tamuning, Guam 96911

Mr. David B. Tydingco
General Manager
Port Authority of Guam
1026 Cabras Highway, Suite 201
Piti, Guam 96925

Mr. Adolfo Sgambelluri
Chief of Police
Guam Police Department
287 W. O'Brien Drive
Agana, Guam 96910

Fire Chief
Guam Fire Department
287 W. O'Brien Drive
Agana, Guam 96910

Mr. Francisco Castro, Director
Department of Land Management
P.O. Box 2950
Agana, Guam 96910

Mr. Fred Castro, Administrator (3 copies)
Guam Environmental Protection Agency
D-107 IT & E. Harmon Plaza
130 Rojas Street
Harmon, Guam 96911

Mr. Richard D. Davis, M.A.
Guam Historic Preservation Officer
Department of Parks & Recreation
Government of Guam
490 Chalan Palasyo
Agana Heights, Guam 96919

Mr. Peter P. Leon Guerrero, Director (5 copies)
Bureau of Planning
Government of Guam
PO Box 2950
Agana, Guam 96910

Mr. Mike Ham
Bureau of Planning
Guam Coastal Management Program
P.O. Box 2950
Agana, Guam 96910

Mr. Marcel Camacho
Executive Assistant
Territorial Planning Council
222 Chalan Santo Papa, Suite 103
Agana, Guam 96910

Mr. Rufo Lujan, Chief
Department of Agriculture
Division of Aquatic and Wildlife
P.O. Box 2950
Agana, Guam 96910

GOV. OF GUAM OFFICIALS AND AGENCIES
(cont'd)

Mr. Anthony M. Mariano, Director
Department of Parks & Recreation
490 Naval Hospital Road
Agana Heights, Guam 96910

Mr. Antonio S. Quitugua, Director
Department of Agriculture
P.O. Box 2950
Agana, Guam 96910

Mr. Leland R. Bettis, Executive Director
Commission on Self-Determination
Government of Guam
P.O. Box 2950
Agana, Guam 96910

Mr. Peter Calvo, Administrator
Agency for Human Resources Development
P.O. Box CP
Agana, Guam 96910

Dr. Leticia Espaldon, Director
Dept. of Public Health & Social Services
P.O. Box 2816
Agana, Guam 96910

Mr. Larry Hernandez
Safety and Health Administrator
Department of Public Works
P.O. Box 2950
Agana, Guam 96910

Ms. Marilyn Wingfield, Director
Department of Public Health
P.O. Box 9400
Tamuning, Guam 96931

Mr. John Cruz, President
Guam Community College
P.O. Box 23069
Barrigada, Guam 96921

Professor Gary Denton
Water & Energy Research Institute
University of Guam
Mangilao Station, Guam 96923

Dr. Wilfred P. Leon Guerrero
President
University of Guam
UOG Station
Mangilao, Guam 96910

Mr. Butch Irish, Marine Technician Supervisor
& Underwater Diving Officer
University of Guam
Marine Laboratory
UOG Station
Mangilao, Guam 96923

Ms. Valerie J. Paul, Director
University of Guam
Marine Laboratory
UOG Station
Mangilao, Guam 96923

Dr. Franklin Quitugua, Director
Department of Education
P.O. Box DE
Agana, Guam 96910

Mr. John Balajadia, Administrator
Department of Youth Affairs
P.O. Box 23672
GMS, Guam 96921

Mr. Ricardo Salas, Director
Department of Corrections
P.O. Box 3236
Agana, Guam 96910

Mr. Frank San Agustin (2 copies)
Territorial Librarian
Nieves M. Flores Public Library
254 Martyr Street
Agana, Guam 96910

Mr. Jose Santos
Chief Executive Officer
Commissioner's Council
P.O. Box 786
Agana, Guam 96910

Ms. Frances J. Taitano
Department of Public Health
Box 2816
Agana, Guam 96911

FEDERAL OFFICIALS & AGENCIES
(other than Navy)

The Honorable Robert Underwood
Congressman
U.S. Territory of Guam
3261 W. Soledad
Agana, Guam 96910

Honorable Daniel K. Inouye
United States Senate
Washington, D.C. 20510-0001

Honorable Daniel K. Akaka
United States Senate
Washington, D.C. 20510-0001

633ABW/CC (1 copy)
Unit 14003
APO AP 96543-4003

HQ PACAF/CE (5 copies)
25E Street, Suite D306
Hickam AFB, HI 96853-5412

633 SPTG/CE (6 copies)
Unit 14041
APO AP 96543-4041

HQ USAF/CEVP (10 copies)
ATTN: Dr. Robert Ellis
Pentagon, Room 5D371
Washington, D.C. 20330-5130

AFCEE/CCR-S
ATTN: Mr. Ron McRobbie
630 Sansome Street, Room 1334
San Francisco, CA 94111-2278

Ms. Kittie Baier
Deputy Asst. Secretary
Office of Territorial Affairs
U.S. Department of the Interior
Office of the Secretary
Washington, D.C. 20240

Ms. Joan B. Perry, Director
U.S. Dept of Agriculture
Soil Conservation Service
Pacific Basin Area
GCIC Building, Suite 602
414 West Soledad Avenue
Agana, Guam 96910

Ms. Jacqueline Wyland, Chief
Office of Federal Activities
EPA, Region IX
76 Hawthorne St.
San Francisco, CA 94105

Guam Project Office
U.S. Army Corps of Engineers
PAC Daily News Bldg., Suite 905
238 O'Hara Street
Agana, Guam 96910

Superintendent
War in the Pacific
National Historic Park
P.O. Box FA
Agana, Guam 96910

Regional Director, Region IX (5 copies)
U.S. Fish and Wildlife Service
911 Northeast 11th Avenue
Portland, Oregon 97232

Hawaii Administrator
U.S. Fish and Wildlife Service
300 Ala Moana Boulevard
P.O. Box 50167
Honolulu, Hawaii 96850

Executive Director
Advisory Council on Historic Preservation
1100 Pennsylvania N.W., Room 809
Washington, D.C. 20004

Director, Western Office Project Review
Advisory Council on Historic Preservation
730 Simms Street, Room 450
Golden, Colorado 80401

Secretary's Field Representative
Pacific Southwest Region
U.S. Dept. of the Interior
450 Golden Gate Ave., Box 36098
San Francisco, CA 94102

Director, Pac SW Region
National Park Service
U.S. Department of the Interior
P.O. Box 36063
San Francisco, CA 94102

Pacific Regional Manager
NOAA, Office of Coastal Zone Mgmt.
U.S. Department of Commerce
3300 Whitehaven Street, NW
Washington, D.C. 20235

Department of Agriculture
Office of the Secretary
Coordinator, Environmental Quality Activities
Washington, D.C. 20250

FEDERAL OFFICIALS & AGENCIES (cont'd)

Office of Environmental Analysis
Federal Maritime Commission
1100 L Street, NW, Room 9102
Washington, D.C. 20573

Regional Administrator
U.S. Dept. of Health and Human Services
50 Fulton Street
San Francisco, CA 94102

Chief
Interagency Archaeological Service
National Park Service
450 Golden Gate Ave., Box 36065
San Francisco, CA 94102

Administrator, Region IX
U.S. Environmental Protection Agency
215 Fremont Street
San Francisco, CA 94105

Commander
U.S. Coast Guard
Marianas Section
FPO San Francisco, CA 96630

U.S. Army Corps of Engineers
Pacific Ocean Division
Planning Branch
Building T-1
Fort Shafter, Hawaii 96858

Hawaii Administrator
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii 96822-2396

INTERESTED PARTIES

Mr. Lorenzo I. DeLeon Guerrero
Governor of the Commonwealth of the
Northern Mariana Islands
Saipan, CNMI 96950

Mr. James Mendiola
Mayor of Tinian
San Jose Village
Tinian, MP 96952

Mr. Ron Rivera, Chair
Organization of People for Indigenous Rights
P.O. Box 12063
Tamuning, Guam 96911

Mr. Robert D. Anderson
Box 24473
G.M.F., Guam 96921

Mr. John Archibald
P.O. Box DN
Agana, Guam 96960

Mr. Antonio Torres Artero
International Real Estate Marketing
2nd Floor, YMLG Bldg. Route 8
P.O. Box 988
Agana, Guam 96910

Ms. Eloise Baza, President
Guam Chamber of Commerce
P.O. Box 283
Agana, Guam 96910

Mr. Robert Beck
35 Cosa de Serenidad
Yona, Guam 96914

Mr. Joey Cepeda
Guam Visitor's Bureau
P.O. Box 3520
Agana, Guam 96910

Mr. Manuel Cruz, President
American Federation of Government Employees
AFG Loca 1689 Inc.
P.O. Drawer DK
Agana, Guam 96910

Mr. Chris Lubon
Vice President, Marianas Audobon Society
University of Guam
Division of Natural Sciences
UOG Station
Mangilao, Guam 96923

Pacific Basin Development Council
Suite 325
567 S. King Street
Honolulu, Hawaii 96813

Mr. Angel Santos, Member
Chamoru Nation Traditional Council
P.O. Box 21806
GMF Barrigada, Guam 96910

Mr. James Underwood, General Manager
Guam Telephone Authority
P.O. Box 9008
Tamuning, Guam 96911

Mr. Kau Kiang Woo, Manager
Guam Educational Telecom. Corp.
P.O. Box 21449
GMF, Guam 96921

Ms. Polly Parks
Unitarian Universalist Service Committee
130 Prospect Street
Cambridge, MA 02139

Haim Habib, Esq.
Attorney-at-Law
P.O. Box 2110
Agana, Guam 96910

Mr. Bruce A. Coppa
Vice President-Marketing & Planning
E. E. Black, Ltd.
1601 Kapiolani Blvd., Suite 1200
Honolulu, Hawaii 96814

Ms. Ann Tate
The Environmental Company
P.O. Box 5127
Charoottesville, VA 22905

Mr. E. Robert Ferguson
President
MK Pacific, Inc.
1601 Kapiolani Blvd., Suite 1200
Honolulu, Hawaii 96814

Mr. Eric C. Steadman, Analyst
SocioTechnical Research Applications, Inc.
Energy & Environment Division
1101 Wilson Blvd., Suite 1950
Arlington, VA 22209

National Forest, Kamas Ranger District, ummit County, UT.

Summary: EPA expressed environmental concerns regarding the proposed project. These concerns were for the lack of adoquate information on water quality and a clear plan for monitoring of project impacts.

ERP No. F-BLM-L65158-OR Lower Deschutes Wild and Scenic River Management Plan, Implementation, Addresses Alternatives for Access to Public Lands Upstream from the Deschutes Club Locked Gate, Wasco County, OR.

Summary: EPA had no objections to the preferred alternative as it was described in the final EIS.

ERP No. F-FHW-H40142-MO Page Avenue Extension, Bennington Place, crossing the Missouri River Bridge to I-70 or US 40, Funding, COE Section 404 Permit and US Coast Guard Bridge Permit, St. Louis and St. Charles Counties, MO.

Summary: EPA still had objections to the proposed project due to wetland and indirect/secondary impacts. EPA does not believe that the red alignment will comply with section 404 (b)(1) Guidelines. EPA requested to be included on the wetland mitigation sultation team.

ERP No. F-FHW-H40146-MO Ozark Mountain Highroad Corridor Construction from existing US 65/MO- north of Branson, then south across ake Taneycomo to another intersection with US 65 south of Branson, Funding, COE Section 10 and 404 Permits and Coast Guard Bridge Permit, Taney and Stone Counties, MO.

Summary: EPA had no objections to he proposed project. The team dministration and the Missouri ighway and Transportation epartment (MHTDO) serves as an xample of how the process can uccessfully work to resolve concerns efore they become issues.

Dated: March 30, 1993.

William D. Dickerson,

eputy Director, Office of Federal Activities.

R Doc. 93-7745 Filed 4-1-93; 8:45 am]

LLING CODE 6560-60-P

R-FRL-4598-1]

nvironmental Impact Statements; otice of Availability

Responsible Agency: Office of Federal ctivities, General Information (202) 5076 or (202) 260-5075.

eekly Receipts Environmental pact Statements filed March 22, 1993 rough March 26, 1993 pursuant to 40 R 1506.9.

EIS No. 930095, DRAFT EIS, FHW, CA, East Sonora Bypass Corridor Construction, CA-108 from Post Mile M1.8 to Post Mile R6.9 near Sonora, Funding and Right-of-Way, City of Sonora, Tuolumne County, CA, Due: May 17, 1993, Contact: James C. Jelinek (209) 948-7918.

EIS No. 930096, DRAFT EIS, FHW, CA, CA-101 Transportation Improvement Project, between Milpas Street in the City of Santa Barbara and 1.1 Miles North of the Ventura County Line in the City of Carpinteria, Funding, COE Section 404 Permit and NPDES Permit, Santa Barbara and Ventura Counties, CA, Due: May 21, 1993, Contact: Gary L. Ruggerone (805) 549-3182.

EIS No. 930097, DRAFT EIS, AFS, OR, Santiam Pass Demo Project, Harvesting Timber and Road Construction, Willamette National Forest, McKenzie Ranger District, Linn County, OR , Due: May 17, 1993, Contact: Joe Zook (505) 822-3381.

EIS No. 930098, DRAFT EIS, FHW, FL, FL-312 Extension Project, Construction, FL-207 to US 1/FL-5 north of the City of St. Augustine, Funding, Right-of-Way Permit, COE Section 404 and NPDES Permits, St. John County, FL, Due: May 17, 1993, Contact: J. R. Skinner (904) 681-7223.

EIS No. 930099, FINAL SUPPLEMENT, COE, KY, IL, Lower Ohio River Navigation Study Area Improvements, Locks and Dams 52 & 53 (Olmsted Locks and Dams) Replacement and Additional Modifications, Cumberland River to Mississippi River Several Counties, KY and IL, Due: May 3, 1993, Contact: Michael Turner (502) 582-6015.

EIS No. 930100, DRAFT EIS, NPS, UT, Timpanogos Cave National Monument General Management and Develop Concept Plans, Implementation, American Fork Canyon, Utah County, UT, Due: June 11, 1993, Contact: Susan K. McGill (801) 756-5239.

EIS No. 930101, DRAFT EIS, GSA, Atlanta Federal Center Consolidation for the housing of several Federal Agencies, Site Specific, Rich's Department Store Martin Luther King, Jr., Drive, Atlanta, GA, Due: May 17, 1993, Contact: Judith M. Cobb (404) 331-7780.

EIS No. 930102, DRAFT SUPPLEMENT, NOA, MA, Northeast Multi-Species Fishery Management Plan, Update Information, Amendment 5, Implementation, Due: May 17, 1993, Contact: Nancy Foster (301) 713-2239.

EIS No. 930103, DRAFT EIS, FHW, PA, Mon/Fayette Transportation Project, Improvements, I-70 in Fallowfield Township to PA-51 in Jefferson Borough, Funding, COE Section 404 Permit and NPDES Permit, Mon Valley, Washington and Allegheny Counties, PA, Due: May 24, 1993, Contact: Manuel A. Marks (717) 782-3461.

EIS No. 930104, DRAFT EIS, FHW, GU, US Navy Facilities Relocation and Development, from the Republic of the Philippines to the Territory of Guam, Implementation and COE Section 404 Permit, GU, Due: May 17, 1993, Contact: Stanley Uehara (808) 471-9338.

Dated: March 30, 1993.

William D. Dickerson,

Deputy Director, Office of Federal Activities.

[FR Doc. 93-7744 Filed 4-1-93; 8:45 am]

BILLING CODE 6560-60-U

[OPPTS-66017; FRL 4579-2]

Receipt of Applications for Approval to Dispose of Polychlorinated Biphenyls

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of receipt of applications.

SUMMARY: EPA Headquarters has received applications from Clean Berkshire, Inc., Kanti Technologies, Inc., Vector Group, Inc., TechPro, Inc., and the Naval Civil Engineering Laboratory of Port Hueneme for nationwide approvals to dispose of polychlorinated biphenyls (PCBs). This approval process is done under the authority of section 6(e) of the Toxic Substances Control Act (TSCA). EPA is notifying interested persons of these requests, and requesting comments.

DATES: Comments should be received by May 3, 1993.

ADDRESSES: Three copies of written comments, identified with the document control number (OPPTS-66017) should be submitted to: TSCA Public Docket Office (TS-790), Office of Pollution Prevention and Toxics, Environmental Protection Agency, Rm. E-699, 401 M St., SW., Washington, DC 20460. The applications (without confidential business information) and comments received in response to this notice are available for public inspection and copying at the TSCA Nonconfidential Information Center (NCIC), also known as the TSCA Public Docket Office in Rm. E-G102 at the address noted above from 8 a.m. to 12 noon, and 1 p.m. to 4 p.m. Monday through Friday, except legal holidays.

FOR FURTHER INFORMATION CONTACT: Susan Hazen, Director, Environmental

3505 NW Anderson Hill Road, Silverdale, Washington, 98383–9130, (Attn: Don Morris, Code 231DM), telephone (206) 396–5976.

Dated: April 1, 1993.

Michael P. Rummel,

LCDR, JAGC, USN, Federal Register Liaison Officer.

[FR Doc. 93–7983 Filed 4–5–93; 8:45 am]

BILLING CODE 3810–AE–M

Public Hearings for the Draft Environmental Impact Statement for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

Pursuant to Council on Environmental Quality regulations (40 CFR parts 1500–1508) implementing procedural provisions of the National Environmental Policy Act, the Department of the Navy, in cooperation with the U.S. Air Force and U.S. Army Corps of Engineers, has prepared and filed with the U.S. Environmental Protection Agency the Draft Environmental Impact Statement (DEIS) for proposed facilities development and relocation of Navy activities to the Territory of Guam from the Republic of the Philippines.

The DEIS has been distributed to various federal, territory, and local agencies, elected officials, special interest groups, and the media. A limited number of single copies are available at the address listed at the end of this notice.

Two public hearings to inform the public of the DEIS findings and to solicit comments will be held on April 20, 1993; one beginning at 2 p.m., and a second at 7 p.m., in the Governor's Cabinet Conference Room at the Executive Building in Adelup, Guam.

The public hearing will be conducted by the Navy. Federal, territory, and local agencies and interested parties are invited and urged to be present or represented at the hearing. Oral statements will be heard and transcribed by a stenographer; however, to assure accuracy of the record, all statements should be submitted in writing. All statements, both oral and written, will become part of the public record on this study. Equal weight will be given to both oral and written statements.

In the interest of available time, each speaker will be asked to limit their oral comments to five minutes. If longer statements are to be presented, they should be summarized at the public hearing and submitted in writing either at the hearing or mailed to the address listed at the end of this announcement. All written statements must be postmarked by May 18, 1993, to become part of the official record.

U.S. Navy facilities in the Philippines were closed in 1992. This DEIS addresses the relocation of activities from the Philippines and the development of facilities at Navy and Air Force installations on Guam. Approximately 1,380 military billets and 1,450 dependents will ultimately be relocated to Guam. There will be several changes in military activities on Guam because of the relocation of various commands from the Philippines. To accommodate these new activities, a total of 25 military construction projects are proposed: 19 located in the Apra Harbor area and the remainder at Andersen Air Force Base (AFB), Naval Magazine, and Nimitz Hill. Facilities at Andersen AFB include a hangar/apron/washrack and renovation of bachelor quarters. In the Apra Harbor Complex, projects include 300 family housing units, Orote Power Plant expansion, Apra Harbor Sewage Treatment Plant modifications, gantry crane and rails, waterfront utilities, and various administrative facilities. Missile magazines and an inert storehouse are proposed at Naval Magazine Guam.

Additional information concerning this notice may be obtained by contacting: Mr. Stanley Uehara (Code 232), Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii 96860–7300, telephone (808) 471–9333.

Dated: April 1, 1993.

Michael P. Rummel,

LCDR, JAGC, USN, Federal Register Liaison Officer.

[FR Doc. 93–7981 Filed 4–5–93; 8:45 am]

BILLING CODE 3810–AE–M

DEPARTMENT OF EDUCATION

Indian Education National Advisory Council; Meeting

AGENCY: National Advisory Council on Indian Education, Education.

ACTION: Notice of closed meeting.

SUMMARY: This notice sets forth the schedule and proposed agenda of a forthcoming meeting of the National Advisory Council on Indian Education. This notice also describes the functions of the Council. Notice of this meeting is required under section 10(a)(2) of the Federal Advisory Committee Act.

DATES: April 26–30, 1993, from 9 a.m. to approximately 5 p.m. each day.

ADDRESSES: The meeting will be held at the Ramada Hotel Old Town, 901 North Fairfax Street, Alexandria, Virginia, 22314, (703) 683–6000.

FOR FURTHER INFORMATION CONTACT: Robert K. Chiago, Executive Director, National Advisory Council on Indian Education, 330 C Street, SW., room 4072, Switzer Building, Washington, DC 20202–7556. Telephone: 202/205–8353.

SUPPLEMENTARY INFORMATION: The National Advisory Council on Indian Education is established under section 5342 of the Indian Education Act of 1988 (25 U.S.C. 2642). The Council is established to, among other things, assist the Secretary of Education in carrying out responsibilities under the Indian Education Act of 1988 (Part C, Title V, Pub. L. 100–297) and to advise Congress and the Secretary of Education with regard to federal education programs in which Indian children or adults participate or from which they can benefit.

Under section 5342(b)(2) of the Indian Education Act, the Council is directed to review applications for assistance and to make recommendations to the Secretary of Education with respect to their approval. The duly authorized Proposal Review Committee of the Council will meet in closed session starting at approximately 9 a.m. and will end at approximately 5 p.m. each day during the proposal review session. The agenda will include reviewing grant applications for assistance for programs authorized by subparts 1, 2, and 3 of the Indian Education Act of 1988 including applications for (1) Discretionary grants to Indian Controlled Schools; (2) Educational Services for Indian Children; and (3) Educational Services for Indian Adults.

The discussion during the review process may disclose sensitive information about applicants, qualifications of proposed staff, funding level requests and the names and comments of expert reviewers. Such discussion would disclose commercial or financial information obtained from a person, and is privileged or confidential and would disclose information of a personal nature where disclosure would constitute a clearly unwarranted invasion of personal privacy if conducted in open session. Such matters are protected by exemptions (4) and (6) of section 552b(c) of the Government in the Sunshine Act (Pub. L. 94–409; 5 U.S.C. 552b(c)).

Records are kept of all Council proceedings, and are available for public inspection. A summary of activities of this closed meeting which are informative to the public consistent with the policy of title 5 U.S.C. 552b shall be available for public inspection

July 23, 1993. Contact: Jeff Hammes (503) 427-3231.

S No. 930171, DRAFT EIS, FHW, WA, I-5/196th Street SW/WA-524 Interchange Project, Improvements, Funding, NPDES and COE Section 404 Permits, Snohomish County, WA, Due: July 19, 1993, Contact: Barry F. Morehead (206) 753-2120.

EIS No. 930172, DRAFT EIS, AFS, AK, Campbell Timber Sale, Implementation, Tongass National Forest, Stikine Area, AK, Due: July 14, 1993, Contact: Meg Mitchell (907) 874-2323.

EIS No. 930173, FINAL EIS, GSA, GA, Atlanta Federal Center Consolidation for the housing of several Federal Agencies, Site Specific, Rich's Department Store, Martin Luther King, Jr. Drive, Atlanta, GA, Due: June 28, 1993, Contact: Judith M. Cobb (404) 331-7780.

Dated: May 25, 1993.

William D. Dickerson,

Deputy Director, Office of Federal Activities.

[FR Doc. 93-12751 Filed 5-27-93; 8:45 am]

BILLING CODE 6560-50-U

[ER-FRL-4621-1]

Environmental Impact Statements and Regulations; Availability of EPA Comments

Availability of EPA comments prepared May 10, 1993 through May 14, 1993 pursuant to the Environmental Review Process (ERP), under Section 309 of the Clean Air Act and Section 102(2)(c) of the National Environmental Policy Act as amended. Requests for copies of EPA comments can be directed to the Office of Federal Activities at (202) 260-5076.

An explanation of the ratings assigned to draft environmental impact statements (EISs) was published in FR dated April 09, 1993 (58 FR 18392).

Draft EISs

ERP No. D-APH-A82123-00 Rating EC2, Medfly (Mediterranean Fruit Fly) Cooperative Eradication Program, Implementation, AL, AZ, CA, FL, GA, LA, MS, SC and TX.

Summary: EPA had environmental concerns with the proposed program regarding information on site-specific characteristics, monitoring, endangered species, and pesticide use. Additional information on these subjects was requested.

ERP No. D-FHW-E40332-FL Rating EC2, FL-312 Extension Project, Construction, FL-207 to US 1/FL-5 north of the City of St. Augustine, Funding, Right-of-Way Permit, COE Section 404 and NPDES Permits, St. Johns County, FL.

Summary: EPA concluded that the major impact to the natural environment from the proposed roadway would be to wetlands. Information on wetland mitigation and noise impacts were not adequate to assess project impacts.

ERP No. D-GSA-K40195-CA Rating EO2, Calexico East Border Station Construction and Road Construction, CA-7 between the near Port of Entry and CA-98 that borders the United States and Mexico, Funding and Right-of-Way Permit, City of Calexico, Imperial County, CA.

Summary: EPA expressed environmental objections due to potential adverse impacts to water quality via indirect growth and the accidental release of hazardous material.

ERP No. D-USN-K11101-GU Rating EO2, US Navy Facilities Relocation and Development, from the Republic of the Philippines to the Territory of Guam, Implementation and COE Section 404 Permit, GU.

Summary: EPA expressed environmental objections because of projected exceedances of Federal air quality standards for sulfur dioxide and particulate matter due to upgrading the Orote Power Plant and potential impacts to water quality and biota from harbor dredging and the disposal of dredge sediments. EPA requested information in the final EIS on dredging and disposal impacts, asbestos and polychlorinated biphenyls, and urged the Navy to adopt a wide variety of pollution prevention measures in the Record of Decision including a comprehensive hazardous waste minimization program at the Guam military facility.

Final EISs

ERP No. F-AFS-K61124-CA Echo Summit Ski Area Site, Operation and Management, Issue Special Use Permit, El Dorado National Forest, Placerville Ranger District, El Dorado County, CA.

Summary: Review of the Final EIS was not deemed necessary. No formal letter was sent to the preparing agency.

ERP No. F-AFS-L65189-ID Steen Creek Salvage Timber Sale, Salvage Harvest Timber and Possible Road Construction, Payette National Forest, Adams County, ID.

Summary: Review of the Final EIS has been completed and the project found to be satisfactory. No formal letter was sent to the preparing agency.

ERP No. F-BOP-E81034-SC Edgefield Low Security Federal Correctional Institution, Construction, Operation and Site Selection, Edgefield County, SC.

Summary: EPA had no objections to this project.

ERP No. F-IBR-K28015-CA Salinas Valley Seawater Intrusion Program, Long-Term Water Supply, Funding, COE Section 10 and 404 Permits, Salinas River, Castroville, Marina and Fort Ord Areas, Salinas Valley, Monterey County, CA.

Summary: Review of the Final EIS was not deemed necessary. No formal letter was sent to the preparing agency.

Other

ERP No. LF-NOA-A91057-00 Regime to Govern the Incidental Taking of Marine Mammals during Commercial Fishing Operations after October 1, 1993, Development, Management and Permit Approval.

Summary: EPA had no objections to the activities suggested in the document. The FEIS has adequately responded to many of the comments that EPA raised in its review of the DEIS in September, 1991.

Dated: May 25, 1993.

William D. Dickerson,

Deputy Director, Office of Federal Activities.

[FR Doc. 93-12752 Filed 5-27-93; 8:45 am]

BILLING CODE 6560-50-U

[FRL-4660-3]

Minnesota: Adequacy Determination of State Municipal Solid Waste Permit Program

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of tentative determination on application of Minnesota for full program adequacy determination, public hearing and public comment period.

SUMMARY: Section 4005(c)(1)(B) of the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, requires States to develop and implement permit programs to ensure that municipal solid waste landfills (MSWLFs) which may receive hazardous household waste will comply with the revised Federal Criteria (40 CFR part 258). RCRA section 4005(c)(1)(C) requires the Environmental Protection Agency (EPA) to determine whether States have adequate permit programs for MSWLFs, but does not mandate issuance of a rule for such determinations. The EPA has drafted and is in the process of proposing the State/Tribal Implementation Rule (STIR) that will provide procedures by which the EPA will approve, or partially approve, State/Tribal MSWLF permit programs as applications are submitted. Thus, the approvals are dependent on final promulgation of the STIR. Prior to promulgation of the STIR, adequacy determinations will be made based on

Department of Agriculture
Division of Aquatic and Wildlife Resources
P.O. Box 2950
Agana, Guam 96910
Telephone Numbers (671)734-3402/3944/3945/5283
Fax Number (671)734-6570
E-mail:SUNIPORTALICUP.PORTAL.COM!GUAM-DAWR

TESTIMONY ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS) FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

My name is Rufo J. Lujan and I am the Chief of the Division of Aquatic and Wildlife Resources at the Department of Agriculture. I am here today to testify on behalf of the Director of Agriculture. This oral testimony is in reference to the Draft Environmental Impact Statement (DEIS) for proposed facilities Development and Relocation of Navy activities to the Territory of Guam from the Republic of the Philippines.

Our foremost concern is the impacts that VRC-50 activities, particularly field carrier landing practice (FCLP) and touch and go operations, that take place on Andersen Air Force Base (AAFB) may have on the endangered Mariana crow and fruit bat. Our comments today will concentrate on the VRC-50 issue; more detailed written comments will be submitted before the May 18 deadline that discuss other aspects of the DEIS .

In a response to the Navy's formal consultation under Section 7 of the Endangered Species Act of 1973, the US Fish and Wildlife Service (USFWS) stated in a June 22, 1992 Biological Opinion, that the 600 foot field carrier landing practices are not likely to jeopardize the continued existence of any endangered or threatened species at AAFB. However, in the Incidental Take Statement contained in that Biological Opinion, the USFWS recognized that the FCLP flight pattern will be over habitat that may contain Mariana Crow nesting territories and nests, and further, that "the sight and sound of aircraft flying at the low elevations required by FCLP's would be expected to harass any birds in close proximity." Harassment is considered a form of take under Section 9 of the ESA. The USFWS specified a number of mandatory reasonable and prudent measures to prevent the taking of crows through harassment. These measures consisted of a program of pre-operational surveys for crows and crow nests within and near the "racetrack" area defined by the FCLP flight pattern. This was to be followed by close observation during controlled flight operations of any crows and/or crow nests, with or without eggs and/or young, that are found, in order to determine the impacts of flight operations upon them. Ultimately, these mandatory, reasonable and prudent measures evolved into a formal, six-month study that has had inconclusive results to date. The intensive survey activity that has taken place, however, has revealed greater use of this area by crows than previously thought.

During the study, two crow nests were located and snake-proofed within the vicinity of the FCLP "racetrack", and a number of other nests were located and snakeproofed elsewhere on AAFB. Unfortunately, both of the nests within the FCLP flight pattern were abandoned due to unknown causes, and the needed observation of the effects of FCLP operations did not take place. The study results have been confounded by many instances of uncontrolled aircraft flying below 1000 feet above ground level (AGL) over the FCLP racetrack area during the survey portion of the study, once while our staff were actually snakeproofing a nest in a nearby area. Whether this uncontrolled aircraft activity was responsible for the loss of the nests cannot be determined.

The effects of certain low flying aircraft on crow behavior are already known from prior observation of helicopters. The low flying aircraft attracts the attention of the male of the breeding pair, preventing him from defending the nest site from adjacent intruder males. Adjacent males have actually been observed to fly into the nest and attack a female incubating eggs while the territorial male is off vocally responding to the helicopter "intruder." No unaided successful fledging of crows has been observed in the wild since 1986, apparently due to predation of eggs by the brown tree snake and this accounts for the observed decline of Marianas crows. Subsequent to these observations of helicopter/crow interactions, Andersen Air Force base imposed a 1600 feet MSL height restriction on flying over forest areas; since this has been in effect we have noticed no problems attributable to aircraft. This past breeding season, three crows were fledged into the wild at Northwest Field as a result of our staff's efforts at snake proofing their breeding sites.

In addition to the possible impacts on the Mariana crow that VRC-50 activities may have, there is concern over the possible impact these activities may have on the Mariana fruit bat.

The Sport Fish and Wildlife Restoration and Endangered Species Conservation Programs under the Department of Agriculture, Division of Aquatic and Wildlife Resources are funded in their entirety with federal money under the Sport Fish Restoration Act of 1950, as amended, the Wildlife Restoration Act of 1937, as amended , and the Endangered Species Act of 1973, as amended.

The largest known colony (300-500) of fruit bats roosts at several different locations at Pati Point. The fruit bats appear to move from one location to another in response to various disturbances such as storms, poaching, and, rarely, aircraft activity. Over the years the colony seems to have adapted to routine aircraft activity involving flying straight in and off the runways. However, on several occasions DAWR biologists have observed disturbances of the colony by small, very loud, aircraft with unusual flight patterns. For instance, on one occasion an F-15 was observed to fly low over the colony, which promptly caused the colony to abandon the site and move to a new location. Not only were the bats disturbed, but the bats movement in suddenly rising from the roost site may pose a direct threat to the aircraft as well. Further, such abrupt movement of the colony may cause young that cannot fly to be left behind or dropped by their mothers, resulting in increased mortality. As stated above with respect to crows, such harassment constitutes take under Section 9 of the ESA, and therefore it is important that the impacts of VRC-50 flight operations on fruit bats be properly assessed.

In the Incidental Take Statement in their Biological Opinion, the USFWS also specified a number of mandatory reasonable and prudent measures to prevent the taking of fruit bats through harassment. These measures consisted of a program of observation of roosting bats during FCLP operations and required modification or suspension of the FCLP operation if the roosting colony is disturbed beyond a specified threshold. Understandably, this required observation of fruit bats cannot be accomplished until FCLP operations are allowed as a part of the required study of FCLP impacts on nesting crows.

Because of the inconclusive results of the crow study to date, we recommend that FCLP operations not be allowed at Andersen Air Force Base until more conclusive results are obtained by continuing the crow study through the next nesting season. During the interim, we suggest that the Navy and the Air Force take measures to ensure that there be no repeat of this year's unauthorized aircraft activity over the proposed FCLP "racetrack", as such activity can only serve to confound the results of what is intended to be a controlled experiment to determine impacts.

With respect to other aspects of the relocation of Navy activities to Guam, we are particularly concerned that care be taken to avoid impacts to wetlands, native limestone forest, and our beaches, coral reefs, and coastal waters. Whenever possible, adverse impacts to these resources should be avoided; where avoidance is not possible, then those impacts should be minimized and appropriate mitigation provided to offset the damage that is done. We are pleased that it appears that some relocation plans, such as the construction of new housing at Naval Station, have been modified somewhat to avoid sensitive areas such as wetlands and species-rich limestone forest.

We appreciate the opportunity to comment on this matter.

RUPO J. LUJAN
Chief, Aquatic & Wildlife Resources
April 20, 1993

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF

May 12, 1993

Planning Division

Mr. Melvin N. Kaku, Director
Environmental Planning Division
Department of the Navy
Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860-7300

Dear Mr. Kaku:

Thank you for the opportunity to review and comment on the Draft Environmental Impact Statement (EIS) for the Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines. The following comments are provided pursuant to Corps of Engineers authorities to disseminate flood hazard information under the Flood Control Act of 1960 and to issue Department of the Army (DA) permits under the Clean Water Act; the Rivers and Harbors Act of 1899; and the Marine Protection, Research and Sanctuaries Act.

a. Mr. Frank Dayton of our Guam Operations Office is reviewing the permit requirements for this project. He will be sending your office the required information under separate cover.

b. According to the enclosed Federal Emergency Management Agency's Flood Insurance Rate Maps, the proposed relocations are located in the following flood zones:

(1) US Naval Station (Nimitz Hill Annex) Site (Panel 660001-0041B, dated November 15, 1985): Zone C (areas of minimal flooding).

(2) US Naval Hospital Site (Panel 660001-0041B, dated November 15, 1985): Zone C (areas of minimal flooding), Zone A (areas of the 100-year flood where base flood elevations and flood hazard factors have not been determined); and, Zone A3 (areas of the 100-year flood with a base flood elevation of 19 feet above mean sea level).

(3) Anderson Air Force Base Site (Panel 660001-0025B, dated November 15, 1985): Zone A (areas of the 100-year flood where base flood elevations and flood hazard factors have not been determined) and Zone C (areas of minimal flooding).

(4) US Naval Magazine Site (Panel 660001-0100B, dated November 15, 1985): Zone A (areas of the 100-year flood wherebase flood elevations and flood hazard factors have not been determined) and Zone C (areas of minimal flooding).

(5) Apra Harbor Naval Reservation Site (Panel 660001-0050B, dated November 15, 1985): Zone A (areas of the 100-year flood where base flood elevations and flood hazard factors have not been determined), Zone C (areas of minimal flooding), and Zone B (areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one foot).

(6) Cabras Island Site (Panel 660001-0037B, dated November 15, 1985): Zone A (areas of the 100-year flood where base flood elevations and flood hazard factors have not been determined), Zone C (areas of minimal flooding), Zone B (areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one foot), Zone AH (areas of 100-year shallow flooding where depths are between one and three feet; base flood elevations are shown, but no flood hazard factors are determined), Zone A6 (areas of the 100-year flood with a base flood elevation of 8 to 9 feet above mean sea level),and, Zone V8 (areas of 100-year coastal flooding with a base flood elevation of 10 to 12 feet above mean sea level).

Sincerely,

Kisuk Cheung, P.E.
Director of Engineering

Enclosures

DEPARTMENT OF THE NAVY

RECEIVED PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

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18 JUN 1993

Mr. Kisuk Chung, P.E.
Director of Engineering
Department of the Army
U.S. Army Engineer District, Honolulu
Fort Shafter, HI 96858-5440

Dear Mr. Chung:

Subj: Draft Environmental Impact Statement (DEIS) for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

Thank you for your letter dated May 12, 1993, regarding the DEIS for the above referenced action. We have taken the information you provided on flood hazards and incorporated it into section 4.12.1.1 of the document.

Sincerely,

Melvin N. Kaku

MELVIN N. KAKU
Director
Environmental Planning
Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

B-13

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, Ca. 94105-3901

May 17, 1993

Melvin N. Kaku, Director
Environmental Planning Division
Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860
ATTN: Stanley Uehara, Code 232

Dear Mr. Kaku:

The U.S. Environmental Protection Agency (U.S. EPA) has reviewed the Draft Environmental Impact Statement (DEIS) for PROPOSED DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES. The DEIS was prepared by the Navy in cooperation with the Air Force and the Army Corps of Engineers. Our comments are provided pursuant to the National Environmental Policy Act (NEPA), the Council on Environmental Quality's Regulations for Implementing NEPA (40 CFR 1500-1508), and Section 309 of the Clean Air Act. U.S. EPA provided written scoping comments to the Navy on June 19, 1992.

Navy facilities in the Philippines were closed in 1992 by mutual agreement between the two governments. Proposed actions include permanent changes in military activities on Guam due to the relocation of various Navy commands and the construction of permanent facilities on Guam to accommodate the relocation of approximately 1,380 Navy positions and 1,450 Navy dependents. A total of 25 military construction projects are proposed.

We have rated the DEIS as Category EO-2, Environmental Objections - Insufficient Information (Enclosure 1). We have rated the DEIS as "Environmental Objections" for three reasons. Our first objection is the apparent absence in the DEIS of a firm commitment to implement a strong, comprehensive program to minimize the amount of hazardous waste requiring storage, treatment or disposal. The Final Environmental Impact Statement (FEIS) needs to more fully discuss how the Navy, the Air Force, and/or the Defense Reutilization and Marketing Office intend to reduce the volume of hazardous waste associated with the proposed action. Appropriate commitments for hazardous waste minimization should be included in the Record of Decision.

B-14

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Our second objection regards projected impacts to air quality. The DEIS states that "[m]odeling of the proposed new plant (Orote Power Plant) showed an anticipated exceedance of the 24-hour PM and SO2 increments." (p. 4-41). This would be inconsistent with a major requirement of the Clean Air Act, namely, the maintenance of federal air quality standards. Please note that U.S. EPA cannot issue a Prevention of Significant Deterioration (PSD) permit unless exceedances of PSD Class II increments are avoided. The DEIS recognizes that one or more air quality mitigation measures will be determined through discussions with U.S. EPA. Appropriate commitments concerning consistency with PSD requirements should be in the Record of Decision.

Our third objection regards undefined impacts to water quality and biota from probable dredging and disposal of sediments.

We have rated the DEIS as "2 - Insufficient Information" for several reasons. We question the Navy's decision to defer its environmental impact assessment of dredging and dredged material disposal to some future time even though planned vessel use will probably necessitate dredging and disposal actions. We believe that the decision not to assess dredging and disposal actions in the current EIS may be inconsistent with the Council on Environmental Quality's requirement that Federal agencies not "piecemeal" projects. Since the dredging is related to the relocation action, we believe it should have been assessed in the current DEIS. If increased maintenance dredging is required to accommodate the proposed relocation, then this issue should be addressed in the current EIS. If a large volume of sediment must be dredged, for example from deepening the harbor/channel, or if the sediments are contaminated, we recommend that the Navy revise this DEIS rather than attempt to present these important issues in the FEIS. If dredging or deepening is not required, the FEIS should so state.

If dredging or deepening is required, the current EIS should contain additional information on the amount of dredging which may be required in the harbor/channel, the areas to be dredged, the extent of sediment contamination (known or suspected), the type(s) of contaminants, and future disposal options.

The FEIS should contain additional information regarding the presence or absence of asbestos and polychlorinated biphenyls at buildings or other facilities which may be renovated or demolished.

We have comments regarding the protection of surface and coastal waters from nonpoint sources of water pollution and the integration of pollution prevention features into the proposed project. Our detailed comments are provided in Enclosure 2.

We appreciate the opportunity to comment on the DEIS. Please send us three copies of the FEIS (or Revised DEIS) at the same time it is filed with U.S. EPA's Washington, D.C. office. If you have any questions, please call me or have your staff contact David Tomsovic, Office of Federal Activities, at 415-744-1569.

Sincerely,

Jacqueline Lyland

for Deanna M. Wieman, Director
Office of External Affairs

Enclosures: 3
Summary of Rating Definitions, 1 page
Specific EIS comments, 8 pages
CEQ Pollution Prevention memo, 4 pages

cc: Vicky Tsuhako, U.S. EPA, PICO-Honolulu
Richard Sanderson, U.S. EPA, OFA/A-104, Washington, D.C.
Dinah Bear, CEQ, Washington, D.C.
Tom Peeling, Navy, Alexandria, VA
LTC James T. Muratsuchi, COE, Fort Shafter, HI
Mike Lee, COE, Fort Shafter, HI
Michael Tye, Air Force, San Francisco
Fred Castro, Guam EPA, Harmon, GU
Peter P. Leon Guerrero, Guam Bureau of Planning, Agana, GU
Joseph Mesa, Public Utility Agency of Guam, Agana, GU
John Goody, Belt Collins & Associates, Honolulu

SUMMARY OF RATING DEFINITIONS AND FOLLOW-UP ACTION

Environmental Impact of the Action

LO-Lack of Objections

The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC-Environmental Concerns

The EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts.

EO-Environmental Objections

The EPA review has identified significant environmental impacts that must be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EU-Environmentally Unsatisfactory

The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of environmental quality, public health or welfare. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommend for referral to the Council on Environmental Quality (CEQ).

Adequacy of the Impact Statement

Category 1-Adequate

EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2-Insufficient Information

The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses, or discussion should be included in the final EIS.

Category 3-Inadequate

EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

*From: EPA Manual 1640, "Policy and Procedures for the Review of Federal Actions Impacting the Environment."

ENCLOSURE 2

INTRODUCTORY COMMENTS

The U.S. Environmental Protection Agency (U.S. EPA) commends the decision to prepare an environmental impact statement (EIS) for the proposed action. We hope that the EIS will serve as a valuable mechanism for the public and government agencies to identify the various impacts of project alternative actions (including cumulative and secondary impacts) as well as mitigation to avoid or reduce adverse impacts.

It is very important for the Defense Department to work closely with the public, other Federal agencies, and the Government of Guam as the proposed project moves forward. For example, various project components may require a permit or permit modifications from U.S. EPA and/or the Guam EPA, including a Prevention of Significant Deterioration air permit; a National Pollutant Discharge Elimination System wastewater permit; and a Resource Conservation and Recovery Act hazardous waste permit. Additionally, it will be necessary for the Defense Department to ensure consistency with applicable Federal and territorial environmental requirements (e.g., consistency with Guam's plans to control nonpoint source water pollution and to protect its coastal waters).

By copy of this letter, we would like to thank the Air Force for sending us a copy of the Scoping Document on the proposed action which was prepared by Belt Collins & Associates. This gave us an early opportunity to review the comment letters submitted by private citizens and Government of Guam agencies on the Notice of Intent.

HAZARDOUS WASTE

The Draft Environmental Impact Statement (DEIS) notes the significant increase in the generation of hazardous waste on Guam due to the proposed relocation. "DRMO [Defense Reutilization and Marketing Office] expects a 30 to 40 percent increase in the volume of hazardous materials that it handles." (p. 4-165). It also appears that military hazardous waste storage facilities on Guam may experience difficulties with increased hazardous waste burdens (e.g., p. 4-159, "Currently, the Andersen storage area is exceeding its capacity.").

One of the objectives of the Solid Waste Disposal Act (SWDA), as amended by the Resource Conservation and Recovery Act (RCRA), is to protect public health and the environment by "minimizing the generation of hazardous waste and the land disposal of hazardous waste by encouraging process substitution, materials recovery,

properly conducted recycling and reuse, and treatment." [SWDA, Section 1003(a)(6)].

Section 3002(b) of the SWDA requires that generators of hazardous waste must certify that they have a program in place to reduce the volume or quantity and toxicity of such waste and that the proposed method of treatment, storage or disposal minimizes the present and future threat to human health and the environment. Hazardous waste treatment, storage, and disposal (TSD) facilities also need to have hazardous waste minimization programs in place. U.S. EPA and Guam EPA are currently reviewing a RCRA permit application (jointly filed by Navy Public Works Center [PWC] and Guam DRMO) to manage hazardous waste in a new storage facility that would be jointly managed by PWC and DRMO. One component of this permit would involve a program to minimize hazardous waste.

We note the statements in the DEIS that the Defense Department has taken steps to identify measures to reduce the waste stream. "[A] mitigation method is to reduce hazardous waste generation through a Hazardous Waste Minimization Program. Such a program has recently been developed for Guam. The goal of the...plan... is to immediately reduce hazardous waste and material by 50 percent. The overall goal is to eliminate hazardous waste generation while maintaining mission responsibilities." (p. 4-164).

While we are very supportive of these goals, the DEIS is unclear whether there is a firm commitment by the Navy, the Air Force and/or the DRMO to actually implement a hazardous waste minimization program. We note that Table 4.26.1 lists four mitigation measures to manage hazardous materials and hazardous waste: adequate DRMO staffing; improvement of DRMO contractor service; construction of a hazardous materials storage building; and construction of a DRMO facility. However, within these management measures, there is no mention of hazardous waste minimization, a deficiency which should be corrected in the FEIS.

The DEIS identifies various reasons why hazardous waste is turned over to the DRMO for disposal: excess purchase, shelf-life restrictions, mission realignment, contamination by hazardous waste, unused residual and spent material or solvents, laboratory waste, and disposal of cleanup debris (p. 4-160). Many of these appear to offer excellent opportunities to advance waste minimization goals. For example, purchases could be more closely monitored to avoid purchasing hazardous materials which have limited shelf-life and then require disposal as hazardous waste; better care could be taken to ensure that small amounts of hazardous waste do not contaminate larger volumes of non-hazardous materials or debris; additionally, product substitution

hazardous materials or debris; additionally, product substitution and process changes at military facilities can help to reduce the hazardous waste volume. As we noted in our 1992 scoping letter, we believe that the Hawaii Hazardous Waste Minimization Program offers useful pointers which can be adopted by the relocation efforts as well as continuing mission activities on Guam. We encourage your office to work closely with the Navy's environmental compliance program at Pearl Harbor (Mr. Leighton Wong) to identify specific activities on Guam which could advance waste minimization goals.

The FEIS should discuss in greater detail the waste minimization programs and techniques that will be implemented by the Navy, the Air Force and/or the DRMO, including the program mentioned on page 4-164. The Record of Decision should contain firm commitments regarding the implementation of a strong, comprehensive hazardous waste minimization program.

AIR QUALITY

The DEIS correctly notes that the expansion of the Orote Power Plant will be subject to review and approval by U.S. EPA under the Clean Air Act's Prevention of Significant Deterioration (PSD) program. The DEIS states (p. ES-8) that mitigation may include one or more of the following measures, to be determined in negotiations with U.S. EPA: limiting the sulfur content of fuel, raising Orote stack heights, limiting operating hours or fuel consumption, and/or installing emission controls. Pursuant to Section 325 of the Clean Air Act, the Navy requested a waiver of the monitoring period and having a final PSD permit prior to beginning construction of the new units, a request which is now under review by U.S. EPA. A decision by U.S. EPA on the Navy's request to allow construction to proceed prior to permit issuance should be issued shortly.

We would like to note that U.S. EPA retains the authority to issue PSD permits for Guam. However, we understand that the Navy transmitted the PSD permit application to Guam EPA rather than to U.S. EPA (conversation between Mark Sims, U.S. EPA with Clyde Haruno, Navy, April 7, 1993). The PSD permit should have been sent to U.S. EPA for review and approval, with a courtesy copy to Guam EPA. We encourage the Navy to submit its PSD permit application to U.S. EPA as soon as possible. Our review of the PSD permit application may take as long as one year following our receipt of a complete permit application. We trust that you are aware that, among other requirements, a complete PSD permit application requires one year of ambient monitoring data.

We are seriously concerned with the statement that "Compliance with the Class II increments...appears more problematic." (p. 4-41). The Navy should note that a PSD permit can only be issued if the source does not violate the Class II increments. The FEIS should more closely examine the question of whether the proposed installation of diesel generating units would comply with the Clean Air Act. Appropriate commitments concerning compliance with PSD requirements should be in the Record of Decision.

MARINE ENVIRONMENT

The DEIS states that Apra Inner Harbor maintenance dredging was initially one of the proposed relocation projects but was subsequently deleted from the scope of this EIS, although a maintenance dredging proposal may proceed in the future as a separate undertaking (p. 4-27). "To accommodate increased traffic...the Navy may need to dredge or dragbeam the western half of the inner harbor as well as a channel connecting the inner and outer harbors. This would require a Corps of Engineers permit and related agency...approvals. The issue of dredge material disposal would have to be addressed in permit documentation." (p. 4-36).

We are concerned that the issue of dredging and disposal has been deferred to a future environmental analysis process. If maintenance dredging is required to accommodate the proposed relocation from Subic Bay to Guam, this issue must be addressed in the current EIS to avoid "piecemealing" the analysis. Should deepening of the inner harbor and channel be proposed (as contrasted with maintenance dredging), we strongly encourage the preparation of a revised DEIS by the Navy. If analysis is deferred to some future time, the Record of Decision for the current relocation DEIS must state that no decision is possible regarding dredging and disposal until and unless future NEPA documentation is completed. However, if the Navy does not have sufficient information about planned vessel use to determine whether deepening or dredging is a necessity, a comprehensive analysis of dredging or deepening and disposal could be deferred to a future EIS. In this case, the Navy should not assume future ship use which requires deeper drafts in the Record of Decision for the current EIS.

At a minimum, the current EIS should discuss whether dredging and disposal are reasonably foreseeable future actions. It is unclear from the DEIS what types of combat and support ships will use Apra Harbor and what depths are necessary to accommodate them. We recommend that the FEIS discuss the types of vessels based in the Philippines which will be homeported or serviced in

Guam. The FEIS should also discuss whether any aircraft carriers are proposed for berthing in the inner harbor. Although we understand that the carriers which visited Subic Bay were homeported in Japan, the FEIS should disclose whether carriers would be serviced or homeported in Guam. We understand that aircraft carriers require berthing depths of -50 feet mean lower low water (MLLW) (Final Supplement I EIS, Disposal of Dredged Material from NAS Alameda and NSC Oakland, California at the Navy Ocean Disposal Site California, Department of the Navy, Western Division, February 1993, p. ES-1 and p. 6).

The DEIS states, "The increase in ship activity at the Naval Station will bring larger vessels with deeper drafts to the piers in inner Apra Harbor." (p. 2-3) (emphasis added). These ships will require a depth of more than 35 feet. Figure 2.3.15 shows depths in the inner harbor: the Sierra area, 34-35 feet; Mike, 35 feet; Bravo, 35 feet; between Romeo and Papa, 37 feet; and Alpha, 44 feet (the print is very blurred but appears to show 44 feet). Depths in the channel vary from 35 to 49 feet. Taken together, the statement regarding the larger vessels and the depths shown in Figure 2.3.15 lead us to question whether dredging or deepening will in fact be required in the future. This should be clarified in the current EIS.

Based upon the drafts of planned vessel use, the current EIS should clearly specify whether the inner harbor and the channel will require maintenance dredging or will need to be deepened. The current EIS should, as fully as possible, discuss the cubic yardage of sediments that will be removed, the known or suspected extent of sediment contamination, and disposal alternatives. You may want to contact your office's installation restoration program to determine if they have information on past historic practices in the harbor/channel areas that may have caused contamination as well as the nature and location of contaminants (heavy metals, pesticides, PCBs, asbestos, etc.). If a large volume of sediment must be dredged, or if contamination is present, we recommend that the Navy revise this DEIS rather than attempt to present these important environmental issues in the FEIS.

The FEIS should note that, if the Navy requires an ocean disposal site for the dredged material, the Guam-Apra Harbor dredged material ocean disposal site is only an interim site which has not been designated or approved for use after January 1, 1997. Section 506 of the Water Resources Development Act of 1992 (P.L. 102-580) provides that as of January 1, 1997, no permit for dumping or authorization for dumping shall be issued for any site unless the site has received a final site designation pursuant to Federal law. The Guam-Apra Harbor interim site has not yet

received such a final designation. Additionally, please be aware that the future designation of a permanent ocean disposal site in Guam will be subject to the preparation of an EIS by U.S. EPA as well as a final rule to manage the site. Based on Region IX's past experience, the site designation process may take two to three years. As one step of the process, the Army Corps of Engineers' Honolulu District needs to finalize a draft Zone of Siting Feasibility (ZSF) for the designation of a permanent dredged material disposal site. U.S. EPA will use the ZSF as the basis for developing its EIS and a joint study plan for physical and biological evaluations of candidate disposal sites.

We would appreciate prompt notification from the Navy at the early stages of planning for any maintenance dredging or deepening project. The EPA Region 9 General Recommendations for Sediment Testing of Dredged Material Proposed for Ocean Dumping (appended to our June 19, 1992 scoping letter) remain in effect and should be followed if ocean disposal is pursued by the Navy.

WATER QUALITY

Section 4.5.2.2. discusses potential impacts to surface and marine waters from the project as well as mitigation measures. The DEIS identifies most potential water quality impacts taking place due to construction of new facilities at the Apra Harbor Complex and at the Naval Magazine. Increased pollutant loading is identified as a potential impact, especially during construction. Various mitigation measures are proposed, including the implementation of the Navy's Spill Prevention Control and Countermeasure (SPCC) Plan as well as utilizing berms, swales and retention basins to filter and manage construction runoff.

U.S. EPA recently issued Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (U.S. EPA, Office of Water, 840-B-92-002, January 1993). Management measures have been developed to protect coastal waters from nonpoint source pollution caused by five source categories: agriculture, silviculture, urban, marinas, and hydromodification.

The guidance document identifies a wide variety of measures to control nonpoint source pollution and stormwater runoff, including impacts that occur during a project's construction phase. Management practices assessed in the document include infiltration basins, infiltration trenches, vegetated filter strips, grassed swales, filtration basins, water quality inlets/catch basins, catch basins with sand filters, inlets with oil/grit separators, extended detention dry ponds, wetponds,

extended detention wet ponds, and constructed stormwater wetlands. The economic, environmental, and operation/management (dis)advantages of these various management practices are assessed in the document. We encourage the Navy and the Air Force to utilize this document as the planning and construction phases of specific project components proceed.

The Navy will need to coordinate its planning, construction and operational activities with both the Guam EPA and the Guam Bureau of Planning since both agencies have responsibilities in identifying and controlling water pollution in coastal waters. The FEIS should demonstrate the project's consistency with Guam's erosion, sediment control and spill prevention requirements and with Guam's coastal zone planning requirements.

POLYCHLORINATED BIPHENYLS

We were unable to find any reference in the DEIS regarding the presence or absence of polychlorinated biphenyls (PCBs) at sites where facilities may be renovated or demolished. The FEIS should discuss whether PCBs are present at any sites proposed for relocation projects or whether any projects will require their removal or disturbance. If PCBs are presently in use or stored at any facilities, the FEIS should discuss compliance with U.S. EPA's PCB rule. The FEIS should note that the Toxic Substances Control Act (TSCA) and U.S. EPA's PCB rule (40 CFR Part 761) govern the use, storage and disposal of PCBs and PCB-contaminated equipment and substances. If PCB materials are disturbed or removed, the FEIS should specify whether the work would be done by Defense Department personnel or by contractors.

ASBESTOS

It is similarly unclear whether the renovation or demolition of buildings, storage areas or other facilities will require the disturbance or removal of asbestos-containing materials (ACMs). In our experience, facility renovations (especially of older buildings) commonly involve ACMs. The FEIS should specify whether ACMs will be disturbed or removed due to relocation actions. If such is the case, the FEIS should briefly discuss compliance with the Federal Clean Air Act's asbestos NESHAP rule (National Emission Standards for Hazardous Air Pollutants). As with our PCB comment above, the FEIS should specify whether asbestos-related work would be performed by Defense Department personnel or by contractors.

POLLUTION PREVENTION

Section 4.26.7.1 identifies several pollution prevention measures which are components of the proposed project: the proposed Hazardous Materials Storage Facility; the control of nonpoint source water pollution; the development of spill prevention and control plans; and upgrading the Apra Harbor Sewage Treatment Plant. We appreciate your efforts to identify methods to control and abate environmental pollution, and suggest that the following pollution prevention measures also be implemented as part of the proposed project (please reference our 1992 scoping letter):

1) an aggressive water conservation program;
2) a comprehensive program to recycle solid wastes such as aluminum cans, glass bottles, and white and colored paper;
3) a vigorous program to substitute non-hazardous materials for hazardous materials while also preserving mission efficiency and national security;
4) a vigorous hazardous waste minimization program similar to the Hawaii Minimization Program; and
5) the installation of energy-efficient lighting, appliances and computers in new naval facilities and family housing units as well as solar energy devices.

For your reference Enclosure 3 is a copy of a memorandum issued by the Council on Environmental Quality (CEQ) concerning the National Environmental Policy Act and pollution prevention (Federal Register, January 29, 1993, pp. 6478-6481). This memorandum encourages Federal agencies to consider pollution prevention principles in their planning and decisionmaking processes in accordance with the policy goals of NEPA Section 101 and to incorporate such considerations in their NEPA documents. In accordance with the guidance, we strongly encourage the Navy to include appropriate commitments on pollution prevention in the Record of Decision.

DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

5090(P)
Ser 232/3884
15 Jul 1993

Ms. Deanna M. Wieman, Director
Office of External Affairs
United States Environmental Agency, Region IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Dear Ms. Wieman:

Subj: DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

Thank you for your letter dated May 17, 1993, regarding the Draft Environmental Impact Statement (DEIS) for the above referenced action. Our responses to your comments are as follows:

a. Comment: Concern regarding the need for the Navy and Air Force to make a firm commitment to implement a strong, comprehensive program to minimize the amount of hazardous materials stored and the amount of hazardous waste generated.

Response: The Navy and Air Force are seriously committed to hazardous waste minimization (HAZMIN). Reverse engineering surveys of the waste generating processes are scheduled for August 1993 at the Naval Ship Repair Facility and the Naval Air Station, Agana, Aircraft Intermediate Maintenance Department with the specific intent of reducing the hazardous waste generated. The Commander, U.S. Naval Forces, Marianas (COMNAVMARIANAS) is in the process of establishing a Regional Management Board for the express purpose of establishing hazardous material control and management procedures. It represents a fundamental shift in the way the Navy presently accounts for and distributes hazardous materials. This new instruction and the Board will establish hazardous material stores to centralize the retail procurement of hazardous material by all Navy users (reducing excessive purchase), require the Fleet and Industrial Supply Center (FISC) to expand their shelf life extension program to minimize the quantity of excess shelf life material declared hazardous waste, and charter working groups to identify potential substitutes for the largest waste streams at each activity (HAZMIN). The Air Force has implemented similar programs called the Pollution Prevention Action plan and the Hazardous Waste Management Plan for Andersen Air Force Base (AFB) which establish goals and policies for reducing the amount of hazardous waste generated at Andersen AFB.

The overall hazardous waste generation is not expected to change appreciably as a result of the relocated activities due to hazardous waste minimization efforts. The 30 to 40 percent increase predicted earlier during preparation of the DEIS is not supported by current information. In fact, a comparison of 1992 hazardous waste disposal statistics from the Defense Reutilization and Marketing Office (DRMO) showed that a 34 percent decrease in Navy generated Resource Conservation and Recovery Act (RCRA) waste from 1991 levels was turned into DRMO. Non-RCRA waste went up 111 percent over 1991 levels. Post-relocation conditions existed for approximately 8 months of 1992. The decrease in generation of hazardous waste is a result of Navy hazardous waste minimization efforts which coincided with the increased workloads.

Revisions to DEIS: The statements above, as well as the following discussion and update of DRMO activities and HAZMIN initiatives at the Navy and Air Force facilities have been added to Section 4.21.2.1.

The bulk of past RCRA wastes resulted from expired shelf life materials. The Navy has been addressing this procurement at a policy level, and the FISC is currently establishing a shelf life extension program. In addition, the implementation of a formal HAZMIN Plan by DRMO and Navy Public Works Center (PWC) is a condition of the Part B RCRA permit. Such a plan will describe every waste reduction activity in place and the standard operating procedures that apply. In addition, the plan shall include projected waste minimization activities and goals for hazardous waste reduction. An approved plan will be necessary before the new treatment storage and disposal facility (TSDF) begins operation in 1995.

b. Comment: Concern regarding consistency with the Prevention of Significant Deterioration (PSD) requirements (air quality impacts from Orote Power Plant Expansion).

Response: The air quality impacts for the Orote Power Plant project initially modeled in Appendix G, were based on baseline parameters before application of increased stack heights and Best Available Control Technology (BACT). The initial modeling predicted exceedence of the PSD Class II increments for PM and SO2. Additional modeling incorporating good engineering practice stack height and BACT analysis were performed during the design process. The additional modeling predicted that PSD Class II increments for PM and SO2 can be met by applying such changes as increasing stack heights and limiting sulfur content in fuel oil. Other possible mitigation options include implementing federally enforceable limitations on operating hours or fuel consumption, and installation of emission controls.

Revisions to DEIS: The above text and mitigations were incorporated into Sections 4.7.4 and 4.7.5.

c. Comment: Dredging

Response: Dredging of inner Apra Harbor is not required as a result of the proposed relocation activities, and the port, in its existing configuration, can handle all projected ship traffic resulting from relocation activities. Deepening of the harbor or new dredging would be required only if requirements for homeporting or accommodating battle groups change. No berthing requirements exist or are anticipated as a result of Subic Bay Rollback which would justify a dredging project.

Revisions to DEIS: All references to a proposed dredging project are deleted.

d. Comment: Concern regarding the protection of surface and coastal waters from nonpoint sources of water pollution and the integration of pollution prevention features into the proposed projects. Need to demonstrate project's consistency with Guam's erosion, sediment control and spill prevention requirements, and with Coastal Zone Management Act requirements.

Response: To mitigate potential impacts to surface and coastal waters during the construction of the various proposed projects, pollution prevention measures and best management practices (BMPs) will be implemented. All contractors will be required to acquire a National Pollutant Discharge Elimination System (NPDES) stormwater permit for construction activity which will include appropriate management practices. The Government of Guam Bureau of Planning granted a positive determination for consistency with the Guam Coastal Management Program for all of the activities proposed for relocation from the Philippines to Guam.

Revisions to DEIS: None.

e. Comment: Concern regarding the potential presence of polychlorinated biphenyls (PCBs) and asbestos at buildings or other facilities which may be renovated or demolished.

Response: The Navy, as required by OPNAVINST 5090.1A, keeps an inventory of all activities which generate, use, treat, store, and/or dispose of PCBs. The only potential PCB removal or disturbance due to proposed relocation activities might come from the transformer work required as part of the proposed family housing project, the power plant project, or the renovations to the bachelors quarters at Andersen AFB. The Toxic Substance Control Act (TSCA) and 40 CFR Part 61 govern the use, storage, and disposal of PCBs and PCB-contaminated equipment and substances. PCB equipment is identified in bid documents for each of the individual projects where it applies, and the work will be completed by the contractor.

Due to the age of some of the facilities at Andersen AFB and at the Apra Harbor Complex, there is potential for asbestos materials to be present in some of the buildings scheduled for renovation or demolition. Asbestos surveys will be performed prior to any renovation or demolition work, and any asbestos-related work will be in compliance with 40 CFR Part 61, Subpart M, the Asbestos National Emission Standards for Hazardous Pollutants (NESHAP). These requirements will be included in the contractor bid documents.

Revisions to DEIS: The above text has been added to 4.21.2.3.

f. Comment: Suggestions for additional pollution prevention measures to be implemented as part of the proposed action:

Response: (1) Water conservation: New projects include water conservation features such as minimal landscaping, low flow shower heads, faucet aerators, and reduced flow toilets in housing. In addition, a Utility Technical Study is being conducted which will include a discussion on the most cost effective conservation techniques which will improve system capacity and reliability. The Navy also participates with the Public Utility Agency of Guam in a water conservation plan. (2) Solid Waste Recycling: COMNAVMARIANAS Instruction 5090.5, Solid Waste Management, was recently issued which provides a regional framework for trash disposal and recycling. It mandates implementation of recycling programs at naval activities as long as a market exists for recovery of recyclable material. (3) Substitution of hazardous materials: A vigorous program to substitute less hazardous materials for hazardous materials is the goal and intent of the newly established Regional Management Board.

(4) HAZMIN program: The Regional Management Board will also address a vigorous HAZMIN program similar to the Hawaii program. (5) Energy efficient equipment: All new projects include the use of energy efficient lighting and appliances. Solar orientation is considered during building design. Active solar energy features may be proposed during bidding on the family housing units. However, due to the prevalence of typhoons and the extremely corrosive atmosphere, active solar features are usually not cost effective. The family housing units will probably use heat recovery systems from air conditioning units to heat domestic hot water.

Revisions to DEIS: None.

We trust that these responses adequately address your concerns. Should you have any questions, contact Mr. Stanley Uehara at (808) 471-9338 or by facsimile transmission at (808) 474-4890.

Sincerely,

Melvin N. Kaku

MELVIN N. KAKU
Director
Environmental Planning Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

Unitarian Universalist Service Committee
130 Prospect Street
Cambridge MA 02139-1845
Tel (617) 868-6600
Fax (617) 868-7102

UUSC Computer Network Fax

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To: MR. STANLEY UEHARA Date: 5-17-93

From: POLLY PARKS Page 1 of 1

May 10, 1993

Dear Mr. Uehara,

Following is comment on the Draft Environmental Impact Statement for Proposed Facilities and Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines.

In regards to the proposed actions put forth in the "Draft Environmental Impact Statement (DEIS) for Proposed Facilities and Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines," I have two comments:

1. The report is intrinsically flawed as indicated on Page ES-2, with the statement, "With few exceptions, data for the DEIS was obtained prior to Typhoon Omar, which struck Guam on August 28, 1992. Typhoon Omar caused considerable infrastructure damage to facilities at Guam. Proposed actions should not go forward without reassessment of their environmental impact.

2. The socio-economic, public health, and environmental impact of the 100% increase in visits (from approximately 4 to 40) by U.S. Naval ships for voyage repair with the transfer of ship repair facilities to the Apra Harbor Complex has not been adequately addressed. Ships in port for one to three days will undoubtedly allow for shore visits. The detrimental impact on the public health, socio-economic, and overall environmental profile of similar visits to civilian sites surrounding the facility being replaced at Subic Bay Naval Base is well documented.

Thank you very much for the opportunity to comment.

Sincerely,

Polly Parks

DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

RECEIVED
1993 JUN 23 AM 5090 (P)
Ser 232/

22 JUN 1993

Ms. Polly Parks
Unitarian Universalist Service Committee
130 Prospect Street
Cambridge, MA 02139-1845

Dear Ms. Parks:

Subj: Draft Environmental Impact Statement for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

Thank you for your facsimile transmission dated May 17, 1993, regarding the Draft Environmental Impact Statement (DEIS) for the above referenced action. Our responses to your comments are as follows:

1. Comment: Concern that data for the DEIS was obtained prior to Typhoon Omar.

Response: In spite of the damage caused by Typhoon Omar, Guam was able to recover from the storm due to the island's frequent experience with such storms and, hence, the high level of preparedness on the part of Guam residents, government agencies, and businesses. Infrastructure and buildings on the island are generally designed and constructed to withstand typhoons. Therefore, the pre-Omar data generally remains valid.

Revisions to the DEIS: None.

2. Comment: Concern about the impact of increased ship visits.

Response: An assessment of Guam's social/cultural environment reveals that no detrimental public health or socioeconomic impacts are expected as a result of the increase in ship visits. The socio-economic situation and level of military activities which promoted the conditions in civilian areas that surrounded the former Subic Bay Naval Base are not projected on Guam. Guam has low unemployment and its population has a higher standard of living compared to the people of the Philippines. The economy of Guam in general including the areas surrounding military bases are not dependent on the military to the extent the civilian areas around the former Subic Bay Naval Base were. Apra Harbor is not expected to be a major liberty port as Subic Bay Naval Base was. There are no plans for aircraft carrier battle groups to visit Guam as a liberty port. As stated in section 4.11.2.4, new activities and personnel will boost the level of business in the East Agana entertainment district, but expansion of this district is not likely.

Revisions to the DEIS: None.

We trust that these responses adequately address your concerns. Should you have any questions, contact Mr. Stanley Uehara at (808) 471-9338 or by facsimile transmission (808) 474-4890.

Sincerely,

MELVIN N. KAKU
Director
Environmental Planning Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

Department of Agriculture
P.O. Box 2950
Agana, Guam 96910

Director's Office 734-3942/43
Aquatic & Wildlife Resources 734-3944/45
Agricultural Development Svcs. 734-3946/47
Forestry & Soil Resources 734-3948
Animal & Plant Industry 734-3940/49

ITONIO S. QUITUGUA
Director

JOSE A. E. MANIBUSAN
Deputy Director

May 18, 1993

Stanley Uehara (Code 232)
Department of the Navy
Pacific Division
Naval Facilities Engineering Command
(Makalapa, HI)
Pearl Harbor, HI 96860-7300

Dear Sir:

Our Department has reviewed the Draft Environmental Impact Statement (DEIS) for proposed facilities Development and Relocation of Navy activities to the Territory of Guam from the Republic of the Philippines and we submit the following comments:

B-24

ANDERSEN AIR FORCE BASE

One concern we have is the impacts that VRC-50 activities, particularly field carrier landing practice (FCLP) and touch and go operations, that take place on Andersen Air Force Base (AAFB) may have on the endangered Mariana crow and fruit bat.

In a response to the Navy's formal consultation under Section 7 of the Endangered Species Act of 1973, the US Fish and Wildlife Service (USFWS) stated in a June 22, 1992 Biological Opinion, that the 600 foot field carrier landing practices are not likely to jeopardize the continued existence of any endangered or threatened species at AAFB. However, in the Incidental Take Statement contained in that Biological Opinion, the USFWS recognized that the FCLP flight pattern will be over habitat that may contain Mariana Crow nesting territories and nests, and further, that "the sight and sound of aircraft flying at the low elevations required by FCLP's would be expected to harass any birds in close proximity." Harassment is considered a form of take under Section 9 of the ESA. The USFWS specified a number of mandatory reasonable and prudent measures to prevent the taking of crows through harassment. These measures consisted of a program of pre-operational surveys for crows and crow nests within and near the "racetrack" area defined by the FCLP flight pattern. This was to be followed by close observation during controlled flight operations of any crows and/or crow nests, with or without eggs and/or young, that are found, in order to determine the impacts of flight operations upon them. Ultimately, these mandatory, reasonable and prudent measures evolved into a formal, six-month study that has had inconclusive results to date.

Commonwealth Now!

During the study, two crow nests were located and snake-proofed within the vicinity of the FCLP "racetrack", and a number of other nests were located and snakeproofed elsewhere on AAFB. Unfortunately, both of the nests within the FCLP flight pattern were abandoned due to unknown causes, and the needed observation of the effects of FCLP operations did not take place. The study results have been confounded by several instances of uncontrolled aircraft flying below 1000 feet above ground level (AGL) over the FCLP racetrack area during the survey portion of the study, once while our staff were actually snakeproofing a nest in a nearby area. Whether this uncontrolled aircraft activity was responsible for the loss of the nests cannot be determined.

The effects of certain low flying aircraft on crow behavior are already known from prior observation of helicopters. The low flying aircraft attracts the attention of the male of the breeding pair, preventing him from defending the nest site from adjacent intruder males. Adjacent males have actually been observed to fly into the nest and attack a female incubating eggs while the territorial male is off vocally responding to the helicopter "intruder". No unaided successful fledging of crows has been observed in the wild since 1986, apparently due to predation of eggs by the brown tree snake and this accounts for the observed decline of Marianas crows. Subsequent to these observations of helicopter/crow interactions, Andersen Air Force base imposed a 1600 feet MSL height restriction on flying over forest areas; since this has been in effect we have noticed no problems attributable to aircraft. This past breeding season, three crows were fledged into the wild at Northwest Field as a result of our staff's efforts at snake proofing their breeding sites.

In addition to the possible impacts on the Mariana crow that VRC-50 activities may have, there is concern over the possible impact these activities may have on the Mariana fruit bat. The largest known colony (300-500) of fruit bats roosts at several different locations at Pati Point. The fruit bats appear to move from one location to another in response to various disturbances such as storms, poaching, and aircraft activity. Over the years the colony seems to have adapted to routine aircraft activity involving flying straight in and off the runways. However, on several occasions DAWR biologists have observed disturbances of the colony by small aircraft with unusual flight patterns. For instance, on one occasion an F-15 was observed to fly low over the colony, which promptly caused the colony to abandon the site and move to a new location. Not only were the bats disturbed, but the bats movement in suddenly rising from the roost site may pose a direct threat to the aircraft as well. Further, such abrupt movement of the colony may cause young that cannot fly to be left behind or dropped by their mothers, resulting in increased mortality. As stated above with respect to crows, such harassment constitutes take under Section 9 of the ESA, and therefore it is important that the impacts of VRC-50 flight operations on fruit bats be properly assessed.

In the Incidental Take Statement in their Biological Opinion, the USFWS also specified a number of mandatory reasonable and prudent measures to prevent the taking of fruit bats through harassment. These measures consisted of a program of observation of roosting bats during FCLP operations and required modification or suspension of the FCLP operation if the roosting colony is disturbed beyond a specified threshold. Understandably, this required observation of fruit bats cannot be accomplished until FCLP operations are allowed as a part of the required study of FCLP impacts on nesting crows.

Because of the inconclusive results of the crow study to date, we recommend that FCLP operations not be allowed at Andersen Air Force Base until more conclusive results are

obtained by continuing the crow study through the next nesting season. During the interim, we suggest that the Navy and the Air Force take measures to ensure that there be no unauthorized aircraft activity over the proposed FCLP "racetrack", as such activity can only serve to confound the results of what is intended to be a controlled experiment to determine impacts.

Another concern we have is the adequacy of the faunal survey. We view that the survey should have been carried out for a longer period. Furthermore, under "study methods" it is stated that "all sites were surveyed on foot by following roads and trails:" By experience, we feel that a well rounded survey for eight different sites would take more than four days and that birds do not always forage in areas where roads and trails exist. In another part of the DEIS it is stated that "no endangered or rare animal species appear in the managed lands or scrub forests around in Andersen." This is a false statement because our staff members and the Navy's own biologists have observed endangered birds in scrub forests on AAFB as well as in forests at Northwest Field.

On Figure 2.3.1, Andersen Air Force Base Projects, the road running along the runway is to be realigned by extending it outward in the direction of the cliffline is shown. We are aware that a building already exists in this area, however we are concerned that allowing the road to be realigned may set a precedent. As mentioned earlier, both the Mariana crow and the Mariana fruit bat forage in the forest area adjacent to the runway. The road realignment may set a precedent by allowing the slow encroachment into valuable habit and eventually may be even the complete destruction of this forested area. Should this road realignment take place, no further development should be allowed north of the new road.

NAVAL STATION/APRA HARBOR COMPLEX

We have reviewed the Botanical Survey of the U.S. Navy Relocation Sites and found a few obscure items. Under the General Warehouse description, it is stated that Pluchea indica is present and that "no wetlands are present" in this area. To our knowledge, P. indica is usually found near a source of brackish water. Under the description of the survey done at Parcel P: Camp Roxas, it is stated that "other areas within the parcel may have some Phragmites present, but mixed with greater amounts of Leucaena, which would exclude them from being considered wetlands." We disagree with this statement because we have seen Leucaena growing within wetlands dominated by Phragmites and thus based on the presence of Phragmites, which is an obligate wetland plant, we would classify this area as a wetland.

As part of the Natural Resource Management Plan (NRMP) for Naval station, aquatic areas are to be surveyed for faunal identification and quantification. However, it is difficult for our department to address whether or not the proposed activities will affect the aquatic environment directly or indirectly because such a survey has never been conducted. As a result, the impacts to these areas cannot be fully addressed. Therefore, we strongly recommend that such a survey be completed as mandated under the NRMP.

Under Section 2.2.2.1 it is stated that "the increase in ship activity at the Naval Station will bring larger vessels with deeper drafts to the piers in inner Apra Harbor" and that "some of these ships will require up to 600 ft. of pier space with over a 35 ft. depth". The environmental impacts that the required dredging may have are not addressed anywhere within this DEIS. We would like to see information regarding the proposed sites, amount of dredging and proposed methods to be used presented in the final EIS.

The potential impacts from the increased ship repair due to the increase in vessel porting in Guam was not presented in the draft and should be addressed in the final EIS. We would like information regarding the ship repair methods to be used and the possible impacts these methods may have on the water and air quality presented in the final EIS.

The demolition exercises discussed in Sections 2.2.2.6 and 4.6.2.2, have been reviewed but not yet approved. The "go-ahead" is dependent on the approval of three government agencies, which are the Department of Agriculture (DAWR), the Guam Environmental Protection Agency, and the U.S. Fish and Wildlife Service prior to the commencement of these exercises. We have concerns regarding sea turtles and the size of the charges to be used during the demolition exercises. It is mentioned under Section 4.6.2.2 that "the area is not suitable turtle habitat, and the nearest coral reefs are at a safe distance of 500 yards south of the anchorage area." We disagree with this statement because this is not the case at all, sea turtles are routinely observed in the area during aerial surveys conducted by our staff. The Apra Harbor area in general is a common forage area for both the green sea turtle and the hawksbill turtle. The fact that sea turtles are routinely observed in the area is the basis for concern for the size of some the charges to be used.

Also in Section 4.6.2.2, it is mentioned that "proposed construction consists of repairing or replacing the sheetpile bulkhead." Sheetpile replacement in Sumay should not be done during turtle nesting season which runs from April though September for the reason that a hawksbill nest site exists in the cove.

In Section 4.6.3 it is stated that "to accommodate increased traffic in Apra Harbor, the Navy may need to dredge or drag-beam the western half of the inner harbor as well as a channel connecting the inner and outer harbors." We view that this proposal was not adequately addressed in the draft EIS. We would like to see information presented regarding the proposed sites, methods of performance, potential impacts, amount to be dredged, disposition of spoils and the frequency of this activity's occurrence.

Section 4.6.2.1 discusses the expansion of the Apra Harbor sewage treatment plant . We have two primary concerns regarding this project. First is the issue of the bentonite clay. From the information provided it still seems quite possible that a fair amount of this material will be deposited on the reef. The DAWR has given considerable thought to the need for this facility versus the impact from the bentonite and views the site, although still a valuable coral reef community, can withstand the short term impacts for the benefit of the treatment plant. Our second concern regards the location of the outfall itself. The present proposal indicates that the outfall will emerge at the 120 ft. contour. From observations at other outfalls, this does not appear to be far enough from shore. There will still be a lot of planktivorous fish which will aggregate at this site and keep the outfall waste in the food chain. The DAWR feels that the outfall needs to be at least a half mile offshore from the reef margin. This will isolate whatever community of organisms may assemble at the site from the rest of the reef in the area. We recognize the additional cost of installing pipe at these depths and feel it is suitable mitigation for the short term impacts to the reef system.

In the marine environmental impact evaluation, we noticed that findings regarding Apra Harbor sediment analyses were compared to those of Ala Wai Canal in Hawaii. We view that there is no relevancy for this comparison because the two systems are not similar. However, if it can be proven that yes indeed there is relevancy we would like this information presented in the final EIS.

In conclusion, we are particularly concerned that care be taken to avoid impacts to wetlands, native limestone forest, and our beaches, coral reefs, and coastal waters. Whenever possible, adverse impacts to these resources should be avoided; where avoidance is not possible, then those impacts should be minimized and appropriate mitigation provided to offset the damage that is done.

ANTONIO S. QUITUGUA

CC: Bureau of Planning
GEPA
USFWS-Honolulu

DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

5090 (P)
Ser 232/3885
15 Jul 1993

Mr. Antonio S. Quitugua, Director
Guam Department of Agriculture
Division of Aquatic and Wildlife Resources
P.O. Box 2950
Agana, GU 96910

Dear Mr. Quitugua:

Subj: DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

Thank you for your letter dated May 18, 1993, and for written testimony provided by Mr. Rufo J. Lujan on April 20, 1993, regarding the Draft Environmental Impact Statement (DEIS) for the above referenced action. Our responses to your department's comments are as follows:

a. Comment: Concern regarding proposed VRC-50 activities, field-carrier landing practices (FCLPs) at Andersen Air Force Base (AFB) and their potential impacts upon the endangered Mariana crow and fruit bat.

Response:

- The Navy will minimize unauthorized aircraft activity.

- The Navy intends to continue the study of the impact of the VRC-50 relocation on endangered species in accordance with the terms and conditions of the Section 7 biological opinion received from the U.S. Fish and Wildlife Service under the Endangered Species Act.

Revisions to the DEIS: None.

b. Comment: Concerns regarding the adequacy of the faunal survey at Andersen AFB.

Response: While longer observation periods would yield more definite data, the Navy is confident that longer surveys of the areas in question would not have changed the results meaningfully. The scope of wildlife studies is determined not only by the size, location, and type of habitats to be evaluated, but also on the anticipated impacts of the proposed activities on those habitats. In planning for the faunal survey, all of these factors were taken into account. The time devoted to this survey was sufficient, particularly since several of the sites were developed areas almost devoid of vegetation and bird habitat.

Revisions to the DEIS: None.

c. Comment: Concern regarding the road realignment for the hangar/apron/washrack project at Andersen AFB.

Response: At the present time, the Navy has no plans to expand construction north of the realigned road.

Revisions to the DEIS: None.

d. Comment: Wetlands are present on the proposed General Warehouse site and Camp Roxas Parcel P.

Response: The dominant tree at the warehouse site is *Leucaena leucocephala*, with a few other species being present. None of the trees is a wetland indicator, so the tree layer is entirely upland. Of the 14 non-tree species found at the site, only *Pluchea indica* (FAC), *Desmanthus virgatus* (FACUP*), and possibly *Nephrolepis hirsutula* (FAC*) are not upland plants. Because the tree layer is entirely upland, the ground layers are predominantly upland, and there is not a single OBL or FACW plant present, the vegetation could not be classified as wetland. The presence of a FAC plant does not make a wetland. *Pluchea indica* is a FAC, which means that between 34 and 66 percent of the time, it is found in wetlands, which is not the case at the General Warehouse site.

For these same reasons, most of the Camp Roxas Parcel P site cannot be classified as a wetland. The area in question is dominated by *Leucaena leucocephala*, an upland species. All the other trees are also upland, except for *Mangifera indica* (mango), which is FACUP. The ground is dominated by *Imperata cylindrica* (UP), *Nephrolepis hirsutula* (FAC*), *Saccharum spontaneum* (FACUP), and *Eupatorium odoratum* (UP), and there are only small scattered patches of *Phragmites*. Therefore, the ground layers are strongly non-wetland, despite the presence of a small amount of the obligate wetland grass *Phragmites*.

The DEIS was reviewed by the Guam Corps of Engineers office, with an emphasis on potential wetland impacts. No concern was expressed about either of these sites.

Revisions to DEIS: None.

e. Comment: A survey of aquatic resources at the Naval Station should be conducted as a part of the Natural Resources Management Plan.

Response: The Navy will pursue funding for such a survey as part of its Natural Resources Management Plan Program, but not as part of this EIS, since the only direct impacts to the aquatic environment will be due to the sheetpile bulkhead repairs. The maintenance dredging of inner Apra Harbor is not required to support the relocation activities.

Revisions to DEIS: None.

f. Comment: Request for more information on dredging of inner Apra Harbor.

Response: Dredging of inner Apra Harbor is not required as a result of the proposed relocation of activities. In its existing configuration, the harbor can handle all projected ship traffic. Deepening of the harbor or new dredging would be required only if requirements for homeporting or accommodating battle groups change. No berthing requirements exist or are anticipated as a result of the relocation which would justify a dredging project.

Revisions to DEIS: Deletion of references to dredging throughout the document.

g. Comment: Need to address increased ship repairs, methods used, and their impacts on air and water quality.

Response: There will be no changes in the way the ship repair facility functions; the same methods will continue to be used. Consequently, no changes in water or air quality are foreseen. The new drydock will obtain a National Pollutant Discharge Elimination System (NPDES) permit before operations begin.

Revisions to DEIS: None.

h. Comment: Concern about sizes of charges to be used and impacts of Explosive Ordnance Disposal Mobile Unit (EODMU)-5 demolition exercises on turtles.

Response: The Navy realizes the potential impacts that demolition exercises may have upon turtles and other marine species in Apra Harbor and entered into a Section 7 consultation with the National Marine Fisheries Service to gain approval for the proposed exercises as well as mitigation measures to be applied. These mitigation measures are incorporated in the Final EIS in Section 4.6.2.2.

Revisions to DEIS: Add mitigation measures to Section 4.6.2.2 and Table 4.26.1.

i. Comment: Disagreement with statement in Section 4.6.2.2 that demolition area is not a suitable turtle habitat.

Response: Navy divers inspected the proposed demolition site and surrounding area to a depth of 140 feet on August 16, 1991. They observed only muddy harbor floor with the closest coral growth at a safe distance of 500 yards south of the anchorage area. Although turtles and other fish species have been observed foraging throughout Apra Harbor, the proposed demolition area is not considered a significant feeding ground or known fisheries habitat.

Revisions to DEIS: Add above text to Section 4.6.2.2

j. Comment: Sheetpile replacement at the EODMU-5 bulkhead should not be done during turtle nesting season which runs from April through September because a hawksbill turtle nest site exists in Sumay Cove.

Response: It is reasonable and feasible to prohibit in-water work at the bulkhead during the turtle nesting season. However, it is probably not necessary to limit dryland work such as backfilling and capping of the new piling.

Revisions to DEIS: Add this mitigation in Section 4.6.2.2 and in Table 4.26.1.

k. Comment: Concerns about the Apra Harbor sewage treatment plant (bentonite clay and location of outfall).

Response: There is no mention of bentonite clay in the discussion of the sewage treatment plant. Since the joint Public Utility Agency of Guam (PUAG)/Navy outfall is a separate project and not a part of the proposed relocation actions, issues concerning the outfall location and its environmental impacts are not discussed in this EIS.

Revisions to DEIS: None.

1. Comment: Are the Ala Wai Canal findings relevant to the Apra Harbor sediment analysis?

   Response: It is stated in the Marine Research Consultants report that "For comparative purposes typical values from a variety of other sediments are also shown in Table 4." These include sediments collected in the Ala Wai Canal and Pearl Harbor, which represent areas that can be considered "worst case scenarios." The Ala Wai receives runoff from a heavily urbanized area, while Pearl Harbor has a long history of military/industrial usage. The comparisons with Apra Harbor are simply intended to put the results into a global context.

   Revisions to DEIS: None.

We trust that these responses adequately address your concerns. Should you have any questions, contact Mr. Stanley Uehara at (808) 471-9338 or by facsimile transmission (808) 474-4890.

Sincerely,

MELVIN N. KAKU
Director
Environmental Planning Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

Territory of Guam
Territorian Guam

OFFICE OF THE GOVERNOR
LIFESMAN I MAGA'LAHI
AGANA, GUAM 96910 U.S.A.

MAY 19 1993

Mr. Stanley Uehara (Code 232)
Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860-7300

Hafa Adai Mr. Uehara:

Thank you for the opportunity to review and comment on the draft environmental impact statement (DEIS) for proposed facilities development and relocation of Navy activities to the Territory of Guam from the Republic of the Philippines. Over the years, Guam has developed a proud reputation of loyalty to the United States which will remain untarnished through our support of the relocation of Navy activities here. However, we cannot continue to fuel the impression that Guam is solely a military base that lacks a vibrant civilian economy. Therefore, while I remain steadfast in my support of the relocation of Navy activities to Guam, this relocation must be accomplished in a fashion that reflects both national and local interests. It is in this vein that I offer the following comments.

B-30

We note that the DEIS reiterates Navy's position that activities to be relocated to Guam will be based at existing military installations and that federal lands previously declared excess will not be used. We emphatically urge that the Navy continue to adhere to this position, particularly given the Territory's long quest to have these lands transferred to the people and Government of Guam.

Directly related to the issue of Guam's quest for the return of federal lands to the Government of Guam is that of the Territory's efforts to have Naval Air Station (NAS) Agana closed and transferred to the Government of Guam; and to have its naval air activities relocated to Andersen Air Force Base (AAFB). Both the Navy and the Air Force have agreed, in concept, to the transfer of NAS Agana property to the Government of Guam and the relocation of NAS activities to Andersen. Consistent with this position, we note that the DEIS indicated that using facilities at NAS Agana was not preferred because of the possibility of relocating NAS operations to Andersen, with regards to alternatives to construction of the VRC-50 hangar, apron and washrack facility. We support these activities.

Commonwealth Now!

Contrary to this position however, the DEIS indicates that NAS Agana will be receiving an additional 138 personnel. (This figure appears to be understated because figures presented in the narrative in Section 2.2.4.1 total 145 additional personnel to augment existing activities plus an additional 62 personnel under the relocated Naval Air Pacific Repair Activity (NAPRA), for a combined total of 207 additional personnel). The DEIS does not address the impacts that the assignment of these additional personnel and expansion of activities at NAS Agana will have on the transfer of NAS to the Government of Guam and the eventual relocation costs of NAS to Andersen. These impacts should be addressed in the EIS. Moreover, we question the desirability and operational effectiveness of maintaining VRC-50 aircraft at NAS despite their basing at AAFB. We request that this issue be addressed in more detail in the EIS from the standpoint of cost and operational effectiveness. We believe that relocation of NAPRA to NAS is inconsistent with the relocation of VRC-50 and its attendant facilities to AAFB. Both should be located at AAFB.

Additionally, the DEIS states in Section 4.1.2.4 that no construction is proposed at NAS Agana. However, we note that in Appendix C, page C-1, a table provides a list of special projects at the affected military installations which are not addressed anywhere else in the DEIS. Included on the list are special projects identified for NAS Agana which appear to be related to the personnel and activities to be augmented at NAS. The special projects should be addressed in the EIS, particularly the impacts that the NAS projects will have on the transfer of NAS to the Government of Guam and, the relocation costs of NAS to Andersen.

The DEIS presents a relatively brief analysis of the impacts resulting from the relocation of the Military Sealift Command to Guam. While we understand that this relocation and subsequent conversion of existing ships under Navy Command to MSC will reduce overall housing needs of the military, we wonder about any near or long term impacts on revenues and activities at the Commercial Port of Guam. The final EIS should assess potential impacts in these areas.

The DEIS mentions that access to Old Wives Beach will be improved. While we support activities that increase access to recreational beaches, we are deeply concerned that improvements at Old Wives Beach are intended more for the proposed Navy Lodge than for increasing accessibility to beach areas as a result of possible closures of GabGab during ammunition off-loading. As you may know, both the Government of Guam and the Guam Chamber of Commerce oppose the construction of the Navy Lodge. The EIS should include improvements to other beach areas, based upon an analysis of the frequency of their use by both the military and the civilian population.

On the question of housing for military personnel and dependents, I request that more detailed but concise information be provided that will allow us to verify the claim that additional housing is needed. We believe that the vacancy rate in military housing is presently high but has been masked by the use of these units by personnel who may not normally qualify for such housing. We do not believe it to be prudent public policy for the military to accommodate 100% of its housing needs when the private sector on Guam can provide such housing.

Lastly, I have been advised by the Guam Department of Agriculture that the impacts of Field Carrier Landing Practices at AAFB need to be fully investigated to ensure minimal impacts on the Mariana Crow. Since an earlier evaluation developed for the DEIS proved inconclusive for various reasons, I support the continued evaluation of impacts on this endangered specie which should be conducted during the next nesting season approximately from September, 1993 to May, 1994. However, please note that it is my firm belief that appropriate mitigation measures can be devised to minimize or eliminate impacts on this specie, which would enable the FCLPs to be conducted in an environmentally conscious manner at Andersen Air Force Base. Any efforts of both the Navy and the Air Force to achieve this goal will assist us in returning NAS Agana to productive civilian use.

Since I believe that a revised DEIS is unnecessary, I recommend that these comments be incorporated and addressed in the final Environmental Impact Statement.

Enclosed is a list of additional comments and questions to be addressed in the EIS.

Thank you for the opportunity to provide comments. We look forward to the same opportunity to review the final EIS.

Sinseru,

Joseph F. Ada

JOSEPH F. ADA
Governor of Guam

Enclosure

B-31

ADDITIONAL COMMENTS

- The DEIS makes reference to the 1990 East Asia Strategy Initiative (EASI), also referred to as Nunn-Warner, and a Department of Defense 1992 report to Congress titled "A Strategic Framework for the Asian/Pacific Rim". As we are unfamiliar with these documents, we request that copies be provided for our perusal.

- The DEIS also refers to an Andersen Air Force Base Master Plan. We are not aware of the availability of a current plan and, therefore, request that a copy of the Master Plan be provided to my office to assist in our review of the final EIS.

- We note that the map in Figure 1.1.1, page 1-2, is incorrect. The figure should be identified as showing landownership rather than military facilities. Furthermore, the map should exclude those former federal lands that have been transferred to the Government of Guam. Those transferred lands include: Apra Harbor Parcel 8A (Southern High School); Naval Cemetery; Veterans Cemetery; NavCams WestPac Barrigada Parcel 1N (GCC); and portions of Camp Edusa (GHURA), Andersen Barrigada Annex (GCC), Andersen Marbo Annex (Northern High School), and Apra Harbor (Commercial Port).

- The EIS should include a facilities inventory for all military bases on Guam which includes the current usage of each facility to enable my staff to verify statements made in the DEIS, particularly one which states that all facilities at Andersen Air Force Base are in full use by the Air Force and are not suited for Navy use.

Page	Paragraph	Line	Correction
2-25	2		Should clarify that the action to increase Orote Power Plant capacity three to four times the present capacity is not entirely due to the increased demand from the Philippines relocation of activities.
2-32	2		Joint use of a new wastewater treatment plant and new ocean outfall by Navy and Government of Guam is planned and necessary for environmental protection. Continued discharge of Navy STP effluent on the dry shore from a pipe several meters above sea level should not be continued, even with upgrades to the STP, as proposed. If proper enforcement of EPA regulations were applied and the polluting discharges were prohibited, the joint Navy and Government of Guam new facility would be "economically reasonable".
2-32	2	Last	Change "4.6.2.2" to "4.6.2.1".
3-3	3	Last	Many of Guam's best examples of agricultural lands and producing farms are in the north in Yigo and Dededo. It is incorrect to say all cultivated agricultural lands are located in Guam's South.
3-7	2	Last	Housing: average price of a house and median gross rent should use newer figures from Guam Housing Corporation/Guam Economic Development Authority studies.

Page	Paragraph	Line	Correction
3-8	1	2	Change "development schemes" to "land use plans incorporating multi-use zoning, performance standards, a capital improvement program and a concurrency management system"...
3-8	4 through 7		Rewrite sections 3.3.5.2 Urban Areas and 3.3.5.3 Rural Areas as follows.
			"Urban intensity development is permitted in those areas with adequate infrastructure and lacking natural constraints. The main urban areas are located in the central part of Guam including the Agana and Tamuning areas and extending into the neighboring municipality of Dededo to the north. Other urban areas are along major highways and in village centers. The Territorial Planning Council's 25-year Land Use Plan calls for greater intensities at village centers, at regional hubs such as Agat and at areas with adequate infrastructure."
			"Rural intensity development includes agricultural use and single family residences on larger size lots, with minimal commercial and service developments. This occurs in southern and northern private lands predominately, and in areas lacking sewer facilities. The 25-year Land Use Plan will require such low intensity land uses over the aquifer recharge areas and in steeper sloped lands. These areas are predominately in the central northern part of the island and throughout the south.

Page	Paragraph	Line	Correction
3-9	4	2	Change "south" to -"northeast of Agana.
4-6	2		Without better hydrological and geological studies, as are being pursued by the Guam Water and Energy Research Institution at the University of Guam, it is not correct to conclude that the proposed facilities "will have no impact" on the Northern Lens Aquifer. Subsurface flow direction and rates of flow of water from the proposed facilities are unknown and could possibly impact on the sole water source lens.
4-17	5	1	The scrub forests around Andersen AFB could contain endangered species at times. The managed areas (lawns, etc.) must harbor migratory birds in winter at times. Flowers, gardens and fruit trees could attract endangered bats which feed on flowers and fruits wile pollinating flowers.
4-20	1	First	The over-wintering migratory birds and protected moorhens in wetlands may utilize these areas.
4-20	5	Last	Add "must" after "determination".
4-21	Last	8	Change "Bubalis" to lower case "bubalis".
4-22	2	Last	The scrub land could contain endangered plant species.
4-22	3	Last	The scrub forest could contain endangered animal species at times.
4-27	5	4	Sp. "Calalan Bank".
4-31	1	2 & 3	Approximately when will the offshore sewage diffuser be constructed? The previously required diffuser was destroyed over 17 years ago and is not yet replaced.
4-31	5	4	Field observations and measurements apply to only one brief time of the year. Impacts of the sewage discharge plume at other times of the year, with different weather and current conditions, are not assessed and should be.
4-33	2	7	"The discharge does not impact a public recreational beach." is misleading. Why is Tipalao Beach not used? Is it closed to the public or not developed for use because of sewage discharge impacts?
4-34	2	Last	The bulkhead restoration would destroy Porites coral heads at the site which appear to be over thirty years old. Recolonization will eventually return such corals, but the time period is very long.
4-76	1	5	Government of Guam controls less than 30% of the island lands and only a part of these lands are for conservation use.
4-106	4	1	Change "Control" to "Clear".
4-142	4	2 & 3	Explain why "the remoteness of Guam" requires more flight operations of VRC-50 than were needed in the Philippines.
4-148	1	1	Sp. "Merizo".
4-148	2	3	Add "The Baza Garden Treatment Plant discharges to a small surface stream."

Page	Paragraph	Line	Correction
4-148	Last	Last	Change "ocean outfall off of Tipalao Bay" to "ocean shoreline outfall at Tipalao Bay".
4-153	3	Last	Does the NPDES permit currently allow on-shore discharge of 3.2 MGD of primary treated sewage?
4-164	5	3	Sp. "Oil and Hazardous".
4-171	5	Last	Also list fire stations in Inarajan and Tamuning.
4-176	4	9	Sp. "receiving".
5-3	2	9	Does present permit allow coastal discharge on land, as now occurs?
Appendix E			This faunal survey is very inadequate.
Appendix F			This Marine Impact Evaluation is inadequate in assessment of biotic communities. It does not assess quality of existing conditions and does not even mention whether any fishes occur in impacted areas. It does not take into account environmental impacts in weather conditions that include on-shore winds at Tipalao sewage discharge.

DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

5090 (P)
Ser 232/3886
15 Jul 1993

The Honorable Joseph F. Ada
Office of the Governor
Territory of Guam
Agana, GU 96910

Dear Governor Ada:

Subj: DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

Thank you for your letter dated May 19, 1993, regarding the Draft Environmental Impact Statement (DEIS) for the above referenced action. Our responses to your comments are as follows:

a. Comment: Impact of relocation of activities to Naval Air Station (NAS) Agana on the transfer of NAS Agana to the Government of Guam; cost to relocate NAS Agana operations to Andersen Air Force Base; desirability of maintaining VRC-50 aircraft at NAS Agana.

Response: The following language will be added to the DEIS to clarify Naval Air Pacific Repair Activity (NAPRA) Guam's mission and to explain why it is being relocated to NAS Agana rather than Andersen AFB:

The mission of NAPRA Guam is to provide complex repair services to active in-service Pacific Fleet aircraft which operate in the southeast Asia and Indian Ocean area, including aircraft based on Guam. It is in essence a repair hub. Routine aircraft maintenance is usually provided by technicians assigned to the particular squadrons. When more complex repair is required, the aircraft is directed to the NAPRA for servicing. Aircraft requiring NAPRA services often cannot be flown to another location for repair and NAPRA services must be performed at the location of the aircraft.

At the present time, more Navy aircraft are assigned to and utilize NAS Agana for operations than Andersen Air Force Base. Eighty five percent of NAPRA's Guam workload is at NAS Agana and only 15 percent of the workload would be for VRC-50 at Andersen. If NAPRA were located at Andersen, maintenance teams would be required to travel by vehicle from Andersen to NAS Agana for most of their work. By locating NAPRA Guam at NAS Agana, this travel is minimized as maintenance teams from the NAPRA would commute to Andersen AFB only to repair VRC-50 aircraft. (Section 2.2.4.1)

Please note that the NAPRA Guam does not represent a new type of activity at NAS Agana, nor is it a part of VRC-50. The NAPRA Guam billets from the Philippines are a specialty component augmenting the existing intermediate maintenance unit at NAS Agana, and they are not capable of functioning independently. NAPRA Guam's proximity to other intermediate and depot level work performed by the intermediate maintenance unit at NAS Agana is important to its success. Furthermore, a typhoon resistant hangar suitable for use by NAPRA Guam was available at NAS Agana, thereby minimizing relocation costs. Again, no additional flights are expected due to relocation of the billets to NAS Agana since aircraft in need of service by NAPRA Guam personnel are usually incapacitated.

The DEIS will be revised as follows to provide clearer information on the number of personnel to be assigned to NAS Agana.

The Naval Air Station Agana (NAS Agana) will receive approximately 151 additional military billets. These will include augmentation of the Fleet Imaging Center (photography) unit by five billets, augmentation of the Aircraft Intermediate Maintenance Department by 57 billets, an aircraft operations detachment of 49 billets, and a security detachment of approximately 36 billets. The relocated Naval Air Pacific Repair Activity (NAPRA) at NAS will have one officer and five enlisted billets, plus a maximum of 56 civilian billets. Billets will be filled with local hires to the extent technically qualified individuals are available. (Section 2.2.4.1)

The issue of transferring NAS Agana operations to Andersen AFB or any other location is beyond the scope of this EIS. If a consensus is reached or if other actions occur such that the issue matures into a foreseeable proposal, the environmental consequences of that proposal will be considered in accordance with applicable laws. To do otherwise would result in the premature expenditure of funds and effort of all concerned.

Revisions to DEIS: Changes to Section 2.2.4.1, as noted above.

b. Comment: Special projects at NAS Agana should be addressed in the EIS.

Response: The special projects are discussed in Section 1.4 of the DEIS. These projects were required to provide temporary accommodations necessitated by the short time that was available for the withdrawal from the Philippines. Environmental consequences of the special projects at NAS Agana, as well as other locations were considered prior to construction. Many of the projects for work such as facility renovations were formally exempted or "categorically excluded" from further National Environmental Policy Act documentation, while environmental assessments have been approved for others. The cumulative impacts associated with these special projects are addressed throughout Chapter 4 of the DEIS. When applicable, the special projects were taken into account in the assessment of impacts on infrastructure.

Revisions to DEIS: None.

c. Comment: Impacts of Military Sealift Command (MSC) relocation on Commercial Port revenues.

Response: The relocation of MSC units will most likely increase Commercial Port revenues since supplies that used to be shipped to the Philippines for distribution will now be shipped to Guam. The existing preference for using the Commercial Port as the route of supplies coming into the Fleet and Industrial Supply Center (FISC), Guam will not change. The port has taken steps to accommodate growth by obtaining a new gantry crane and by the continuing development of land previously transferred to the port by the Navy. As stated in Section 4.14.2 of the DEIS, there will be no adverse impacts upon the commercial port resulting from this increased activity.

Revisions to DEIS: None.

5090 (P)
Ser 232/3886

d. Comment: Improvements should be made to other beaches besides Old Wives Beach.

Response: Improving access to Old Wives Beach will adequately mitigate the loss of use of Gab Gab Beach as a result of increased ammunition wharf operations. To be effective, mitigative measures should be directed at the affected population as much as possible. Old Wives Beach is the best site for improved access because it serves the same Naval Station population served by Gab Gab. There are no other unimproved beaches fronting Navy property that might be suitable for improved recreational access.

Revisions to DEIS: None.

e. Comment: Request for more information on military housing occupancy and housing policy; question about housing shortage.

Response: The Navy's most recent housing survey for Guam November 4, 1992 shows that even with the proposed 300 family housing units, there is still a deficit of 312 units. As stated in the DEIS, 250 units are planned for Fiscal Year (FY) 96-97 to help meet this need.

The vacancy rate in Navy housing on Guam is presently 1.5 percent. The only time any vacancy occurs is while a housing unit is being prepared for a new occupant or turned over to a contractor for extensive renovations. All personnel currently in military housing qualify for assignment by law. As a result of the severe housing shortage, leases with non-Department of Defense federal employees hired from off-island were terminated last year.

Housing reports used to validate family housing projects show that the Navy is planning to accommodate 86 percent of the total requirement, not 100 percent. Dependent families are now denied entry to Guam until they can execute a lease in the private sector or are assigned to family housing. Waiting time for assignment to quarters is as long as six months, depending on family size and the sponsor's rank.

Preliminary results of a comprehensive housing study prepared for the Territorial Planning Council (TPC) provide an insight into Guam's housing shortage. According to the study, Guam will need over 11,000 new or renovated rental units by 1998, and an estimated 22 percent of Guam's households live in rental units or homes that they cannot reasonably afford. Moreover, the study estimates that 14 percent of Guam families live in overcrowded conditions, and 12 percent reside in structurally inadequate units. (Source: *Pacific Daily News*, May 21, 1993)

Revisions to DEIS. None.

f. Comment: Supports continued study of the Mariana crow through the next nesting season; wants field carrier landing practices (FCLPs) to be conducted at Andersen AFB.

Response: The Navy intends to continue the study of the impact of the VRC-50 relocation on endangered species in accordance with the terms and conditions of the Section 7 biological opinion received from the U.S. Fish and Wildlife Service under the Endangered Species Act.

Revisions to DEIS: None.

g. **Comment:** Figure 1.1.1 should be corrected to show land ownership rather than military facilities; former federal lands transferred to the Government of Guam should be excluded.

Response/Revisions to DEIS: Figure 1.1.1 has been revised as recommended.

h. **Comment:** Should include a facilities inventory for all military bases on Guam to demonstrate that all facilities at Andersen AFB are in full use and not suited for Navy use.

Response. Provision of this information would go beyond the scope of the DEIS, which is not required to address the issue of verifying usage of all military facilities on Guam. The existing hangars at Andersen AFB are not suited to permanent use by VRC-50 because they are not typhoon-resistant (except for one, which will be jointly used for corrosion control), lack fire protection equipment, encroach upon active taxiways, lack ramp space immediately in front of the hangar, and have no shop or administrative space within the hangar suitable for squadron use.

Revisions to DEIS: None.

i. **Comment:** Request for copies of Munn-Warner and the Andersen AFB Master Plan.

Response: A copy of the Munn-Warner document will be transmitted to your office via Commander, U.S. Naval Forces, Marianas (COMNAVMARIANAS). Regarding the Andersen AFB Master Plan, please note that the plan referenced in the DEIS is in draft form only. Your request for a copy has been forwarded to the Air Force.

Revisions to DEIS: None.

j. **Comment:** Clarify that the power plant expansion is not entirely due to the rollback.

Response: The three diesel generators that will be installed for the Orote Point Power plant were originally slated for use at Subic Bay. The availability of these units and the need for their use on Guam is due to the closure of Subic Bay Naval Base. The EIS will include the use priorities of the new units.

Revisions to DEIS: Changes to the first and second paragraphs of Section 2.3.2.7 as follow:

The project will ensure an emergency military power supply and help meet the peak demands that were not being met by the islandwide power system. Taking no action could severely affect military operations during times of emergency power demand and would not address the inadequate islandwide power supply.

k. **Comment:** Suggests joint use of a new sewage treatment plant (STP) by the Navy and Government of Guam.

Response: Although there is a joint Navy/Public Utility Agency of Guam deep ocean effluent diffuser planned as a separate project, there is no joint wastewater treatment plant planned as a part of the proposed actions or as a separate project.

Revisions to DEIS: None.

l. **Comment:** All agricultural lands are not located in the south.

Response/Revisions to DEIS: The last sentence in the second paragraph of Section 3.1.2.1 has been deleted.

m. **Comment:** Use newer figures on average price of a house and median gross rent.

Response: Newer figures on the average price of a house and median gross rent are not yet available, pending official release of the housing study report prepared for the TPC (see item e above). To date, there have been only preliminary discussions of the findings at a meeting of the TPC held on May 20, 1993 (*Pacific Daily News*, May 21, 1993).

Revisions to DEIS: None.

n. **Comment:** Suggested revisions relating to the TPC's Land Use Plan for Guam.

Response/Revisions to DEIS: Your suggested revisions have been incorporated into Sections 3.3.5 and 3.3.5.2.

o. **Comment:** Questions the conclusion that actions will have no impact on the Northern Lens.

Response: The conclusion stated in the DEIS is that proposed facilities and activities at Andersen AFB *are not expected to impact* the Northern Lens Aquifer. This conclusion is based on the fact that there will be no significant change in current land use (airfield operations), and the washrack or other potential sources of groundwater contamination will be constructed with modern environmental measures such as drainage catch basins, oil water separators, and enclosed sewer systems to ensure that contaminated waters do not infiltrate the ground.

Revisions to DEIS: The statement in Section 4.2.2.1 has been revised to say that these facilities are not expected to impact these water resources. The above mitigation measures have been added to Section 4.2.2.1.

p. **Comment:** The scrub forests around Andersen AFB could contain endangered species at times.

Response/Revisions to DEIS: The fourth paragraph of Section 4.4.2.1 has been revised by replacing the first sentence with the following text:

Endangered or rare animal species do not generally appear in the managed lands around Andersen, although managed lands might harbor the Micronesian Starling and harbor migratory birds during the winter, and endangered bats could be attracted to flowers, gardens, and fruit trees.

q. Comment: Migratory birds and moorhen may use the wetland areas in the Tipalao Housing Expansion Areas, Northeast.

Response/Revisions to DEIS: The description in Section 4.4.2.2 of animal species found in this area has been rewritten to add a sentence (underlined) about these birds, as follows:

Other notable species to inhabit the small, marshy wetland area include the native Pacific reef heron (Egretta sacra) and the yellow bittern (Ixobrychus sinensis). Migratory birds and the protected common moorhen may also use these areas seasonally.

r. Comment: Scrub land and scrub forest could contain endangered species.

Response/Revisions to DEIS:

The last sentence in the first paragraph of Section 4.4.3.1 has been deleted.

The second paragraph of Section 4.4.3.1 has been rewritten as follows:

Endangered or protected animal species could use the second-growth forest areas at times. However, any adverse impacts to animal species generated by construction of the hangar/apron/washrack facility and relocation of the access road and above-ground line will be minimal.

s. Comment: When will the offshore sewage diffuser be constructed?

Response: According to PUAG, construction will commence around February 1994, based on a design completion in September 1993. Construction will take about two years.

Revisions to DEIS: None.

t. Comment: Assess impact of sewage discharge plume at other times of the year, under different weather and current conditions.

Response: Field work at the existing Tipalao outfall was conducted during a period of extremely calm wind and sea conditions. These conditions result in minimal dispersion of material (sewage effluent) that is discharged into the ocean. Impacts to water quality and marine biota are expected to be maximal during such periods of minimum dispersion, as the effluent would remain most concentrated during such conditions. Therefore, the conditions that occurred during the survey can be considered a "worst case scenario." The findings of the survey during the worst case conditions were that effects to water quality and biota were minimal to nonexistent owing

to rapid mixing and dilution of the effluent. Thus, during the range of weather conditions that were not actually surveyed, but where wind and sea states would promote even greater mixing, it can be interpreted that potential impacts would be equally benign.

Revisions to DEIS: None.

u. Comment: Concern about Tipalao beach access.

Response: The beach at Tipalao is rocky, not sandy, and for this reason it is not heavily used. The beach is open to the public--it is not "off limits" to hikers or swimmers--but physical access is difficult.

Revisions to DEIS: None.

v. Comment: Concern about destruction of *Porites* coral by bulkhead restoration.

Response: During the proposed repair and construction activities, the destruction of some corals on or close to the Explosive Ordnance Mobile Unit (EODMU)-5 bulkhead is almost unavoidable. However, given the dilapidated condition of the existing facility, some corals may be harmed by the crumbling bulkhead as it continues to deteriorate. The repair of the EOD bulkhead is necessary to continue the use of the EOD facility, as well as ensure the safe navigation of Sumay Cove.

Revisions to DEIS: In Section 4.6.2.2, the following sentence has been added to describe mitigation measures:

During repair, best management practices will be applied to the maximum extent practical to limit the impacts to nearby biotic communities.

w. Comment: The Government of Guam controls less than 30 percent of the land, and only part of this is for conservation use.

Response/Revisions to DEIS: The 30 percent figure is a rough estimate used for comparative purposes. This sentence in Section 4.11.1.3 has been revised to delete the phrase "as conservation land."

x. Comment: Explain why more VRC-50 flight operations are required on Guam compared to the Philippines.

Response: The increase in flight hours is due to Guam's greater distance (i.e., remoteness) from the carrier battle group's shipping lanes and deployment sites. Unlike Guam, Subic Bay Naval Base was a regular port of call for the carriers.

Revisions to DEIS: None.

y. Comment: The Baza Garden Treatment Plant discharges to a small surface stream.

Response/Revisions to DEIS: In Section 4.19.1.1, under Southern Sewage District, the following sentence has been added at the end of the second paragraph:

The Baza Garden Treatment Plant discharges to a small surface stream.

z. **Comment:** Change "ocean outfall off of Tipalao Bay" to "ocean shoreline outfall at Tipalao Bay (Section 4.19.1.2).

Response: The sewage discharge is presently into the ocean, not on land—even at low tide.

Revisions to DEIS: None.

aa. **Comment:** Question whether or not National Pollutant Discharge Elimination System (NPDES) permit currently allows onshore discharge of 3.2 mgd of primary treated sewage, and whether it allows coastal discharge of effluent on land as it exists now. (Sections 4.19.2.5 and 5.1.9)

Response: The current NPDES permit does not specify a flow rate or a discharge depth. It merely indicates discharge to the Philippine Sea for the STP. The permit is based on a design capacity of 3.2 mgd. The permit expires in November 1993 and has been submitted for renewal. The permit application will be amended to reflect the completed secondary treatment upgrade and the actual permit will be modified upon completion of the P-239 expansion.

Revisions to DEIS: None.

bb. **Comment:** List the fire stations in Inarajan and Tamuning.

Response/Revisions to DEIS: Section 4.25.2.1 has been revised to read as follows (deletions are bracketed; additions are underlined):

Guam has approximately 300 full-time professional civilian firefighters operating [six] eight civilian fire stations. These stations are located in Agat (one fire truck, one ambulance, one rescue unit); [and] Umatac (one tanker, one fire truck, one ambulance); as well as Inarajan and Tamuning.

cc. **Comment:** The faunal survey is very inadequate.

Response: The Navy is confident that the faunal survey was sufficient to address anticipated impacts. The scope of wildlife studies is determined not only by the size, location, and type of habitats to be evaluated, but also on the anticipated impacts of proposed activities on those habitats. In planning for the faunal survey, all of these factors were taken into account. However, it is noted that while longer observation periods would yield more definite data, there are practical limits to how much time is warranted for surveys. The time devoted to this survey was sufficient, particularly since several of the sites were developed areas almost devoid of vegetation and bird habitat.

Revisions to DEIS: None.

dd. **Comment:** The marine impact evaluation is inadequate in its assessment of biotic communities.

Response: The Marine Impact Evaluation was intended to assess potential impacts on the marine environment resulting from the relocation of specific activities or construction of specific facilities. From this standpoint, it is adequate, especially since dredging is no longer a proposed action. Except for the bulkhead repair, no other in-water work is planned.

Revisions to DEIS: None.

In addition, based on your comments, we have made a number of simple editorial revisions to the DEIS—for example, correction of typographical errors, spellings, etc. These are listed below:

- Changed Section 4.6.2.2 to 4.6.2.1.
- Changed "south" to "northeast of Agana." (Section 3.4.2)
- Added the word "must" after "determination." (Section 4.4.2.2)
- Changed "Bubalis" to lower case. (Section 4.4.2.3)
- Corrected the spelling of Calalan Bank. (Section 4.6.1.1)
- Changed "control zones" to "clear zones." (Section 4.12.2.3)
- Corrected the spelling of Meriso. (Section 4.19.1.1)
- Corrected the spelling of "oil." (Section 4.21.2.2)
- Corrected the spelling of "receiving." (Section 4.26.7.1)

We trust that these responses adequately address your concerns. Should you have any questions, contact Mr. Stanley Uehara at (808) 471-9338 or by facsimile transmission (808) 474-4890.

Sincerely,

MELVIN N. KAKU
Director
Environmental Planning Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

SETBISION MAMPLANEHA
Bureau of Planning
GOVERNMENT OF GUAM
AGANA, GUAM 96910

MAY 28 1993

Mr. Stanley Uehara
Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96806-7300

Hafa Adai Mr. Uehara:

The Bureau of Planning has completed its review of the Draft Environmental Impact Statements (DEIS) with the Federal Consistency Assessment for the Proposed Pacific Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines.

We conducted our review of Federal Consistency Assessment by site and separable activity being proposed for Guam, rather than the action of relocation of Subic Bay activities. We find the DEIS to be generally adequate in its discussions of the proposed permanent activities and the expected economic, social, cultural, and environmental impacts of those activities and the proposed mitigating measures to avoid or minimize negative impacts. The proposed activities for Naval Station, Apra Harbor, Naval Magazine, and Anderson Air Force Base are found to be consistent with Guam Coastal Management Program (GCMP) policies.

We believe however, that the proposed permanent relocation of the Naval Air Pacific Repair Activity (NAPRA) to Naval Air Station (NAS), Agana, may not necessarily be consistent, to the extent practicable, with GCMP. We refer specifically to the GCMP policies on Major Facility Siting, Urban Development, and Hazardous Areas. To be more specific, the discussion within the Federal Consistency format provided to our office, requires more detail in several areas.

Under the discussion on Urban Development, we feel that there should be significantly more detail as to the impacts on the surrounding urban environment due to flights from Andersen AFB to NAS for maintenance and repair work to be undertaken by Naval Air Pacific Repair Activity (NAPRA). These flights would not have to be made if the facility were located at Andersen, thus eliminating unnecessary noise and potential for disaster in a highly developed community. A more clear and reasonable explanation as to the necessity, beyond financial reasoning, for the separation of repair facilities from the objects being repaired, is necessary.

Also, under the same policy, we will require clearer information on the number of personnel which will be assigned to NAS, because of potential housing and other urban impacts. The DEIS indicates 138 personnel, while a narrative section (2.2.4.1) indicates 145 additional personnel plus to augment current activities, and an additional 62 persons for NAPRA, which totals 207 personnel, not 138.

Under the Major Facility Siting policy, the GCMP does recognize the national interest in the permanent relocation of NAPRA from the Philippines to Guam. This does not mean, however, that the DEIS has adequately demonstrated the national interest need to relocate the facility to NAS rather than to Andersen. Economic considerations alone will not constitute adequate justification for employing the national interest argument. By the same token, it can be argued that it is in the national interest to relocate all military air activities, including support facilities, to Andersen, thus allowing full use of NAS facilities for expansion of civilian air activities, thereby increasing GovGuam's capabilities for self-sufficiency and thereafter, less reliance on federal support.

Under the policy of Hazardous Areas, it is stated that "...no new (emphasis added) operations will require modification of their current respective boundaries." The point that continued hazardous operations (overflights of civilian communities) will be unnecessarily continued, thus jeopardizing those communities unnecessarily. Full discussion of NAPRA activities from this perspective should be more thoroughly investigated.

As you are aware, there is an on-going negotiation between the Government of Guam and the Department of the Navy to consolidate NAS operations to Andersen and to transfer NAS Agana to the Government of Guam. Relocating NAPRA to Andersen is in concert with the intent of the on-going negotiation. The eventual transfer of NAS Agana to GovGuam is vital to Guam's economic growth toward self sufficiency in the long term. From the community planning and management perspective, the suggested location of NAPRA to NAS is detrimental to the public welfare.

We strongly recommend that the alternative of permanently relocating NAPRA to Andersen Air Force Base be fully evaluated in other than simply economic terms, and incorporated in a redraft EIS or final EIS.

Until such time as further information is received regarding the issues raised in this letter, we will withhold further review of the consistency determination request for the NAPRA activity. All

other activities discussed within the combined DEIS are, however, herein found to be consistent with the policies of the Guam Coastal Management Program.

Thank you for the opportunity to review and comment on the DEIS. We look forward to receiving the revised EIS.

Si Yu'os Ma'ase',

CARMELITA C. BLAS
Acting Director

DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

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Ser 232/1375
15 Jun 1993

Ms. Carmelita C. Blas
Acting Director
Bureau of Planning
Government of Guam
P.O. Box 2950
Agana, Guam 96910

Dear Ms. Blas:

Subj: Draft Environmental Impact Statement and Federal Coastal Management Consistency Assessment for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

Thank you for your letter dated May 28, 1993, regarding the Draft Environmental Impact Statement (DEIS) and Federal Consistency Assessment for the above referenced action. Our responses to your comments on the proposed permanent relocation of the Naval Air Pacific Repair Activity (NAPRA) to Naval Air Station (NAS) Agana are given below:

1. The following language will be added to the DEIS to clarify NAPRA's mission and to explain why it is proposed for relocation to NAS Agana rather than Andersen Air Force Base.

The mission of NAPRA Guam is to provide complex repair services to active in-service Pacific Fleet aircraft which operate in the southeast Asia and Indian Ocean area, including aircraft based on Guam. It is in essence a repair hub. Routine aircraft maintenance is usually provided by technicians assigned to the particular squadrons. When more complex repair is required, the aircraft is directed to the NAPRA for servicing. Aircraft requiring NAPRA services often cannot be flown to another location for repair and NAPRA services must be performed at the location of the aircraft.

At the present time, more Navy aircraft are assigned to and utilize NAS Agana for operations than Andersen Air Force Base. Eighty five percent of NAPRA's Guam workload is at NAS Agana and only 15 percent of the workload would be for VRC-50 at Andersen. If NAPRA were located at Andersen, maintenance teams would be required to travel by vehicle from Andersen to NAS Agana for most of their work. By locating NAPRA Guam at NAS Agana, this travel is minimized as maintenance teams from the NAPRA would commute to Andersen AFB only to repair VRC-50 aircraft. (Section 2.2.4.1)

The last sentence in the above paragraph responds to the concern expressed in your letter under the Urban Development discussion. Most of VRC-50 aircraft repairs will take place at Andersen, so there will be minimal impacts on the surrounding urban environment due to flights between the two bases for maintenance work.

This paragraph also addresses your concerns under the Major Facility Siting policy. As explained above, the decision to relocate to NAS Agana was not based on economic considerations but on operational requirements.

Regarding the policy of Hazardous Areas, please note that the NAPRA does not represent a new type of activity at NAS Agana nor is it a part of VRC-50. The NAPRA billets from the Philippines are a specialty component augmenting the existing intermediate maintenance capability at NAS Agana, and they are not capable of functioning independently. NAPRA's proximity to other intermediate and depot level work performed by the intermediate maintenance unit at NAS is important to its success. Furthermore, a typhoon resistant hangar suitable for use by NAPRA was available at NAS, thereby minimizing relocation costs. Although NAPRA will support naval aviation throughout the Pacific, few additional flights are expected due to relocation of the billets to NAS Agana.

2. The DEIS will be revised as follows to clarify information on the number of personnel to be assigned to NAS Agana.

The Naval Air Station Agana (NAS Agana) will receive approximately 151 additional military billets. These will include augmentation of the Fleet Imaging Center (photography) unit by five billets, augmentation of the Aircraft Intermediate Maintenance Department by 57 billets, an aircraft operations detachment of 49 billets, and a security detachment of approximately 34 billets. The relocated Naval Air Pacific Repair Activity (NAPRA) at NAS will have one officer and five enlisted billets, plus a maximum of 56 civilian billets. Billets will be filled with local hires to the extent technically qualified individuals are available. (Section 2.2.4.1)

3. The issue of transferring NAS Agana operations to Andersen Air Force Base or any other location is beyond the scope of this environmental impact statement. If a consensus is reached or if other actions occur such that the issue matures into a foreseeable proposal, the environmental consequences of that proposal will be considered in accordance with applicable laws. To do otherwise would result in the premature expenditure of funds and effort of all concerned.

B-42

We trust that these responses adequately address your concerns and that a Federal Consistency Certification can be issued for this proposed action. Should you have any further questions, contact Mr. Stanley Uehara at (808) 471-9338 or by facsimile transmission at (808) 474-4890.

Sincerely,

Melvin N. Kaku

MELVIN N. KAKU
Director
Environmental Planning Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

TED M. CASTRO
Administrator
DIANNE M. BROWN
Deputy Administrator

GUAM ENVIRONMENTAL PROTECTION AGENCY

D-107 Harmon Plaza, 130 Rojas St., Harmon, Guam 96911 Tel. No. 646-8863/5 Fax: 646 9402
Ahensian Pruterksion Lina'la Guahan

MEMORANDUM JUN 0 8 1994

Stanely Uehara, Code 232
Pacific Division, Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860-7300

Re: Draft Environmental Impact Statement (DEIS) For Proposed Facilities Development And Relocation Of Navy Activities To The Territory Of Guam From The Republic Of The Philippines

Dear Mr. Uehara:

The Agency has reviewed and evaluated the referenced DEIS. The Agency's comments which follow are organized first by geographic region and then activity within the region. The Agency also recognizes that certain relocated base activities represent no significant impact individually and will therefore be omitted from our discussion as appropriate.

ANDERSEN AIR FORCE BASE, YIGO

Andersen AFB will primarily accommodate the personnel support and maintenance requirements of the VRC-50 Fleet Logistics Support Squadron should a permanent relocation from NAS Agana occur.

The environmental concerns with the proposed relocation to Andersen are potentially significant from two stand points. First, the potential impacts of flight operations to endangered species both the Marianas Crow and the two species of Marianas Fruit Bats must be critically considered. The Agency defers this assessment to the Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR) and the U.S. Fish and Wildlife Service (USFWS). Studies underway should quantify impacts and the significance of the impacts to the species for establishing long term mitigation. Should there be an adverse impact scenario then the Navy should specify which alternative is available as the preferred secondary alternative for the continued mission of the squadron.

The text on page 2-3, section 2.2.1 should include statements that no Installation Restoration Programs (IRP) activities will be affected by changes in military activities at Andersen or other Guam military bases. Secondly, Guam EPA's primary impact consideration is for the protection of groundwater resources in the Northern Water Lens. Our review of the VRC-50 hanger and apron construction and operation sections indicates that adequate information was not presented on refueling operations and infrastructure development.

In addition, we are in general agreement with plans for total containment of wash rack effluent yet, the Agency believes that materials (fuel and solvents) to be used and methods of storage, treatment and disposal were not specified. Potential impacts and proposed mitigation measures were not adequately addressed in section 4.3.2.1, p. 4-10.

Controlling drainage and installing oil/water separators does not include mitigation for fueling operations and no direct link is made between operations and existing infrastructure.

The Agency requires additional information as to the types of hazardous materials which will be stored at the site and quantities of fuel and materials expected.

The DEIS does not adequately include discussions of existing ground water contamination of the lens beneath the AFB as identified in recent IRP investigations. The investigations include the Marbo Annex and Naval Air Station. As a matter of technical accuracy it is not recommended that the Navy or Air Force disconnect the importance of the recharge area at the P-203 location from the larger aquifer. All water resources of the northern lens recharge zone are of preeminent importance.

As groundwater is more thoroughly investigated there is increasing evidence of contamination due to the low natural filtration of karst aquifers and the nature of past and probably present base operations. (ES-4, Air and Water Quality, p.3-4, Section 3.1.3). The entire limestone plateau is classified as a recharge zone whereas any restriction to recharge capabilities is mainly a function of human activity and modification of surface conditions (p.4-5, Section 4.2.1)

Solid waste management for Andersen AFB to include operations of the VRC-50 Squadron was not addressed to the extent which should have included discussion of the Andersen AFB Landfill closure plans. Previous discussions with consulting personnel working on the landfill Environmental Impact Assessment (EIA) seem to favor the construction of a short term landfill to meet base needs until a more permanent landfill solution is found. The siting of a new landfill has proven difficult given both groundwater and wildlife concerns. It would have been appropriate to include a more thorough discussion of this issue. The reduction and minimization of non-hazardous waste from VRC-50 operations must be considered in order to minimize impact (quantity) to the existing landfill facility.

NAVAL MAGAZINE, SANTA RITA

The Agency supports Navy plan alternatives of recapturing Fena surface water losses to groundwater by means of constructing wells within the magazine. However, on the subject of groundwater wells, it is highly unlikely that the Agency will support additional production well development in northern Guam for exclusive military use.

The statement made in the DEIS that the Navy is the major supplier of potable water in Guam is incorrect. The Navy is actually the second major supplier with PUAG producing a substantially greater portion of the potable water supply for Guam.

An additional water development alternative not adequately addressed would be the expansion of the Fena Reservoir to at least obtain the capacity lost due to siltation since the facility resource was first developed. Capacity of the reservoir could be recovered by dredging. The reservoir is already over taxed during the dry season contrary to statements made in the DEIS (page ES-6, Water Resources).

Any plans for expansion of water source capacity must also include corresponding expansion of distribution and off-site storage of water in order to realize the efficient use of potable water supplies. Expansion of the existing water treatment plant at Santa Rita is a desireable option; yet, the analysis of constructing a new treatment plant with a capacity of 20 MGD would also represent a viable option that was not adequately considered in the DEIS. In order to safeguard and monitor Fena water supplies and storage capacity, the Navy must develop and implement a substantive watershed protection plan which encompasses all aspects of possible impacts and particularly targeting negative impacts to the reservoir system.

The Agency is concerned with the storage of explosive ordinance in close proximity to a known seismic zone. The DEIS does not indicate what type of mitigative measures will be incorporated into the bunker facilities to protect against accidents. We would assume that bunker designs include considerations for seismic loading however, this is not stated.

Any expansion of activities and/or construction within the Naval Magazine area raises concern for the protection of wetland resources. The area is rich in wetland types, flora, and fauna. The Navy must consider expansion activities to be potentially detrimental to natural drainage and the general viability of on-site wetlands. Discussion of potential impacts to wetlands was not adequate for proposed construction areas; therefore, the Agency will require additional wetlands information prior to construction. We are assuming that the Navy's policy of "no impact" also applies to Naval Magazine.

APRA HARBOR COMPLEX (NAVAL STATION), GUAM

The bulk of relocation activities will occur at this base location. The following comments are arranged according to activity due to the overall number of individual activity areas.

Proposed Navy Tipalao Housing

Eventual housing subdivision and design plans must provide more accurate information on wetlands encountered in close proximity to the housing areas. Accurate mapping of these wetlands is the only acceptable method of ensuring that housing related construction and siting does not impact or infringe upon the resource. The DEIS states that the Navy intends to avoid all wetlands.

Stormwater management at Naval Magazine will be a key consideration in addressing wetland water source (watershed) characteristics which must be protected. On-site stormwater disposal designs should be incorporated into development plans. Likewise, overland channeling of stormwater to ocean discharge will not be permitted. A careful assessment of drainage patterns to groundwater is necessary given the substrate type. Non-point discharges must be minimized whenever possible to ensure water quality is maintained throughout the marine environment.

The shallow aquifer beneath the Orote Peninsula must be considered as a possible water resource. Its influence on Apra Harbor and the surrounding marine environment likewise is potentially significant. Nearly all stormwater recharge on Naval Station terminates in the aquifer with a regular discharge to the surrounding marine waters. A thorough evaluation of the aquifer and the potential for contamination of marine waters must be realized within the base.

In addition to wetland impacts, the Guam EPA is concerned about the possible impacts of "H-2" being brought into work on federal projects needed to accomodate the Subic relocation and operations to Guam. The current "H-2" work force on island have a negative impact on the rental and the local housing market. Substandard Temporary Workers Housing Facilities (TWHF) are found around the island. Governmental regulatory agencies are trying to close most of these substandard TWHF down or bring the facilities into compliance. It is recommended that the Navy phase in construction activities and encourge local hire of construction workers to reduce the migration of "H-2" workers on Guam.

Tipalao Sewage Outfall and Wastewater Treatment Plant
The current outfall situation at Tipalao is unacceptable. The DEIS Indicates findings that the immediate impact of the damaged outfall is negligible given off-shore currents, depth at discharge and lack of significant marine resources (coral/fish). Guam EPA

disagrees with the findings. Additional flows amounting to a 30% increase are not acceptable given the current state of the U.S. Navy Tipalao Sewer Outfall. Generally, the effluent which was evaluated may, under normal conditions, pose no significant impact however, conditions are not always normal and the assessment fails to adequately consider conditions which occur during certain months of the year when prevailing winds are from the south west and west. There may be very different consequences for water quality along the Orote Peninsula and adjacent shoreline ecosystems during calm or summer conditions of reversed wind direction.

In any case the Agency will require permanent reestablishment of a submarine deep water outfall which must be considered for replacement within the current planning phase for additional housing and facilities at Naval Station.

The current treatment and capacity concerns with the Agana Wastewater Treatment Plant are near a critical stage with regard to private development requirements. All possible solutions for the diversion of new sewage flows to the Northern District Treatment Plant must be explored. The increased requirements for sewage treatment capacity which will be experienced within the next two years will most likely overburden the Agana Treatment Plant.

Public Works Center: P-237 Waterfront Utilities

The proposed repair and improvement plans for certain pier sections will require additional assessment for construction impacts. Any dredging of construction of new water front facilities (wharfs, piers, or ramps) may significantly impair water quality.

Harbor dredging impacts and the project assessment was deferred in the DEIS due to uncertain circumstances. As stated in the DEIS, the Navy anticipates the home porting of or frequent use of Apra Harbor by larger vessels as a result of relocation activities. We fail to understand why dredging impacts would not be included in the DEIS since ship operations are dependent upon adequate draft depths in the Harbor. If the dredging proposal will be delayed for whatever reason it would have been appropriate to include proposed areas of dredging, methods anticipated to be employed, alternatives for dredge spoil disposal and a survey of resources likely to be impacted. The Final Environmental Impact Statement (FEIS) must address the dredging proposal (requirement) for the anticipated increase in number and size of vessels.

The Agency favors renovation of pier structures in the form of improving the existing structures (sheet pile method) as opposed to possible demolition and reconstruction of significant lengths of pier facilities. An additional concern is the timing of pier renovations with possible dredging in order to minimize the number of major disturbances to the inner harbor vicinity.

Explosive Ordinance Disposal Mobil Unit Five (EODMU-5)/Outer Apra Navy Special Warfare Unit One (NSWU-1)

The DEIS only recognizes impacts to turtles and coral from use of explosives in training operations by EODMU-5. A much greater impact and certainly one of importance to Guam EPA and DAWR is the significant destruction such underwater explosions have on all area fishing resources. These impacts must be thoroughly addressed.

In the past the Agency along with the Department of Agriculture, DAWR, has reviewed and monitored similar exercises upon notification by the Navy Environmental Office, PWC.

While the system of notification and monitoring has been generally adequate, there are opportunities for improvement which may further reduce impacts to marine life which frequent the Harbor. An overall two fold increase in exercise events may significantly degrade conditions necessary to minimize impacts associated with the protective nature of the harbor for certain marine life. The Agency recommends the Navy reevaluate the need for increases in these activities. Any opportunities to find an acceptable alternative, and to consolidate exercises or reduce the overall number and size of underwater detonations would be desireable.

Naval Station (NAVSTA), Military Sealift Command (MSC), Naval Supply Depot (NSD), Ship Repair Facility (SRF)

An increase in overall commercial port shipping of approximately 150 containers may represent a significant impact. What affect will this have on the cost of commercial port shipping to Guam? This is a concern because Governor Ada has filed suit claiming that commercial shipping rates to Guam have been artificially inflated. Shipping representatives have claimed that the high rates are at least a function of inadequate port facilities. Please assess the impacts form an additional 150 container units per month on the already questionable situation.
The possibility for increased incidence of anchor dragging and mooring anchor damage to marine resources and water quality is of concern. It is critical that the Navy identify adequate alternatives for harbor activities including storm mooring capabilities to reduce anchor dragging and grounding. These alternatives should take into serious consideration constraints associated with existing mooring buoy and mooring facilities and the potential damage to rich colonies of coral and fish habitat. The Agency has yet to review a complete inventory of resources of the inner harbor in relation to existing or planned operational areas for regular activities and emergency requirements.

A wealth of information exists including the survey inventory data gathered for this DEIS which needs to be synthesized into a working plan for the requirements of all Naval Vessels currently home Navy

ported or planned for home porting (temporary or otherwise) in Apra Harbor.

The situation which prevails at this time almost guarantees repeat occurrences of damage to marine resources as ignorance of the location of sensitive areas continues. The Navy should seek the services of qualified marine consultants including local sources to formulate plans which will transcend commands to ensure adequate knowledge is formulated into a useful plan for protection of marine resources.

An additional issue brought out in the DEIS is the potential risk of introducing foreign pathogens or marine organisms to the Guam environment by way of ballast water or other appurtenances on board naval and commercial ships. The DEIS does not offer preliminary recommendations for operational precautions to minimize exotic species introduction. The Agency is interested in learning of any Navy policy for protection against such foreign organisms as soon as recommended procedures are identified. The DEIS did not state a time frame for the delivery of recommendations or when the study would be completed (Memorandum to Commander of Naval Sea Systems, Nov. 2, 1992).

NSD: P-141 Hazardous Material Storage Building

The facility for handling hazardous materials and adequate staffing will be a welcome improvement to Naval operations. Given the overall size and scope of operations anticipated for this unit it would be appropriate to provide additional information prior to actual construction of the facility. The DEIS states that a significant increase (nearly double) of hazardous materials will be processed through Guam however, the types and processing logistics were not offered. Any importation of hazardous waste must include a 60 day notification period and GEPA Administrative consent prior to shipment. Furthermore, the current limit on hazardous waste quantity is 105,600 gallons as per DRMO Application part A..

The U.S. Coast Guard is responsible for ocean oil and hazardous waste spills while Guam (GEPA) is responsible for all inland spills contrary to the text on p. 4-164.

It is disturbing to note that Guam must absorb potentially significant environmental impacts due to the relocation of Subic activities and the waste from other base locations such as Deigo Garcia. Rather than categorically assume hazardous waste storage and handling duties the Navy should apply considerable effort to an overall reduction in the waste stream. At any point during a relocation plan there would seem to be an opportunity to identify means of reducing waste quantities as opposed to increasing handling capabilities. The Agency recommends that any additional

quantities of Hazardous waste planned for transportation through Guam Naval facilities be thoroughly identified as to type, point of origin, and methods for possible reduction in the FEIS.

The DEIS should include discussion of Guam's existing hazardous waste regulations as well as federal Resource Conservation and Recovery Act (RCRA) definitions and requirements p. 4-159, section 4.21.1.1.

On the next page there is a statement that significant illegal dumping of hazardous waste prevails in Guam's civilian sector due to inadequate facilities and high disposal costs. This statement appears unfounded.

We would be interested in data quantifying and locating hazardous dumps island-wide which are not associated with IRP investigations, p. 4-160, section 4.21.1.1.

Public Works Center: P:234 Orote Power Plant Expansion

The Agency has several concerns with regard to the planned expansion of power generation facilities at Naval Station. Data for Table 4.7.1, Carbon Monoxide, incorrectly specifies units of measure. The correct unit of measure is milligrams/cubic meter in accordance with Guam's Air Pollution Control Standards and Regulations. Spill Prevention Control Counter Measure (SPCC) plans must be in place for the new facility and both above and below ground storage tanks must conform to UST and SPCC requirements. Air quality must be monitored for various pollutants and there may be requirements for additional monitoring stations and prior monitoring (one year advance data) in the non-attainment area.

Navy Water Supply

A statement contained in the executive summary on page ES-7, first sentence is not supported. If the Navy must reserve critical water supplies and limit new supplies for private development in current Navy supported service areas then additional supplies must be developed in the Northern Lens to account for the new demand. PUAG does not have the capacity to support all new housing or any other type new private development without adding new production wells in northern Guam.

Again, the statement in section 4.2.3 Cumulative Impacts, p.4-8 is misleading and false. Technically, nearly all of the construction projects are located over water lens areas. The main issue may be that the aquifers in question are not currently used for potable water production. Guam EPA does not limit regulatory activities to active production zones.

Navy Relocation DEIS, page 9.

The Tolaeyuus River Watershed contains outcroppings of carbonates and unconsolidated sediment which are potential sources of groundwater. Mitigation measures must be taken to ensure protection of these resources p. 4-26, section 4.5.2.2.

It should be noted that the figure of 60 million gallons per day sustained yield is an estimate and not thoroughly substantiated. Additional data is required to verify a more accurate estimate, p. 4-126, section 4.16.1.1.

Social/Economic Impacts

In standard economic analysis, economic decisions are based upon a comparison of expected future marginal revenues verses expected marginal costs. In reviewing the criteria for economic considerations in accounting for the additional costs associated with the relocation it was noted that overall government service costs were calculated as average costs. Marginal costs would more appropriately reflect actual impacts and therefore better assist both military and Government of Guam planning entities. This difference is critical considering the costs already demanded to complete infrastructure shortfalls as a result the most current economic expansion. In addition, the present value of a future revenue stream should be based on depreciated values of future revenues using present interest rates. What might be anticipated as costs and revenues to cover those costs from current rates and value could be overstated in both cases.

In summary, the Agency has identified several issues with regard to the DEIS and a few significant errors which must be addressed in the FEIS. Overall, we feel that the document provides an adequate assemblage of data and information on relocation plans which include critical mitigative strategies to adequately accomadate Navy activities in Guam. Guam EPA welcomes any additional comments which might facilitate the completion of the NEPA process. The level of integrity necessary for cooperative efforts toward disclosure of both possible detrimental and beneficial results of proposed actions should be maintained.

Thank you for the opportunity to comment.

JOANNE M. BROWN
Acting Administrator

CC: Department of Agriculture, DAWR
Region IX, U.S EPA

DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

5090 (P)
Ser 232/3888
15 Jul 1993

Mr. Fred M. Castro, Administrator
Guam Environmental Protection Agency
Harmon Plaza Complex Unit D-107
130 Rojas Street
Harmon, GU 96911

Dear Mr. Castro:

Subj: DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

Thank you for your letter dated May 17, 1993, regarding the Draft Environmental Impact Statement (DEIS) for the above referenced action. Our responses to your comments are as follows:

a. Comment: Concern regarding proposed VRC-50 activities (FCLPs) at Andersen Air Force Base (AFB) and their potential impacts upon the endangered Mariana crow and fruit bat.

Response:

- The Navy will minimize unauthorized aircraft activity.
- The Navy intends to continue the study of the impact of the VRC-50 relocation on endangered species in accordance with the terms and conditions of the Section 7 biological opinion received from the U.S. Fish and Wildlife Service under the Endangered Species Act.

b. Comment: Lack of a discussion of Installation Restoration (IR) programs and changes in IR activities in Section 2.2.1.

Response: The (IR) Program sites on military facilities on Guam are discussed in detail in Section 4.21.1.2, and are shown in Figure 4.21.1. As the DEIS states in Section 4.21.3, the proposed actions will not cause any impacts to these IR sites.

Revisions to DEIS: None.

c. Comment: Lack of discussion of refueling operations and infrastructure development at the proposed VRC-50 hangar and apron.

Response: Refueling operations will take place in a specific refueling area to be built along with the hangar and apron. Drainage from the hangar floor, wash down area, and refueling stand will pass through physical separation type oil/water separators and drain to a sewer system.

Revisions to DEIS: The above information will be added to Chapter 4.

d. Comment: Lack of a discussion of materials (fuels and solvents) to be used and methods of storage, treatment, and disposal. Types of hazardous materials to be stored at the site. Potential impacts and mitigations in Section 4.3.2.1.

Response: A hazardous/flammable materials storage facility will be constructed as part of the VRC-50 hangar facility for brake fluid, hydraulic fluid, paint and lubricants used for aircraft maintenance. Use and disposal of hazardous materials will be in accordance applicable regulations and the Navy's hazardous waste minimization program.

Revisions to DEIS: The above information will be incorporated in Section 4.3.2.1.

e. Comment: Controlling drainage, and installing oil/water separators does not include mitigation for fueling operations. Discuss existing groundwater contamination of lens beneath Andersen AFB as identified in IRP investigations. All water resources of the recharge zone are important. Entire limestone plateau is a recharge zone.

Response: Drainage from the hangar floor, wash down area, and refueling stand will pass through physical separation type oil/water separators and drain to the sanitary sewer system. In addition, a plastic lined retention basin will be constructed to retain aircraft fire-fighting foam and water. The hangar fire sprinkler system will be tested once a year for seven minutes per test, and this basin is designed to hold the foam and water from the system during the test. Once the testing is complete, the water will be pumped at a slow rate to the sanitary sewer system for dilution and treatment. Although there have been investigations, the extent of any groundwater contamination below Andersen AFB is still unclear. The above mentioned design features will ensure that there will be no additional effect on the groundwater lens from VRC-50 operations.

Revisions to DEIS: None.

f. Comment: Need to address solid waste management issues for Andersen AFB and the closure of the landfill. The reduction and minimization of non-hazardous waste from VRC-50 operations must be considered in order to minimize impacts to the existing landfill facility.

Response: A recent initiative by the Navy, Commander, U.S. Naval Forces, Marianas (COMNAVMARIANAS) Instruction 5090.5, Regional Solid Waste Management Plan for Navy Activities, establishes management policies and goals for reducing the volumes of non-hazardous wastes generated by Navy facilities on Guam, including VRC-50.

Revisions to DEIS: The above mitigation will be included in Section 4.20.3.

g. Comment: The Navy is not the major supplier of potable water on Guam.

Response/Revisions to DEIS: The statement in the executive summary that *the Navy is the major supplier of potable water on Guam* was changed to say that *the Navy is a major supplier of potable water on Guam.*

h. Comment: Concerns regarding water resource development/expansion options as well as water conservation measures.

Response: A utility Technical Study is being conducted which will include a discussion of the most cost effective conservation techniques which will improve naval water system capacity and reliability. The potential requirement to expand Fena treatment capacity, reservoir storage, or distribution capacity is within the scope of the Utility Technical Study, and expansion is being investigated. A water conservation program is already in place. The Navy participates with the Public Utility Agency of Guam (PUAG) in a water conservation plan as potable water reservoirs reach critical levels. In addition, proposed projects include water conservation features such as minimal landscaping, low-flow shower heads, faucet aerators, and reduced flow toilets in housing.

The Fena watershed is delineated as a Resource Protection Area in the Natural Resources Management Plan for the Naval Magazine (NAVMAG) Guam.

Revisions to DEIS None.

i. Comment: Concern with storage of ordnance in close proximity to seismic zone.

Response: As stated in Section 4.12.13, munitions stored at NAVMAG are configured to reduce potential for damage to stored ordnance. Facilities are also designed and constructed to withstand seismic effects.

Revisions to DEIS: None.

j. Comment: Concern about protection of wetlands at NAVMAG.

Response: Neither project planned for NAVMAG encroaches on any wetland and are of sufficient distance from wetland areas. This has been confirmed by the Guam office of the Army Corps of Engineers.

Revisions to DEIS: None.

k. Comment: Concern about wetlands at Tipalao housing; need accurate mapping.

Response: The wetlands at the Tipalao housing site have been mapped, and the delineation has been approved by the Guam office of the Army Corps of Engineers.

Revisions to DEIS: The second paragraph in Section 4.4.3.2 has been revised as follows (deletions are bracketed; additions are underlined):

Wetlands in this parcel [are currently being] have been delineated to facilitate the construction of housing away from these areas (see Figure 2.3.12). The delineation, as presented in Appendix I, has been approved by the Corps of Engineers.

l. Comment: Concern about stormwater management and watershed protection in regard to the Tipalao Housing project.

Response: To mitigate potential impacts to surface and coastal waters during construction, pollution prevention measures and best management practices (BMPs) will be implemented. All contractors

will be required to acquire a National Pollutant Discharge Elimination System (NPDES) stormwater permit for construction activity which will include appropriate management practices. In addition, as stated in Section 5.2 of the DEIS, the proposed actions will be carried out in consultation with the Guam Bureau of Planning, which is charged with administering Coastal Management Program Consistency Certification.

Revisions to DEIS: None.

m. Comment: Need to evaluate impact on shallow aquifer beneath Orote Peninsula and potential for contamination of marine waters.

Response: Except for the Orote Point Power Plant expansion, none of the proposed projects on Orote peninsula include the use or addition of any above ground storage tanks (ASTs), underground storage tanks (USTs), underground injection wells, or other facilities or activities that could contaminate groundwater resources or marine waters. The power plant expansion will include a above ground fuel tank. The existing power plant has above ground storage tanks and the potential for spills into marine waters is addressed in the Oil Pollution Act of 1990 response plans. The construction of the new tank should not significantly alter the spill scenario, although the Navy Public Works Center (PWC) Guam's Spill Prevention Control and Countermeasure (SPCC) plan for the power plant will need to be updated once the tank is completed.

Revisions to DEIS: None

n. Comment: Concern about H-2 workers.

Response: Although the Navy cannot legally place hiring requirements on its construction contractors with regard to H-2 workers, it is likely that the number of H-2 workers needed during construction of the proposed projects will be relatively small, given the recent decline in civilian construction activities. In any case, the requirement for in-migrant construction workers (whether from Hawaii, the mainland U.S., or elsewhere) would be short-term.

Revisions to DEIS: None.

o. Comment: Disagreement and concern about impacts of increased sewage at Tipalao outfall.

Response: With respect to the observed effects of the sewage discharge at Tipalao, field work was conducted during a period of extremely calm wind and sea conditions. These conditions result in minimal dispersion of material (sewage effluent) that is discharged into the ocean. Impacts to water quality and marine biota would be expected to be maximal during such periods of minimum dispersion as the effluent would remain most concentrated during such conditions. Thus, the conditions that occurred during the survey can be considered a "worst case scenario." The findings of the survey during the worst case conditions were that effects to water quality and biota were minimal to nonexistent owing to rapid mixing and dilution of the effluent. Thus, during the range of weather conditions that were not actually surveyed, but where wind and sea states would promote even greater mixing, it can be interpreted that potential impacts would be equally benign.

Prior to the expansion of the Apra Harbor Sewage Treatment Plant (STP), effluent from the outfall had only undergone primary treatment. Although proposed activities will increase flows from the outfall by approximately 30 percent, this effluent will undergo secondary treatment. Therefore, the net increase in secondary treated effluent flow will not cause any more adverse impacts than the previous flows of primary treated effluent. It should also be pointed out again that the present mode of sewage disposal (discharge through a broken pipeline close to the shoreline) should not be considered a permanent situation. As a separate project, the Navy and Public Utility Agency of Guam (PUAG) are jointly funding a deep ocean outfall to replace the existing broken outfall at Tipalao.

Revisions to DEIS: None.

p. Comment: Concern that treatment and capacity at the Agana Wastewater Treatment Plant are near a critical stage.

Response: The increase in flows from additional Navy personnel at NAS Agana, Nimitz Hill, and the Naval Hospital represents a small incremental increase of 0.036 mgd. Given baseline demographic parameters, it is estimated that sewage flows to the Agana Wastewater Treatment Plant will approach the 12 mgd treatment capacity in 1995. In order to accommodate future private development requirements over the next two years, PUAG may need to consider expanding the capacity of the Agana plant or diverting flows elsewhere.

Revisions to DEIS: The above discussion is included in Section 4.19.2.3.

q. Comment: Construction impact of waterfront utilities project and more information on dredging.

Response: Dredging of inner Apra Harbor is not required as a result of the proposed relocation activities, and the port, in its existing configuration, can handle all projected ship traffic resulting from relocation activities. Deepening of the harbor, or new dredging, would be required only if requirements for homeporting or accommodating battle groups change. No berthing requirements exist or are anticipated as a result of the relocation to justify a dredging project. The only in-water construction activity will be associated with the repair of the Explosive Ordnance Disposal Mobile Unit (EODMU)-5 bulkhead.

Revisions to DEIS: All references to a dredging project are deleted.

r. Comment: Concern about timing of pier renovations.

Response: It is reasonable and feasible to prohibit in-water work on the bulkhead during the turtle nesting season. However, it is probably not necessary to limit dryland work such as backfilling and capping of the new piling.

Revisions to DEIS: None.

s. Comment: Concern about impact of EODMU-5 explosives on fishing resources.

Response: Naval divers inspected the proposed demolition site and surrounding area to a depth of 140 feet on August 16, 1991, and observed only muddy harbor floor with the closest coral growth at a safe distance of 500 yards south of the anchorage area. Although turtles and other fish species have been observed foraging throughout Apra Harbor, the proposed demolition area is not considered a significant feeding ground or known fisheries habitat.

The Navy realizes the potential impacts that demolition exercises may have upon turtles and fish species in Apra Harbor and is currently going through a Section 7 consultation with the National Marine Fisheries Service to gain approval for the proposed exercises as well as any mitigation measures that must be applied.

Revisions to DEIS: These mitigation measures have been incorporated into Section 4.6.2.2 as follows:

Mitigation measures include notification of GEPA and DAWR at least one week in advance and allowing unrestricted on-site review of the training exercises. . . On-site spotter boats will be used to provide warnings of hazards, and to check for turtles and other marine wildlife in the hazard area before authorizing detonations.

t. Comment: Recommendation that the Navy re-evaluate the need for increased explosives training activities.

Response: Explosive training exercises are necessary for the EODMU-5 unit to maintain skills and stay prepared for its mission requirements. The Navy constantly evaluates the need for all explosive and ammunition training programs to ensure efficiency and personnel safety. The proposed exercises are deemed necessary and are a component of existing exercises. Since there is no substantiated damage resulting from past exercises or evidence that further exercises will further exacerbate any damage, the Navy will continue to conduct these activities in cooperation with the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and other appropriate agencies.

Revisions to DEIS: None.

u. Comment: Concerns regarding the increased load of approximately 150 containers per month of cargo to the commercial port.

Response: A typical cargo barge carries an average of 200 to 220 fullsize cargo containers, and a typical cargo ship carries an average of 1,000 full-size containers (Matson Navigation, June 1993). Therefore, the projected increase of 150 containers would be comparable to less than one cargo barge a month. Section 4.14 states, "Military materials present a relatively small burden upon the commercial port facilities." According to the Port Authority of Guam (PAG), there will be no container storage or handling problems at the commercial port associated with the increase in FISC shipping volume." Given the very small volume of cargo attributed to relocation activities, there would be little or no effect upon shipping costs and other economic issues associated with the commercial port.

Revisions to DEIS: None.

v. Comment: Concerns regarding the possibility of increased incidence of anchor dragging and mooring anchor damage to marine resources and water quality. Need to identify alternatives for harbor activities, including storm mooring capabilities.

Response: Naval vessels using anchorages and typhoon moorings in the harbor are assigned specific anchorages based upon vessel length, draft, and weight. During bad storms or typhoons, service craft are moored to their assigned typhoon buoys, smaller craft are brought upon land, and large ships put out to sea. These moorings are consistently maintained by PWC Guam. The only situation where anchor dragging or mooring damage to marine resources could occur is if non-Navy vessels tie on to inadequate moorings in times of emergency. Relocation activities require the placement of three new typhoon buoys in the inner harbor, one in the outer harbor, and one to be relocated in the outer harbor. All moorings placed in the Naval anchorage areas require an Army Corps of Engineers permit. In addition, mooring work done in the outer Apra Harbor is reviewed by the Guam Environmental Protection Agency (GEPA) to ensure that no impacts to marine resources will occur.

Revisions to DEIS: Text describing the new moorings is added in Section 4.6.2.4.

w. Comment: Need for a complete inventory of Apra Harbor marine resources in relation to existing or planned operational areas.

Response: The Navy will pursue funding for such a marine resources survey as part of its Natural Resources Management Plan, but not as part of this EIS, since the only direct impacts to the aquatic environment will be due to the sheetpile bulkhead repairs. The maintenance dredging of inner Apra Harbor is not required to support relocation activities.

Revisions to DEIS: None.

x. Comment: Provide information on procedures to minimize risk of foreign pathogens being introduced in ballast water.

Response: One of the main ways in which ships can prevent foreign organisms from entering the coastal marine waters of Guam is to pump and exchange ballast water in the ocean, prior to entering an exclusionary zone around the port of entry. However, as stated in the DEIS in Section 4.6.3, neither the Coast Guard or any other agency requires commercial or military ships to do this.

Revisions to DEIS: None.

y. Comment: Coast Guard is responsible for ocean oil and hazardous waste spilled, while GEPA is responsible for inland spills.

Response/Revisions to DEIS: The text in Section 4.21.2.2 has been revised accordingly.

z. Comment: Concern about the large projected increase in hazardous waste; need to reduce the hazardous waste stream rather than increase handling capacity.

Response: The overall hazardous waste generation is not expected to change appreciably as a result of the relocated activities, and the 30 to 40 percent predicted increase is overestimated. In fact, a comparison of 1992 hazardous waste disposal statistics from Defense Reutilization Marketing Office (DRMO) showed Resource Conservation Recovery Act (RCRA) waste generated by the Navy and turned into DRMO was 34 percent less than 1991 levels. Non-RCRA waste went up 111 percent over 1991 levels. Post-relocation conditions existed for approximately eight months of 1992 (COMNAVMARIANAS, June 2, 1993).

The Navy is seriously committed to hazardous waste minimization. A reverse engineering survey of waste generating processes at the Naval Ship Repair Facility and the NAS Aircraft Intermediate Maintenance Department is scheduled for August 1993, with the specific intent of reducing the hazardous waste generated. COMNAVMARIANAS is in the process of establishing a Regional Management Board for the express purpose of establishing hazardous material control and management procedures. It represents a fundamental shift in the way the Navy presently accounts for and distributes hazardous materials. This new instruction and the Board will: (1) establish hazardous materials stores to centralize the retail procurement of hazardous material by all Navy users (reducing excessive purchase), (2) require the Fleet and Industrial Supply Center (FISC)--previously known as Naval Supply Depot or NSD--to expand their shelf life extension program to minimize the quantity of excess shelf life material declared hazardous waste, and (3) charter working groups to identify potential substitutes for the largest waste streams at each activity (hazardous waste minimization).

Revisions to DEIS: The statements above, as well as a further discussion and update of DRMO activities and hazardous waste minimization initiatives at the Navy and Air Force facilities, has been added to Section 4.21.2.1 as follows:

The decrease in generation of hazardous waste is a result of Navy hazardous waste minimization efforts coinciding with the increased workloads. The bulk of past RCRA wastes resulted from expired shelf life materials. The Navy has been addressing this procurement at a policy level, and the Naval Supply Depot is currently establishing a shelf life extension program. In addition, the implementation of a formal HAZMIN plan by DRMO and PWC is a condition of the Part B RCRA permit. Such a plan will describe every waste reduction activity in place and the standard operating procedures that apply. In addition, the plan will include projected waste minimization activities and goals for hazardous waste reduction . An approved plan will be necessary before the new treatment storage and disposal facility (TSDF) begins operation in 1995. The Air Force has implemented similar programs called the Pollution Prevention Action plan and the Hazardous Waste Management Plan for Andersen Air Force Base which establish goals and policies for reducing the amount of hazardous waste generated at Andersen facilities.

aa. Comment: Need to identify Guam's existing hazardous waste regulations and federal RCRA requirements.

Response: Hazardous waste regulations applicable to military activities on Guam are identified in Section 5.1.11.

Revisions to DEIS: None.

bb. Comment: Unfounded statement that significant illegal dumping of hazardous waste occurs in Guam's civilian sector.

Response/Revisions to DEIS: This statement will be deleted (Section 4.21.1.1, last paragraph).

cc. Comment: Correct unit of measure in Table 4.7.1. Concern with SPCC plans and air monitoring requirements at the Orote Power Plant expansion.

Response: The units of concentration in the table are correct. Although concentrations for carbon monoxide are usually expressed in milligrams per cubic meter, the units of micrograms per cubic meter were constantly used in the table to show the relatively larger allowable concentrations of carbon monoxide. In regards to the concerns about the power plant expansion, air quality modelling is being done under the supervision of the U.S. EPA and all UST and SPCC requirements will be met as outlined in the facility permits.

Revisions to DEIS: None.

dd. Comment: The first sentence on page ES-7 on water supply is not supported.

Response: As a result of the loss of the B-52 squadrons, water supply at Andersen AFB is not expected to be significantly affected by the proposed activities.

Revisions to DEIS: None.

ee. Comment: Statement in Section 4.2.3 regarding the water lens needs to be corrected.

Response/Revisions to DEIS: The text will be revised to say: *In general, none of the proposed military construction projects or activities will impact the northern aquifers, watersheds, or other water resources on Guam.*

ff. Comment: Provide mitigation to protect the Tolaeyuus River watershed groundwater resources.

Response: None of the proposed projects at NAVMAG include the use or addition of any ASTs, USTs, underground injection wells, or other facilities or activities that could contaminate groundwater resources in the Tolaeyuus watershed.

Revisions to DEIS: Above text will be added to Section 4.5.2.2.

gg. Comment: 60 mgd is an unsubstantiated estimate of sustained yield.

Revisions to DEIS: Statement in Section 4.16.1.1 will be revised to say: *This Northern Lens Aquifer has an estimated sustainable yield of up to 60 mgd and provides 70 percent of the island's potable water.*

hh. Comment: Questions about the methodology used in the fiscal impact analysis: (1) accuracy and usefulness of the average cost approach used in the EIS, and (2) the difference between a constant dollar analysis (used in the EIS) and a present value approach.

Response: The average cost methodology provides a useful planning tool, while a marginal cost approach may be impossible to develop--and may be no more accurate--at the EIS or conceptual stage of analysis. With regard to valuation, the constant dollar approach provides information needed about both year-by-year and cumulative revenue balances. The present value approach refines the estimate of cumulative balance of revenues over costs. For the Guam analysis, it is clear that cumulative revenues far outweigh costs using either method.

Average versus Marginal Cost Approach. The average cost approach provides an estimate of future government costs over several years, based on the population affected by the project. Cost estimates are based on historical trends in government spending. This methodology may tend to overestimate future costs since it makes no allowance for increased efficiency, which is possible when services are extended to just a few more clients. Moreover, recent government spending on Guam was based on a booming economy and was, hence, quite high.

Ideally, a marginal cost approach pinpoints the exact government services needed in connection with a project and estimates the cost to the government for providing those services. In an EIS for a complex action, such a detailed analysis is rarely possible—and could be misleading—for the following reasons:

- It may not be clear which costs will be borne by the project's sponsor and which by the local government. Determination of the contributions by the Navy and Government of Guam to meet current and future infrastructure needs will be a continuing process.

- Even in hindsight, it can be extremely difficult to isolate a project's share of actual costs when the project involves intensified or changed activity at several sites, not just new construction at a single site. The analytic problem is worse when (as is often the case) capital improvements are made to correct existing deficiencies and to meet anticipated needs.

- Finally, any estimation of future government spending must be based, at least implicitly, on a service delivery standard. If the existing standard is used, then the "marginal cost" is, in effect, the "average cost." If a different standard is used, then the study assumes that the government will provide a higher level of service than at present. Depending on public revenues, the local government is not bound by an EIS it reviews and is rarely in a position to guarantee future levels of service delivery. Hence, there is no assurance that assumptions used for marginal cost analysis are realistic.

Constant Dollar versus Present Value Approach. In the EIS fiscal analysis, all future revenues and costs were shown in constant value 1992 dollars. Future costs and revenues were compared for specific years so the reader could see that anticipated revenues were greater than costs on a year-by-year basis, as well as cumulatively. A cumulative balance was shown, in constant dollars, of nearly $100 million in additional revenues for the Government of Guam through 2010.

If the annual balances are viewed as a revenue stream continuing through 2010, and future values (both revenues and costs) are discounted at a rate of 8 percent, the cumulative balance would amount to about $67 million. This calculation suggests that the proposed action would be of substantial benefit to the Government of Guam.

We trust that these responses adequately address your concerns. Should you have any questions, contact Mr. Stanley Uehara at (808) 471-9338 or by facsimile transmission at (808) 474-4890.

Sincerely,

Melvin N. Kaku

MELVIN N. KAKU
Director
Environmental Planning Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Affairs
600 Harrison Street, Suite 515
San Francisco, California 94107-1376

IN REPLY REFER TO:

June 24, 1993

ER 93/400

Clay Ching, Commander
Facilities Planning and Real Estate, Code 232
Naval Facilities Engineering Command
U.S. Navy, Pacific Division
Pearl Harbor, Hawaii 96860-7300

Dear Commander Ching:

The Department of the Interior (Department) has reviewed the Draft Environmental Impact Statement (DEIS) for the Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines. The following comments are provided for your consideration and use when preparing the final documents.

GENERAL COMMENTS

B-54

The Department finds that the proposed facilities development and relocation of certain Navy activities from the Philippines to Guam may result in adverse impacts to trustee fish and wildlife resources and to historic resources. These comments are provided in the spirit of resolving resource issues and identifying information needed for evaluating impacts to wetlands, endangered and threatened species, marine resources, and historic resources.

The Navy has requested reinitiation of formal section 7 consultation under the Endangered species Act (ESA) with the Fish and Wildlife Service (FWS) for the relocation of Fleet Logistics Support Squadron Fifty (VCR-50) to Guam from the Philippines. Further consultation is necessary since the proposed project, as defined in the DEIS, is significantly different from the temporary field carrier landing practice (FCLP) activity proposed in the former Environmental Assessment and could result in greater impacts than previously described.

The formal consultation should address impacts to proposed critical habitat, impacts to federally endangered Mariana crows and Mariana fruit bats resulting from the FCLP flights, perimeter/runway/apron lights, road and hangar construction noise, engine "run-up" maintenance noise, loss of habitat, and any indirect effects of undisclosed flight training (support or transient air traffic by other squadrons) expected to occur in

the north runway area from the permanent relocation of VRC-50 Squadron to Andersen Air Force Base.

Impacts to the War in the Pacific National Historical Park have not been identified in the DEIS. We anticipate an increase in use of the park facilities as additional military personnel are stationed on Guam. The potential impact of increased visitation on additional park staffing and expanded visitor facilities needs to be addressed. The potential impact of increased visitation on additional park staffing and expanded visitor facilities needs to be addressed.

Adequate mitigation measures for the protection and preservation of Orote Point historic resources need to be included. Simply avoiding construction in the immediate area of a cave may not be effective in assuring that a historic resource would be protected. We recommend locating proposed development well away from historic resources and developing interpretive devices to inform visitors of the sites' significance and their needs for protection.

Submerged historic resources have been documented in the harbor, and potential impacts to these resources from dredging, anchoring, and increased marine traffic need to be identified. For protecting these submerged resources, we recommend designating protection zones of sufficient area around these submerged sites to prevent disturbance or destruction.

Designating these resources as National Register Properties is another protective means which should be considered in the final documents. We believe that the oversight of the designation process and the monitoring of the protection zones would be more effective with a non-military agency.

It is especially critical to prevent damage to the submerged sites from large ships dropping and weighing anchors within the protection zones. Recent incidents of dragging anchor chains across coral heads and reefs emphasize the need to protect these natural resources. We recommend that anchoring activities be eliminated within the protection zones and guidelines be developed to provide adequate protection for submerged natural resources during buoy maintenance and military training exercises.

We also recommend excluding underwater demolitions training, listed as an anticipated activity in the Apra Harbor area, from the protection zones described above. This proposed exclusion measure would prevent inadvertent destruction of the historic sites.

SPECIFIC COMMENTS

Specific comments are listed in the attached appendix.

SUMMARY COMMENTS

Issues on endangered and threatened species, wetlands, marine resources, and historic resources need to be clarified or further evaluated in the final documents. In addition to including specific information to comprehensively evaluate project impacts to these trustee resources, the Department recommends providing detailed mitigation plans to minimize impacts.

One of the Department's major concerns regarding the FCLP maneuvers is the impact on endangered Mariana crows and Mariana fruit bats.

The major factor affecting the reproductive success of the crows and bats on Guam is predation by the brown tree snake. Nevertheless, disturbances such as FCLP maneuvers may also be responsible for reproductive failure and/or abandonment of nests.

The critically low populations of the crow and bat on Guam indicate the possibility of their extinction on the island. Even the loss of one or two crow nests or fruit bat reproductive efforts as a result of aircraft overflights would be considered a significant impact.

Thus, it is important that any adverse impacts on these endangered species from the proposed VRC-50 project be accurately assessed and avoided. Any unavoidable impacts should be minimized to the extent possible and fully mitigated to help attain the mutual goal of the continued existence and recovery of the species.

Consultations under section 7 of the ESA are needed for evaluating impacts to federally listed sea turtles, the Mariana common moorhen, the Mariana crow, and the Mariana fruit bat. In particular, proposed housing developments adjacent to wetlands and water withdrawals from Fena Reservoir may negatively impact the endangered Mariana common moorhen.

Increased demolition exercises may negatively impact endangered and threatened sea turtles. The visual and noise disturbances resulting from increased FCLP flights of VCR-50 aircraft may impact the endangered Mariana crow and Mariana fruit bat.

Secondary impacts to crows and bats from construction and maintenance activities associated with the VCR-50 Squadron also need to be fully addressed. We recommend completing formal consultation prior to the Record of Decision on the final

document to allow incorporation of conclusions and recommendations into the final decision.

The endangered Mariana crow and Mariana fruit bat research should be continued for at least two years. We believe that such an extended study is necessary to fully assess the significance of the impact of the proposed project on the two species.

Information collected may ultimately benefit conservation of the species and assist in more accurately assessing the impacts of future or other flight operations/squadrons proposed for relocation to Andersen Air Force Base.

The War in the Pacific National Historical Park needs to be protected from the impacts of anchoring, dredging, and increased marine training activities. The anticipated increase in use of park facilities by military personnel stationed on Guam needs to be addressed.

We appreciate the opportunity to comment.

Sincerely,

Patricia Sanderson Port
Regional Environmental

cc: Director, OEA (w. incoming)
Reg Dir, FWS, Portland
Reg Dir, NPS, San Fransisco

APPENDIX

SPECIFIC COMMENTS

Comments on Fish and Wildlife Resources

Page ES-4. Affected Environment. Marine Environment. We recommend that the term "coral table reef" be replaced with the correct term "fringing coral reef." In addition, it would be more accurate to state that "Shallow, fringing coral reefs extend seaward from most of Guam's coastline. Barrier coral reefs, each separated from the island by a deep lagoon, occur at Apra Harbor and Cocos lagoon."

Page ES-4. Affected Environment. Terrestrial Biota. A major factor contributing to the cumulative loss of native forest habitat, especially in southern Guam, is the destruction resulting from wildland fires that begin in grassy savannah lands and spread to adjacent native forests which border streams and rivers. This information should be included in the final documents.

Page ES-7. Environmental Consequences and Mitigation Measures. Terrestrial Biota. The potential for various relocation activities to result in the introduction of non-native species into the terrestrial environment of Guam, and the potential cumulative impacts to native terrestrial biota from such introductions, are not identified in this section of the DEIS. The Service recommends that the DEIS include an assessment of these potential impacts within this section.

Page 2-3. Chapter 2. Proposed Actions and Alternatives. 2.2.2. Changes in Military Activities. Apra Harbor Complex. The numbers of military vessels homeported at Guam and the numbers of port calls made to Guam by large military vessels (i.e., vessels requiring "...up to 600 feet of pier space with over a 35 foot depth") are expected to increase. The major sources of these increases are described in Sections 2.2.2.1 - Naval Station, 2.2.2.2 - Military Sealift Command, 2.2.2.3 - Naval Supply Depot, and 2.2.2.4 - Ship Repair Facility.

Proposed methods to accommodate these additional vessels (e.g., by the creation of suitable space by dredging, filling, or other construction activities) are not adequately covered in the DEIS and should be fully addressed in Section 2.3.2 - Military Construction Projects at the Apra Harbor Complex under each appropriate subsection.

An evaluation of the environmental impacts resulting from increases in vessel numbers and construction activities associated with accommodating these additional vessels is not adequately presented in the DEIS and should be included in Section 4.6.2 - Potential Impacts and Proposed Mitigation Measures.

Page 2-5. Chapter 2. Proposed Actions and Alternatives. Changes in Military Activities. Apra Harbor Complex. 2.2.2.6. Explosive Ordnance Disposal Mobile Unit Five (EODMU-5) and Pages 4-33 to 4-35. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Marine Environment. Potential Impacts and Proposed Mitigation Measures. 4.6.2.2. Explosive Ordinance Disposal Mobile Unit Five (EODMU-5). The information in these sections should be corrected in the final documents to reflect the presence of green and hawksbill sea turtles in Apra Harbor and Sumay Cove. Green and hawksbill sea turtles have been observed in Apra Harbor and Sumay Cove by biologists from the Guam Division of Aquatic and Wildlife Resources, and a hawksbill nest site was documented in Sumay Cove last year.

A more thorough discussion of the proposed project to repair or replace the sheetpile bulkhead in Sumay Cove is warranted. Construction of the project during the sea turtle nesting season (April - September) is discouraged since this activity could interfere with further attempts by sea turtles to nest in this area.

Increased demolition exercises on the Explosive Ordnance Disposal (EOD) beach between Tarague Beach and Pati Point need to be addressed. There is concern that explosions on the EOD beach have already resulted in a "hardening" of the beach through sand compaction. Hardened beaches would become too compact for turtles to dig nests and can result in increased false crawls and aberrant nests.

The final documents should completely discuss potential impacts to sea turtles from underwater demolition exercises and exercises which would be conducted at the EOD beach and discuss the mitigation measures that would be implemented to avoid or minimize adverse impacts to sea turtles from these activities.

The DEIS states that consultation with the National Marine Fisheries Service (NMFS) regarding sea turtles will be carried out. Under the Endangered Species Act of 1973, as amended (Act), the Fish and Wildlife Service (FWS) and the NMFS share responsibility for the conservation, protection, and recovery of federally listed endangered and threatened sea turtles.

The NMFS has sole agency jurisdiction for sea turtles while they are in the water, and the Service has jurisdiction for sea

turtles while they are on land. Section 7 of the Act requires that all federal agencies consult with the FWS or the NMFS when any action authorized, funded, or carried out by the action agency may affect a listed species or designated critical habitat.

Therefore, the section 7 consultation process should be initiated with the Service for any demolition activities which may affect federally listed sea turtles on land. The consultation process should be completed prior to issuing the final documents and the results included in the federal consistency section of the final document.

Page 3-2. Chapter 3. 3.1.2. Terrestrial Biota. The information in this section of the DEIS concerning "critical habitat" federally endangered fauna on Guam under the Act is incomplete and misleading. Critical habitat is defined under the Act and is designated by the Service or the NMFS to promote conservation of federally endangered and threatened species. While critical habitat does require special management considerations or protection, the Act does not "preclude any alterations to the areas" as stated in the DEIS.

The manner in which the DEIS attempts to summarize the issue of proposed critical habitat and the "overlay wildlife refuge" (proposed Guam National Wildlife Refuge) in this section is confusing. We recommend that the summary statement in this section be expanded in the final documents to include information which more clearly explains the issue. Alternately, the summary statement should reference section 4.4.1., which includes a more complete discussion of the critical habitat/overlay refuge issue.

Page 4-6. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Hydrology/Water Resources. Potential Impacts and Proposed Mitigation Measures. 4.3.2.2. Apra Harbor Complex. The DEIS states that there would be an increased demand upon the Fena Reservoir system as a result of increased activities and facilities in the Apra Harbor Complex. The Department is concerned that increased water withdrawal from Fena Reservoir may negatively impact endangered Mariana common moorhen.

Fena Reservoir is an important dry season refuge for moorhens. The number of moorhens in the reservoir typically increases during the dry season as ephemeral wetlands dry up (Stinson et al., 1991). An assessment of impacts to the endangered Mariana common moorhen from this action should be provided.

If the assessment indicates that adverse impacts to moorhens are likely to occur as a result of the proposed water withdrawals, the Section 7 consultation should be initiated with the FWS. The

results should be included in the federal consistency section of the final documents.

Page 4-13. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Potential Impacts and Proposed Mitigation Measures. 4.3.2.1. Andersen Air Force Base. The DEIS states that "Water used for washing aircraft will be treated and recycled. Oil and other contaminants will be collected and disposed of appropriately. Oil water separators will be installed where necessary... ". Terms such as "treated," "contaminants," and "appropriately" as used in the above context are too vague to allow an adequate evaluation of potential contaminant-related impacts to trustee wildlife resources from this action. The final documents should present additional information on types of contaminants expected, specific treatment methods to be used, monitoring to be implemented, and a mitigation/contingency plan to handle spills or emergency situations.

Page 4-13. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Drainage. 4.3.2.2. Potential Impacts and Proposed Mitigation Measures. 4.3.2.2. Apra Harbor Complex. Silt screens and sediment basins will be required to minimize construction-related erosion impacts to wetlands downslope of the Tipalao family housing expansion site, and a buffer zone will be maintained between the proposed housing site and Orote Point Ecological Reserve to prevent runoff and pollutants from entering the reserve. The final documents should define the limits of the buffer zone and describe the existing vegetation community so that the adequacy of the mitigation measures to protect these sensitive habitats can be evaluated.

Page 4-14. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Terrestrial Biota. 4.4.1 Background. The information in this section adequately summarizes the proposed critical habitat designation for four federally listed species of Guam forest birds and two species of fruit bats and describes the proposed Guam National Wildlife Refuge. To further clarify these FWS actions, we recommend inserting the following sentence at the beginning of paragraph five: "Prior to the proposed rule for critical habitat there were a number of attempts to agree on special land management provisions through a multiple party Memorandum of Understanding (MOU) among the military, the FWS, the Government of Guam, and the Marianas Audubon Society. The attempt to write and agree on the MOU has not yet succeeded."

Page 4-17. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Terrestrial Biota. Existing Conditions. 4.4.2.1. Andersen Air Force Base. Appendix E. The time spent conducting the bird and mammal surveys (4-days on 8 separate sites) is inadequate to conclusively document the

presence or absence of sensitive and endangered species. Moreover, the FWS was not contacted for information regarding sensitive or endangered species in the project area, either by the biological consultant or the DEIS preparers, even though the Navy was aware that a FWS biologist was stationed on Guam for 6 months to survey the area for such species. The lack of adequate field surveys and coordination with the FWS is reflected in the DEIS which states that "No endangered or rare animal species appear in the managed lands or scrub forests around Andersen." This statement needs to be corrected to reflect the presence of the Micronesian starling in the scrub forest and on managed lands in and adjacent to Andersen Air Force Base.

Page 4-19, Chapter 4, Existing Conditions, Environmental Consequences, and Mitigation Measures, Terrestrial Biota, 4.4.2.2, Existing Conditions, Apra Harbor Complex, Appendix J, Tipalao Housing Expansion Area, Northeast. The DEIS indicates that five separate areas comprising a total of approximately 11.2 acres of wetlands are located within the Apra Harbor Complex. Four of the areas comprise less that 0.4 acres of wetland. The remaining wetland is 10.8 acres in size.

Avifaunal observations in these wetlands have documented the presence of several species of migratory shorebirds and two native wading birds. Although not documented during the surveys, the wetlands may provide suitable habitat for the endangered Mariana common moorhen. Moorhens are known to move about during the wet season, taking advantage of ephemeral, seasonal, and persistent wetlands. Moorhens are also secretive, and these factors combined make them difficult to count (Stinson et al., 1991). We believe that the time spent conducting the bird surveys was too limited to conclusively document the presence or absence of the endangered Mariana common moorhen.

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Based on the preliminary site plans presented in the DEIS, the Department is concerned that negative impacts to migratory birds and the Mariana common moorhen may occur from the proposed residential development. We recommend additional surveys for the moorhen be conducted during the wet season and the results of these surveys and an assessment of the value of the habitat as potential moorhen habitat be included in the final documents. If a "may affect" determination for the moorhen is made, Section 7 consultation should be initiated with the FWS, and the results of the consultation included in the federal consistency section of the final document.

To ensure protection for wetlands and associated wetland-dependent birds in this area, including potential habitat for the endangered Mariana common moorhen, we recommend development of a mitigation plan that includes conservation measures beyond simple avoidance. Conservation measures such as a vegetation buffer, predator control fencing, and enhancement of the wetland area

should be considered. They should be implemented as a part of the overall project and incorporated into the final document.

Page 4-20, Chapter 4, Existing Conditions, Environmental Consequences, and Mitigation Measures, Terrestrial Biota, 4.2.2.2, Existing Conditions, Apra Harbor Complex, New Apra Heights, Polaris Point. The DEIS needs to provide sufficient information to determine whether wetlands occur at the alternative housing sites at New Apra Heights and Polaris Point. If these sites are given further consideration as residential development sites, jurisdictional wetland determinations should be made and the results of the determinations included in the final document.

Page 4-22, Chapter 4, Existing Conditions, Environmental Consequences, and Mitigation Measures, Terrestrial Biota, 4.4.1.1, Potential Impacts and Proposed Mitigation Measures, Andersen Air Force base. We disagree with the statement in the DEIS that "Any adverse impacts to animal species generated by the construction of the hangar/apron/washrack facility and relocation of the access road and above-ground line will also be minimal."

Although the proposed hangar/apron/washrack facilities and the road realignment will be located on "previously developed land," the secondary forest which now occurs on the site has value as wildlife habitat and lies within an area proposed for critical habitat designation. Such habitat may be necessary for the continued existence and recovery of the Mariana crow, fruit bat, and other species currently involved in captive breeding programs.

More importantly, the DEIS does not address the indirect impacts of the facilities on species existing within the remaining adjacent secondary and primary forest habitats. An analysis of the effects of noise, lights, and additional aircraft activity on these species should be provided in the final documents.

For example, the noise generated during apron maintenance "run-ups" may affect the ability of endangered Mariana crows to communicate vocally which is vital for defending nests, maintaining territories and for feeding activities. Service biologists conducting crow surveys during 1993 documented that the noise generated by the "run-ups" made it difficult to impossible to hear crows. The engine noise interfered with call surveys as far away as the cliff line, and the planes could be heard across distances of up to one mile.

The Service is concerned that crows may avoid or abandon suitable nesting and foraging areas specifically because they are inhibited by the noise or cannot communicate adequately because of it.

Mitigation measures to reduce or eliminate ambient noise reaching the adjacent forest should be developed. Such measures might include constructing earthen or structural berms and/or modifying the orientation of facilities and aircraft. The measures developed should be described in detail in the final document.

We are also very concerned about the secondary effects of the present and proposed outside lighting at the VRC-50 facilities, including apron, runway, and perimeter lighting. This lighting may inhibit Mariana crows from using the adjacent forest north of the area for roosting and/or nesting.

The floodlights on the runway currently shine out to the cliff-line, up to one mile away. The flightline perimeter lights are also directed out towards the forest, and during the 1993 crow nesting season, these lights actually illuminated two crow nests within the FCLP study area.

The nests were made by a single pair of crows that attempted to nest twice. Each nest was located fewer than 150 feet away from the perimeter lights, and both of the nests failed. The lights may have been a source of disturbance to the crows and also may have increased the risk of predation on the nest by making the nest more visible at night to predators.

Lighting should be minimized, filtered, and directed down and away from the forest to reduce the potential for negative lighting-induced impacts on crows. Specific mitigation measures such as these should be developed and presented in the final document.

Relocation of the VRC-50 to Guam may also result in increased accidental exports of brown tree snakes in Navy aircraft or cargo to other Pacific Islands, including Hawaii. Specific measures to prevent the accidental export of brown tree snakes should be developed in coordination with the FWS' Research Division and the U.S. Department of Agriculture's Animal Damage Control representatives on Guam. Any measures developed should be included in the final documents.

Page 4-21, Chapter 4, Existing Conditions, Environmental Consequences, and Mitigation Measures, Terrestrial Biota, 4.4.4, Cumulative Impacts. The DEIS states that faunal species diversity will not be affected by the proposed actions. However, the potential for non-native species to be introduced into the terrestrial environment of Guam as a result of relocation activities is not discussed. The issue applies to the relocation activity in general and is not restricted to any one military installation in particular. Because of this, and the fact that Guam already has a severe problem with introduced species, the Service recommends that this issue be addressed from a cumulative

impact perspective and the proposed procedures to prevent such introductions be identified in the final document.

We disagree with the statement that "Although these impacts [FCLPs on endangered birds and bats] are seemingly unavoidable, they can be minimized as to avoid being significant." The results of the FWS' 6-month study to document the impact of the FCLPs on endangered Mariana crows and fruit bats was inconclusive. Further monitoring is required prior to making a determination on whether the relocation of the VRC-50 Squadron to Guam would result in a significant impact to these endangered species.

We are concerned that the relocation of VRC-50 to Andersen Air Force Base may result in increased training activities or flights associated with VQ-1, VQ-5, HC-5, or by other aircraft stationed at the Naval Air Station Agana or by transitory aircraft. During the course of the 6-month study on crows and bats, it appeared that such flights and training exercises were increasing. Several unauthorized low overflights by both planes and helicopters were documented by the Service.

If similar training is planned in the future by other squadrons, section 7 consultation with the FWS should be initiated for these actions and the results of the consultation disclosed in the final documents.

Page 4-5, Chapter 4, Existing Conditions, Environmental Consequences, and Mitigation Measures, Water Quality, 4.5.1.2, Existing Conditions, Standards and Classification of Guam's Waters, Surface and Marine Waters. In the last paragraph, vessels from small outboard fishing boats to large military ships should be included in the list of potential oil and toxic pollutant dischargers existing at Guam. This clarification should be included in the final document.

Page 4-36, Existing Conditions, Environmental Consequences, and Mitigation Measures, Marine Environmental Consequences, and Mitigation Measures, Marine Environment, 4.6.3, Other Impacts/Cumulative Impacts. The DEIS states that the Naval Sea Systems Command will develop procedures to minimize the introduction of potentially dangerous pathogens and organisms into U.S. coastal waters by discharged ballast water and in sediments retained on anchors, cables, chains, etc. The Service recommends that these procedures be presented in the final documents.

Page 4-38, Chapter 4, Existing Conditions, Environmental Consequences, and Mitigation Measures, Marine Environment, 4.6.1.5, Existing Conditions at Apra Harbor, Marine Biota. In the second paragraph, the coral species"...M. platyphylla..." is misspelled and should be corrected in the FEIS.

Page 4-38. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Marine Environment. 4.6.2.1. Potential Impacts and Proposed Mitigation Measures. Wastewater Treatment Plant Expansion. It is stated in the second paragraph of this section (p. 4-31), that the seaward end of the outfall pipe for the proposed, relocated Tipalao Outfall will terminate in 120 feet of water. The submarine topography in the Tipalao area is steep and a depth of 120 feet is reached at a relatively short distance from shore.

The potential for retention of bacteria and other harmful microorganisms in the reef-fish food chain, especially with the proposed expanded volume of effluent, may be high, and this is not addressed in the DEIS. The location of the actual point of outfall discharge and the potential food chain pathways for various bacteria and other microorganisms should be discussed in the final document more rigorously from biological and environmental perspectives.

Page 4-35. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Marine Environment. 4.6.2.3. Potential Impacts and Proposed Mitigation Measures. Naval Special Warfare Unit One (NSWU-1). In the second paragraph, it is stated that the NSWU-1 has "...requested that additional typhoon moorings be assigned to them to accommodate their requirements. The introduction of any new swing moorings would temporarily increase turbidity and could cause severe damage to benthic communities in the drag chain radius."

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Details on the number of needed additional moorings, potential sites for the moorings, and the potential impacts which could result from mooring installation work are absent in the DEIS and should be provided in the final documents.

Page 4-35. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Marine Environment. 4.6.5. Other Impacts/Cumulative Impacts. In the fifth paragraph of this section (p. 4-36), it is stated that "Anchor chain damage to coral reefs also needs to be prevented.... Mitigation includes the placement of moorings away from reef areas." Details on potential mooring buoy design and number and locations of potential mooring sites under consideration are absent from the DEIS and should be provided in the final documents.

In the sixth paragraph, it is stated that "...the Navy may need to dredge or drag-beam the western half of the inner harbor as well as a channel connecting the inner and outer harbors." Details on the exact areas to be dredged, the estimated amount of spoil to be dredged, the planned method and location of spoil disposal, and the potential impacts associated with this activity are absent from the DEIS and should be provided in the final documents.

Page 4-42. Chapter 4. Existing Conditions, Environmental Consequences, and Mitigation Measures. Noise. 4.8.1.1. Andersen Air Force Base. We believe that the noise analysis in the DEIS adequately predicts the impacts of the proposed relocation of the VRC-50 Squadron on the current sound levels. The noise analysis was based on a predictive model that is over three years old and time-averaged and does not accurately reflect either the present or proposed actual sound levels. More sophisticated and detailed measurements should be taken from strategic points in the area both prior to and during FCLP maneuvers at various elevations.

We agree that the permanent relocation of VRC-50 Squadron could significantly impact the Mariana crow and Mariana fruit bat. Visual and noise disturbances of FCLP aircraft would affect nesting, roosting and foraging behavior of the species. Fewer than 400 bats currently occur on Guam, and almost all of these bats roost under the proposed FCLP flight pattern at Pati Point on Andersen Air Force Base. These bats have previously been flushed from their roost by low-flying aircraft, and may have moved from their traditional roost during the last 6 months to avoid unauthorized low-flying aircraft.

As few as 50 crows may remain on Guam, and only three young are known to have fledged since 1986; it is not known if these fledglings survived. Of the 12 pairs known to have initiated nesting in 1993, none reached the nestling phase, apparently due to brown tree snake predation and other potential disturbances.

A six-month Navy-funded crow/bat monitoring program has recently been completed by FWS biologists, and a separate report on that study is in preparation. The purpose of the study is to determine the presence and distribution of crows in the FCLP area and to study the potential effects of the temporary FCLP training on the crows and bats, pursuant to the terms and conditions of the FWS' Biological Opinion for the temporary relocation of FCLP training to Guam.

Scheduled experimental FCLPs were to be flown over incubating/brooding crows while the nests (and bat roosts) were being monitored to determine if and how the overflights might negatively impact the foraging, breeding and defense behaviors of these species.

The study was unable to produce the necessary disturbance data because the pair of crows nesting in the study area never reached the incubation stage, and the scheduled overflights were not conducted. While the cause of this nest abandonment/failure could have been due to snake predation or other disturbances, it is also possible that unauthorized aircraft flights over the nest site could have resulted in abandonment of the nest.

A large number of Navy and Air Force planes were observed flying over the nest area below 1000-foot elevation during and following the nest-building period, and many more such unauthorized, unscheduled flights likely occurred during the late afternoon, evening, and night hours when the biologists were not present at the nest sites.

Low-flying aircraft have been known to distract the defending male Mariana crow, leaving the female and eggs vulnerable to attack from other crows or other predators. At least one nest is known to have failed in this manner when a helicopter flew over the nest. The potential for VRC-50 airplanes to induce nest abandonment is supported by an observation of two crows in the study area dropping nesting material, calling in alarm, and flying out of the nest area when a Viking (S-3) aircraft flew directly overhead below 1000 feet.

In subsequent weeks, however, these birds continued constructing nests in the area. Observations of nesting crows in an adjacent area revealed that crows can be flushed from their nest by certain loud jets, as occurred when a B-1 bomber took off from a run-way over 1.5 miles from the nest. While these aircraft impacts are negative, this information is not sufficient to determine the significance of the impact of the proposed FCLPs on the reproductive success and continued existance of the Mariana crows and Mariana fruit bats.

Page 4-172. SUMMARY. 4.26.1. Direct and Indirect Effects and Their Significance. The potential for indirect or secondary impacts to marine and terrestrial biota by introduced species as a result of relocation activitiential impacts be identified in this section of the FEIS. Table 4.26.2. already presents this information with regard to the marine environment, and the Service further recommends that the table include similar information for the terrestrial environment in the FEIS.

Page 5-1. Chapter 5. Consistency with Land Use Plans, Policies, and Controls. Federal Government. 5.1.3. Endangered Species Act of 1973. The information in this section should be corrected to reflect that the NMFS and the FWS share responsibility for listed sea turtles (See comment (d) above). In addition, the information concerning section 7 responsibilities should be corrected to reflect that the Endangered Species Act requires federal agencies to consult with the FWS or the NMFS on federal actions that may affect listed species or confer on actions which will likely cause jeopardy to the continued existence of proposed species. Candidate species are not protected under the Act until they are officially proposed to be added to the federal list of endangered and threatened species.

Comments on Historic Resources
(Buildings, structures, Non-Archaeological Sites, and Objects)

Page 1-6. 1.5.2.1. Andersen Air Force Base. Work activities at Andersen may affect the VRC Hangar, Apron and Washrack. The renovation of Staff Non-Commissioned Officer Quarters (SNCOQ) and Bachelor Officers' Quarters (BOQ) may also be affected. We recommend including photographs of these resources in the final document.

Page 1-6. 1.5.2.2. Apra Harbor Complex. Eighteen resources are listed, including 300 units of housing. Photographs of the resources and a reference to the site map should be included in the final document.

Page 1-6. 1.5.2.4. Others. Renovation of Oceanography Building, U.S. Naval Oceanography Command Center/Joint Typhoon Warning Center, Nimitz Hill, is not listed in section 4.10.2. This raises questions about the resource: Is it National Register listed or eligible? There should be a clarifying statement. There should also be a description of the renovation work, a photograph of the building and a reference to the site map.

Page 4-68. 4.10.2.1. Andersen Air Force Base. The historic importance statement describes a period of significance from 1945 to the 1960's, but only in regard to Northwest Field. It does not address auxiliary structures such as hangars and associated buildings. Additionally, there is no discussion of administrative, technical, and residential buildings associated with the activities related to the significance of Northwest Field.

Questions must be raised then about what changes may be made to the VRC Hangar, Apron, and Washrack. Is this related/not related to the activities of Northwest Field? Either way, there should be a clarifying statement. Further, are the SNCOQ and BOQ related to the activities associated with Northwest Field? Has there been a determination of eligibility made for these structures? What does the renovation work involve?

There should be a clarifying statement regarding the historic importance of the resources, a description of the work to be completed, and the impact of the work on the structures.

Any work undertaken on any historic resource must meet the Secretary of the Interior's Standards. This statement should be clearly stated in the text.

Clay Ching, Commander 17

Page 4-68. 4.10.2.2. Apra Harbor Complex. These resources and National Register determinations of the individual buildings/complexes should be discussed in this section. The additions, alterations, and modifications for the structures listed on page 1-6 need to be included for discussion in this section.

Pages 4-69 and 70. 4.10.2.3. Naval Magazine. The description of the bridges should be expanded, and the significance of their construction should be discussed. Photographs of these resources and the landscape would be extremely helpful in understanding their relationship, and a reference to the site map should be included.

Page 4-70. 4.10.3. Cumulative Impacts

Project activities should be defined; unless activities are defined, the effect of an activity on a historic resource cannot be assessed. Historic landscapes and environments can be altered by new construction (e.g., roads, overhead wires, grading) which may not be directly attached to a historic building. We suggest including sketch maps to show the historic resources districts in relation to the new development or activities.

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DEPARTMENT OF THE NAVY
PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
(MAKALAPA, HI)
PEARL HARBOR, HAWAII 96860-7300

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Ser 232/3887
15 Jul 1993

Ms. Patricia Sanderson Port
Regional Environmental Officer
U.S. Department of the Interior
Office of Environmental Affairs
600 Harrison Street, Suite 515
San Francisco, CA 94107-1376

Dear Ms. Port:

Subj: DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS) FOR PROPOSED FACILITIES DEVELOPMENT AND RELOCATION OF NAVY ACTIVITIES TO THE TERRITORY OF GUAM FROM THE REPUBLIC OF THE PHILIPPINES

Thank you for your letter dated June 24, 1993, regarding the DEIS for the above referenced action. Our responses to your comments are as follows:

a. GENERAL COMMENTS

(1) Comment: Proposed actions may result in adverse impacts; further Section 7 consultation is needed.

Response/Revisions to DEIS: Terms and conditions of Section 7 consultations to address the issues listed in your letter will be incorporated in the Record of Decision.

Revisions to DEIS: None.

(2) Comment: Impacts on the Pacific National Historical Park.

Response: The increase in population due to the relocation represents less than two percent of the projected population for 1995 (see Section 4.11.2.1). There might be an increase in visits to the Park as a result of the relocation, but the increase will be minimal.

Revisions to DEIS: None.

(3) Comment: Need to include mitigation measures for protection of Orote Point historic resources.

Response: All proposed developments will be located well away from historic resources. The cave and other historic resources referred to in your letter are located in what the archaeologists refer to as the indirect impact areas. These sites will not be directly affected by either construction or military activities, but their proximity to the proposed Tipalao housing means that they might be affected by the increased number of people in the general area. As stated in Section 4.10.1.2, efforts to protect these sites will include flagging certain areas during construction and putting up signs to notify people of the sites' significance.

Revisions to DEIS: None.

(4) Comment: Need to protect submerged historic resources in the harbor.

Response: Text revisions to provide more information on potential impacts to submerged resources are given below. The concepts of designating protection zones and designating these resources as National Register Properties will be considered.

Revisions to DEIS: The following text has been added to Section 4.10.2.2 under Potential Impacts and Proposed Mitigation:

None of the proposed facilities or activities will affect known submerged historic resources. The only in-water construction project will be associated with the EODMU-5 bulkhead repair, located well away from the submerged resources. EODMU-5 training operations in the harbor, including underwater detonation, will not occur in areas close to the submerged resources.

Increased ship traffic should have little or no impact on these resources. Existing moorings are located a sufficient distance away to prevent adverse effects of anchor chains. Any new moorings in the outer harbor will be placed in consultation with the Guam Environmental Protection Agency.

(Note: See response to item b(4) below. The existing harbor can accommodate all projected ship traffic, so no dredging is required as a result of the relocation.)

b. SPECIFIC COMMENTS

(1) Comment: Suggested text changes to Executive Summary write-up on Marine Environment.

Response/Revisions to DEIS: The term "coral table reef" has been replaced by "fringing coral reef." However, we have chosen not to include the additional suggested text since this is an Executive Summary and should be kept as brief as possible.

(2) Comment: Need to address loss of native forest habitat due to wildland fires.

Response/Revisions to DEIS: The Executive Summary under Terrestrial Biota has been revised as follows (added text is underlined):

Guam's once abundant forests have been depleted by urban and agricultural development as well as <u>fires and</u> natural forces.

(3) Comment: Need to address potential for relocation activities to result in introduction of non-native species into Guam's terrestrial environment.

Response: All aircraft and ships arriving in Guam are subject to the same customs and agricultural regulations and inspection procedures. Hence, the same regulations apply to both civilian and military carriers. In cooperation with civilian government officials, the U.S. military provides personnel to inspect incoming military aircraft and vessels. The existing

regulations and procedures are adequate to control the introduction of non-native species into Guam's terrestrial environment.

Revisions to DEIS: A paragraph has been added to Section 4.4.4, Cumulative Impacts, to address this issue:

- *Introduction of Non-native Species. There is concern that the relocation activities will result in introduction of non-native species into Guam's terrestrial environment (for example, plants and insects). All aircraft and ships arriving in Guam—both civilian and military—are subject to customs and agricultural regulations and inspection procedures. In cooperation with civilian government officials, the U.S. military provides personnel to inspect incoming military aircraft and vessels. The existing regulations and procedures are adequate to control the introduction of non-native species into Guam's terrestrial environment.*

(4) Comment: Need to adequately evaluate impacts resulting from increases in vessels and construction activities (Section 2.3.2).

Response: Section 2.3.2 describes the proposed military construction projects. Impacts of these projects, as well as changes in military activities, are addressed in Chapter 4. See Section 4.6.3, which covers potential impacts of increased ship traffic.

The waterfront utilities (P-237) and gantry crane and rails (P-156) are the only improvements to the harbor planned as a result of increased vessel traffic associated with the relocation. The existing harbor can accommodate all projected ship traffic. Deepening of the harbor or new dredging would be required only if requirements for homeporting or accommodating battle groups change. No berthing requirements are expected as a result of the relocation to justify a dredging project. The only in-water construction project will be associated with the Explosive Ordnance Mobile Unit (EODMU)-5 bulkhead repair.

Revisions to DEIS: None.

(5) Comment: Correct the information in Chapter 4 to reflect presence of green and hawksbill turtles in Apra Harbor and Sumay Cove. Provide more thorough discussion of bulkhead repair project; should discourage construction during turtle nesting season.

Response: The section on marine biota has been revised to reflect the presence of both green and hawksbill turtles (see below). There will be no disturbance to turtle nesting beaches in Sumay Cove. It is reasonable and feasible to prohibit in-water work on the bulkhead during the turtle nesting season. However, it is probably not necessary to limit dryland work such as backfilling and capping of the new piling.

Revisions to DEIS: Section 4.6.1.5 has been revised by adding the following text to the third paragraph:

In addition, both green and hawksbill turtles have been observed in Apra Harbor and Sumay Cove by DAWR biologists.

Text has been added to the fourth paragraph of Section 4.6.2.2 as follows:

Because of the presence of green and hawksbill turtles in the harbor, in-water work on the bulkhead will be prohibited during turtle nesting season (April-September). Dryland work such as backfilling and capping of the new piling will be permitted during this period.

(6) Comment: Include information on increased demolition exercises on EOD beach between Tarague Beach and Pati Point; concern about "hardening" of beach through sand compaction and impact on turtle nesting.

Response: The relocation will not result in increased usage of Andersen Air Force Base (AFB) EOD facilities, so study of the EOD beach is beyond the scope of the EIS. EODMU-5 intends to use the EOD site at the Naval Magazine (NAVMAG)--the same one used by the EOD detachment that was in Guam before the relocation. The tempo of use of the NAVMAG site is not expected to increase significantly, since unexploded ordnance is not normally transported back to Guam for demolition following an exercise.

Revision to DEIS: None.

(7) Comment: Should initiate Section 7 consultation with U.S. Fish and Wildlife Service (USFWS) for demolition activities which affect turtles on land.

Response: Section 7 consultant with the National Marine Fisheries Service (NMFS) on the impact to sea turtles is in progress. Should it be determined that there may be an impact to sea turtles on land, the USFWS will be contacted.

Revisions to DEIS: None.

(8) Comment: Provide correct/complete information on critical habitat.

Response/Revisions to DEIS: Rather than expand this section, which is meant to provide a brief overview, we have referred the reader to Section 4.4.1 for more details. The third and fourth sentences in Section 3.1.2 have been revised as follows (deletions bracketed; additions underlined):

Critical habitats are defined in the Endangered Species Act and attempt to promote preservation of the species [by precluding any alterations to the] protecting areas surrounding their respective nesting and roosting sites. As an alternative, the Navy has proposed [delineating the same areas as] a wildlife refuge overlay. See Section 4.4.1 for more details.

(9) Comment: Concern that increased withdrawal from Fena Reservoir may negatively impact common moorhen.

Response: Demand on the Navy's Fena system will increase by an estimated 0.5 mgd as a result of the relocation. During the dry season, this represents about a 4.8 percent increase, and during the wet season, it is an increase of approximately 4.0 percent. Assuming complete drought conditions for seven months (worst case scenario), post-relocation demand would represent an estimated 5.8 percent of capacity. According to our calculations, if there is no inflow into Fena Reservoir for one month, water level is estimated to decrease anywhere between three to four inches due to the relocation demand of 0.5 mgd, depending on conditions. A 3.5-inch monthly drawdown for seven months of the year would result in a decrease in water level of slightly over two feet. Total reservoir drawdown, including rollback demand, during drought conditions can be as high as five feet per month. The effect of this drawdown on the actual reservoir level varies and is dependent upon the level of the reservoir before drought conditions set in.

It is unlikely that a drawdown of these magnitudes, which can be further decreased through water conservation and other mitigation measures, will adversely affect Fena Reservoir's value as a moorhen habitat. This may have either no impact or a positive impact if it provides more shallow water areas that could be used as moorhen feeding and nesting habitat. The Department of Aquatic and Wildlife Resources (DAWR) biologist who is knowledgeable about moorhen at Fena Reservoir concurs that lower water levels provide better moorhen habitat by exposing flats on the southern end of the reservoir, that is used for feeding, nesting, and loafing (personal communication with Mr. Tim Sutterfield, Navy Biologist, June 26, 1993).

Revisions to DEIS: Section 4.4.4, Cumulative Impacts, has been revised to discuss the possible impact of increased water demand on the Fena Reservoir water level and, hence, on the reservoir's habitat potential for moorhen. The following text has been added:

Section 4.16.4 of this document addresses the cumulative potable water demand due to the relocation. In its comments on the DEIS, the U.S. Fish and Wildlife Service questioned whether increased water withdrawal from Fena Reservoir may negatively impact endangered Mariana common moorhen. The Mariana Common Moorhen Recovery Plan (U.S. Department of Interior, Fish and Wildlife Service, September 1992) identifies Fena Reservoir as a "primary" habitat for moorhen. Fringes of portions of the reservoir provide good habitat for moorhen, but steep banks and deep water over most of the reservoir limit its habitat potential.

Potable water demand due to the relocation is estimated to increase by 4.0 percent during the wet season and 4.8 percent during the dry season. In the worst case scenario—complete drought conditions over a seven month period—the new demand would represent an estimated 5.8 percent of capacity. If there is no inflow into Fena Reservoir for one month, water level is estimated to decrease anywhere between three to four inches due

to the relocation demand of 0.5 mgd, depending on conditions. A 3.5-inch monthly drawdown for seven months of the year would result in a decrease in water level of slightly over two feet. Total reservoir drawdown, including rollback demand, during drought conditions can be as high as 5 feet per month. The effect of this drawdown on the actual reservoir level varies and is dependant upon the level of the reservoir before drought conditions set in. This is expected to have either no impact or a positive impact on moorhen if it provides more shallow water areas that could be used as feeding and nesting habitat. The DAWR biologist who is knowledgeable about moorhen at Fena Reservoir concurs that lower water levels provide better moorhen habitat by exposing flats on the southern end of the reservoir that is used for feeding, nesting, and loafing (personal communication with Tim Sutterfield, Navy Biologist, June 26, 1993).

(10) Comment: Regarding the hangar/washrack, provide more information on types of contaminants expected, treatment methods used, and plan to handle spills or emergency situations.

Response: The aircraft washing facility at Andersen AFB is being designed as a closed system, with any effluent disposed through the sanitary sewer. A new oil-water separator is being designed as part of the project. Andersen AFB has an existing spill contingency plan which will be reviewed and updated as needed to reflect the differences posed by VRC-50 aircraft. It is unlikely that use of the north ramp for aircraft parking and servicing will be different than when it was previously occupied by B-52 and other aircraft. In fact, VRC-50 operations are at a much smaller scale.

Revisions to DEIS: The first sentence in the second paragraph of Section 4.3.2.1 has been revised by deleting the word "contaminants" and replacing it with "petroleum products."

(11) Comment: Silt screens and sediment basins are required to minimize construction-related erosion impacts on the wetlands in the Tipalao housing site. Define limits of buffer zone with Orote Point Ecological Reserve and describe existing vegetation community so that adequacy of mitigation measures can be evaluated.

Response: The use of silt screens and sediment basins is specified in Section 4.3.2.2.

The Orote Point Ecological Reserve was established by the Navy to maintain the natural conditions of the cliff and undersea areas along the Peninsula's east side, insofar as possible. The southeast boundary of the Reserve is approximately 4,000 feet from Haputo Road. Note in Figure 2.3.13 that no housing will be constructed north of Haputo Road. Hence, the buffer zone will be a minimum of 4,000 feet from the edge of the Reserve.

Revisions to DEIS: Section 4.4.3.2 has been revised to clarify that no development will occur north of Haputo Road and the magnitude of the buffer zone.

(12) Comment: Add text to section summarizing USFWS actions regarding proposed critical habitat and proposed Guam National Wildlife Refuge.

Response/Revisions to DEIS: The recommended text has been inserted in Section 4.4.1:

Prior to the proposed rule for critical habitats, there were a number of attempts to agree on special land management provisions through a multiple party memorandum of Understanding (MOU) among the military, the Service, the Government of Guam, and the Marianas Audubon Society. The attempt to write and agree on the MOU failed.

(13) Comment: Time spent conducting bird/mammal survey was inadequate to conclusively document presence/absence of sensitive and endangered species. There was a lack of coordination with the USFWS. DEIS should be corrected to reflect presence of Micronesian starling at Andersen AFB.

Response: The time spent on the bird and mammal surveys was appropriate in view of the level of disturbance anticipated in the areas studied. While longer observation periods would have yielded more definite data, there are practical limits to how much time is warranted for faunal surveys. The scope of wildlife studies is determined not only by the size, location, and type of habitats to be evaluated, but also on the anticipated impacts of the proposed activities on those habitats. In planning for the faunal survey, all of these factors were taken into account. The time devoted to this survey was sufficient, particularly since several of the sites were developed areas almost devoid of vegetation and bird habitat.

The biologist who conducted the faunal survey was on Guam in July 1992, several months prior to commencement of the USFWS survey at Andersen AFB. He did coordinate closely with staff from the Guam Division of Aquatic and Wildlife Resources, the only experienced wildlife observers on Guam at the time.

Section 4.4.2.1 does include mention of the presence of the Micronesian starling at Andersen AFB (see last paragraph), as noted by the biologist in his report (Appendix E). This bird is not a federally listed endangered species.

Revisions to DEIS: The first sentence of Section 4.4.2.1 has been deleted and replaced with the following:

Endangered or rare animal species do not generally appear in the managed lands or scrub forests around Andersen, although managed lands might harbor migratory birds during the winter, and endangered bats could be attracted to flowers, gardens, and fruit trees.

(14) Comment: Concern about impacts on moorhen and migratory birds which may frequent wetlands in Tipalao housing area. Recommends additional surveys for moorhen during the wet season and development of a mitigation plan to include measures beyond simple avoidance.

Response: These wetlands are not listed in the USFWS *Mariana Common Moorhen Recovery Plan* (September 1992) as either a primary or secondary habitat, although it is possible that they might be used seasonally by moorhen. Since the project will avoid all wetlands at the Tipalao housing site, further surveys to identify moorhen are unnecessary. Sufficient mitigation is proposed to protect the wetlands, including fencing and vegetated buffers of between 50 and 100 feet. In addition, silt fencing will be used during construction, and there will be no direct drainage into the wetlands after construction is completed. The housing will not affect the wetlands or any potential moorhen sites. There is a separate project aimed at improving the wildlife value to much larger and more important wetlands in the vicinity of Camp Covington and the Navy Public Works Center (PWC) landfill.

Revisions to DEIS: The following paragraph has been added to Section 4.4.2.2 under Tipalao Expansion Area, Northeast:

Although these wetlands are not listed in the Mariana Common Moorhen Recovery Plan (U.S. Department of Interior, Fish and Wildlife Service, September 1992) as either a primary or secondary habitat, it is possible that they might be used seasonally by moorhen. The endemic Mariana common moorhen (Gallinula chloropus guami) is listed as an endangered species, and habitat loss is considered the prime factor causing its decline in population. Mitigation would include fencing of the wetlands and establishing vegetated buffers of between 50 and 100 feet. These will provide both a physical and visual barrier from humans and potential predators.

(15) Comment: DEIS lacks sufficient information to determine whether wetlands occur at alternative housing sites. If sites are further considered, need to do wetland determination.

Response: Wetlands were observed by the botanical consultant on the alternative housing sites. As explained in the DEIS, both the Polaris Point and New Apra Heights sites were not chosen as the preferred alternative for a number of reasons. The DEIS states in Section 4.4.2.2 that if either site is reconsidered for housing, wetland determinations will be made.

Revisions to DEIS: None.

(16) Comment: Disagree that impact on secondary forest displaced by realigned road for the hangar project will be minimal.

Response: A rough calculation shows that less than five acres of land will be displaced north of the existing road by the hangar project. This includes the wide grassy strip between the road and the secondary forest. It is estimated that about half of the area to be displaced is secondary forest. Therefore, the effect of the realigned road will be minimal.

It is acknowledged that the proposed project site will impact a limited amount of forest within an area proposed as critical habitat, but the area to be cleared is not high-value wildlife habitat for threatened or endangered species. In surveys

conducted between August to December 1992, the Navy wildlife biologist observed no crows or fruit bats within 200 meters from the area in question.

Revisions to DEIS: The following text has been added to Section 4.4.3.1:

Less than five acres of land will be displaced for the road realignment, and only about half of this area is forest land. The area to be cleared is not high-value habitat for threatened or endangered species.

(17) Comment: Should address indirect impacts of noise, lights, and additional aircraft activity.

Response: The effects of engine run-up noise and exterior, apron, runway, and perimeter lighting on crows, bats, and other species is unknown, but some of these are pre-existing conditions not attributable to the relocation. As stated above, Andersen AFB provides the only significant habitat for these species on Guam, in spite of ongoing air operations. The Navy intents to continue the study of the impact of the VRC-50 relocation on endangered species in accordance with the terms and conditions of the Section 7 biological opinion received from the USFWS.

(18) Comment: Concern about accidental export of brown tree snakes to other Pacific islands by VRC-50 aircraft.

Response: All aircraft leaving Guam, including those associated with VRC-50, are inspected for brown tree snakes by trained military customs personnel. There is no evidence to support the position that VRC-50 aircraft may increase brown tree snake exports. VRC-50 does not normally fly to Hawaii or other Pacific islands; most land on aircraft carriers. (See Section 2.2.1 for a description of the VRC-50 mission.)

Revisions to DEIS: Section 4.4.4, Cumulative Impacts, has been revised to add the following paragraph:

The increase in military activities on Guam due to the relocation may increase the probability of brown tree snake introductions to other locations. Pacific islands such as Saipan, Tinian, and Hawaii are particularly vulnerable to such incursions. All military aircraft and ocean vessels departing Guam are currently inspected for brown tree snakes by trained military customs personnel. Adequate inspection staff is available to handle the increase in aircraft and ship traffic associated with the relocation. Funding has been provided to the Department of Agriculture Animal Damage Control unit to assist military customs staff with brown tree snake inspections using dogs trained in snake detection.

(19) Comment: Concern about introduction of non-native species to Guam's terrestrial environment.

Response/Revisions to DEIS: See item b(3) above under Specific Comments.

(20) Comment: Disagrees with statement that field-carrier landing practice (FCLP) impacts can be minimized as to avoid being significant; study was inconclusive. Further monitoring is required.

Response: FCLP impacts are unknown until conclusive studies can be completed. The Navy intends to continue the study of the impact of VRC-50 relocation on endangered species in accordance with the terms and conditions of the Section 7 biological opinion.

Revisions to DEIS: Section 4.4.3.1 and Table 4.26.1 have been revised to include proposed FCLP mitigation, including continuation of the monitoring program. (See response to summary comments.)

(21) Comment: Concerned that relocation of VRC-50 to Andersen AFB may result in increased training or flights associated with aircraft stationed at the Naval Air Station (NAS) Agana or by transitory aircraft.

Response: The VRC-50 squadron's relocation will not result in any aircraft stationed at NAS Agana to use Andersen AFB. There is no planned increase in other training flights for Navy squadrons based at NAS Agana. The transitory aircraft flights commented on have been occurring for many years but do not represent any increase in activity due to the relocation. If there is a decision to relocate NAS operations to Andersen AFB, Section 7 consultations will be conducted as part of the NEPA process.

Revisions to DEIS: None.

(22) Comment: Should include vessels from small outboard fishing boats to large military ships in list of potential oil and toxic pollutant dischargers.

Response/Revisions to DEIS: The last sentence of Section 4.5.1.2 has been revised as follows (deletions are bracketed; additions are underlined):

These discharges may occur from agricultural runoff, storm drains, industrial discharge, [and] vehicles, and seagoing vessels.

(23) Comment: Concern about pathogens and organisms introduced into coastal waters by discharged ballast water and sediments retained on anchors, cables, etc.

Response/Revisions to DEIS: The following text has been added to Section 4.6.3:

There are currently no regulations or policies in place at the national or territorial level to address this issue. Navy vessels represent only a relatively small percentage of the overall ship traffic to Guam. Therefore, initiatives to deal with this potential problem will need to be cooperative and encompass both military and commercial shipping. Individual states and territories have the prerogative to deal with this

issue on a local or regional level. In Hawaii, for example, Governor Waihee is considering convening a task force to seek solutions for the state, and the Navy is funding a research project to provide baseline data on existing organisms in Pearl Harbor.

(24) Comment: Correct the spelling of *N. platyphylla*.

Response/Revision to DEIS: The spelling has been corrected in Section 4.6.1.5.

(25) Comment: Concern about the retention of bacteria and other harmful microorganisms in the reef fish food chain, especially with the proposed expanded volume of effluent. Should discuss location of the outfall discharge and potential food chain pathways.

Response: The proposed modification of the Apra Harbor Sewage Treatment Plant (STP) will enable the plant to accommodate the projected increase in average flow of about 0.4 mgd (about a 13 percent increase when compared to the present average sewage discharge). The proposed modifications augment an upgrade of the plant to *secondary* treatment currently being performed under a separate contract. Furthermore, a new offshore outfall will be constructed by the Government of Guam (GOVGUAM) (jointly funded by GOVGUAM and the Navy). The outfall project is not a part of the proposed action but a responsibility of the Public Utility Agency of Guam (PUAG). The discharge depth of 120 feet, 1,800 feet from shore has been approved by the U.S. Environmental Protection Agency. A Draft Environmental Impact Assessment on the outfall prepared by PUAG provides a more thorough analysis of project impacts. It should be pointed out that the proposed modification of the Navy STP includes an expansion of chlorination and dechlorination facilities, which will reduce the amount of bacteria in the outfall.

Given these improvements, together with the high die-off rate of bacteria and other microorganisms in ocean water, and the fact that bacteria generally do not concentrate in the food chain (unlike toxins), there should be little or no concern about the retention of bacteria in the food chain.

Revisions to DEIS: None.

(26) Comments: Provide details on number of additional typhoon moorings for Naval Special Warfare Unit (NSWU)-1, potential sites, and impacts. Provide details on mooring buoy design and number/locations of mooring sites.

Response/Revisions to DEIS: The second paragraph of Section 4.6.2.3 has been replaced with the following text to provide more information on the typhoon moorings:

During typhoon alerts, the coastal patrol boats, the PBRs, and the causeway sections will be moored to designated typhoon buoys in either the inner or the outer harbor. NSWU-1 has requested that additional typhoon moorings be assigned them to accommodate their requirements. All other vessels will be lifted out of the water and secured on land during typhoons. The only other

NSWU-1 activity in outer Apra Harbor, other than the passage to outside destinations, will be dive training operations similar to those conducted by EODMU-5.

As a result of the relocation activities, three new typhoon moorings will be placed in the inner harbor in Naval Anchorage Areas A and B. Also, a new typhoon mooring will be placed in the outer harbor, and an existing one will be relocated. The introduction of any new swing moorings will temporarily increase turbidity and could cause severe damage to corals and other benthic organisms within the drag chain radius. Therefore, they will be designed in accordance with specifications in Naval Design Manuals DM 26.5 and 26.6, and placed to insure minimal impacts. The moorings to be placed in the inner harbor will be designed and placed according to an Army Corps of Engineers permit filed by PWC Guam. Mooring work in the outer harbor will take place in consultation with the GEPA, which will review mooring placement plans before work begins.

(27) Comment: Provide details on dredging.

Response: As explained above, dredging of inner Apra Harbor is not required as a result of the proposed relocation activities.

Revisions to DEIS: Deletion of references to dredging throughout the document.

(28) Comment: Need to take more detailed noise measurements prior to and during FCLPs at various elevations and locations. Concern about impacts of FCLPs on crows and bats.

Response: Regarding the noise analysis, use of a three-year-old model is not inappropriate if better models have not been developed. Completing a new noise survey after FCLPs begin at Andersen AFB may be an acceptable mitigation and would be required to update the Air Installation Compatibility Use Zones (AICUZ) for the base.

In response to the comments about impacts on fruit bats, the fruit bat nesting area at Pati Point is not within the proposed FCLP pattern but at the end of the existing runways. FCLPS should have a minimal effect, if any, on the bats. Speculation that the bats moved due to low-flying aircraft is just that; bats are more often known to move as a result of poaching or other human disturbance. Note that there is no height limitation on straight in and out aircraft approaches and departures from the north runway.

The use of terms such as "large number" and "many more" to describe the number of "unauthorized" overflights of northwest field is inaccurate. Biologist field notes cite 11 aircraft for violating self-imposed flight restrictions. This is a relatively small number, given the total number of Andersen AFB flight operations. Several years ago, a low-flying helicopter was associated with the "take" of a crow, but this is the only confirmed incident.

Because two crows were observed dropping nesting material and flying out of the area when a Viking (S-3) flew overhead, but subsequently continued nest construction, demonstrates that low-flying aircraft may not lead to nesting territory abandonment. The B-1 bomber referred to in the comment is an Air Force plane engaged in existing missions at Andersen AFB and is not associated with the relocation action.

Revisions to DEIS: None.

(29) Comment: Add information to Table 4.26.1 regarding impacts to terrestrial biota by introduced species.

Response/Revisions to DEIS: The table has been revised.

(30) Comment: Correct the information on Section 7 responsibilities.

Response/Revisions to DEIS: Section 5.1.3 has been corrected to reflect that the NMFS and USFWS share responsibility for listed sea turtles, and to reflect requirements for federal agencies to consult with the NMFS or USFWS.

(31) Comment: Recommend including photos of Andersen AFB facilities in the final document.

Response: The hangar/washrack is a proposed project; work activities at Andersen AFB will not affect it except to accomplish its construction. The Staff Non-Commissioned Officer's Quarters (SNCOQ) and Bachelor Officer's Quarters (BOQ) projects will mainly involve interior renovations. Including photographs would not add any value to the EIS document in terms of providing information regarding potential environmental impacts.

Revisions to DEIS: None.

(32) Comment: Provide photographs of 18 resources in the Apra Harbor Complex listed on page 1-6.

Response: The 18 items listed on page 1-6 are *proposed* military construction projects being assessed in the DEIS. Therefore, photos are not yet available. Locations of these projects are shown in Figure 2.3.4 and subsequent figures.

Revisions to DEIS: None.

(33) Comment: Is the Oceanography Building National Register listed or eligible? Describe the renovation work, provide a photograph of the building, and show it on a site map.

Response/Revisions to DEIS: The building is neither listed nor eligible for listing on the National Register. This has been clarified in Section 4.10.2. The proposed construction will be interior renovation only. Providing a photo would not add measurable value to the EIS as a decision document. See Figure 2.3.18 for a site map.

(34) Comment: Concern about Northwest Field.

Response: As stated in Section 4.10.2.1, the proposed construction and activities at Andersen AFB will have no impact on Northwest Field. None of the proposed construction projects or activities will be related to activities associated with Northwest Field. The VRC-50 hangar/apron/washrack is a proposed, not an existing, facility. No historic resources at Andersen AFB will be affected by the proposed relocation actions.

Revisions to DEIS: None.

(35) Comment: Expand discussion of historic resources in the Apra Harbor Complex.

Response: The information in Section 4.10.2.2 and Figure 4.10.2 is provided as general background to give the reader a sense of the historic resources found in the Apra Harbor Complex. It is stated in Section 4.10.2.2 that none of the proposed facilities or activities will displace any historic sites, nor will these be directly affected by the proposed actions. Therefore, providing more detailed information would not add measurable value to the EIS as a decision document.

For more detailed information on these resources, please refer to the *Cultural Resources Management Overview Survey* prepared by Ogden Environmental and Energy Services Co., Inc., listed in Chapter 7, References (under U.S. Department of the Navy).

Revisions to DEIS: None.

(36) Comment: Expand description of the bridges.

Response: A comparison between Figures 2.3.17 and 4.6.10 reveals that the bridges are not located in the vicinity of either the proposed magazines or inert storehouse. Any photographs or additional information would not add measurable value to the EIS as a decision document.

Revisions to DEIS: None.

(37) Comment: Project activities should be defined. Suggest including sketch maps to show the historic resource districts in relation to the new developments/activities.

Response: Project activities (including site maps) are defined in detail in Chapter 2. Because the maps showing project locations (various maps in Chapter 2) and the locations of historic resources (Figures 4.10.1, 4.10.2, 4.10.5, and 4.10.6) are very detailed, it is easier to compare these maps side-by-side rather than present them as overlays.

Revisions to DEIS: None.

c. SUMMARY COMMENTS

Comment: Recommends that the Navy continue the crow/bat study for at least two years; need to resume formal Section 7 consultation.

Response: The Navy has initiated Section 7 consultation on the permanent relocation of VRC-50 to Andersen AFB. Some of the issues such as lighting are pre-existing conditions, unrelated to the relocation actions. Assessment of impacts associated with VRC-50 will be accomplished by a monitoring study in accordance with the terms and conditions of the Section 7 biological opinion.

Revisions to DEIS: The last paragraph of Section 4.4.3.1 has been rewritten as follows:

Due to the possible conflict between FCLP operations and crow nesting and bat roosting behavior, the Navy carried out a six-month monitoring program to determine the effect of flight operations on these endangered species. The survey of territories and nesting/roosting sites began in August 1992, and the study of flight impacts on nesting behavior was initiated in December of 1992, the start of the Mariana crow nesting period. This program was conducted by Navy and U.S. Fish and Wildlife Service biologists, in cooperation with the Guam Division of Aquatic and Wildlife Resources.

Findings of the nesting behavior study were inconclusive, so a two-year study will be funded to obtain the data necessary to make a determination on the impacts of the VRC-50 permanent relocation and operations on the breeding and foraging behavior of the Marina crow and Mariana fruit bat. The study will also seek to determine whether engine run-up noise and airfield lights affect these species. Efforts will be made to reduce low overflights at Andersen Air Force Base during the study period.

During the two-year monitoring program, VRC-50 will fly FCLPs on a controlled basis at Andersen Air Force Base, in accordance with the terms and conditions of the Section 7 consultation, and as needed at NAS Agana. If the monitoring finds that flight activity has no significant adverse effects on the endangered species, VRC-50 FCLPs will be performed at Andersen permanently. If the study finds that significant adverse effects are experienced as a result of the FCLPs, these landing practice exercises may be permanently transferred to

NAS Agana. This issue is also covered in the Environmental Assessment for the Relocation of the VRC-50 Squadron to Andersen, prepared by Belt Collins & Associates for the U.S. Navy (Navy, 1992e; USPWS, 1992a).

We trust that these responses adequately address your concerns. Should you have any questions, contact Mr. Stanley Uehara at (808) 471-9338 or by facsimile transmission at (808) 474-4890.

Sincerely,

MELVIN N. KAKU
Director
Environmental Planning Division

Copy to:
Ms. Sue Rutka
Belt Collins & Associates
680 Ala Moana Boulevard
Honolulu, HI 96813

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GOV. OF GUAM OFFICIALS AND AGENCIES

Governor Joseph Ada
U.S. Territory of Guam
P.O. Box 2950
Agana, Guam 96910

The Honorable Eddie C. Artero
Mayor of Yigo
Mayor's Council
P.O. Box 786
Agana, Guam 96910

The Honorable Antonio Babauta
Mayor of Agat
Mayor's Council
P.O. Box 786
Agana, Guam 96910

Mr. John Balajadia, Administrator
Department of Youth Affairs
P.O. Box 23672
GMS, Guam 96921

The Honorable George Bamba
Senator
Twenty-Second Legislature
155 Hesler Street
Agana, Guam 96910

Mr. Peter R. Barcinas, Director
Department of Commerce
590 S. Marine Drive, Suite 601
Tamuning, Guam 96911

Atty. Gen. Elizabeth Barrett/Anderson
237 O'Hara Street
Agana, Guam 96910

Mr. John Benavente
General Manager
Guam Power Authority
P.O. Box 2977
Agana, Guam 96910

Mr. Leland R. Bettis, Executive Director
Commission on Self-Determination
Government of Guam
P.O. Box 2950
Agana, Guam 96910

Ms. Carmelita C. Blas, Acting Director (3 copies)
Bureau of Planning
Government of Guam
PO Box 2950
Agana, Guam 96910

Lt. Gov. Frank F. Blas
Executive Chambers
P.O. Box 2950
Agana, Guam 96910

Mr. Joaquin Blaz, Director
Department of Revenue & Taxation
855 W. Marine Drive
Agana, Guam 96910

The Honorable Madeleine Z. Bordallo
Chairperson, Committee on Education
Twenty-Second Legislature
155 Hesler Street
Agana, Guam 96910

The Honorable Greg Borja
Mayor of Santa Rita
Mayor's Council
P.O. Box 786
Agana, Guam 96910

Mr. Peter Calvo, Administrator
Agency for Human Resources Development
P.O. Box CP
Agana, Guam 96910

Mr. Marcel Camacho
Executive Assistant
Territorial Planning Council
222 Chalan Santo Papa, Suite 103
Agana, Guam 96910

Mr. Francisco Castro, Director
Department of Land Management
P.O. Box 2950
Agana, Guam 96910

Mr. Fred Castro, Administrator (3 copies)
Guam Environmental Protection Agency
D-107 IT & E. Harmon Plaza
130 Rojas Street
Harmon, Guam 96911

Mr. Charles Crisostomo, Administrator
Guam Economic Development Authority
ITC Building, Suite 911
590 S. Marine Drive
Tamuning, Guam 96911

Mr. John Cruz, President
Guam Community College
P.O. Box 23069
Barrigada, Guam 96921

GOV. OF GUAM OFFICIALS AND AGENCIES (cont'd)

Mr. Richard D. Davis, M.A.
Guam Historic Preservation Officer
Department of Parks & Recreation
Government of Guam
490 Chalan Palasyo
Agana Heights, Guam 96919

Professor Gary Denton
Water & Energy Research Institute
University of Guam
Mangilao Station, Guam 96923

Mr. Joseph Ducnas, Chairman
Public Utilities Commission
P.O. Box 2950
Agana, Guam 96910

Dr. Leticia Espaldon, Director
Dept. of Public Health & Social Services
P.O. Box 2816
Agana, Guam 96910

Fire Chief
Guam Fire Department
287 W. O'Brien Drive
Agana, Guam 96910

Mr. Edward A. Guerrero, Director
Department of Labor
ITC Building
P.O. Box 9970
Tamuning, Guam 96911

The Honorable Carl T.C. Gutierrez, Chairman
Twenty-Second Legislature
Committee on Ways and Means
155 Hesler Street
Agana, Guam 96910

The Honorable Isabel Haggard
Mayor of Piti
Mayor's Council
P.O. Box 786
Agana, Guam 96910

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Bureau of Planning
Guam Coastal Management Program
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Agana, Guam 96910

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Safety and Health Administrator
Department of Public Works
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Agana, Guam 96910

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& Underwater Diving Officer
University of Guam
Marine Laboratory
UOG Station
Mangilao, Guam 96923

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Port Authority of Guam
1026 Cabras Highway, Suite 201
Piti, Guam 96925

University of Guam
Micronesian Area Research Center
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United States Senate
Washington, D.C. 20510-0001

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U.S. Army engineer District, Honolulu
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U.S. Coast Guard
Marianas Section
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Washington, D.C. 20240

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National Park Service
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San Francisco, CA 94102

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Office of Environmental Affairs
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Honolulu, Hawaii 96822-2396

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Soil Conservation Service
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GCIC Building, Suite 602
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U.S. Territory of Guam
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Agana, Guam 96910

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War in the Pacific
National Historic Park
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Yona, Guam 96914

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Commonwealth of the Northern Mariana Islands
Division of Historic Preservation
Department of Community and Cultural Affairs
Saipan, MP 96950

International Archaeological Research Institute, Inc.
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Cambridge, MA 02139

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Tamuning, Guam 96911

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Chamoru Nation Traditional Council
P.O. Box 21806
GMF Barrigada, Guam 96910

Mr. Antonio Torres Artero
International Real Estate Marketing
2nd Foor, YMLG Bldg. Route 8
P.O. Box 988
Agana, Guam 96910

Mr. James Underwood, General Manager
Guam Telephone Authority
P.O. Box 9008
Tamuning, Guam 96911

Mr. James C. Williamson
Williamson & Associates
17535 W. 112th Street
Olathe, Kansas 66061

Mr. Kau Kiang Woo, Manager
Guam Educational Telecom. Corp.
P.O. Box 21449
GMF, Guam 96921

Appendix C

List of MILCON Projects and Population Projections

GUAM FACILITIES PLANNING/PROGRAMMING — PHILIPPINE WITHDRAWAL

Project No.	Loc.	Description
SPECIAL PROJECTS		
C22-92	AAFB	Shops Storage PEB
C23-92	AAFB	Sqdn Admin Office PEB
C24-92	AAFB	Fuel Distribution Mods
C28-92	AAFB	Apron Mods, Tiedown/Groundings
R20-92	AAFB	Mod/Repair AMu B 2642
R21-92	AAFB	Repair Supply Warehouse B2600
R27-92	AAFB	Demo Existing Revetmetns
R30-92	AAFB	Repair BEQ B25009
R29-92	AAFB	Repair Hangar B18021
RCM25-92	AAFB	Repair SNCO Qtrs B27001
RCM26-92	AAFB	Repair BOQ 27000
C20-92	MSC	Site prep for Reloc Admin Off
C3-92	MSC	COMMSC Ship Support
CR6-92	MSC	Convert B6010 to Comsc Admin
C13-92	NAS	Aircrft Eng test Cell Sitework
C15-92	NAS	Disaster Control Storage
C16-92	NAS	Operational Storage
C17-92	NAS	Security Office Addn
C18-92	NAS	Vehicle Parking & Ped Bridge
C19-92	NAS	Alt B17-80 OMD Hangar For Napra
C31-92	NAS	Expand OMD Hangar Ramp
R12-92	NAS	Repair Hangar Power Holdback
CR14-92	NAS	Alt/Repr BEQ B13-14
C1-92	NAVHOSP	Alts to Offices/Labs, WgA-3
C2-92	NAVHOSP	Alts to Offices/Labs Wg B-3
C3-92	NAVHOSP	Alts to Offices/Labs, Wg- D-3
C10-92	NAVMAG	Collateral Equip Stor
C11-92	NAVMAG	Tem Inert Stor @ Orote Pt
C12-92	NAVMAG	Temp Security Off Site Prep
C13-92	NAVMAG	Temp Ordnance Off Site Prep
C2-92	NAVMAG	Alt B870 NAWMU Missle Maint
C3-92	NAVMAG	Security Office Adj to B400
C4-92	NAVMAG	Ordnance Off Addn B400
C5-92	NAVMAG	Temp Inert Storage
C6-92	NAVMAG	MHE Storage
C7-92	NAVMAG	Sidewinder Missile Test Rvtmnt

GUAM FACILITIES PLANNING/PROGRAMMING — PHILIPPINE WITHDRAWAL

Project No.	Loc.	Description
SPECIAL PROJECTS		
C8-92	NAVMAG	Sparrow Missile Test Rvtmnt
C9-92	NAVMAG	HARM Missile Test Rvtmnt
C10-92	NAVSTA	Waterfront OPS Fac.
C11-92	NAVSTA	Const OPS Stor. (SEALS)
C12-92	NAVSTA	Site Sec. (Fence/Lights)
C13-92	NAVSTA	Vehicle Maint Shed
C14-92	NAVSTA	Temp EOD OPS Bldg.
C15-92	NAVSTA	Temp EOD Admin Fac Site Prep
C19-92	NAVSTA	Temp EOD Vehicle Maint
C23-92	NAVSTA	Security Fence EOD
C24-92	NAVSTA	Diver/Gear Locker/Showers
C7-92	NAVSTA	Alts B3110 for SEALs Admin
C8-92	NAVSTA	Academic Instr. Bldgs
C9-92	NAVSTA	Const SEAL Team Bldg
R1-92	NAVSTA	Repair Bldg 4175 BCQ
RC 2-92	NAVSTA	Repair Bldg 179 Nimitz Hill BOQ
C14-92	NSD	Temp Whses
C15-92	NSD	Temp Transit Sheds
C17-92	NSD	ILO
C18-92	NSD	Loading Docks Whse 384
C21-92	NSD	Refer Box Site Prep
C3-92	PWC	Temp Transp Whse
C4-92	PWC	Power Distr. Sierra
C5-92	PWC	Power Distr. Bravo
R1-92	PWC	Repl Comps & Dist Line "V" Wharf
C1-92	SRF	AFDL Supp Fac
C2-92	SRF	Operational Storage
C3-92	SRF	Temp Ship Material Whse
CO Project	Apra Hts	Reconfig Legal Spaces
CO Project	NAVSTA	Mod Dental Clinic B

GUAM FACILITIES PLANNING/PROGRAMMING — PHILIPPINE WITHDRAWAL

Project No.	Loc.	Description	FY*	Costs*
MILCON PROJECTS				
P-001	Nimitz Hill	Oceanography/Typhoon Center	94	$616,000
P-203	AAFB	Hangar/Apron/Washrack	92	$29,000,000
P-207	AAFB	Renovate SNCO	94	$3,600,000
P-209	AAFB	Renovate BOQ	94	$3,800,000
P-829	NAVMAG	Tomahawk Magazine	93	$8,210,000
P-830	NAVMAG	Inert Storehouse	94	$4,600,000
P-141	NAVSTA	Hazardous Material Storage Fac.	93	$14,820,000
P-151	NAVSTA	Gas Bottle Storage	94	$1,250,000
P-152	NAVSTA	Integrated Material Handling Fac.	93	$21,600,000
P-153	NAVSTA	General Warehouse	96	$10,600,000
P-156	NAVSTA	Gantry Crane Rails	96	$12,500,000
P-157	NAVSTA	Cold Storage Warehouse	95	$15,500,000
P-158	NAVSTA	Supply Systems Support Bldg.	96	$3,400,000
P-160	NAVSTA	MSC Operations Building	94	$2,100,000
P-168	NAVSTA	Ship/Spare Storage	93	$5,200,000
P-391	NAVSTA	Child Care Center Esp. I	93	$2,900,000
P-389	NAVSTA	Child Care Center Esp. II	94	$2,050,000
P-393	NAVSTA	EOD Facility	94	$12,700,000
P-394	NAVSTA	Seal Maintenance/Storage Bldg.	96	$4,800,000
P-395	NAVSTA	Seal Team Building	94	$10,600,000
H-236	PWC	Family Housing	93	$56,700,000
P-234	PWC	Orote Power Plant	93	$18,200,000
P-235	PWC	Transportation Parts Storage	94	$1,750,000
P-237	PWC	Waterfront Support Utilities	94	$12,000,000
P-239	PWC	WWTP Expansion	94	$12,000,000

* The timing and costs of the individual projects may change as planning and design proceed.

POPULATION PROJECTIONS BY ACTIVITY FOR SUBIC ROLLBACK TO GUAM

Version: 3/93		PERMANENT DUTY				TRANSIENT PERSONNEL		
Activity	Location	Officers	Enlisted	Dependents	Civilians*	TAD	Civilians	Ship Crews
Supply	NAVSTA	4	45		137			
Ship Repair	NAVSTA	1	30		150			160
Transport	NAVSTA	–	27		30			
Naval Special Warfare Unit	NAVSTA	11	25			179		
Fleet Training*	NAVSTA	–	8			50		
EOD*	NAVSTA	9	38			15		
Ordnance	NAVMAG	4	79					
Security Detachment	NAVMAG	0	36					
Missile Maintenance*	NAVMAG	1	30		2		20	
Air Maintenance	NAS	0	57			10		
Security Detachment*	NAS	1	33					
VRC-50	AAFB	73	432	580				
USS Holland^	NAVSTA	–	100					
T-AE Kilauea - 16 days/yr*	NAVSTA	–	41					123
T-AFS Sioux - 48 days/yr*	NAVSTA	5	44					126
T-AFT Spica - 48 days/yr*	NAVSTA	–	4					16
Estimated Other Dependents	VARLOC			875				
CBMU	NAVSTA	1	44					
COMSUBGRUP	NAVSTA	2	3					
NAS A/S OP DET	NAS	0	49					
FLTIMAGCENPAC	NAS	0	5					
PSD		0	10					
NAVSTA	NAVSTA	1	0					
CNSGWP		1	6					
MOMOMAG		0	10					
NAVLEGSVCOFF		2	2					
NAVMARTIJUD		2	0					
NAVHOSP	NAVHOSP	20	50					
NAVDENCEN		2	5					
NAESU DEPT		1	1					
NPPSBO		–	12					
NAVOCEANCOM		1	0					
TRAGRU								
MOB ENV TM		1	8					
MSC Cleveland								50
Ship Training (15 @ 3 wks/yr)								300
Visiting Navy Ships per year								
TOTALS		143	1,234	1,455	319	274	20	775

* Numbers determined through interviews with activity commanders. All other numbers provided by CINCPACFLT.
^ Number represents difference in crew complements on Holland versus Proteus

Appendix D

Botanical Survey

BOTANICAL SURVEY

OF THE

U.S. NAVY RELOCATION SITES, TERRITORY OF GUAM

by

DR. W. ARTHUR WHISTLER
BOTANICAL CONSULTANT

for

BELT COLLINS AND ASSOCIATES
HONOLULU, HAWAII

JULY 1992

The area of study comprises 15 parcels of land upon which the U. S. Navy is proposing to construct various kinds of facilities in their upcoming relocation to Guam from Subic Bay, the Philippines. Most of the sites are quite small and involve the construction of a single building, but some parcels being considered as housing project sites consist of as much as 240 acres. One site is located at Andersen Air Force Base on the north end of the island, two are located at the U. S. Naval Magazine in the central part of the island, and the rest are at the Naval Station (NAVSTA) at Apra Harbor on the west-central coast of the island.

SURVEY METHODS

Prior to the onset of the field study, a search was made of the pertinent literature to familiarize the consultant with the flora and vegetation of the sites. The most useful of the botanical sources are the flora checklists of the Marianas (Fosberg et al. 1979, 1982, 1987) and the Flora of Guam (Stone 1970). A description of the various vegetation types present on the island is found in The vegetation of Micronesia (Fosberg 1960). Topographic and site maps supplied by Belt Collins were examined to determine the terrain and reference points. The sites were visited during five days in the period from 11 to 19 May 1992.

The botanical survey employed a "walk-through" method in which a series of informal transects were walked across the area. The areas most likely to contain native species (e.g., those with

limestone forest) were given more emphasis than disturbed areas. Notes were taken on species present, vegetation characteristics, substrate types, topography, and anything else of interest. Species identifications were made in the field, except for a few plants that were collected and compared with material in the herbarium of the University of Guam.

DESCRIPTION OF THE VEGETATION

Based on the field survey, nine types of vegetation can be distinguished at the sites: herbaceous strand, littoral forest, marsh, swamp forest, mangrove scrub, limestone forest, Pandanus scrub forest, managed land, Leucaena scrub forest, and Casuarina forest. These are briefly discussed below, and in more detail in the vegetation descriptions of the sites in which they are found.

Herbaceous Strand

This is the vegetation, dominated by salt-tolerant herbs, that occurs on the seashore. Most of the species found here are native, but since they are widely dispersed by sea water, few of them are endemic, i.e., restricted to a single archipelago or island such as Guam. However, because of the extensive coastal development in recent years, undisturbed examples of this plant community are becoming increasingly uncommon. Only one site had a definable herbaceous strand--Old Wives Beach (Parcel Y).

Littoral Forest

This is the vegetation, dominated by salt-tolerant trees, that occurs on the seashore. As in the herbaceous strand, most

of the species in this community are native but not endemic. Typical species include Casuarina equisetifolia (ironwood), Thespesia populnea (Pacific rosewood), Cordia subcordata, Barringtonia asiatica (fish-poison tree), Calophyllum inophyllum (Alexandrian laurel), and Hernandia nymphaeifolia (Chinese-lantern tree). This community has also come under increasing pressure, so that few undisturbed examples exist, and most of those that remain are heavily disturbed or are found on rugged limestone coasts. The only two study sites with littoral forest are Old Wives Beach (Parcel Y) and Polaris Point (Parcel T).

Marsh

This is the vegetation, dominated by herbaceous species, that occurs in areas saturated with fresh water. Any of a number of wetland plants may dominate the marshes, depending on factors such as soil profile, whether or not the wet conditions are seasonal or permanent, and so forth. Several types may be distinguished, and these may be divided into one dominated by the reed Phragmites karka and those, such as Scirpus marsh and Cyperus marsh, that are dominated by other, smaller species (Fosberg 1960). The former type was found on the edges of the Polaris Point (Parcel T) and Camp Roxas (Parcel P). The latter types were noted at two points inside the Polaris Point parcel, and on the margins of the Tipalao Housing Site (Parcel F).

Swamp Forest

This is the forest vegetation that grows in areas saturated with fresh water. It is distinct from mangrove forest and

mangrove scrub, which are found in areas under the influence of saline water. Several types of swamp forest can be recognized, but the main type found during the study is one distinguished by Fosberg (1960) as Hibiscus tiliaceus swamp. It was noted only at Polaris Point (Parcel T), and on the margins of Camp Roxas (Parcel P). Another type of swamp forest dominated by Pandanus tectorius with an understory of the wetland reed Phragmites karka is present at the Inert Storehouse site (P-830) at the Naval Magazine.

Mangrove Scrub

This is the wetland vegetation dominated by salt-tolerant trees. If the trees form a forest, the community may be called mangrove forest, but if the trees are smaller and bush-like, as they are here, then mangrove scrub is a better term. Mangrove vegetation is typically found in estuaries and in places where there is a freshwater flow into the sea, and is characterized by a lack of species diversity--only a few, specially adapted species can survive in the water-logged, saline environment. The typical trees dominating this community are Rhizophora spp., Bruguiera gymnorrhiza, and Avicennia marina. The only study site in which it occurred was Polaris Point (Parcel T), but the reconfiguration of this site may have excluded most or all of it.

Pandanus Scrub Forest

This is the vegetation dominated by Pandanus tectorius (screwpine), a monocot tree that also occurs in littoral forest.

The community was distinguished as Pandanus forest by Fosberg (1960), who described it as a secondary forest common in the interior plateaus of Guam. Since it does not form what is typically recognized as a forest, scrub forest is a better term. Sometimes, however, the community has a more open structure, and in these cases "woodland" would be a better adjective to use with Pandanus.

In addition to Pandanus, a number of other trees are found here, some native, some introduced. Because of the open canopy, there is a distinct ground cover dominated by sun-loving rather than shade-tolerant plants. The only study site with this type of vegetation was the Tomahawk Magazine (P-829) located in the Naval Magazine.

Limestone Forest

This is the native forest covering areas of exposed limestone on Guam, typically on escarpments and level areas of karst. Limestone forest probably originally covered much of the island before the arrival of man, but now it is restricted to those areas unsuitable for agriculture and/or inaccessible enough to be left uncut by timber seekers. Most of the species found in this community are native, and a few of them are endemic. Typical trees found here include Ficus prolixa (banyan), Pisonia grandis, Premna serratifolia, Pandanus tectorius, Aglaia marianniana, and Guamia mariannae. When disturbed, other species, especially Triphasia trifolia and Leucaena leucocephala (tangantangan), may predominate.

This type of vegetation is what Fosberg (1960) described as

"forests of elevated hard limestones." Several subcategories were distinguished by Fosberg, but none of them correspond to the limestone forest found at the two sites--Andersen Air Force Base (P-203) and the Seabee Quarry (Parcel D).

Managed Land

This is the vegetation that covers areas that have been so thoroughly and continually disturbed that they are entirely dominated by weedy, introduced species. Weeds are fast-growing, readily dispersed plants that are able to take advantage of disturbances such as clearing for agriculture, road grading, and mowing. If these areas are left undisturbed for long enough, the herbaceous weeds will eventually be shaded out and replaced by Leucaena scrub forest. The most common plant species on managed land are Eupatorium odoratum, Bidens alba, Dichantium bladhii, Stachytarpheta jamaicensis, Passiflora foetida, small individuals of Leucaena leucocephala, and various grass species. The majority of the species recorded during the study (Table 1) are found in this type of vegetation.

Leucaena Scrub Forest

This is the scrub forest dominated by Leucaena leucocephala (tangantangan) that covers some of the sites, and is what Fosberg (1960) delineated as "Leucaena glauca [the former name for Leucaena leucocephala] thicket" in the "weed communities" category. Leucaena completely dominates here, but disappears or becomes a minor forest component in areas lacking soil (i.e., on limestone). This community is not a natural one, since Leucaena

is an introduced species native to the Caribbean. However, native species find it difficult to become established in the dense thickets, and thus the community is relatively stable, at least over short periods (decades).

In addition to Leucaena, a few other trees, such as Casuarina equisetifolia and Pithecellobium dulce, both much larger species, occur, but only in small numbers. Most of the associated species--vines, shrubs, and herbs--that occur here are introduced. If this forest is left without further disturbance for long enough, however, native species may eventually become increasingly common. This vegetation was found on most of the study sites located on the Naval Station.

Casuarina Forest

This is the forest that is dominated by Casuarina equisetifolia (ironwood). Although this tree is considered native, it appears to be planted in many of the places where it is currently found--such as on the study sites. The community is sometimes becomes quite open, as in the eastern portion of Polaris Point (Parcel T), and is then probably better described as a Casuarina woodland. The plants found in this forest are almost entirely introduced species.

THE STUDY SITES

The parcels upon which the vegetation was studied are described below. They are arranged in four categories--those of Andersen Air Force Base, those of the Naval Magazine, those of the Naval Station, and those of the proposed housing sites.

ANDERSEN AIR FORCE BASE

P-203: HANGAR/APRON/WASHRACK

This site, on Andersen Air Force Base on the north end of the island, is located just north of North Taxiway Loop and northwest of Fire Station 2. It consists of two parcels, one about 300 by 150 feet and the other about 75 by 50 feet, which lie within the perimeter of the security area of the runway, between a chain link fence and a road parallel to the main road. Two types of vegetation can be distinguished at the site--managed land and limestone forest.

Managed Land

The actual site is classified as managed land, since it currently comprises mowed lawns dominated by low, introduced herbaceous species such as Dichantium bladhii, Dichantium caricosum, and Lippia nodiflora. If this were all there was to the project, the botanical impact of the construction would be practically nil. However, the project will involve the relocation of the road and an above-ground fuel line that runs parallel to the perimeter fence; these are to be moved northward into a vegetated area.

The area north of the road is covered with several types of vegetation. Immediately along the roadside there is a zone of managed land about 30 feet wide, comprising a mowed lawn similar to that inside the runway perimeter fence. North of that is a parallel zone, about 70 feet wide, covered with a patchy, disturbed scrub forest dominated by trees such as Pandanus

tectorius, Morinda citrifolia, Guamia mariannae, and Premna serratifolia, all of which are native species common over much of the island. Between the patches of scrub are disturbed areas dominated by weedy herbs. North of this scrubby zone is another parallel zone, about 50 feet wide, which appears to have been an old roadway. This comprises managed land dominated by herbaceous weeds such as Lippia nodiflora, Fimbristylis cymosa, Bidens alba, Conyza canadensis, Eustachys petraea, and Nephrolepis hirsutula. These three zones, perhaps 150 feet wide in all, are severely disturbed, and would not offer any botanical impediments to relocation of the road and pipeline. However, if the relocation is to going to affect a wider area, native vegetation will be impacted.

Limestone Forest

North of this 150 feet wide strip is a scrubby limestone forest dominated by Hibiscus tiliaceus (beach hibiscus), Wikstroemia elliptica, Psychotria mariana, and Morinda citrifolia (Indian mulberry). Other native species present in small quantities include Ficus prolixa (banyan), Aglaia mariannensis, Premna serratifolia, Neisosperma oppositifolium, Guamia mariannae, Pandanus tectorius (screwpine), Glochidion marianum, Elaeocarpus joga, and Cycas circinalis (cycad). A few introduced trees and shrubs are also present, but these are in a definite minority.

The scrub forest is mostly 6--12 feet high, with some emergent trees up to 20 feet, and is penetrated only with difficulty. This scrub was probably disturbed in the past, and

while most of the species are native, the structure does not appear to be pristine. However, at the west end of the site, opposite the fire station, there is a patch of what appears to be relatively undisturbed limestone forest. The open forest floor under the canopy allows relative ease of passage. The dominant trees here are Premna serratifolia, Neisosperma oppositifolium, and Guamia mariannae. Less common are Pandanus tectorius, Aglaia mariannensis, Hibiscus tiliaceus, Ficus prolixa, Psychotria mariana, Maytenus thompsonii, and Eugenia palumbis (the latter two are shrubs). Because of the quality of this patch of forest, it should be avoided if possible during planning and construction.

While the vegetation of this site, particularly in the limestone forest, is interesting, and many of the species present are native, only a few of the plants are endemic to the Marianas Islands--Guamia, Aglaia, Piper guamense, and Maytenus. These are relatively common on the island in limestone forest, except Maytenus which is uncommon. No wetlands are present, although there is a small patch of wetland plants, primarily the introduced, weedy Brachiaria mutica (California grass), in a drainage channel beside the road. A listing of all the plants found at the site is shown in Table 1.

NAVAL MAGAZINE

P-829: TOMAHAWK MAGAZINE

This site consists of two rectangular parcels estimated to be 100 by 200 feet in dimension and located on a short dead end

road leading off another road east of an active, fenced magazine, and about two miles southeast of the Naval Magazine main gate on Route 5. The area consists of rolling hills that have probably been disturbed by agriculture and fires over centuries of human habitation. The two parcels contain already existing, abandoned storage bunkers.

The vegetation around the area consists of an open Pandanus scrub forest dominated by Pandanus tectorius (screwpine). Other common trees include Hibiscus tiliaceus (beach hibiscus), Cynometra ramiflora, Guamia mariannae, Glochidion marianum, Vitex parviflora, and Pimenta racemosa (bay rum tree). The first five are native species, the latter two are introduced. Shrubs are also common in the openings between the trees, most notably Scaevola taccada, Wikstroemia elliptica, Decaspermum fruticosum, Clerodendrum inerme, Morinda citrifolia, and Melastoma malabathricum--all of which are native species. Herbs are also common on the red soil of the area, mostly sedges and grasses such as Scleria polycarpa, Chrysopogon aciculatus, and Carex fuirenoides. The herbs are a mixture of native and introduced species. A native climbing member of the screwpine family, Freycinetia reineckei, is common on trees.

The vegetation at the site is interesting, because of the many native species. However, it is disturbed and only two of the species recorded are endemic to the Marianas--Glochidion marianum and Guamia mariannae; both are common in the islands. A listing of the plant species recorded here is shown in Table 1. No wetlands are present.

P-830: INERT STOREHOUSE

This site is located along north-south road opposite an already existing facility less than a mile southeast of the Naval Magazine main gate on Route 5. The rectangular-shaped parcel is about 100 by 400 feet, and much of it is currently a parking lot that extends about 80 feet from the road to a row of planted Casuarina equisetifolia trees.

The parcel is very disturbed, and much of it comprises the parking lot. Around the parcel, on the slope east of it, and in adjacent areas, the vegetation is managed land that has not been cut for some time, and is dominated by weedy species such as Imperata conferta, Stachytarpheta jamaicensis, Eupatorium odoratum, and Saccharum spontaneum (wild sugarcane).

The area east of the parking lot, at the base of a short slope, is a small meadow dominated by a mixture of wetland and dryland species. The dominant plants here are Kyllinga brevifolia, with lesser amounts of Fimbristylis littoralis, Mimosa pudica, and Mikania scandens. Kyllingia is a facultative plant, Fimbristylis is a facultative wetland plant, and the other two are facultative upland species. Three other wetland species are present in small amounts: Eclipta alba, which is a facultative wetland species, and Bacopa monnieri (water hyssop) and Acrostichum aureum (swamp fern), which are obligate wetland species. The other species present are either facultative or facultative upland species. This area is a marginal wetland, but because it is small in extent and probably lies beyond the planned construction area, it may not be impacted by the proposed action.

East of the meadow the vegetation abruptly turns into a scrub forest dominated by Pandanus tectorius, with lesser amounts of Hibiscus tiliaceus and Casuarina equisetifolia. Because of the presence of the wetland reed Phragmites karka between the trees, this would probably be classified as a wetland. However, it is probably outside the construction area and may not be impacted by the proposed construction. The flora for the whole study site is a mixture of introduced and native species, with most of the native species being found in the small meadow and the adjacent scrub forest. None of these species are endemic to Guam or the Marianas. A listing of the plant species recorded here is shown in Table 1.

NAVAL STATION (NAVSTA)

P-141: HAZMAT STORAGE FACILITY

This rectangular site, measuring about 100 by 200 feet, is located on Harbor Road just to the west of its intersection with Sumay Road, and just west of a drum storage lot. The area is flat, and covered with white calcareous soil. The vegetation is highly disturbed, probably by centuries of human habitation, without a trace of the original native forest.

The site is classed as managed land and comprises a mosaic of shrubby thickets mixed with low herbaceous vegetation. The dominant species are Saccharum spontaneum (wild sugarcane), Leucaena leucocephala (tangantangan), Waltheria indica, Stachytarpheta jamaicensis (Jamaica vervain), and Pennisetum polystachion (mission grass). The only native plants present are widespread weedy species; none are endemic to Guam or the

Marianas. A listing of the plant species recorded here is shown in Table 1. No wetlands are present.

P-151: GAS BOTTLE STORAGE

This small rectangular site, perhaps measuring 25 by 50 feet, is located behind Bldg. 3180 between Sumay Drive (north of its intersection with Marine Drive) and Berth V-2 on the inner Apra Harbor. The area is flat reclaimed land covered with calcareous soil brought in as landfill.

Because of the artificial nature of the surface, and its presence in the middle of a warehouse area, the area is quite disturbed and is classified as managed land. It comprises a mowed lawn dominated by weedy species, most of which are introduced, such as Tridax procumbens and Bidens alba; any native plants present are widespread species, none of which are endemic. No listing of the plants at this site was made, and it is therefore not included in Table 1. No wetlands are present.

P-153: GENERAL WAREHOUSE

This square site, measuring about 100 by 100 feet, is located just southwest of the intersection of Sumay Road with a small road that leads in a southwest direction to the U.S. Navy Supply Depot about 200 feet away. The area is flat, and the soil is calcareous.

The disturbed vegetation, which has probably been left alone for many years, is currently covered with a Leucaena scrub forest dominated by Leucaena leucocephala (tangantangan). Other

trees present include Pithecellobium dulce, Casuarina equisetifolia (ironwood), Muntingia calabura, and Premna serratifolia, but these are few in number compared to the Leucaena. The understory is mostly herbaceous and is dominated by Phymatosorus scolopendria and Nephrolepis hirsutula, both of which are native ferns. Also present are a few shrubs such as Pluchea indica. Vines are common, particularly Passiflora suberosa, an introduced, weedy species of inedible passionfruit. The only native plants present are widespread species, with the exception of Jasminum marianum, which is endemic to the Marianas, where it is common on most of the main islands. A listing of the plant species recorded here is shown in Table 1. No wetlands are present.

P-157: COLD STORAGE WAREHOUSE

This rectangular site, measuring about 50 by 100 feet, is located north of the main part of the Naval Station, at the end of a small road coming from Marine Drive just north of its intersection with Agat Drive. It is bounded on its west side by a chain link fence, and on its north and east sides by small roads; a power line passes through the site on its western boundary. The area is quite flat and comprised of calcareous soil.

The study site is managed land and its vegetation is highly disturbed, probably by periodic mowing. The whole area is a lawn comprised entirely of low herbaceous weeds that show signs of the drought that has been occurring in Guam. The dominant species are Sporobolus fertilis, Bidens alba, Fimbristylis cymosa,

Chrysopogon aciculatus, and Tridax procumbens. The majority of the plants present are introduced weeds, and the only native species are widespread in distribution. A listing of the plant species recorded here is shown in Table 1. No wetlands are present.

P-234: OROTE POWER PLANT

This rectangular site, measuring about 50 by 100 feet, is located along Sumay Drive just north of its intersection with Marine Drive, and adjacent and east of an existing storage tank. The flat area is comprised of a landfill of calcareous soil.

Not surprisingly, the vegetation on the site is disturbed, but the absence of recent disturbance has allowed the growth of a Leucaena scrub forest dominated by Leucaena leucocephala (tangantangan). The only other trees noted on the site are Muntingia calabura and Pithecellobium dulce, but these are uncommon. The understory is dominated by herbaceous and shrubby species, the most common of which are Pennisetum polystachion (mission grass), Eupatorium odoratum, Saccharum spontaneum (wild sugarcane), and vines such as Passiflora foetida (wild passionfruit) and Passiflora suberosa, two species of weedy passionfruit. The area along Sumay Drive is managed land consisting of a mowed lawn dominated by low grasses and herbs. The only native plants present at the site are widespread weedy species, and none is endemic to Guam or the Marianas. A listing of the plant species recorded here is shown in Table 1. No wetlands are present.

P-239: WASTE WATER TREATMENT PLANT EXPANSION

This pentagonal site, about 300 by 300 feet in extent, is located on Marine Drive just east of its intersection with Shoreline Drive. It is currently occupied by a sewage treatment plant. The area is flat and comprised of calcareous soil.

Two types of vegetation are found on the site, both of them disturbed. The area on the southern portion of the land, between Marine Drive and the entrance road to the facility, and in a zone around the facility, is managed land consisting of a mowed lawn dominated by introduced weedy species such as Bidens alba, Tridax procumbens, and Sporobolus fertilis.

The north and west sides of the facility are covered with a Leucaena scrub forest dominated by Leucaena leucocephala (tangantangan). Other trees present in this scrub forest include Casuarina equisetifolia (ironwood), which occurs as scattered trees and a few stands up to 60 feet in height, Muntingia calabura, Pithecellobium dulce, Melanolepis multiglandulosa, and Pouteria obovata. The latter two are native species, but only a few saplings were noted. The understory is dominated by weedy herbs, shrubs, and vines, particularly Passiflora foetida (wild passionfruit), Mikania scandens (mile-a-minute vine), and Eupatorium odoratum. Because of the highly disturbed nature of the site, most of the species present are introduced weeds; the native plants, with the exception of Melanolepis, which is endemic (but common) in the Marianas, are widespread species. A listing of the plant species recorded here is shown in Table 1. No wetlands are present.

HOUSING SITES

PARCEL D: SEABEE QUARRY

This parcel is located on the Naval Station northwest of the Tipalao Family Housing and extends north along the coast towards the Seabee Quarry. As originally described, the parcel comprised 52 acres, but the redefined parcel consists of only about 19 acres extending on both sides (north and south) of Haputo Road. The western boundary runs parallel to steep coastal cliffs, which are designated as the Orote Peninsula Ecological Reserve Area, according to the U.S. Navy report (1990b).

The area is mostly a rugged karst limestone that is traversed only with difficulty. Some of this comprises jagged limestone ridges and pinnacles where the plants present grow out of rock cracks. The vegetation is limestone forest dominated by native tree species, the most common of which are Ficus prolixa (banyan), Pisonia grandis, and Neisosperma oppositifolium. Less common native trees include Cynometra ramiflora, Intsia bijuga (ifil), Pipturus argenteus, Aglaia mariannensis, Premna serratifolia, Polyscias grandifolia, Pouteria obovata, Psychotria mariana, Guettarda speciosa, Melanolepis multiglandulosa, Pandanus tectorius (screwpine), and Pandanus dubius. Two other trees were noted to be less common: Tristeriopsis acutangula and Heritiera longipedunculata. Tristeriopsis was found only south of Haputo Road. Heritiera, a large tree listed by the Goverment of Guam as an endangered species, is endemic to the Marianas (Guam, Rota, and Saipan), and is reported from only a few localities on the island. Another rare (but not officially

listed as endangered) tree species, Drypetes dolichocarpa, is reported to occur in the limestone forest to the west on Orote Peninsula, and could conceivably also be found on this parcel. Also common in Seabee Quarry forest is the native cycad Cycas circinalis, which is more of an understory species. Native epiphytic ferns, such as Phymatosorus scolopendria, Microsorium punctatum, and Pyrrosia lanceolata, are also present.

Other areas have a veneer of soil, which possibly because of disturbance, is dominated by introduced species. The two most common shrubs or small trees in these areas are Leucaena leucocephala (tangantangan) and Triphasia trifolia. The presence of the thorny shrub Triphasia makes passage through areas dominated by it very difficult and sometimes painful. Some of the more disturbed areas, such as along the side of Haputo Road and the area adjacent to the Tipalao Family Housing, have an assortment of weeds, but these are not common in the forest shade.

No wetlands are present on this parcel. However, the high number of native species recorded, the relatively high quality of the areas of limestone forest, the proximity of the site to the Orote Peninsula Ecological Reserve Area, and the presence of the officially listed endangered tree Heritiera longipedunculata on the parcel do not recommend this site for development. A list of the plant species recorded in the study site is shown in Table 1.

PARCEL F: TIPALAO HOUSING

This parcel is located on the Naval Station northwest of the Tipalao Family Housing. As originally described, the parcel was

73 acres in area and extended to Shoreline Drive on the east and Haputo Road on the north, but the boundaries were redrawn to exclude the wetlands known to exist on the parcel. The current area is approximately 22 acres.

Leucaena Scrub Thicket

The portion of the revised Parcel F, redrawn to exclude the wetlands, is a highly disturbed secondary vegetation dominated by Leucaena leucocephala (tangantangan). In some places that appear to have been relatively undisturbed for some time, the understory is dominated by Phymatosorus scolopendria, a native fern. In more heavily disturbed areas, weedy, mostly introduced plants such as Pluchea indica, Bidens alba, Mikania scandens, and Nephrolepis hirsutula are particularly common. Other species of trees are also found here, the most common of which is Casuarina equisetifolia (ironwood). In some places, particularly on the west side of the parcel at the base of the slope, Casuarina forms groves with Scaevola taccada and Pluchea indica dominating the shrub layer. In some places, the Leucaena gives way to clearings dominated by Saccharum spontaneum (wild sugarcane).

Several native species, particularly Phyllanthus marianus, a small shrub, and seven of the eight native, non-wetland ferns recorded during the whole survey, are found here. Only two of the native species, Jasminum marianum and Macaranga thompsonii, are endemic to the Marianas, but neither is uncommon on Guam.

Marsh

The Apra Harbor regional optimal land utilization study (U.S. Navy 1990b) indicates that the original parcel contained wetlands covering 14 acres, but describes this as "part of a drainage sump with no natural surface drainage. Although designated as a wetlands, it is likely seasonal in nature." The larger of the wetlands shown on the map contained in this report is a marsh comprising a mosaic of associations in which different herbaceous wetland species dominate. The most significant of these species are Brachiaria mutica (California grass, a weed), Cyclosorus interruptus (marsh fern), Acrostichum aureum (swamp fern), Lygodium microphyllum (a vinelike fern), Paspalum vaginatum (a littoral and coastal marsh grass), Scirpus littoralis (a sedge), Eleocharis dulcis (water chestnut), and Polygonum minus (an herb). A thicket of Hibiscus tiliaceus (beach hibiscus) covers the southeast side of the wetland.

Two other wetlands are shown on the U.S. Navy (1990b) map, but these did not appear to be wetlands, at least not during the time of the survey (which occurred during a prolonged drought). They were basically Leucaena thickets (described below). However, since they are both located in shallow basins lacking drainage, they may be covered with standing water for periods of time during the wet season.

A listing of the plant species recorded from the parcel is shown in Table 1. No wetlands are found on the revised parcel, depending on exactly where the redrawn boundaries are put. However, this parcel will probably be revised and enlarged again.

PARCEL M: EXCHANGE

This parcel is located on the Naval Station between the PWC Transportation Compound and the intersection of Shoreline Drive and Exchange Road. The original parcel was 43 acres in extent, but the revised area includes only that portion south of Bright Road and comprises 21 acres. The area is level and was formerly occupied by buildings, the foundations of which may still be found there.

The original vegetation of the parcel was entirely removed long ago, and what remains is managed. The parcel has probably been regularly mowed, since herbaceous plants dominate rather than Leucaena leucocephala (tangantangan) which would be expected here. Virtually the only trees on the property are Casuarina equisetifolia found in a grove at the south corner, and some Leucaena 2 m high on the north side of the property. The rest of the area is covered with a low, grassy veneer that extends down into the drainage ditches that run along the southern two sides of the property. The dominant weedy herbs are Bidens alba, Tridax procumbens, Fimbristylis cymosa, and Lippia nodiflora. The only native plants present are widespread, mostly weedy species, and none is endemic to the Marianas. A listing of the species recorded on the parcel is shown in Table 1. No wetlands are present.

PARCEL P: CAMP ROXAS

This site is located southeast of the main area of the Naval Station in an area formerly called Camp Roxas. The original

parcel comprised an area of 145 acres and included the Agat Bus Yard and small hills in the center of the property. However, the boundaries were redefined to exclude the hilly area and bus yard, and the current area is approximately 60 acres in extent, bounded on three sides by Agat Drive, Magazine Road, and the New Apra Heights Family Housing. Because the botanical survey was done before this revision was made, some of the species noted in Table 1 are not actually found on the parcel as now defined. This probably includes Timonius nitidus, a shrub endemic to (but not uncommon on) Guam.

Most of the currently defined parcel is covered with Leucaena scrub forest dominated by Leucaena leucocephala (tangantangan), with lesser amounts of Morinda citrifolia (Indian mulberry) and scattered trees of Casuarina equisetifolia (ironwood). The understory, whose abundance is dependent upon the density of (and shade produced by) the trees, is dominated by herbaceous species such as Nephrolepis hirsutula (sword fern), Eupatorium odoratum, Bidens alba, Phymatosorus scolopendria, Saccharum spontaneum (wild sugarcane), and Imperata conferta.

Although the parcel size was scaled down presumably to delete wetlands, steep slopes, and other possible impediments to development, a marsh is apparnetly located on the current property. Although the estimated location of the wetland area does not match any shown on maps such as Moore et al. (1977) or the U.S. Navy study (1990b), it appears to be in the western corner of the irregularly shaped property. It is dominated by Phragmites karka, a wetland reed that characterizes marshes in this area. The boundary may have already been surveyed by

someone, since a trail tagged with numbers in the series A-3J, A-3I, etc. has been cut along the margin of the marsh. If this marsh is within the property, it is only on the corner. Other areas within the parcel may have some Phragmites present, but mixed with greater amounts of Leucaena, which would exclude them from being considered wetlands.

There is another area with some wetland characteristics just down the slope from the New Apra Heights Family Housing. It is a thicket dominated by Hibiscus, with a forest floor cover comprised mostly of Nephrolepis, Amphineuron opulentum, and Eupatorium. Hibiscus is listed as a facultative wetland plant, but the combination of ground cover species indicates that the thicket is not a wetland. In places at the south end, probably off the revised parcel, there is some standing water in what appears to be depressions or an intermittent stream course.

PARCEL T: POLARIS POINT

This parcel is located on the Naval Station about two miles north of the main gate along Marine Drive. It includes all the land on the peninsula excluding the submarine support area at the southwest tip and the beach facilities at the northwest tip. As originally drawn, the parcel comprises about 265 acres, but the revised version excludes the northeast and southeast corners, which are wetlands, and is now about 240 acres in extent. The whole area is highly disturbed, which is not surprising since it is flat and consists mostly of reclaimed land covered with landfill. Several plant communities are found on the parcel.

Littoral Forest

The littoral vegetation on the site consists of a thin zone of littoral forest trees and shrubs, most notably along the south shore fence and extending down to the south end of the peninsula, and along the north portion of the parcel within the restricted western half. The dominant trees on the south shore are trees, such as Cordia subcordata, Hibiscus, and Leucaena, and lesser amounts of Xylocarpus moluccensis (puzzle nut), Thespesia populnea (Pacific rosewood), and Casuarina, and shrubs, such as Pluchea symphytifolia and Colubrina asiatica. Because of its narrow width and location on a landfill, this vegetation is not a good example of this type of littoral forest.

Marshes

Two marshy areas are found on the property. One lies north of the guardhouse just inside the restricted end of the peninsula, and perhaps 600 feet south of the shoreline. It is rather small in extent, and is dominated by Bacopa monnieri, Paspalum orbiculare, and Eleocharis geniculata, which are wetland species, and Panicum maximum, which is not. The other marsh is located along the north side of the Polaris Point road in the eastern, unrestricted half of the peninsula. It lies between the grassy shoulder of Polaris Point road and in the scrub forest just south of the mangroves. The marshy conditions may be a result of impeded drainage caused by the construction of the road. The dominant species here are Acrostichum aureum (swamp fern), Mariscus javanicus, and Scirpus littoralis. Another area

of marsh is located at the south end of the site, along Marine Drive, but this may be outside the revised parcel boundaries. It is dominated by the large wetland reed Phragmites karka.

Swamp Forest

This community occurs along Marine Drive on the eastern side of the southern tip of the parcel, and is dominated by thickets of Hibiscus tiliaceus. This begins about 1800 feet south of the Polaris Point road corner, and is perhaps just outside of the revised parcel boundaries. Another area of somewhat similar forest lies between the Polaris Point road and the mangroves to the north. It comprises a scrubby forest dominated by Hibiscus, Leucaena, Pandanus tectorius, and Calophyllum inophyllum. This is perhaps transitional vegetation that is replaced to the north by the mangroves, since only the Hibiscus is a typical swamp forest tree. It may lie in an area of poor drainage that is sometimes covered with standing water.

Mangrove Scrub

This community occupies the mudflats on the northeast side of the parcel and the southern tip, and is dominated by Rhizophora apiculata and Avicennia marina. It is relatively undisturbed, since it is of little use, and few if any species other than the two native mangrove trees are present. It probably lies outside the revised boundary of the parcel.

Managed Land

The majority of the area inside the restricted western half

of the peninsula (which is separated from the eastern portion by a high fence) comprises a well-cut lawn dominated by introduced, weedy herbaceous species, some of the most common of which are Tridax procumbens, Bidens alba, and Sporobolus fertilis. This area is maintained by periodic mowing that prevents trees and shrubs from becoming established.

On the northern part of this area, north of the guardhouse and extending up to the north shore, the vegetation had not recently been mowed, and is dominated my a mixture of shrubs and herbs, most notably Leucaena leucocephala (up to 4 m in height), Eupatorium odoratum, Waltheria indica, and Saccharum spontaneum (wild sugarcane). In some places the vegetation is overgrown by the orange, leafless parasitic vine Cassytha filiformis, a native littoral species. Another area east of the athletic fields and surrounded by scattered Casuarina equisetifolia (ironwood) trees had not recently been cut and is dominated by Bidens alba, Nephrolepis hirsutula (sword fern), Leucaena, Eupatorium, and Lepturus repens (a littoral grass).

Casuarina Forest and Woodland

Some of the remaining western area of the peninsula is covered with roads, athletic fields, and parking lots, as well as a Casuarina forest just south of the guard house. The forest is dominated by tall Casuarina equisetifolia trees, and the floor beneath it is covered with the fallen "needles" (branches), which, along with the canopy shade, prevent all but some small Leucaena trees from growing. In areas where the Casuarina trees

are less dense, patches of introduced weeds, such as Eupatorium and Passiflora suberosa, are common. The only other large tree recorded from this forest is Spathodea campanulata (African tuliptree).

Most of the area east of the fence is a woodland dominated by scattered trees and a denser ground layer of shrubs and herbs. In addition to Casuarina, and some Leucaena, the trees found here include Pithecellobium dulce, Spathodea, and Muntingia calabura. The dominant shrub is Scaevola taccada, and the dominant herbs are Eupatorium, Bidens, Saccharum, Phymatosorus scolopendria, and Nephrolepis. The center of the area south of the Polaris Point road shows obvious signs of disturbance, such as a dirt road and a berm that surrounds the remains of a naval supply depot.

The parcel is quite large, compared to the others being considered for a housing site, so the presence of small patches of wetland in the center, and mangroves and swamp forests on the periphery, is no obstacle; they amount to only a small percentage of the area. Most of the species on the parcel are introduced, except for many of the plants in the wetlands and littoral forest. A list of the plant species recorded on the parcel is shown in Table 1.

PARCEL Y: OLD WIVES BEACH

This parcel is located on the southwest coast of the Naval Station seaward of Shoreline drive, south of Tipalao Family Housing, and north of Rizal Beach on Agat Bay. The linear-shaped parcel is approximately 32 acres in area, and is currently used mostly as a beach park. The north end is marked by a coral

headland, above which is the Tipalao Family Housing. The north side of the property, parallel to Shoreline Drive, is flat and heavily disturbed (partly as a lawn), but from there a slope extends from the 30--40 feet elevation down to the beach.

The site is heavily disturbed, but some of the original native vegetation on the shore is more or less intact. Several different plant communities or associations can be distinguished, although the boundaries are often hard to distinguish because of the mosaic pattern of the vegetation.

Herbaceous Strand

This is the shoreline vegetation dominated by native herbaceous species that are restricted to littoral areas. At Old Wives Beach, the dominant species are Ipomoea pes-caprae (beach morning-glory), Thuarea involuta (a grass), and Paspalum vaginatum (another grass). It occurs in a narrow zone along the sandy beach between the dirt road and the high-tide mark, especially on the northwest end of the parcel.

Littoral Forest/Scrub

This type of vegetation is dominated by Casuarina equisetifolia (ironwood) and Hibiscus tiliaceus (beach hibiscus), between which often is a dense scrubby cover of Scaevola taccada, Wollastonia biflora (beach sunflower), and Colubrina asiatica. Casuarina sometimes forms small groves inland of this, with or without Hibiscus, and in disturbed places, with the weedy Bidens alba and Eupatorium odoratum. Along the southeast portion of the parcel, Hibiscus dominates to form thickets; with smaller amounts

of Thespesia populnea (Pacific rosewood) and Leucaena leucocephala (tangantangan) present. The forest floor here is sometimes entirely dominated by Hymenocaulis littoralis (spiderlily), but in other places Thuarea, Colubrina, and Derris trifoliata are sometimes common.

Leucaena Scrub Forest

Much of the area between Shoreline Drive on the upper edge of the parcel and the littoral zone by the shore is heavily disturbed, and is dominated by Leucaena leucocephala (tangantangan), which is typical for disturbed, non-limestone areas over the whole island. Other common species here include Saccharum spontaneum (wild sugarcane), Antigon leptopus (Mexican creeper), Colubrina asiatica, and Panicum maximum (Guinea grass). Many other weedy species are found along the dirt access roads and in clearings.

Although the herbaceous strand and littoral forest present are native communities dominated by native species, they are quite disturbed by human activities--including the current use of the area of the beach park. A number of native species are present, but these are all widespread, non-endemic plants. A list of the plant species recorded from the parcel is shown in Table 1. No wetlands are present on the parcel.

DISCUSSION AND RECOMMENDATIONS

The vegetation on most of the sites, particularly the smaller parcels on the Naval Station, are highly disturbed, and

are covered mostly with Leucaena scrub forest and managed land vegetation. There are no botanical reasons why these sites cannot be developed as planned.

Some of the other sites have native vegetation, wetlands, or endangered species that require further consideration. The non-wetland, native vegetation found at the study sites comprises herbaceous strand, littoral forest, Pandanus scrub forest, and limestone forest. Littoral vegetation is found at Old Wives Beach (Parcel Y) and Polaris Point (Parcel T). The former is disturbed, but retains some native elements, in addition to being a good swimming beach. The littoral vegetation at Polaris Point is either highly disturbed, since much of the shore and the peninsula itself is composed of landfill, or is adjacent to mangrove scrub, which would not be expected to be developed.

The Pandanus scrub forest found at the Naval Magazine (P-839) is actually a disturbed type of vegetation dominated by a native species (Pandanus tectorius). However, even if it were a good example of intact native vegetation, the actual site to be used consists of already existing magazines, and thus little of the surrounding vegetation would be expected to be disturbed by construction.

Limestone forest is found at two sites, one at Andersen Air Force Base (P-203), the other at the Seabee Quarry (Parcel D). The former site seems to be disturbed, except at the end north of the fire station. However, depending on the width of land needed for the relocation of the road, maybe even this would not be impacted by the construction. The limestone forest at the Seabee Quarry is high quality limestone forest, especially north of

Haputo Road. This is the site of the only sensitive species found during the survey--Heritiera longipedunculata. This tree is on the Government of Guam's endangered species list, but not on the Federal list. Construction here, which would seem impractical because of the jagged karst topography, would probably entail further studies to map the distribution of this tree and some kind of mitigative measures. Depending upon the final configurations of the parcels, Parcel D is the one most likely to be negatively impacted by construction of housing units.

The wetlands could constitute a problem, depending upon how the final parcel boundaries are drawn. Wetlands occurred only on the housing sites--Parcels F, P, and T--and at the Inert Storehouse (P-830) at the Naval Magazine. All three housing sites were reconfigured, at the time of the field study, to exclude wetlands that were known to be there. The wetlands at Polaris Point were on the fringes of the parcel, and if they are still found in the reconfigured parcel, then it is only at the margins, except for two small marshy areas in the interior of the property. If the Tipalao parcel is going to be expanded in size, as is likely to happen, it may infringe on the marsh in the center of the property. This is an interesting marsh dominated mostly by native wetland species, and for this reason, should not be included within any areas slated for development.

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Table 1. CHECKLIST OF THE FLORA OF THE GUAM NAVY RELOCATION SITES

The scientific names on this list have been taken from the series by Fosberg, Sachet, and Oliver (1979, 1982, 1987), with some revision from the more recent publications of Wagner (1990) in Hawai'i, and Smith (1979-1991) and Brownlie (1977) on Fiji. The common names have been taken mostly from Stone (1970). The species are arranged in four groups: (1) ferns; (2) gymnosperms; (3) monocots; and (4) dicots. Within each of these groups the species are arranged in alphabetical order by family, and in alphabetical order within the families.

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
FERNS (PTERIDOPHYTES)															
ADIANTACEAE															
Acrostichum aureum L.	I	-	-	x	-	-	-	-	-	-	x	-	-	x	-
Pteris vittata L.	X	-	-	-	-	-	-	-	-	-	x	x	x	x	-
ASPLENIACEAE															
Asplenium nidus L.	I	-	-	-	-	-	-	-	-	-	x	-	-	x	-
NEPHROLEPIDACEAE															
Davallia solida (Forst. f.) Sw.	I	-	-	-	-	-	-	-	-	-	x	-	x	x	-
Nephrolepis hirsutula (Forst. f.) Presl	I	x	x	x	-	x	-	-	-	x	x	-	x	x	-
POLYPODIACEAE															
Belvisia spicata (L. f.) Mirb. ex Copeland	I	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Microsorium punctatum (L.) Copeland	I	-	-	-	-	x	-	-	-	x	x	-	x	x	-
Phymatosorus scolopendria (Burm. f.) Pichi Serm.	I	x	-	-	x	x	-	-	-	x	x	x	x	x	x
Pyrrosia lanceolata (L.) Farw.	I	x	-	-	-	x	-	x	-	x	x	-	x	x	x

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FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
SCHIZAEACEAE															
Lygodium microphyllum (Cav.) R. Br.	I	-	-	-	-	-	-	-	-	-	x	-	x	-	-
THELYPTERIDACEAE															
Amphineuron opulentum (Kaulf.) Holttum	X	x	-	-	-	-	-	-	-	-	x	-	x	x	-
Christella parasitica (L.) Léveillé	X	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Cyclosorus interruptus (Willd.) H. Ito	X	-	-	-	-	-	-	-	-	-	x	-	-	x	-
GYMNOSPERMS															
CYCADACEAE															
Cycas circinalis L.	I	x	-	-	-	-	-	-	-	x	x	-	-	-	-
MONOCOTS															
AGAVACEAE															
Sansevieria trifasciata Prain	X	-	-	-	-	-	-	-	-	x	x	-	-	-	-
AMARYLLIDACEAE															
Hymenocallis littoralis (Jacq.) Salisb.	X	-	-	-	-	-	-	-	-	x	-	-	x	-	x
ARACEAE															
Alocasia macrorrhiza (L.) Schott	X	-	-	-	-	-	-	-	-	-	x	-	x	-	-
Syngonium podophyllum Schott	X	-	-	-	-	-	-	-	x	x	-	-	x	-	-

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
ARECACEAE															
Arecha catechu L.	X	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Cocos nucifera L.	I?	x	x	-	-	-	-	-	x	-	x	x	x	x	x
Heterospathe elata Scheffer	X	-	-	-	-	-	-	-	-	-	x	-	-	-	-
COMMELINACEAE															
Rhoeo spathacea (Sw.) Stern	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CYPERACEAE															
Carex fuirenoides Gaud.	I	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus alternifolius L.	X	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Cyperus compressus L.	X	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Cyperus ligularis L.	X	x	-	-	-	-	-	-	-	-	-	-	-	x	x
Eleocharis dulcis (Burm.f.) Trin. ex Hensch.	X	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Eleocharis geniculata (L.) R. & S.	I	-	-	x	-	-	-	-	-	-	-	-	x	x	-
Fimbristylis autumnalis (L.) R. & S.	I	-	-	x	-	-	-	-	-	-	-	-	-	-	-
Fimbristylis cymosa R. Br.	I	x	-	-	x	-	x	-	-	-	-	x	x	x	-
Fimbristylis dichotoma (L.) Vahl	I	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Fimbristylis littoralis Gaud.	I	-	-	x	-	-	-	-	-	-	-	-	x	-	-
Fimbristylis tristachya R. Br.	I	-	-	x	-	-	-	-	-	-	-	-	-	-	-
Kyllinga brevifolia Rottb.	I	-	-	x	-	-	-	-	x	-	-	-	-	-	-
Mariscus javanicus (Houtt.) Merr. & Metcalfe	I	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Pycreus polystachyos (Rottb.) Beauv.	I	-	-	x	-	-	-	-	-	-	x	-	-	x	x
Scirpus littoralis Schrader	I	-	-	-	-	-	-	-	-	-	x	-	-	x	-
Scleria lithosperma (L.) Swartz	I	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Scleria polycarpa Bock.	I	-	x	-	-	-	-	-	-	-	-	-	x	-	-
Torulinium odoratum (L.) S. Hooper	X	-	-	-	-	-	-	-	-	-	-	-	-	-	x
FLAGELLARIACEAE															
Flagellaria indica L.	I	-	-	-	-	-	-	-	-	x	-	-	x	-	-

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
MUSACEAE															
Musa x paradisiaca L.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
ORCHIDACEAE															
Spathoglottis plicata Bl.	X	-	-	-	-	-	-	-	-	-	-	-	x	x	-
Taeniophyllum mariannense Schr.	I	-	-	-	-	-	-	-	-	-	-	-	x	-	-
PANDANACEAE															
Freycinetia reineckei Warb.	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pandanus dubius Spreng.	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Pandanus tectorius Parkinson	I	x	x	x	-	-	-	-	-	x	x	-	x	x	x
POACEAE															
?Bambusa vulgaris Schrad. ex Wendl.	X	-	-	-	-	-	-	-	-	-	-	-	x	x	-
?Bothriochloa pertusa (L.) A. Camus	X	-	-	-	x	-	-	x	-	-	-	x	-	-	-
Brachiaria mutica (Forssk.) Stapf	X	x	-	-	-	-	-	x	x	-	x	-	x	x	x
Brachiaria subquadripara (Trin.) Hitchc.	X	-	-	-	-	-	-	-	x	-	-	-	-	-	x
Cenchrus echinatus L.	X	-	-	-	-	x	x	-	-	-	-	x	x	x	x
Centotheca lapaccea (L.) Desv.	X	-	-	-	-	-	x	-	-	-	-	-	x	-	-
Chloris barbata (L.) Sw.	X	-	-	-	x	-	-	x	x	-	-	x	x	x	-
Chloris radiata (L.) Sw.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Chrysopogon aciculatus (Retz.) Trin.	I	x	x	-	-	-	x	-	-	-	-	x	x	-	-
Cynodon dactylon (L.) Pers.	X	-	-	-	-	-	-	x	x	-	-	x	x	x	x
Dactyloctenium aegyptium (L.) Willd.	X	-	-	-	x	-	-	-	-	-	-	-	-	-	x
Dichantium bladhii (Retz.) Clayton	X	x	x	-	x	-	x	x	x	-	x	x	x	x	x
Dichantium caricosum (L.) A. Camus	X	x	-	-	x	-	-	-	x	-	-	-	-	x	-
Digitaria ciliaris (Retz.) Koel.	I	x	-	-	-	-	-	-	-	-	-	-	x	x	x
Dimeria chloridiformis (Gaud.) K. Schum. & Laut.	E	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Echinochloa colonum (L.) Link	X	-	-	-	-	-	-	-	-	-	-	-	-	-	x

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
POACEAE (cont'd.)															
Eleusine indica (L.) Gaertn.	X	x	-	-	-	-	-	-	x	-	-	x	-	x	x
Eragrostis brownii (Kunth) Nees ex Steud.	X	-	-	-	x	-	x	-	-	-	-	x	x	x	x
Eragrostis tenella (L.) P. Beauv. ex R. & S.	I?	-	-	-	x	-	-	-	-	-	-	x	x	x	-
Eriochloa procera (Retz.) Hubb.	X	-	-	-	x	-	-	-	x	-	-	-	-	-	-
Eustachys petraea (Sw.) Desv.	X	x	-	-	-	-	-	-	-	-	x	x	-	x	-
Hyparrhenia rufa (Nees) Stapf	X	-	-	-	x	-	-	-	-	-	-	-	x	-	-
Imperata conferta (Presl) Ohwi	X	-	x	x	-	-	-	-	-	-	-	-	x	-	-
Lepturus repens (Forst. f.) R. Br.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Miscanthus floridulus (Labill.) Warb. ex K. Schum. & Laut.	I	-	-	-	-	-	-	-	-	-	x	-	x	-	-
Panicum maximum Jacq.	X	-	-	-	-	-	-	-	-	-	-	-	x	x	x
Paspalum conjugatum Berg.	X	-	-	x	-	-	-	-	-	-	-	-	x	-	-
Paspalum fimbriatum Kunth	X	-	-	-	-	-	-	-	-	-	-	x	-	-	-
Paspalum orbiculare Forst. f.	I	-	-	-	-	-	x	-	-	-	-	-	x	x	x
Paspalum paniculatum L.	X	x	-	-	-	-	x	-	x	-	-	-	x	-	x
Paspalum setaceum Michx.	X	x	-	-	x	-	-	-	x	-	-	x	-	-	-
Paspalum urvillei Steud.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	x
Paspalum vaginatum Sw.	X	-	-	-	-	-	-	-	-	-	x	-	x	-	x
Pennisetum polystachion (L.) Schult.	X	x	-	-	x	x	-	x	x	-	x	-	x	x	x
Pennisetum purpureum Schumach.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phragmites karka (Retz.) Trin. ex Steud.	I	-	-	x	-	-	-	-	-	-	-	-	x	x	-
Rhynchelytrum repens (Willd.) Hitchc.	X	-	-	-	-	-	-	-	-	-	-	-	x	x	-
Saccharum spontaneum L.	I	-	-	x	x	x	-	x	x	-	x	x	x	x	x
Sacciolepis indica (L.) Chase	I?	-	-	x	-	-	-	-	-	-	-	-	-	x	-
Sorghum halepense (L.) Pers.	X	-	-	-	-	-	-	-	-	-	-	-	x	x	x
Sporobolus fertilis (Steud.) Clayton	X	x	-	-	x	-	x	x	x	-	x	x	x	x	-
Stenotaphrum micranthum (Desv.) Hubb.	I	-	-	-	-	-	-	-	-	-	-	-	-	-	x
Thuarea involuta (Forst. f.) R. Br. ex R. & S.	I	-	-	-	-	-	-	-	-	-	-	-	-	-	x

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
DICOTS															
ACANTHACEAE															
Blechum brownei Juss.	X	-	-	-	-	-	-	x	x	-	-	x	-	x	x
AMARANTHACEAE															
Achyranthes aspera L.	I	-	-	-	-	-	-	x	-	-	-	-	-	-	x
Deeringia amaranthoides (Lam.) Merr.	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Gomphrena celosioides Mart.	X	-	-	-	-	-	-	x	x	-	-	x	-	x	-
ANACARDIACEAE															
Mangifera indica L.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
ANNONACEAE															
Annona muricata L.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Annona squamosa L.	X	-	x	-	-	-	-	-	-	x	x	-	x	-	-
Guamia mariannae (Safford) Merr.	E	x	x	-	-	-	-	-	-	x	-	-	-	-	-
APIACEAE															
Centella asiatica (L.) Urb.	I	-	x	x	-	-	-	-	-	-	-	-	x	-	-
APOCYNACEAE															
Neisosperma oppositifolium (Lam.) Fosb. & Sachet	I	x	-	-	-	-	-	-	-	x	-	-	-	-	-
ARALIACEAE															
Polyscias grandifolia Volk.	I	-	-	-	-	-	-	-	-	x	x	-	-	-	-

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
ASTERACEAE															
Bidens alba (L.) DC.	X	x	-	x	x	x	x	x	x	x	x	x	x	x	x
Calyptocarpus vialis Less.	X	-	-	-	-	-	-	-	x	-	-	x	-	-	-
Conyza canadensis (L.) Cronq.	X	x	-	-	x	-	-	-	-	-	x	x	x	-	-
Eclipta alba (L.) Hassk.	X	-	-	x	-	-	-	-	-	-	-	-	x	-	-
Elephantopus mollis Kunth	X	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Eupatorium odoratum L.	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mikania scandens (L.) Willd.	X	x	-	x	-	-	-	-	x	x	x	-	x	x	-
Pluchea x fosbergii Coop. & Gal.	X	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Pluchea indica (L.) Less.	X	-	-	-	-	x	-	x	-	-	x	-	-	x	-
Pluchea symphytifolia (Mill.) Gillis	X	-	-	-	-	-	-	-	-	-	x	-	-	x	-
Synedrella nodiflora (L.) Gaertn.	X	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Tridax procumbens L.	X	x	-	-	-	-	x	x	x	-	-	x	x	x	-
Vernonia cinerea (L.) Less.	I	-	-	-	-	-	-	-	x	-	-	x	-	-	-
Wedelia trilobata (L.) Hitchc.	X	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Wollastonia biflora (L.) DC.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	x
BARRINGTONIACEAE															
Barringtonia asiatica (L.) Kurz	I	-	-	-	-	-	-	-	-	-	-	-	-	-	x
BIGNONIACEAE															
Spathodea campanulata Beauv.	X	-	-	-	-	-	-	-	-	-	-	-	x	x	-
Tabebuia pallida Miers	X	-	-	-	-	-	-	-	x	-	-	-	x	-	-
BORAGINACEAE															
Cordia subcordata Lam.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Heliotropium procumbens Mill.	I	-	-	-	x	-	-	x	x	-	-	x	x	x	-
Tournefortia argentea L. f.	I	-	-	-	-	-	-	-	-	-	-	-	-	-	x
CARICACEAE															
Carica papaya L.	X	-	-	-	-	x	-	-	x	x	x	-	-	x	x

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
CASSYTHACEAE															
Cassytha filiformis L.	I	-	-	x	-	-	-	-	-	-	-	-	x	x	-
CASUARINACEAE															
Casuarina equisetifolia L.	I	-	x	x	x	x	-	-	x	-	x	x	x	x	x
CELASTRACEAE															
Maytenus thompsonii (Merr.) Fosb.	E	x	-	-	-	-	-	-	-	-	-	-	-	-	-
CLUSIACEAE															
Calophyllum inophyllum L.	I	-	-	-	-	-	-	-	x	-	-	-	-	x	-
COMBRETACEAE															
Terminalia catappa L.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	x
CONVOLVULACEAE															
Ipomoea indica (Burm.) Merr.	I	x	-	-	-	-	-	-	x	-	x	-	-	-	x
Ipomoea pes-caprae (L.) R. Br.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Ipomoea triloba L.	X	-	-	-	-	-	x	x	x	-	-	-	x	x	x
CUCURBITACEAE															
Luffa cylindrica (L.) Roem.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Momordica charantia L.	X	x	-	-	-	x	-	x	x	x	x	-	x	x	x
CUSCUTACEAE															
Cuscuta campestris Yuncker	X	x	-	-	-	-	-	-	x	-	-	x	x	x	-
ELAEOCARPACEAE															
Elaeocarpus joga Merr.	I	x	-	-	-	-	-	-	-	-	-	-	-	-	-

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
EUPHORBIACEAE															
Acalypha indica L.	X	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Chamaesyce hirta (L.) Millsp.	X	x	-	-	x	-	x	-	-	-	-	x	x	x	x
Chamaesyce hypericifolia (L.) Millsp.	X	x	-	-	-	-	-	-	-	-	-	-	-	x	x
Chamaesyce prostrata (Ait.) Millsp.	X	x	-	-	x	-	-	-	-	-	-	-	-	-	-
Chamaesyce thymifolia (L.) Millsp.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	x
Codiaeum variegatum (L.) Bl.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Euphorbia heterophylla L.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	x
Glochidion marianum Muell. Arg.	I	x	x	-	-	-	-	-	-	-	-	-	x	-	-
Macaranga thompsonii Merr.	E	-	-	-	-	-	-	-	-	x	x	-	-	-	-
Melanolepis multiglandulosa (Reinw. ex Bl.) Reichenb. f. & Zoll.	I	-	-	-	-	-	-	-	x	x	x	-	-	-	-
Phyllanthus amarus Sch. & Th.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	x
Phyllanthus marianus Muell. Arg.	I	-	-	-	-	-	-	-	-	x	x	-	-	-	-
FABACEAE															
?*Aeschemone indica* L.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Albizzia sp.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Alysicarpus vaginalis (L.) DC.	X	x	-	-	x	-	x	-	x	-	-	x	x	x	-
Bauhinia monandra Kurz	X	-	-	-	-	-	-	-	x	-	x	-	-	-	-
Caesalpinia major (Medic.) Dandy & Exell	I	x	-	-	-	-	-	-	-	-	-	-	-	-	-
?*Calapogonium mucunoides* Desv.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Canavalia cathartica Thou.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Canavalia rosea (Sw.) DC.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	x
?*Crotalaria pallida* Ait.	X	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Crotalaria retusa L.	X	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Cynometra ramiflora L.	I	-	x	-	-	-	-	-	-	x	-	-	-	-	-
Derris trifolia Lour.	I	-	-	-	-	-	-	-	-	-	-	-	-	-	x
Desmanthus virgatus (L.) Willd.	X	-	-	-	-	x	-	x	x	-	-	x	x	x	x
Desmodium tortuosum (Sw.) Dc.	X	-	-	-	x	-	-	-	-	-	-	-	x	-	-
Desmodium triflorum (L.) DC.	X	-	-	-	-	-	-	-	x	-	-	x	-	x	x
Erythrina variegata L.	I	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Indigo tinctoria L.	X	-	-	-	-	-	-	-	-	-	x	-	-	x	-

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
FABACEAE (cont'd.)															
Intsia bijuga (Colebr.) Kuntze	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Leucaena leucocephala (Lam.) de Wit	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mimosa pudica L.	X	-	-	x	x	-	x	x	-	-	-	x	x	x	x
Pithecellobium dulce (Roxb.) Benth.	X	-	-	-	-	x	-	x	x	x	x	-	-	x	x
Samanea saman (Jacq.) Merr.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Senna alata (L.) Roxb.	X	-	-	-	-	-	-	-	x	-	x	-	x	-	-
Stylosanthes guianensis (Aubl.) Sw.	X	-	-	-	x	-	x	x	-	-	-	-	-	x	-
Teramnus labialis (L.f.) Spreng.	X	-	-	x	-	-	-	-	-	-	-	-	-	-	-
Vigna marina (Burm.) Merr.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
GOODENIACEAE															
Scaevola taccada (Gaertn.) Vahl	I	-	x	x	-	-	-	-	-	-	x	-	x	x	x
HERNANDIACEAE															
Hernandia nymphaeifolia (Presl) Kub.	I	-	-	-	-	-	-	-	-	-	-	-	-	-	x
LAMIACEAE															
Hyptis capitata Jacq.	X	-	x	x	-	-	-	-	-	-	-	-	x	-	-
LOGANIACEAE															
Polypremnum procumbens L.	X	-	-	-	x	-	-	-	-	-	x	x	-	-	x
LYTHRACAEAE															
Pemphis acidula Forst.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
MALVACEAE															
Hibiscus tiliaceus L.	I	x	x	x	-	-	-	-	-	x	x	-	x	x	x
Malvastrum coromandelianum (L.) Garcke	X	-	-	-	-	-	-	-	-	x	-	x	-	-	-

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
MALVACEAE (cont'd.)															
Sida acuta Burm. f.	X	-	-	-	-	-	-	x	-	-	-	-	-	x	x
Sida rhombifolia L.	X	x	-	-	-	-	-	x	x	-	-	x	x	-	x
Thespesia populnea (L.) Sol. ex Correa	I	-	-	-	-	-	-	-	-	-	-	-	-	x	x
MELASTOMACEAE															
Melastoma malabathricum L.	I	-	x	-	-	-	-	-	-	-	-	-	-	-	-
MELIACEAE															
Aglaia mariannensis Merr.	E	x	-	-	-	-	-	-	-	x	-	-	-	-	-
Xylocarpus moluccensis (Lam.) Roem.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
MORACEAE															
Artocarpus altilis (Parkinson) Fosb.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	x
Ficus prolixa Forst. f.	I	x	-	-	-	-	-	-	-	x	x	-	-	-	-
Ficus tinctoria Forst. f.	I	-	-	-	-	-	-	-	-	-	x	-	-	-	x
MYRTACEAE															
Decaspermum fruticosum Forst.	I	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Eugenia palumbis Merr.	I	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Eugenia reinwardtiana (Bl.) DC.	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Pimenta racemosa (Willd.) J.W.Moore	X	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Psidium guajava L.	X	-	-	-	-	-	-	-	-	-	-	-	x	-	-
NYCTAGINACEAE															
Boerhavia repens L.	I	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Pisonia grandis R. Br.	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
OLEACEAE															
Jasminum marianum DC.	E	-	-	-	-	x	-	-	-	x	x	-	x	x	-

FAMILY Scientific name	Status[2]	DISTRIBUTION[1] 203	829	830	141	153	157	234	239	D	F	M	P	T	Y
PASSIFLORACEAE															
Passiflora foetida L.	X	-	-	-	x	x	-	x	x	x	x	-	x	x	x
Passiflora suberosa L.	X	x	-	-	-	x	-	x	-	x	x	x	x	x	-
PIPERACEAE															
Piper guamense DC.	E	x	-	-	-	-	-	-	-	-	-	-	-	-	-
POLYGALACEAE															
Polygala paniculata L.	I?	x	-	x	-	-	-	-	-	-	-	-	x	-	-
POLYGONACEAE															
Antigonon leptopus H. & A.	X	-	-	-	-	-	-	x	-	-	-	-	x	-	x
Polygonum minus Huds.	I	-	-	-	-	-	-	-	-	-	x	-	-	-	-
RHAMNACEAE															
Colubrina asiatica (L.) Brongn.	I	-	-	-	-	-	-	-	-	x	x	-	-	x	x
RHIZOPHORACEAE															
Rhizophora apiculata Bl.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Rhizophora mucronata Lam.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
RUBIACEAE															
Dentella repens Forst.	X	-	-	-	x	-	-	-	-	-	-	-	-	x	x
Guettarda speciosa L.	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Hedyotis corymbosa (L.) Lam.	X	-	-	-	-	-	-	-	x	-	-	-	x	x	x
Morinda citrifolia L.	I	x	x	x	-	-	-	-	-	x	x	-	x	x	x
Psychotria mariana Bartl. ex DC.	E	x	-	-	-	-	-	-	-	x	-	-	-	-	-
Spermacoce assurgens R. & P.	X	x	-	-	x	-	x	x	x	-	-	x	x	x	x
Spermacoce ernstii Fosb. & Powell	X	-	-	-	-	-	x	-	-	-	-	-	-	-	-
Timonius nitidus (Bartl. ex DC.) F.-Vill.	E	-	-	-	-	-	-	-	-	-	-	-	x	-	-

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RUTACEAE															
Citrus sp.	X	-	-	-	-	-	-	-	x	x	-	-	-	-	-
Triphasia trifolia (Burm f.) P. Wils.	I?	x	-	-	-	-	-	-	-	x	x	-	-	-	-
SAPINDACEAE															
Tristeriopsis acutangula Radlk.	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
SAPOTACEAE															
Pouteria obovata (R. Br.) Baehni	I	-	-	-	-	-	-	-	x	x	x	-	-	-	-
SCROPHULARIACEAE															
Bacopa monnieri (L.) Wettst.	X	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Buchnera floridanus Sm.	X	x	-	x	x	-	x	-	-	-	-	-	-	-	-
Limnophila sp.	X	-	-	-	-	-	x	-	-	-	-	-	-	-	-
Limnophila sp.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	x
SOLANACEAE															
Capsicum frutescens L.	X	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Cestrum diurnum L.	X	x	-	-	-	-	-	-	-	-	-	-	-	-	-
STERCULIACEAE															
Heritiera longipedunculata Kaneh.	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Waltheria indica L.	X	-	x	-	x	-	-	x	-	-	x	-	x	x	x
THYMELAEACEAE															
Wikstroemia elliptica Merr.	I	x	x	-	-	-	-	-	-	-	-	-	x	-	-
TILIACAEAE															
Muntingia calabura L.	X	-	-	-	-	x	-	x	x	-	x	-	-	x	-

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URTICACEAE															
Dendrocnide latifolia (Gaud.) Chew	I	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Pilea microphylla (L.) Lieb.	X	x	-	-	-	-	-	-	-	-	-	x	-	x	-
Pipturus argenteus (Forst. f.) Wedd.	I	-	-	-	-	-	-	-	-	x	x	-	-	-	-
VERBENACEAE															
Avicenia marina (Forssk.) Vierh.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Callicarpa candicans (Burm.f.) Hochr.	I	-	-	-	-	-	-	-	-	x	-	-	x	-	-
Clerodendrum inerme (L.) Gaertn.	I	-	x	-	-	-	-	-	-	-	x	-	-	-	-
Lantana camara L.	X	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Lippia nodiflora (L.) Rich.	X	x	-	-	x	-	x	-	-	-	-	x	-	x	x
Premna serratifolia L.	I	x	-	-	-	x	-	-	-	x	x	-	x	x	-
Stachytarpheta jamaicensis (L.) Vahl	X	x	x	x	x	-	x	x	-	-	x	x	x	x	-
Stachytarpheta urticifolia (Salisb.) Sims	X	-	x	x	-	-	-	-	-	-	-	-	-	-	-
Vitex parviflora Juss.	X	-	x	-	-	-	-	-	-	-	-	-	x	-	-
Vitex trifolia L.	I	-	-	-	-	-	-	-	-	-	-	-	-	x	-

[1] The numbered sites are arranged in the same order as in the text discussion. The letters are the six proposed housing site parcels.

[2] E= Endemic to the Marianas; I= Indigenous (non-native); X= Alien species.

BOTANICAL SURVEY

OF THE

PROPOSED FAMILY HOUSING SITES,

U.S. NAVAL STATION,

TERRITORY OF GUAM

by

DR. W. ARTHUR WHISTLER
BOTANICAL CONSULTANT

for

BELT COLLINS AND ASSOCIATES
HONOLULU, HAWAII

DECEMBER 1992

INTRODUCTION

The study area comprises two parcels of land on the Naval Station (NAVSTA) at Apra Harbor on the west-central coast of Guam. These were originally designated as "Parcel D: Seabee Quarry" and "Parcel F: Tipalao Housing" and were studied, along with other sites, during a five-day visit in May. The other sites were subsequently eliminated from consideration and Parcels D and F were modified in size and shape.

The currently circumscribed Parcel D comprises the land adjacent to the coast at the end of Haputo Road (Fig. 1), and is 30 acres in extent. The upper portion that extends north of the road was enlarged on the east and west sides, and the lower portion that extends south of the road was nearly doubled in size. The currently circumscribed Parcel F was greatly expanded and now comprises most of the area between Haputo road on the northwest and north, Shoreline Drive on the east (excluding a large semicircular chunk), and the Tipalao Housing Area on the south and east (Fig. 1) It is about 66 acres in extent, part of which is a freshwater marsh.

SURVEY METHODS

Prior to the onset of the field study, a search was made of the pertinent literature to familiarize the investigator with the flora and vegetation of the sites. The most useful of the botanical sources are the flora checklists of the Marianas by Fosberg et al. (1979, 1982, 1987) and the Flora of Guam (Stone 1970). A description of the various vegetation types present on the island is found in The vegetation of Micronesia (Fosberg

1960). Topographic and site maps supplied by Belt Collins were examined to determine the terrain and reference points. The two sites were surveyed for two days during early December 1992. Unfortunately, several major hurricanes devastated the island in the previous months, and much damage was done to the limestone forest. This made access into the forest easier, but made identification of species more difficult since many of the trees lacked branches and leaves.

The botanical survey involved a "walk-through" method in which a series of informal transects were walked across the area. The areas most likely to contain native species (i.e., the marsh and limestone forest) were given more emphasis than disturbed areas. Notes were taken on species present, vegetation characteristics, substrate types, topography, and anything else pertinent. Species identifications were made in the field, except for a few plants that were collected and compared with material in the herbarium of the University of Guam, with the help of Dr. Lynn Raulerson.

DESCRIPTION OF THE VEGETATION

Based on the field survey, six main types of vegetation can be distinguished at the sites: managed land, Leucaena scrub forest, limestone forest, Casuarina forest, Hibiscus woodland, and freshwater marsh. These are described below.

Managed Land

This comprises the areas where the vegetation has been so thoroughly and continually disturbed that it is entirely

dominated by weedy, introduced species. Weeds are fast-growing, readily dispersed plants that are able to take advantage of disturbances such as clearing for agriculture, road grading, and mowing. If these areas are left undisturbed for long enough, the herbaceous weeds will eventually be shaded out and replaced by Leucaena scrub forest.

The managed land at the two sites is found mostly in the northeast corner of Parcel F, which is a mowed grassy field, the northwest corner, which is currently a baseball field, and along the roadsides and margins of the other types of vegetation. The area at the site covered with this type of vegetation is shown in Figure 1. Nearly 50 weedy plant species were found in these areas (Table 1), the most common of which are Bidens alba, Tridax procumbens, Bothriochloa pertusa, Fimbristylis cymosa, and Paspalum setaceum. Small areas or patches of weedy herbaceous vegetation are present within the Leucaena scrub forest that could either be included in managed land based on species composition or in Leucaena scrub forest based on the small size of the patches and surrounding scrubby vegetation.

Leucaena Scrub Forest

This is the scrub forest dominated by Leucaena leucocephala (tangantangan) and is what Fosberg (1960) described as "Leucaena glauca (the former name for Leucaena leucocephala) thicket" in the "weed communities" category. Leucaena completely dominates here, but it becomes a minor forest component in areas lacking soil (i.e., undisturbed limestone). This vegetation covers the

major portion of Parcel F, giving way on the margins to managed land and to freshwater marsh in low-lying, wetter places.

Leucaena scrub forest is not a natural community, since Leucaena is an introduced species native to the Caribbean. However, it forms such dense thickets that native species find it difficult or impossible to become established in it, making it a stable community, at least over short periods of time (decades). It most often occurs on land that was previously disturbed, but sometimes appears to be common or even dominant in what would otherwise be considered limestone forest.

In addition to Leucaena, a few other trees, such as Casuarina equisetifolia (ironwood) and Pithecellobium dulce, both much larger species, occur here, but only in small numbers. Most of the associated species--vines, shrubs, and herbs--are introduced plants. In places that appear to have been relatively undisturbed for some time, the understory of the scrub forest is dominated by Phymatosorus scolopendria, a native fern. In more heavily disturbed areas, weedy, mostly introduced plants such as Pluchea indica, Bidens alba, Mikania scandens, Passiflora foetida, Momordica charantia, and Nephrolepis hirsutula, are particularly common. In some places, Leucaena gives way to clearings dominated by Saccharum spontaneum (wild sugarcane), and one clearing south of the baseball field is dominated by Antigonon leptopus (Mexican creeper), Hymenocallis littoralis (spiderlily), and Mikania scandens (mile-a-minute vine), all three of which are introduced species.

Several native species, particularly Phyllanthus marianus, a small shrub, and the seven native, non-wetland ferns recorded

during the whole survey, are found here. Only three of the native species recorded, Psychotria mariana, Jasminum marianum and Macaranga thompsonii, are endemic to the Marianas, and none of them is uncommon on Guam. If this forest is left without further disturbance for long enough, native species may eventually become increasingly common.

Limestone Forest

This is the native forest covering areas of exposed limestone on Guam, typically on escarpments and level areas of karst. Limestone forest probably originally covered much of the island before the arrival of man, but it is now restricted to those areas unsuitable for agriculture and/or inaccessible enough to be left uncut by timber seekers. Most of the species found here are native, and a few are endemic. This type of vegetation is what Fosberg (1960) described as "forests of elevated hard limestones." Several subcategories were distinguished by Fosberg, but none of them correspond to the limestone forest found at the study site.

Limestone forest covers most of Parcel D, on both the north and south sides of Haputo Road, and these will be discussed separately below. The surface here is mostly a rugged karst consisting of jagged limestone ridges and pinnacles where the plants grow out of rock cracks.

The portion north of Haputo Road had a greater species diversity and much of it, particularly the portion nearest the coast, was less disturbed (prior to the recent hurricanes). The

most common trees present are Ficus prolixa (banyan), Pisonia grandis, and Neisosperma oppositifolium. Less common native trees include Cynometra ramiflora, Intsia bijuga (ifil), Pipturus argenteus, Aglaia mariannensis, Premna serratifolia, Polyscias grandifolia, Pouteria obovata, Psychotria mariana, Guettarda speciosa, Melanolepis multiglandulosa, Guamia mariannae, Pandanus tectorius (screwpine), and Pandanus dubius.

The palm-like conifer Cycas circinalis (cycad) is common as an understory species among the trees. Native epiphytic ferns, such as Phymatosorus scolopendria, Microsorium punctatum, and Pyrrosia lanceolata, are also present, as are the native climbers Jasminum marianum and Flagellaria indica, and the native shrubs Deeringia amaranthoides and Phyllanthus marianus.

Also present in limited numbers on this portion north of Haputo Road is Heritiera longipetiolata, a large tree that is listed as an endangered species on Guam by the local government, is endemic to the Marianas (Guam, Rota, and Saipan), and is reported from only a few localities on the island. Another rare (but not officially listed as endangered) tree species, Drypetes dolichocarpa, is reported to occur in the limestone forest to the west on Orote Peninsula, and could conceivably also be found on this parcel.

Other areas have a veneer of soil, which possibly because of disturbance, is dominated by introduced species. The two most common shrubs or small trees in these areas are Leucaena leucocephala and Triphasia trifolia. The presence of the thorny shrub Triphasia makes passage through areas dominated by it very difficult and sometimes painful.

The portion of Parcel D south of Haputo Road was generally more disturbed in the past, judging by the greater amount of Leucaena leucocephala (tangantangan) present. There are also a few escaped ornamentals that appear to have gotten into the forest at the edges from the adjacent Tipalao Housing, such as Sansevieria trifasciata (bowstring hemp) and bananas.

The most common tree in this south portion of Parcel D is Leucaena leucocephala, but also frequent are Neisosperma oppositifolium, Guamia mariannae, Premna serratifolia, and Eugenia reinwardtiana. However, these are all understory species, and none of them sampled during the December survey is greater than about 9 inches in diameter. Canopy species are fewer in number but have a greater relative dominance (based on the sum of the basal area at breast height of all the individuals in an area). The most dominant of these are Ficus prolixa (banyan), Pisonia grandis (pisonia), Tristiropsis obtusangula (faia), and Intsia bijuga (ifil). Banyans are few in number, but their great size, with multiple trunks and thick hanging roots, give them a high amount of relative dominance.

Cycads are also very common in this forest. Native climbers such as Flagellaria indica and Jasminum marianum, are also common, as is the native shrub Phyllanthus marianus.

The forest both north and south of the road took a terrible beating from the recent hurricanes. Most of the trees were not killed, but those that remain standing have had most or all of their branches removed, giving an eerie, open appearance to the forest. The cycads present seem to have been the least affected,

since their thick trunks hardly branch, but many of them looked unhealthy, possibly because they are not accustomed to the bright sunny conditions, since they are understory species. Despite the severity of the damage, the limestone forest is adapted to hurricanes and will eventually recover, if allowed to do so.

Casuarina Forest

This is forest dominated by Casuarina equisetifolia (ironwood). Small patches of this are found on Parcel F, particularly on the west side at the base of the slope below Tipalao Housing. The only other major trees present here are Leucaena leucocephala and Pandanus tectorius, which are both much smaller than the tall ironwood trees. Mixed in with these are Cycas circinalis (cycad), with patches of Scaevola taccada, Colubrina asiatica, and Pluchea indica that sometimes dominate the shrub layer. The ground cover, where shrubs do not prevail, is mostly Phymatosorus scolopendria, with lesser amounts of Nephrolepis hirsutula. This is an unnatural community, since many of the species present are introduced, and the area has been extensively disturbed in the past.

Hibiscus Woodland

These are areas dominated by the native Hibiscus tiliaceus (beach hibiscus) that forms dense, nearly impenetrable thickets. Two types will be recognized here for discussion purposes--one forming a zone around the main marsh on Parcel F, the other comprising two or more discontinuous patches located to the northwest of the marsh.

The hibiscus woodland surrounding the marsh is made up almost entirely of Hibiscus tiliaceus with a ground cover of Cyclosorus interruptus beneath it. On the north side of the marsh, between the marsh itself and the loop road through the U.S. Navy Public Works Center, the hibiscus is mixed with Leucaena leucocephala, Casuarina equisetifolia, Morinda citrifolia (Indian mulberry), Heterospathe elata (palma brava), and Pithecellobium dulce. Because of all these other, non-wetland species, this latter area would probably not be considered a wetland.

The second type of hibiscus woodland noted above comprises at least two discontinuous thickets near the base of the cliff below the current Tipalao Housing, probably at the site of an old quarry. Besides the hibiscus that forms the thickets, the only trees in these two areas were a few coconuts. The ground cover is made up mostly of Phymatosorus scolopendria, Nephrolepis hirsutula, Acrostichum aureum, and Amphineuron opulentum. These four are all ferns, which presumably dominate here because of their shade tolerance. Only one is a wetland species, Acrostichum aureum, which also formed a pure patch about 20 x 20 ft. in diameter at one end of the woodland.

At the time of the site visit in December, no standing water was present in these patches. Because of the absence of standing water and the prevalence of non-wetland ground cover species, these woodlands are only marginal wetlands at best. In any case, the patches are very small.

Freshwater Marsh

This is the vegetation, dominated by hydrophytic (water-loving) herbaceous species, that occurs in areas saturated with fresh water. The Apra Harbor regional optimal land utilization study (U.S. Navy 1990b) indicates that Parcel F contains wetlands covering 14 acres, but describes this as "part of a drainage sump with no natural surface drainage. Although designated as a wetlands, it is likely seasonal in nature." However, the larger of the wetlands shown on the map contained in that report is a high quality, relatively undisturbed freshwater marsh dominated by several herbaceous, mostly indigenous wetland plant species.

At the time of the original survey in May, the marsh was relatively dry, and one could walk across it without getting his feet wet. During the visit in December, however, the water was ankle deep or deeper in most of the marsh.

The marsh is covered with a mosaic of associations, most of which have in common a dominance or co-dominance of Cyclosorus interruptus (marsh fern). In some places, particularly in areas of deeper water, Cyclosorus shared dominance with Scirpus littoralis (bulrush). In other places the associated species were Clerodendrum inerme (typically a littoral shrub), Lycodium scandens (a climbing fern), Eleocharis dulcis (a leafless sedge). On the south margin, close to the road, the dominant species is the introduced Brachiaria mutica (California grass), mixed with Cyclosorus. In the center are what appears to be small hummocks dominated by Acrostichum aureum (swamp fern), again mixed with Cyclosorus and a few other species. The Cyclosorus also extends

into the Hibiscus woodland that surrounds much of the marsh. Along some of the margins another wetland herb, Polygonum minum, is often dominant, with or without Cyclosorus.

These differences in species combinations may be caused by factors such as soil profile, whether or not the wet conditions are seasonal or permanent, and so forth, which may vary across the extent of the marsh.

Two other wetlands are shown on the U.S. Navy (1990b) map, but these are very small in extent. One is located outside the present study area southeast of the main marsh (but within the area planned for development), the other northwest of it. These occur in shallow basins with poor drainage and may be covered with standing water for periods of time during the wet season.

The northwest area of marsh is a series of small wetlands more or less in a line; these are very small with the largest estimated be no more than 30 x 30 ft. in diameter. The dominant species is again Cyclosorus interruptus, with lesser amounts of Acrostichum aureum and Marsicus javanicus (a sedge). Also present are the littoral shrubs Clerodendrum inerme and Colubrina asiatica, as well as Saccharum spontaneum (wild sugarcane), which is not considered a wetland species. At the time of the last survey (early December), these wetlands were being delineated with red flagging by a local environmental company.

DISCUSSION AND RECOMMENDATIONS

Three of the plant communities listed above, managed land, Leucaena scrub forest, and Casuarina forest comprise disturbed vegetation dominated by introduced species, and have little to

recommend them botanically. Two communities, Hibiscus woodland and the freshwater marsh are of concern because they are wetlands that are afforded protected status by federal laws. The sixth community, the limestone forest, is significant because it is a native vegetation type that has largely been removed from the island.

As noted in the discussion of Hibiscus woodland, two types may be distinguished. The continuous one around the freshwater marsh is largely comprised of two species, hibiscus and Cyclosorus interruptus, both of which are wetland species. Because of this, and the presence of standing water, this is a wetland. The status of the other discontinuous patches is not so clear, because no standing water was found and most of the ground cover plants are non-wetland species. Soil and hydrology criteria may have to be employed to see if they would actually be classified as wetlands. However, they are very small in area and do not have much botanically to recommend them.

The large freshwater marsh is probably one of the better and more diverse marshes on Guam. The ten native and several introduced species found here form a mosaic of different associations across the marsh. Since it is a wetland, it is protected by federal laws. In any case, the most recent plans (December 1992) for the layout of the housing indicate that this area will not be utilized.

What will be utilized, however, are all the other areas of marsh. As noted earlier, however, these are very small (possibly less 1000 sq. ft. each) and the species diversity is low, so that

their utilization during the development of the housing may be justifiable.

According to the current development plans (December 1992), only the south half of Parcel D is slated for development. The north half on the development map is annotated with "no structures in this area." Because this area is covered with limestone forest (the majority of which has now been eliminated from Guam), the presence of many native species, and the presence of the rare Heritiera longipetiolata, which is listed by Guam as an endangered species, the site has much to recommend it botanically. Consequently, if possible, it should be left fenced and left alone.

The south half appears to be much more disturbed (before the hurricanes) and apparently does not have as many native species, including Heritiera longipetiolata. But because it is limestone forest, it would be preferable, botanically, to leave it alone as well--if any other viable alternative is available for the rest of the house sites needed during the project.

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Table 1. CHECKLIST OF THE FLORA OF THE APRA NAVAL STATION HOUSING SITE

The scientific names on this list have been taken from the series by Fosberg, Sachet, and Oliver (1979, 1982, 1987), with some revision from the more recent publications of Wagner (1990) on Hawai'i, and Smith (1979--1991) and Brownlie (1977) on Fiji. The common names have been taken mostly from Stone (1970). The species are arranged in four groups: (1) ferns; (2) gymnosperms; (3) monocots; and (4) dicots. The plants in these four groups are placed within their respective families arranged in alphabetical order, with the species also arranged in alphabetical order within the family.

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CP	HW	FM
FERNS (PTERIDOPHYTES)								
ADIANTACEAE (Maidenhair-fern Family)								
Acrostichum aureum L.	I	swamp fern	-	-	-	-	x	x
Pteris vittata L.	X	-----	-	x	x	-	-	-
ASPLENIACEAE (Asplenium Family)								
Asplenium nidus L.	I	bird's-nest fern, galak	-	x	-	-	-	-
DAVALLIACEAE (Sword-fern Family)								
Davallia solida (Forst.f.) Sw.	I	leather fern, pagua-machena	-	x	-	x	-	-
Nephrolepis hirsutula (Forst.f.) Presl	I	sword fern	x	x	x	x	x	-
POLYPODIACEAE (Common Fern Family)								
Phymatosorus scolopendria (Burm.f.) Pichi Serm.	I	-----	x	x	x	x	x	-
(= Polypodium scolopendrium)								
Pyrrosia lanceolata (L.) Farw.	I	-----	-	x	x	x	x	-
Microsorium punctatum (L.) Copel.	I	-----	-	x	x	x	-	-
(= Polypodium punctatum)								
SCHIZAEACEAE (Schizaea Family)								
Lygodium microphyllum (Cav.) R. Br.	I	-----	-	-	-	-	-	x

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
CYPERACEAE (Sedge Family)								
Cyperus difformis L.	X	-----	x	-	-	-	-	-
Cyperus ligularis L.	X	-----	x	-	-	-	-	-
Eleocharis dulcis (Burm. f.) Trin. ex Hensch.	X	water chestnut, uchaga-lane	-	-	-	-	-	x
Fimbristylis cymosa R. Br.	I	-----	x	-	-	-	-	-
Fimbristylis dichotoma (L.) Vahl	I	-----	x	-	-	-	-	-
Mariscus javanicus (Houtt.) Merr. & Metcalfe (=Cyperus javanicus)	I	-----	-	x	-	-	-	x
Pycreus polystachyos (Rottb.) Beauv.	I	-----	-	-	-	-	-	x
Scirpus littoralis Schrader	I	bulrush	-	-	-	-	-	x
FLAGELLARIACEAE (Flagellaria Family)								
Flagellaria indica L.	I	false ratan, bejuco halum-tano	-	x	x	-	-	-
LEMNACEAE (Duckweed Family)								
Lemna perpusilla Torrey	X	duckweed, almagosa	-	-	-	-	-	x
MUSACEAE (Banana Family)								
Musa x paradisiaca L.	X	banana, chotda	x	x	-	-	-	-
PANDANACEAE (Screwpine Family)								
Pandanus dubius Spreng.	I	screwpine, pahong	-	-	x	-	-	-
Pandanus tectorius Parkinson	I	screwpine, kafu	-	x	x	-	-	-
POACEAE (Grass Family)								
Brachiaria mutica (Forssk.) Stapf (= Panicum muticum)	X	California grass	x	-	-	-	-	x
Cenchrus echinatus L.	X	bur grass	x	x	-	-	-	-
Chloris barbata (L.) Sw. (= Chloris inflata)	X	finger grass	x	x	-	-	-	-
Chrysopogon aciculatus (Retz.) Trin.	I	-----	x	-	-	-	-	-

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
THELYPTERIDACEAE (Downy Woodfern Family)								
Amphineuron opulentum (Kaulf.) Holttum (= Thelypteris opulenta)	X	-----	-	x	-	-	x	-
Cyclosorus interruptus (Willd.) H.Ito (= Thelypteris interrupta)	X	-----	-	-	-	-	x	x
VITTARIACEAE (Ribbon-fern Family)								
Antrophyum plantagineum (Cav.) Kaulf. Kaulf.	I	-----	-	x	-	-	x	-
GYMNOSPERMS								
CYCADACEAE (Cycad Family)								
Cycas circinalis L.	I	cycad, fadang	-	x	x	x	-	-
MONOCOTS								
AGAVACEAE (Yucca Family)								
Sansevieria trifasciata Prain	X	bowstring hemp	-	x	x	-	-	-
AMARYLLIDACEAE (Amaryllis Family)								
Hymenocallis littoralis (Jacq.) Salisb.	X	spiderlily, lirio	-	x	x	-	-	-
ARACEAE (Aroid Family)								
Alocasia macrorrhiza (L.) Schott	X	giant taro, papao-apaka	-	x	-	-	-	-
Syngonium podophyllum Schott	X	synconium	-	x	x	-	-	x
ARECACEAE (Palm Family)								
Cocos nucifera L.	I?	coconut, niyog	x	x	-	-	x	-
Heterospathe elata Scheffer	X	palma brava	-	x	-	x	x	-
COMMELINACEAE (Spiderwort Family)								
Rhoeo spathacea (Sw.) Stern	X	oyster plant	x	-	x	-	-	-

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
ANNONACEAE (Soursop Family)								
Annona squamosa L.	X	sweetsop, atis	-	-	x	-	-	-
Guamia mariannae (Safford) Merr.	E	pai-pai	-	-	x	-	-	-
APOCYNACEAE (Dogbane Family)								
Neisosperma oppositifolium (Lam.) Fosb. & Sachet	I	fago	-	-	x	-	-	-
ARALIACEAE (Panax Family)								
Polyscias grandifolia Volkens	I	pepega	-	-	x	-	-	-
ASTERACEAE (Sunflower Family)								
Bidens alba (L.) DC.	X	beggar's tick	x	x	-	-	x	-
Conyza canadensis (L.) Cronq.	X	Canadian fleabane	x	-	-	-	-	-
Eupatorium odoratum L.	X	-----	x	x	-	-	-	-
Mikania scandens (L.) Willd.	X	mile-a-minute vine	x	x	-	x	-	x
Pluchea indica (L.) Less.	I	Indian pluchea	-	x	-	-	-	-
Pluchea x fosbergii Coop. & Gal.	X	hybrid pluchea	-	x	-	-	-	-
Pluchea symphytifolia (Mill.) Gillis	X	pluchea	-	x	-	-	-	-
Synedrella nodiflora (L.) Gaertn.	X	saigon	x	-	-	-	-	-
Tridax procumbens L.	X	coat buttons	x	-	-	-	-	-
CAMPANULACEAE (Bluebell Family)								
Hippobroma longiflora (L.) G. Don	X	star of bethelehem	-	x	-	-	-	-
CARICACEAE (Papaya Family)								
Carica papaya L.	X	papaya	-	x	x	-	-	-
CASUARINACEAE (Ironwood Family)								
Casuarina equisetifolia L. (= Casuarina litorea)	I	ironwood, gagu	-	x	-	x	x	-
CLUSIACEAE (Mangosteen Family)								
Calophyllum inophyllum L.	I	Alexandrian laurel, da'og	-	x	-	-	-	-

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
POACEAE (cont'd.)								
Cynodon dactylon (L.) Pers.	X	Bermuda grass, grama	x	x	-	-	-	-
Dactyloctenium aegyptium (L.) Willd.	X	crowfoot grass	x	-	-	-	-	-
Dichantium caricosum (L.) A. Camus	X	-----	x	-	-	-	-	-
Digitaria ciliaris (Retz.) Koel.	I	-----	x	x	-	-	-	-
Eleusine indica (L.) Gaertn.	X	goose grass, umog	x	-	-	-	-	-
Eragrostis brownii (Kunth) Nees ex Steud.	X	-----	x	-	-	-	-	-
Eragrostis ciliaris (L.) R. Br.	X	love grass	x	-	-	-	-	-
Eragrostis tenella (L.) P. Beauv. ex R. & S. (= Eragostis amabilis)	I?	love grass	x	-	-	-	-	-
Eustachys petraea (Sw.) Desv.	X	-----	x	-	-	-	-	-
Imperata conferta (Presl) Ohwi	X	-----	-	x	-	x	-	-
Panicum maximum Jacq.	X	Guinea grass	x	x	-	-	-	-
Paspalum fimbriatum Kunth	X	-----	x	-	-	-	-	-
Paspalum paniculatum L.	X	-----	x	-	-	-	-	-
Paspalum setaceum Michx.	X	-----	x	-	-	-	-	-
Paspalum vaginatum Sw.	X	saltgrass	-	-	-	-	-	x
Pennisetum polystachion (L.) Schult.	X	mission grass	x	x	-	-	-	-
Saccharum spontaneum L.	I	wild cane	x	x	-	-	-	x
Sporobolus fertilis (Steud.) Clayton	I	rat-tail dropseed	x	-	-	-	-	-
Stenotaphrum micranthum (Desv.) Hubb.	I	-----	-	x	-	-	-	-
DICOTS								
ACANTHACEAE (Acanthus Family)								
Blechum brownei Juss.	X	yerbas babui	-	x	-	-	-	-
AMARANTHACEAE (Amaranth Family)								
Achyranthes aspera L.	I	chichitun	-	x	-	-	-	-
Deeringia amaranthoides (Lam.) Merr.	I	-----	-	-	x	-	-	-
Gomphrena celosioides Mart.	X	-----	x	-	-	-	-	-

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
FABACEAE (cont'd.)								
Mimosa pudica L.	X	sensitive plant	x	-	-	-	-	-
Pithecellobium dulce (Roxb.) Benth.	X	kamachile	-	x	x	-	-	-
Senna alata (L.) Roxb. (= Cassia alata)	X	candlebush, andadose	-	x	-	-	-	-
Stylosanthes guianensis (Aubl.) Sw.	X	-----	x	-	-	-	-	-
Teramnus labialis (L.f.) Spreng.	X	chaguan cacaguates	-	x	-	-	-	-
GOODENIACEAE (Goodenia Family)								
Scaevola taccada (Gaertn.) Roxb.	I	scaevola, nanaso	-	x	-	x	-	-
LYTHRACAEAE (Loosestrife Family)								
Pemphis acidula Forst.	I	nigas	-	-	x	-	-	-
MALVACEAE (Mallow Family)								
Hibiscus tiliaceus L.	I	beacn hibiscus, pago	-	x	x	-	-	x
Malvastrum coromandelianum (L.) Garcke	X	-----	x	x	x	-	-	-
Sida acuta Burm.f.	X	escobilla papago	x	-	-	-	-	-
Sida rhombifolia L.	X	escobilla dalili	x	-	-	-	-	-
MELIACEAE (Mahogany Family)								
Aglaia mariannensis Merr.	E	mapunyao	-	-	x	-	-	-
MORACEAE (Mulberry Family)								
Ficus prolixa Forst.f.	I	banyan, nunu	-	x	x	-	-	-
MYRTACEAE (Myrtle Family)								
Eugenia reinwardtiana (Bl.) DC.	I	a'abang	-	-	x	-	-	-
NYCTAGINACEAE (Four-o'clock Family)								
Pisonia grandis R. Br.	I	pisonia, umumu	-	-	x	-	-	-
OLEACEAE (Olive Family)								
Jasminum marianum DC.	E	banago	-	x	x	x	-	-

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
CONVOLVULACEAE (Morning-glory Family)								
Ipomoea indica (Burm.) Merr.	I	blue morning-glory,	-	x	-	-	-	-
Ipomoea triloba L.	X	fofgu-sabana	-	x	-	-	-	-
Stictocardia tiliifolia (Desr.) Hall.f.	I	-----	-	x	-	-	-	-
CUCURBITACEAE (Gourd Family)								
Momordica charantia L.	X	balsam apple, almagosa	-	x	x	-	-	-
CUSCUTACEAE								
Cuscuta campestris Yuncker	X	dotter	-	x	-	-	-	-
EUPHORBIACEAE (Spurge Family)								
Acalypha indica L.	X	hierba del cancer	x	x	-	-	-	-
Chamaesyce hirta (L.) Millsp. (= Euphorbia hirta)	X	garden spurge, golondrina	x	-	-	-	-	-
Chamaesyce hypericifolia (L.) Millsp. (= Euphorbia glomerifera)	X	-----	x	x	-	-	-	-
Glochidion marianum Muell. Arg.	I	chosga, abas duendes	-	x	-	x	x	-
Macaranga thompsonii Merr.	E	pangua	-	x	x	-	-	-
Melanolepis multiglandulosa (Reinw. ex Bl.) Reichenb.f. & Zoll.	I	alom	-	x	x	-	-	-
Phyllanthus urinaria L.	X	-----	x	-	-	-	-	-
Phyllanthus marianus Muell. Arg.	I	gaogao-uchan	-	x	x	-	-	-
FABACEAE (Pea Family)								
Aeschynomene indica L.	X	-----	x	-	-	-	-	-
Alysicarpus vaginalis (L.) DC.	X	-----	x	-	-	-	-	-
Crotalaria retusa L.	X	-----	x	-	-	-	-	-
Cynometra ramiflora L.	I	-----	-	-	x	-	-	-
Desmanthus virgatus (L.) Willd.	X	-----	x	x	-	-	-	-
Desmodium triflorum (L.) DC.	X	agsom	x	-	-	-	-	-
Intsia bijuga (Colebr.) Kuntze	I	ifil	-	-	x	-	-	-
Leucaena leucocephala (Lam.) de Wit	X	wild tamarind, tangantangan	x	x	x	x	x	-

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
SCROPHULARIACEAE (Snapdragon Family)								
Buchnera floridanus Sm.	X	-----	x	-	-	-	-	-
SOLANACEAE (Nightshade Family)								
Capsicum frutescens L.	X	chili pepper, doni-sali	-	x	x	-	-	-
STERCULIACEAE (Cacao Family)								
Heritiera longipetiolata Kanehira	E	ufa-halomtano	-	-	x	-	-	-
Waltheria indica L.	X	escobilla sabana	x	-	-	-	-	-
TILIACAEAE (Linden Family)								
Corchorus aestuans L.	X	bilimbines chaka	x	x	-	-	-	-
Muntingia calabura L.	X	Panama cherry, calabura	-	x	-	-	-	-
URTICACEAE (Nettle Family)								
Dendrocnide latifolia (Gaud.) Chew	I	nettle tree	-	-	x	-	-	-
Pilea microphylla (L.) Lieb.	X	-----	x	x	-	-	-	-
Pipturus argenteus (Forst. f.) Wedd.	I	amahadyan	-	x	x	-	-	-
VERBENACEAE (Verbena Family)								
Callicarpa candicans (Burm. f.) Hochr.	I	-----	-	-	x	-	-	-
Clerodendrum inerme (L.) Gaertn.	I	lodugao	-	x	-	-	-	x
Lippia nodiflora (L.) Rich.	X	lippia	x	-	-	-	-	-
Premna serratifolia L.	I	ahgao	-	x	x	x	-	-
Stachytarpheta jamaicensis (L.) Vahl	X	false verbena	x	x	-	-	-	-

[1] ML= Managed Land; LS= Leucaena Scrub Forest; LF= Limestone Forest; CF= Casuarina forest; Hibiscus woodland; and CM= Coastal Marsh.
[2] E= Endemic to the Marianas; I= Indigenous (non-native); X= Alien species.

Scientific name	Status[2]	Common Name	DISTRIBUTION[1] ML	LS	LF	CF	HW	FM
PASSIFLORACEAE (Passionflower Family)								
Passiflora foetida L.	X	love-in-a-mist	x	x	x	x	-	x
Passiflora suberosa L.	X	-----	x	x	x	-	-	-
POLYGONACEAE (Buckwheat Family)								
Antigonon leptopus H. & A.	X	chain-of-love, cadena de amor	x	x	-	-	-	-
Polygonum minus Huds.	I	mamaka, mamaca	-	-	-	-	-	x
PORTULACACEAE (Purslane Family)								
Portulaca oleracea L.	X	purslane, botdolagas	x	-	-	-	-	-
RHAMNACEAE (Buckthorn Family)								
Colubrina asiatica (L.) Brongn.	I	gasoso	-	x	x	x	x	-
RUBIACEAE (Coffee Family)								
Guettarda speciosa L.	I	panao	-	-	x	-	-	-
Hedyotis corymbosa (L.) Lam.	X	-----	x	-	-	-	-	-
Morinda citrifolia L.	I	Indian mulberry, lada	-	x	x	x	x	-
Psychotria mariana Bartl. ex DC.	E	aplokating	-	x	x	-	-	-
Spermacoce assurgens R. & P.	X	-----	x	-	-	-	-	-
Spermacoce ernstii Fosb. & Powell	X	-----	x	x	-	-	-	-
RUTACEAE (Citrus Family)								
Citrus macroptera Montr.	X	wild orange, kahet	-	x	x	-	-	-
Triphasia trifolia (Burm.f.) P. Wils.	I?	limeberry, limon-china	-	-	x	-	-	-
SAPINDACEAE (Soaberry Family)								
Tristiropsis obtusangula Radlk.	I	faia	-	-	x	-	-	-
SAPOTACEAE (Sapodilla Family)								
Pouteria obovata (R. Br.) Baehni	I	lalahag	-	x	x	x	-	-

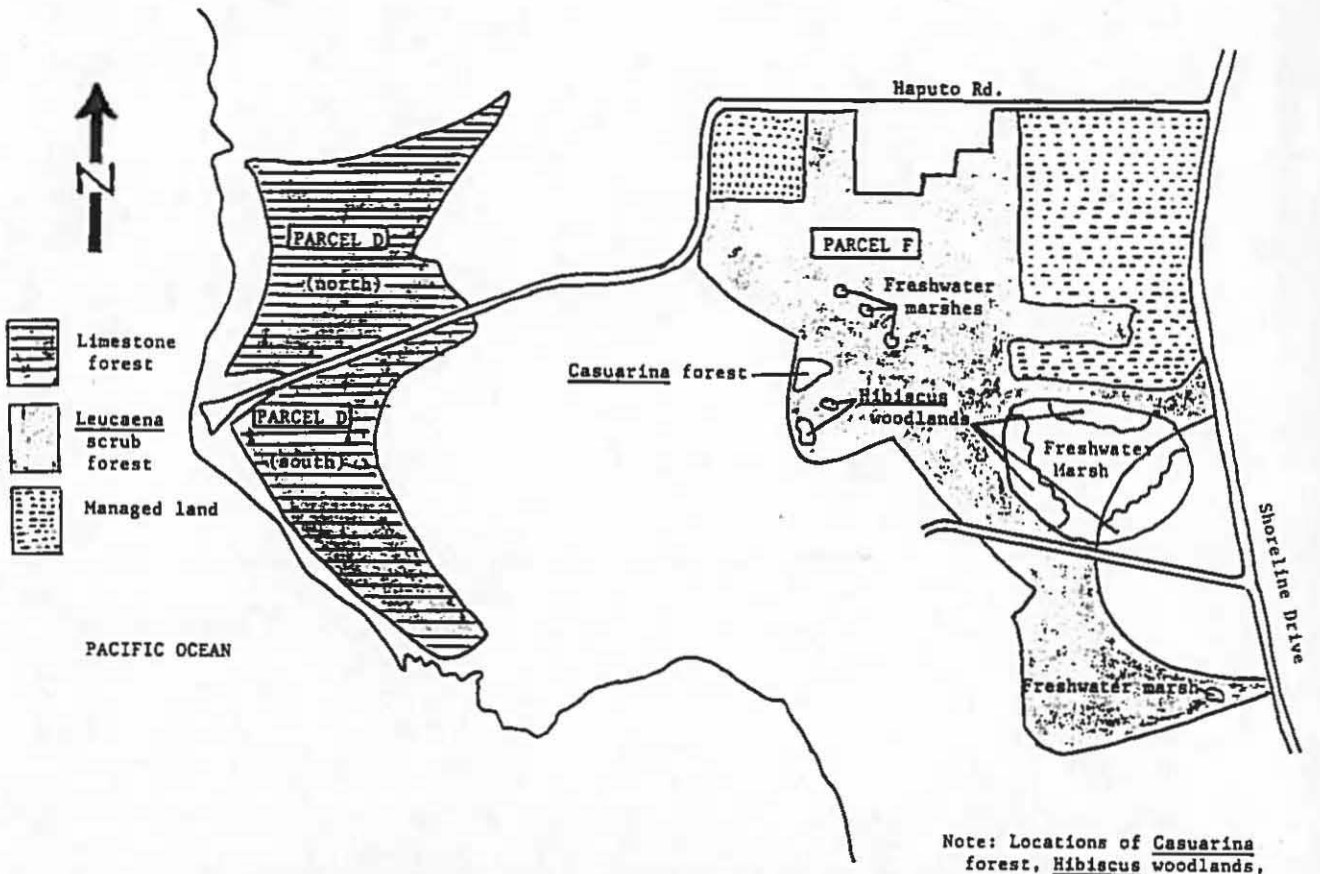

Figure 1. Vegetation Map of the Proposed Housing Sites, NAVSTA, Guam.

Note: Locations of Casuarina forest, Hibiscus woodlands, and freshwater marshes are only approximate.

Appendix E

Faunal (Bird and Mammal) Survey

FAUNAL (BIRD AND MAMMAL) SURVEY OF LANDS PROPOSED FOR POSSIBLE DEVELOPMENT AT NAVY AND AIR FORCE INSTALLATIONS ON GUAM, MARIANA ISLANDS

Prepared for

Belt Collins & Associates

by

Phillip L. Bruner
Assistant Professor of Biology
Director, Museum of Natural History
Environmental Consultant - Faunal (Bird & Mammal) Surveys
BYU-H
Laie, Hawaii 96762

5 August 1992

INTRODUCTION

The purpose of this report is to summarize the findings of a four day (21-24 July 1992) bird and mammal field survey of eight separate sites proposed for possible development at Navy and Air Force installations on Guam, Mariana Islands (see Fig. 1 for approximate locations of these sites). Also included in this report are references to pertinent literature as well as unpublished reports and information obtained through personal communications.

The objectives of the field survey were to:

1- Document what bird and mammal species presently occur on the various properties.

2- Provide some baseline data on the relative abundance of each species.

3- Note which sites are of greatest importance for native birds and mammals, particularly any that are considered "endangered".

SITE LOCATIONS AND GENERAL HABITAT DESCRIPTIONS

A total of eight sites were surveyed: two at Andersen Air Force

Base (Fig. 2,3); two at Naval Magazine (Fig. 4) and four at Naval Station/APRA Harbor Complex (Fig. 5,6).

The Andersen sites are both presently covered in second growth forest with some areas of open grass along roadsides. Site "A" (shown enlarged in Fig. 3) parallels the perimeter road. The forest is low in stature in the area proposed for development. The habitat beyond and towards the cliff line contains some good examples of native forest with several large emergent trees. Site "B" adjoins an existing fuel storage field and a housing complex. Second growth forest and patches of tall grass dominate this property.

Naval Magazine sites (Fig. 4) contain second growth brush and a few scattered trees. Site "C" is a former ammunition storage facility accessed by a narrow, weed infested road. Site "D" is a cement slab with a row of Ironwood trees and brush along one edge.

The four Naval Station/APRA Harbor sites are areas proposed for housing. Site "E" (Fig. 5), also known as Polaris Point, has a large lawn area, forests of Ironwood, second growth patches of brush and coastal mangrove thickets. This site contained the greatest diversity of habitats of all the eight sites examined on this survey. Site "F" (Fig. 5) is a large heavily forested property surrounded by housing, roads and other military installations. The habitat is second growth forest with some large trees. Site "G" (Fig. 5,6) has a large open field, second growth forest and a small fern choked wetland. Housing and other buildings surround the site. The final area surveyed, Site "H" (Fig. 5,6) is located along the cliff line. The property contains some good examples of native forest. A housing project adjoins a portion of the site.

STUDY METHODS

Field observations were made with the aid of binoculars and by listening for vocalizations. Attention was also paid to the presence of tracks and scats as indicators of bird and mammal activity. All sites were surveyed on foot by following existing roads and trails. Transects were also made through representative sections of each site so as to provide an adequate coverage of the property. All birds seen or heard were recorded.

Observations of feral mammals were limited to visual sightings and evidence in the form of tracks and scats. No attempts were made to trap mammals in order to obtain data on their relative abundance.

Scientific names used in this report follow those given in Pratt et al. (1987) and Honacki et al. (1982).

RESULTS AND DISCUSSION

Table One summarizes the findings of the bird survey portion of the field study. Each site had at least two species. Site "E" (Polaris Point Fig. 5) had the largest number of species, eight. As noted earlier this site also contained the broadest habitat diversity.

Three common shorebirds were found on sites "E" and "G". All but one bird was in non-breeding plumage and were likely over-summering birds that did not migrate to their arctic breeding grounds. This behavior is not uncommon in juveniles (Johnson et al. 1983,1989).

The small wetland in Site "G" and the coastal mangrove and intertidal habitat at Site "E" support the native Pacific Reef-heron (Egretta sacra) and Yellow Bittern (Ixobrychus sinensis).

The present status of native birds is summarized by Beck and Wiles (1987) and Aguon and Wiles (1991). Endangered forest birds were only recorded on the surveys of the two Andersen AFB properties. The endangered Mariana Crow (Corvus kubaryi) prefers native forest over second growth habitat (R. Beck DAWR pers. comm.). Two crows were seen flying over the native forest approximately 200m. (toward the cliff line) from Site "A". Given the type of forest on this site it seems unlikely that crows would nest in the area proposed for development. Two Micronesian Starlings (Aplonis opaca) were recorded on Site "B". Black Drongos (Dicrurus macrocercus) were observed chasing these birds. Micronesian Starlings are known from the housing areas at Andersen AFB (R. Beck pers. comm.).

Feral mammal observations were limited to two cats seen on Site "E" and one deer (Cervus unicolor mariannus) recorded along the perimeter road at Andersen AFB near to, but not actually on Site "A". The endangered Marianas Fruit Bat (Pteropus mariannus) was not seen on the Andersen AFB sites but does occur in native forest nearby and apparently readily moves between this area and the island of Rota (Wiles 1987a, 1987b; Wiles et al. 1989; Wiles and Glass 1990).

CONCLUSIONS AND RECOMMENDATIONS

This survey examined eight separate sites and sought to learn what birds and feral mammals occurred at these locations and at what relative densities. Savidge (1987) and McCoid (1991) have documented the problems that birds and mammals have faced on Guam from the introduced Brown Tree Snake (Boiga irregularis). It was not surprising, therefore, that relatively few birds were tallied on each site. The greater abundance of introduced species such as the Black Drongo, Philippine Turtle-DOve (Streptopelia bitorquata) and Eurasian Tree Sparrow (Passer montanus) was likely due to their ability to utilize nest sites that

are less accessible to snakes or with lower snake densities (R. Beck pers. comm.). The endangered Marianas Fruit Bat was not found on the properties covered by this survey and probably makes little or no use of any of the eight sites.

The small wetland in Site "G" and the coastal habitat at Site "E" support native waterbirds and thus should be protected from development. In order to preserve these habitats a buffer of brush and trees should separate any structures from these wetlands. In the case of the wetland at Site "G" a fence may also need to be provided to exclude dogs and discourage human intrusion.

Site "H" contains some good native forest that may be of value if and when the snake problem is brought under control and native birds are reintroduced from captive propagative stock. I would not recommend this site for housing or any other type of development. If possible this area should be preserved.

Site "A" at Andersen AFB is not a particularly valuable site for native wildlife. However, the habitat beyond (towards the cliff line) this site is less disturbed and therefore of much greater importance. I would not recommend any development north of the area proposed for the road realignment at Site "A".

The remaining sites (B, C, D, F) are either in second growth forest or are so disturbed that they are unlikely to be important to native birds. Development of the types proposed for these areas should present no serious problems to native wildlife.

Fig. 1. General locations of areas involved in the faunal su

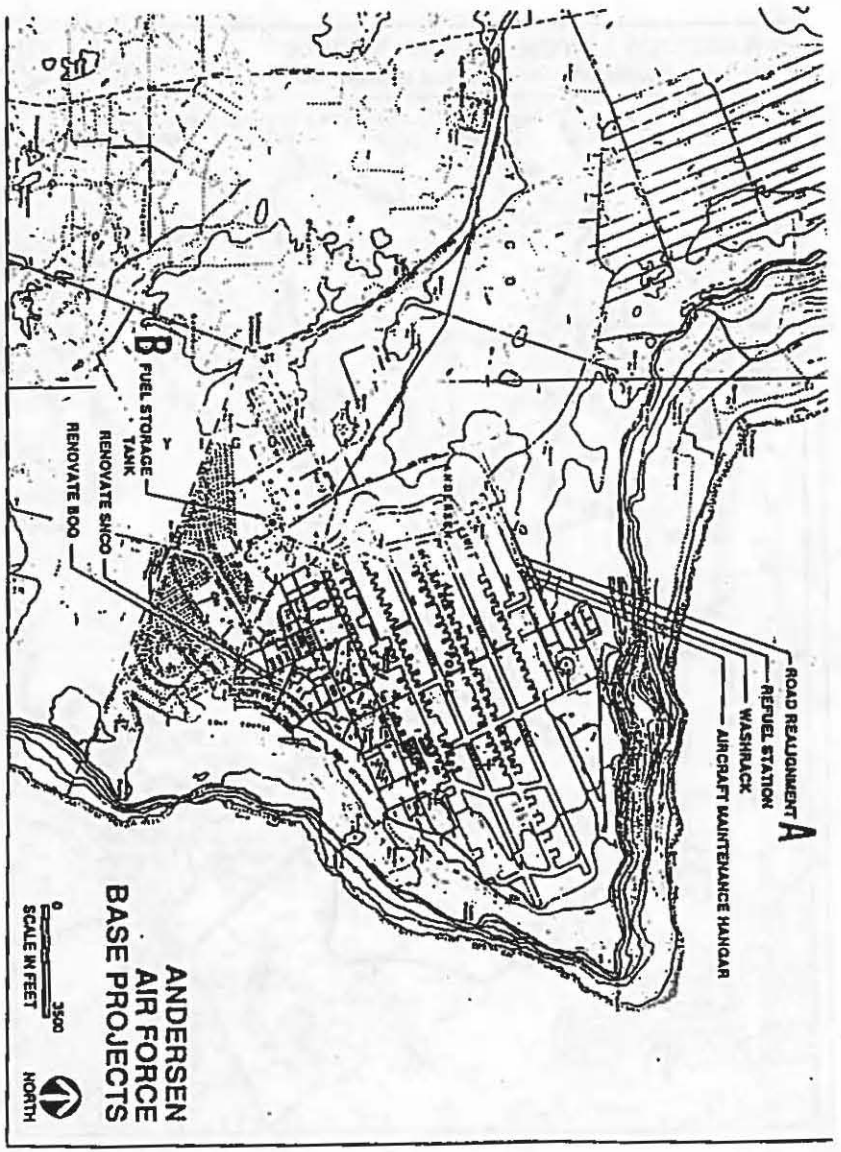

Fig. 2. Location of faunal survey sites "A" and "B".

Fig. 4. Location of faunal survey Sites "C" and "D".

NAS MCON P-203, MAINTENANCE HANGAR at Andersen Air Force Base, Guam, M. I.

3. Enlarged view of faunal survey Site "A" at Andersen AFB, Guam.

Fig. 6. Enlarged view of faunal survey Sites "G" and "H", Naval Station, Guam.

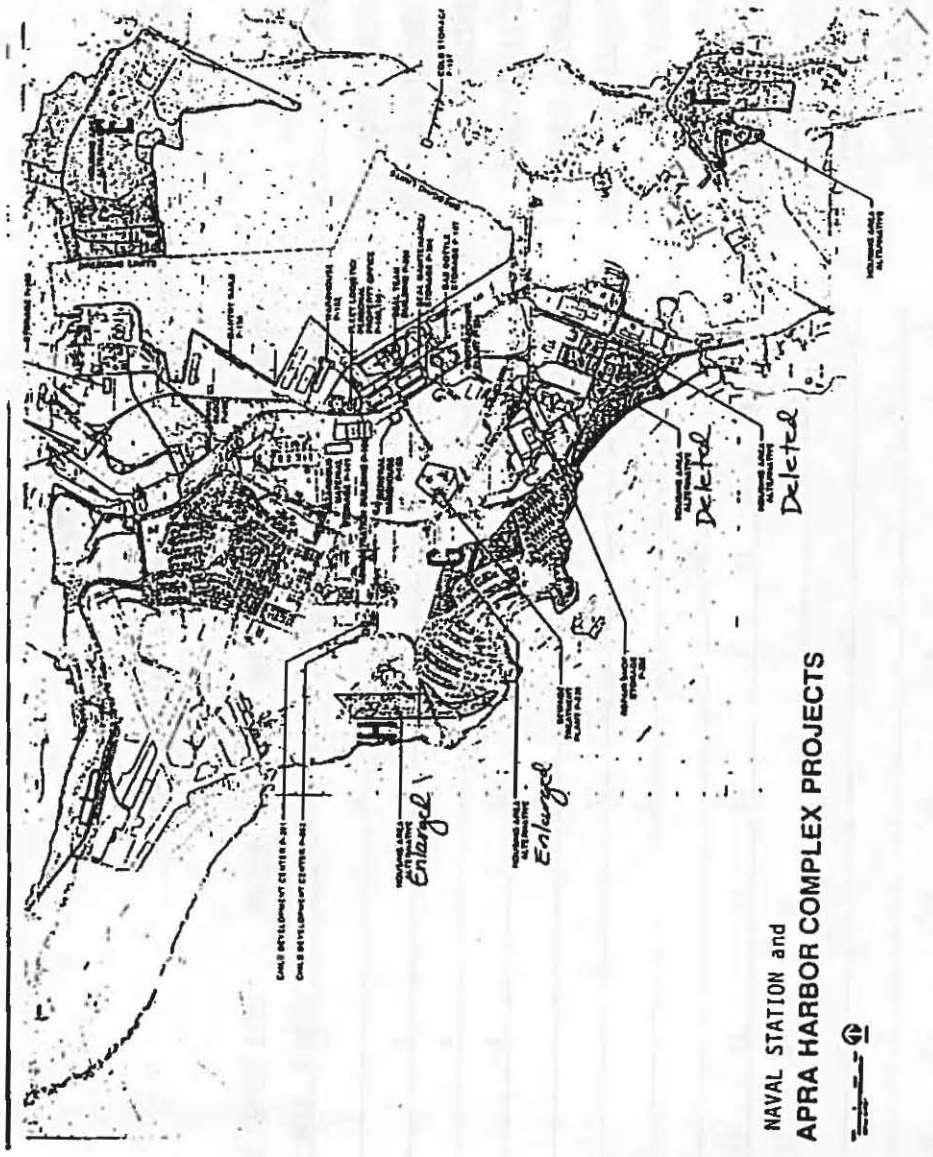

Fig. 5. Location of faunal survey Sites "E", "F", "G" and "H".

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TABLE 1

Summary of total birds recorded at eight sites on Guam, Mariana Islands.

Species	Andersen AFB		Naval Magazine	Naval Station / APRA Harbor Complex				
	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H
Egretta sacra				1				
Ixobrychus sinensis					5	3		
Francolinus francolinus			3				4	
Pluvialis fulva				10		9		
Numenius phaeopus				1				
Arenaria interpres				22				
Gygis alba					4			
Columba livia			10					
Streptopelia bitorquata	18	6	10	3	23	19	17	14
Dicrurus macrocercus	9	15				4	6	11
Corvus kubaryi	2							
Aplonis opacus		2						
Passer montanus	15	11		2	48	20	33	16

Appendix F

Marine Environment Assessments

MARINE ENVIRONMENTAL IMPACT EVALUATION: RELOCATION OF FACILITIES FROM SUBIC BAY NAVAL BASE, PHILIPPINES TO APRA HARBOR, GUAM

Prepared For:

Belt Collins & Associates
Honolulu, Hawaii

Prepared By:

Sea Engineering, Inc.
Waimanalo, Hawaii

JULY 1992

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I. INTRODUCTION

SCOPE OF WORK

Sea Engineering, Inc. was retained by Belt Collins & Associates to assist with the Environmental Impact Statement being prepared to address potential impacts associated with the relocation of military missions and personnel from the Subic Bay Naval Base, Philippines to the Naval Station, Apra Harbor, Guam. Increased activity at the Apra Harbor Naval Complex will include the construction of various facilities and the implementation of additional activities - increased shore support facilities, additional homeported ships and harbor support craft, and increased fleet operations.

Our scope of work included assessment of marine impacts associated with the following activities:

1. Expansion of the Apra Harbor Sewage Treatment Plant: The existing plant will be expanded to treat and dispose of wastewater generated within the Apra Harbor Naval Complex. The increased sewage load is projected to be 0.5 million gallons per day (MGD).

2. Maintenance Dredging of Inner Apra Harbor: Selected areas of Inner Apra Harbor, and the channel between the inner and outer harbor will be dredged to ensure safe navigation and berthing for the increased fleet operations.

3. Explosive Ordinance Disposal Facility at Sumay Cove: Permanent facilities for Explosive Ordinance Disposal Mobile Unit Five (EODMU FIVE) will be relocated to Sumay Cove. The work will include replacement or repair of 900 linear feet of steel sheetpile and concrete bulkhead.

4. Possible relocation of a gantry crane from the Subic Bay Naval Base to Sierra Wharf at the Naval Supply Depot. The project will include relocation of the crane and its electrical equipment, and also installation of new rails at the wharf. The crane will increase the cargo handling capacity at the supply depot.

5. SEAL Team/Special Warfare Facilities: Seal Team Marine Oerations, including causeway sections and several vessels ranging up to 170 feet long, will be based along Victor wharves in Inner Apra Harbor.

REPORT LAYOUT

The location and physical oceanographic characteristics the project area are detailed in Section II. This includes description of winds, tides, waves, currents and storms in the harbor area; computation of possible storm wave height and storm surge in the harbor; and presentation of the results of our field study of currents in the vicinity of Apra Inner Harbor.

Section III describes the evaluation of potential impacts of the dredging in the inner harbor using a numerical model of suspended sediment dispersion and settling. The expansion of the Apra Harbor Sewage Treatment Plant and its potential impacts are described in Section IV. The construction of the Explosive Ordinance Facility, relocation of the Gantry Crane, and location of the SEALS facility are discussed in Sections V, VI and VII. Finally, the possible impacts of an overall increase in operations in the harbor area are considered in Section VIII.

II. PHYSICAL OCEANOGRAPHIC CHARACTERISTICS OF APRA HARBOR

STUDY AREA LOCATION

Guam is the largest and southernmost island of the Marianas. The island is situated at 13 degrees north latitude and 145 degrees east longitude, approximately 3,810 statute miles west of Honolulu, 1,720 miles east of Manila, and 1,550 miles south of Tokyo (Figure II-1.). The island is 30 miles long from north to south, and between 4 and 8.5 miles wide. The area of Guam is approximately 210 square miles.

Apra Harbor is on the west central coast of Guam and is about 6 miles from the capital city of Agana (Figure II-2.). The harbor is a deepwater lagoon protected by 15,000-foot-long Glass Breakwater and Cabras Island on the north, and by Orote Peninsula on the south. The eastern part of the lagoon is bordered by hilly land and by coastal lowland. The entrance to Apra Harbor is at the west side of the lagoon.

The harbor contains Outer Apra Harbor, Inner Apra Harbor and the Comercial Port (Figure II-2.). Outer Apra Harbor is about 3 miles long by 1-1/2 miles wide and is used primarily for the mooring of Navy vessels. Inner Apra Harbor is at the southeast portion of the lagoon and it is used as the Navy's repair facility and Polaris submarine base. The Commercial Port is on Cabras Island and on the east end of outer Apra Harbor.

CLIMATE

The climate of Guam is uniformly warm and humid throughout the year. Afternoon temperatures are typically in the middle or high eighties and night temperatures typically fall to the low seventies or high sixties. The mean annual temperature at Apra Harbor is 80 degrees with a mean range of 70 to 85 degrees. Relative humidity commonly ranges between 65 and 75 percent in the afternoon, and from 84 to over 90 percent at night. The mean annual rainfall on Guam ranges from less than 90 inches in the vicinity of Apra Harbor to over 110 inches in the higher mountain areas.
(U.S. Army Engineer District, 1977)

WINDS

The dominant winds on Guam are the easterly trade winds. Table II-1 shows the annual occurrence of winds at Agana Naval Station, Guam. Winds from east-northeast through southeast occur about 70 percent of the time. Wind speeds greater than 21 knots occur only 0.4 percent of the time. The trades are strongest and most consistent during months from January to April with common wind speeds of 10 to 20 knots. Winds are variable with frequent calms during the main typhoon season from July to October. Typhoons bring heavy rainfalls and strong winds.

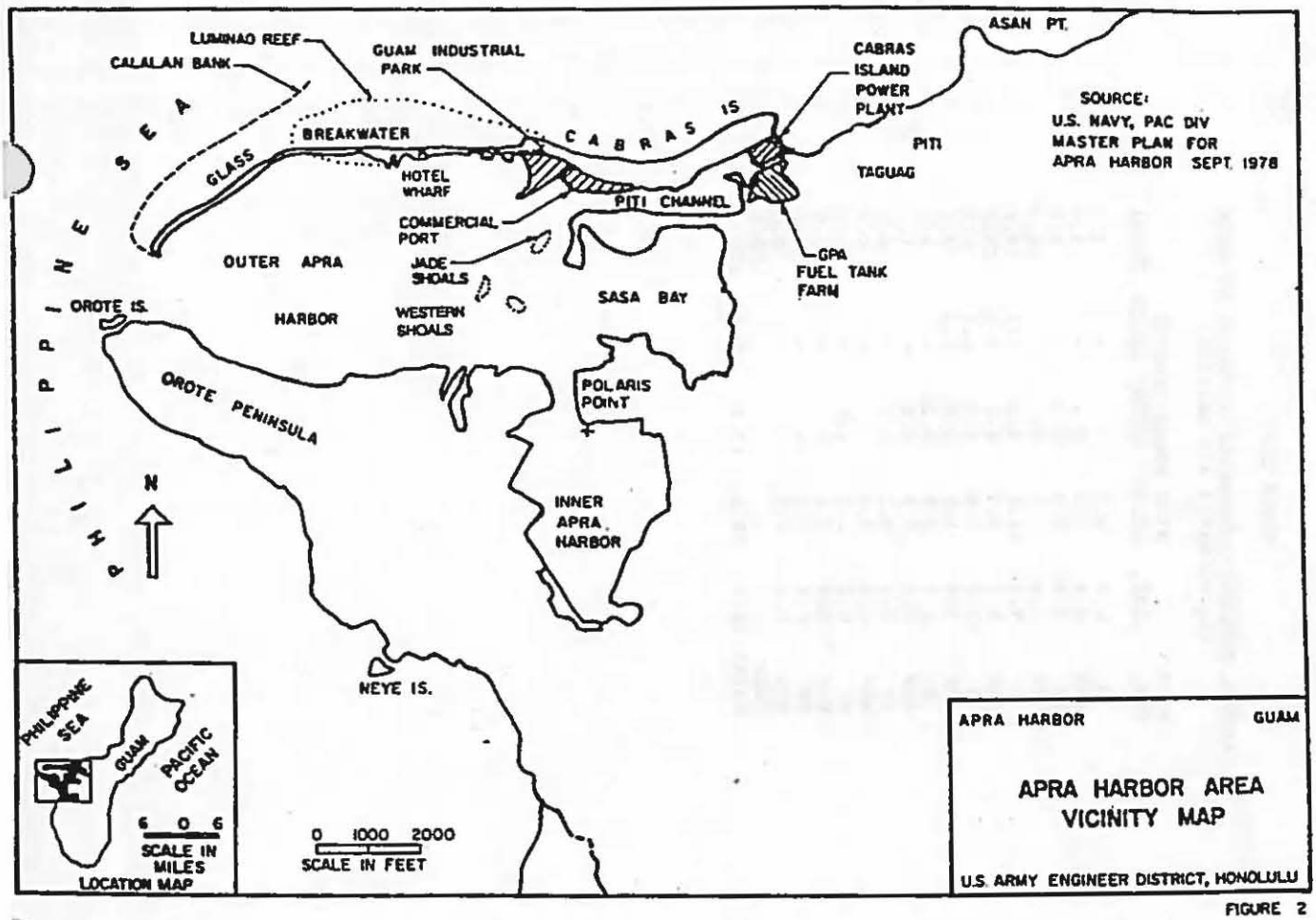

FIGURE 2

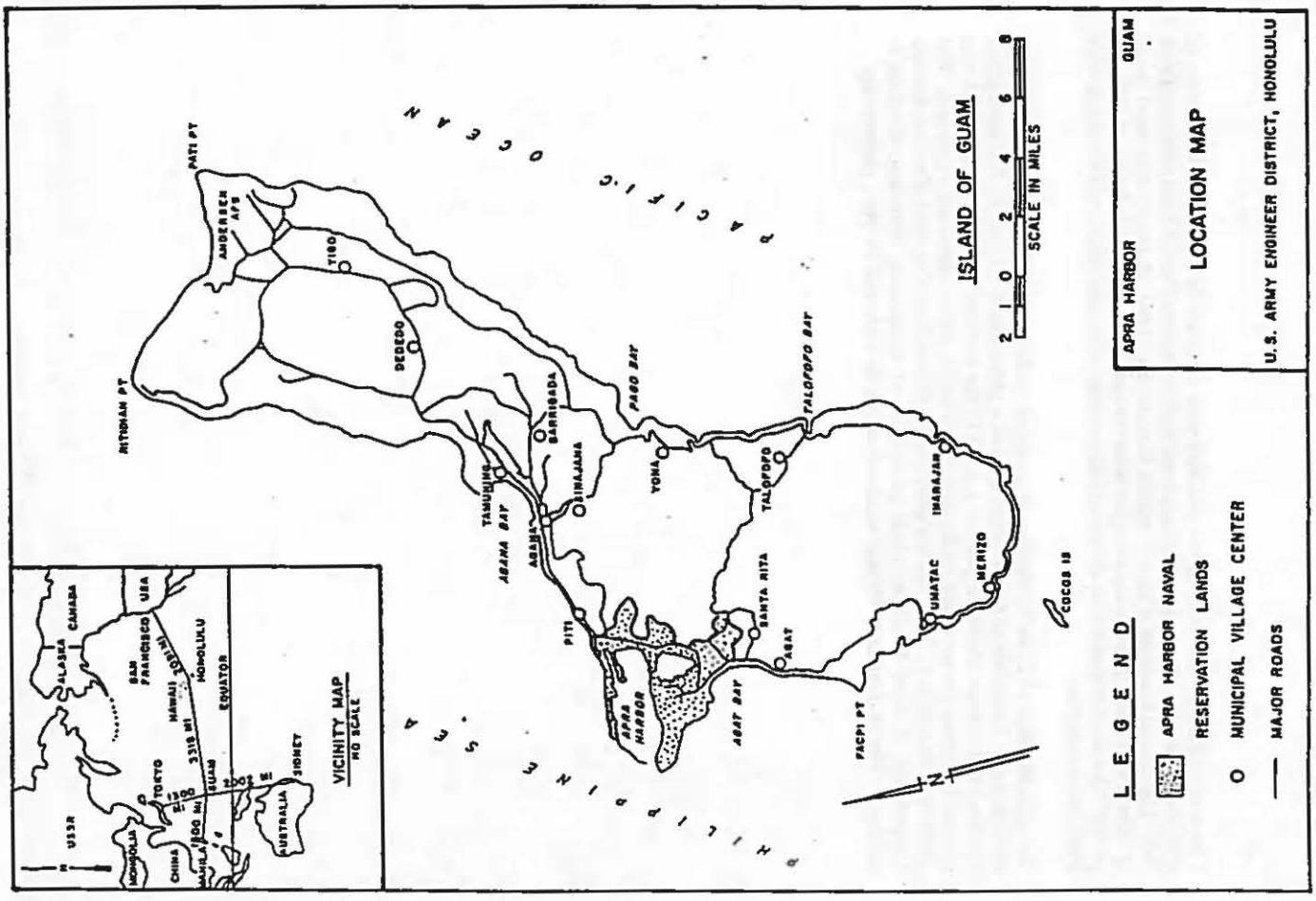

FIGURE II-1.

The annual fastest mile wind speed and direction reported by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), are shown in Table II-2. The data is based on a 33-year record from 1958 to 1990. A fastest mile wind speed of 80 miles per hour (mph) is the strongest wind speed recorded at Guam during the 33-year period. The wind directions for the annual fastest mile winds are more from northeast than from other directions.

The data in Table II-2 can be statistically analyzed to determine the frequency of extreme wind speed as a function of return occurrence of a given event. Gumbel's first asymptotic distribution has been shown to provide a good fit for extreme wind predictions, and was used to determine the predicted wind speed versus return period shown on Table II-3. For simplicity, the results in Table II-3 are determined without including wind direction and are independent of wind direction; equal probability of occurrence from any direction is assumed. The 50-year and 100-year wind speeds are 84 mph and 94 mph, respectively.

TABLE II-1

ANNUAL PERCENT OCCURRENCE OF WINDS AT GUAM
(Agana Naval Air Station)

Wind Dir.	Wind Speed (knots) 3-7	8-12	13-20	21-30	Total
N	0.7	0.3	-	-	1.1
NNE	0.8	0.5	0.1	-	1.5
NE	3.6	2.3	0.6	-	6.5
ENE	7.6	7.1	2.1	-	16.7
E	9.6	12.1	4.5	0.1	26.4
ESE	5.7	9.3	4.2	0.1	19.2
SE	3.2	3.6	1.2	0.1	8.0
SSE	1.4	1.3	0.4	0.1	3.2
S	1.5	0.8	0.2	-	2.6
SSW	0.5	0.3	0.1	-	1.0
SW	0.4	0.2	0.1	-	0.7
WSW	0.2	0.2	-	-	0.4
W	0.3	0.2	0.1	-	0.5
WNW	0.3	0.2	-	-	0.5
NW	0.4	0.2	-	-	0.6
NNW	0.4	0.2	-	-	0.6
CALM					10.5
Total	36.7	38.5	13.8	0.4	100

TABLE II-2

THE ANNUAL MAXIMUM FASTEST MILE WIND SPEED AND DIRECTION AT GUAM
(NOAA Data 1958-1990)

Year	Fastest Mile Wind Speed (mph)	Fastest Mile Wind Direction (°TN)	Year	Fastest Mile Wind Speed (mph)	Fastest Mile Wind Direction (°TN)
1958	26	NE	1974	32	W
1959	30	E	1975	34	SE
1960	30	NE	1976	76	NE
1961	34	NE	1977	33	NE
1962	80	NE	1978	38	SE
1963	64	SW	1979	43	SE
1964	33	E	1980	37	NE
1965	29	E	1981	31	SE
1966	28	E	1982	40	E
1967	40	SW	1983	28	SE
1968	44	W	1984	60	E
1969	29	E	1985	35	E
1970	30	SE	1986	34	SW
1971	47	E	1987	33	W
1972	29	NE	1988	64	W
1973	29	E	1989	47	NE
			1990	67	NE

TABLE II-3

THE PREDICTED WIND SPEED AT GUAM
AS A FUNCTION OF RETURN PERIOD
(Based on NOAA Data)

Return Period (years)	Fastest-Mile Wind Speed (mph)
10	62
25	74
50	84
100	93

TIDES

The tides in Guam are semi-diurnal with pronounced diurnal inequalities. Tide data from the US Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey (1992), shows that the mean tide range is 1.7 feet and diurnal range is 2.4 feet. The extreme tides observed in Apra Harbor are high tide of 3.31 feet and low tide of -1.89 feet (U.S. Army Engineer District, 1977). Tidal data for Apra Harbor are as follows:

	Feet
Highest tide observed	3.31
Mean higher high water	2.4
Mean high water	2.2
Mean tide level	1.4
Mean low water	0.5
Mean lower low water	0.0
Lowest tide observed	-1.89

All elevations in this report are referenced to the mean lower low water (MLLW) datum.

WAVES

The entrance to Apra Harbor is exposed to deepwater waves generated west of Guam. It is well protected from the easterly tradewind waves which dominate the wave regime in the Guam area. Storm waves generated from the northwest to southwest are the most critical deepwater waves affecting the Apra Harbor entrance. On a yearly average, less than 2 percent of the waves affecting Apra Harbor are greater than 8 feet and less than 5 percent are greater than 5 feet. These data are based on the National Weather Record Center's compilation of 13,000 observations of waves reported by ships operating in the vicinity of Guam (U.S. Army Engineer District, 1977).

The Commercial Port area is situated on the east end of the outer Apra Harbor and is well sheltered from deepwater waves. A design wave study conducted for the US Navy, Bureau of Yards and Docks predicted that waves in the area of the Commercial Port will be less than 3 feet, 93 percent of the time. However, the Commercial Port area is subject to typhoon waves which may exceed 5 feet. Damaging typhoon waves can affect Apra Harbor even when a typhoon center is hundreds of miles from Guam. The Commercial Port would not be able to operate during typhoon conditions (U.S. Army Engineer District, 1983).

Inner Apra Harbor is located on the southeast end of Apra Harbor. The entrance channel connecting Inner Apra Harbor and Outer Apra Harbor is approximately 900 feet wide and it opens in the north direction. The entrance channel orientation prevent most of the deepwater wave energy from coming into Inner Apra Harbor. Design waves in Inner Apra Harbor will be generated inside the harbor and they are function of a fetch distance and wind velocity.

Characteristics and Frequency

Guam is subject to strong winds and rain associated with tropical storms and typhoons. Due to its proximity to typhoon breeding grounds, the island is threatened year around with the passage of developing typhoons. Typhoons are defined as storms with sustained wind speeds equal to or greater than 64 knots, while tropical storms are defined as having sustained wind speeds between 34 and 63 knots. Based on information from the US Fleet Weather Central, Guam, typically at least 19 typhoons occur annually across the western North Pacific and South China Sea. Several of these storms threaten the Mariana Islands each year.

For a 44-year period, 1946-1989, 126 tropical cyclones were tracked within 180 n.m. of Guam with at least tropical storm strength. Of these storms, 49 were of typhoon intensity, yielding an average of 1.1 typhoons per year (Noda & Associates, 1990). Recently, Typhoon Russ in 1990 and Typhoon Yuri in 1991 approached within 30 n.m of Guam and affected Guam severely. This data indicates a great likelihood of a typhoon threatening Guam each year.

Table II-4 shows the characteristics of the most severe storm which affected Guam in each year between 1946 and 1990 (Holliday, 1975; Joint Typhoon Warning Center, Guam). If no tropical storms or typhoons approached within 180 n.m. from Guam for a given year, no storm characteristics are listed. Among these storms, typhoons Karen (1962), Pamela (1976), and Russ (1990) caused significant damage on Guam. Tropical cyclones generally move from east to west and pass north or south of Guam. Storms occasionally pass directly over the island. Six storms between 1946 and 1990 virtually passed over the island.

Northerly winds generate high waves in the inner harbor during storms. This occurs when storms pass north of the island or directly over the island.

TABLE II-4

ANNUAL WORST STORMS AFFECTING GUAM
(1946 - 1990)

Year	Minimum Distance at CPA (nm)	Maximum Sustained Wind (knots)	Forward Speed at CPA (knots)	Minimum Pressure (mbs)
1946	26	90	13	955
1948	40	60	15	980
1949	60	135	12	909
1950	135	120	11	922
1951	120	65	20	978
1952	120	100	22	945
1953	15	65	12	976
1954	180	70	10	975
1957	40	140	12	900
1958	170	105	11	940
1959	125	90	20	953
1960	175	40	11	996
1961	95	130	15	910
1962	10	135	17	908
1963	75	75	12	948
1964	10	65	20	976
1965	30	35	-	995
1966	145	45	-	998
1967	55	100	10	945
1968	95	115	9	935
1969	0	35	20	1000
1970	90	50	12	987
1971	90	120	9	920
1972	150	50	13	985
1974	105	45	8	989
1976	0	120	8	930
1977	0	60	15	980
1978	80	150	17	886
1979	30	60	12	980
1980	30	70	21	972
1981	30	40	9	994
1982	0	60	10	980
1983	160	50	13	987
1984	20	85	18	959
1985	120	45	12	990
1986	110	130	12	910
1988	40	110	12	931
1989	80	140	12	898
1990	30	125	12	916

Note: CPA = Closest Point of Approach

Storm Surface Pressure Reduction

Surface pressure reductions in Guam during storms are estimated using the storm data given in Table II-4. A pressure reduction at a distance is calculated using a following equation:

$$\frac{P - P_o}{P_n - P_o} = e^{-\frac{R}{r}}$$

where,
- P = pressure at a distance of r
- P_o = the central pressure of the scenario typhoon
- P_n = the normal pressure
- R = radius of maximum wind
- r = a distance from the center of typhoon

The radius of maximum wind is estimated using a following equation (ref. 11):

$$R = R^* + AV_F - k_1B + k_2C$$

where,
- R^* = 18 n.m
- V_F = typhoon forward speed
- k_1 = 22
- k_2 = 6
- A = 0.7
- B = $\tanh[3.17(\sin 35^\circ - \sin\phi)]$
- ϕ = storm latitude
- C = $\Delta P_o \exp[-\pi/4\ (\Delta Po)^2]$
- ΔP_o = central pressure reduction in inches of mercury

The prediction equation was determined by considering a total of 210 U.S. East and Gulf Coast hurricanes and Western North Pacific cyclones. The data included latitudes in range of 4.4° to 35°; radius of maximum winds of 6 to 54 nautical miles (n.m.); forward speeds of 6 to 34 knots; and central pressures between 0.95 and 3.61 inches of mercury.

Table II-5 lists estimated surface pressure reductions at Guam. Statistical pressure reductions for given return periods were determined using a Gumbel's asymptotic distribution:

Return Period (years)	Pressure reduction (inches mercury)
10	1.4
25	1.8
50	2.2
100	2.5

TABLE II-5

ESTIMATES OF RADIUS OF MAXIMUM WIND SPEED, AND MINIMUM SURFACE PRESSURE AND PRESSURE REDUCTION AT GUAM DURING ANNUAL WORST STORM EVENTS (1946 - 1990)

Year	Radius of Max. Wind (nm)	Minimum Surface Pressure (mbs)	Pressure Reduction (inches Hg)
1946	11	993	0.59
1948	14	1003	0.30
1949	9	999	0.41
1950	8	1008	0.15
1951	17	1008	0.15
1952	16	1005	0.24
1953	12	993	0.59
1954	10	1011	0.06
1957	9	990	0.68
1958	9	1009	0.12
1959	15	1006	0.20
1960	11	1012	0.03
1961	10	1003	0.30
1962	12	939	2.19
1963	10	1005	0.24
1964	17	982	0.92
1965	9	1003	0.30
1966	6	1008	0.15
1967	16	1003	0.30
1968	6	1008	0.15
1969	16	1000	0.38
1970	12	1010	0.09
1971	6	1007	0.18
1972	12	1010	0.09
1974	9	1011	0.06
1976	6	930	2.45
1977	14	980	0.97
1978	12	995	0.53
1979	12	1002	0.32
1980	17	995	0.53
1981	10	1007	0.18
1982	10	980	0.97
1983	12	1011	0.06
1984	14	985	0.83
1985	11	1010	0.09
1986	10	1004	0.27
1988	9	996	0.50
1989	9	1000	0.38
1990	9	989	0.71

North winds will generate larger waves in Inner Apra Harbor than those generated by winds from other directions because of a longer fetch distance in the north direction. The longest fetch distance is 2.8 miles along a north-south azimuth, extending the fetch outside Inner Apra Harbor through the entrance channel. Fetch distances for other directions are about 1 mile. The fetch limited wave conditions in Apra Inner Harbor are determined using following equations:

$$\frac{gH_s}{U_A^2} = 0.283 \tanh\left[0.530\left(\frac{gd}{U_A^2}\right)^{3/4}\right] \tanh\left[\frac{0.00565\left(\frac{gF}{U_A^2}\right)^{1/2}}{\tanh\left[0.530\left(\frac{gd}{U_A^2}\right)^{3/4}\right]}\right]$$

$$\frac{gT}{U_A} = 7.54 \tanh\left[0.833\left(\frac{gd}{U_A^2}\right)^{3/8}\right] \tanh\left[\frac{0.0379\left(\frac{gF}{U_A^2}\right)^{1/3}}{\tanh\left[0.833\left(\frac{gd}{U_A^2}\right)^{3/8}\right]}\right]$$

where,

H_s	=	significant wave height (feet)
T	=	wave period (sec.)
U_A	=	wind stress factor (ft/sec)
d	=	water depth (feet)
g	=	acceleration of gravity (ft/sec_2)

The calculated results are shown in Table II-6. The 50-year wind, for example, has been determined to be 84 mph in a previous section. When blowing from the north, the 50-year wind is expected to generate waves of 4.8 feet in height with a period of 3.5 seconds. For the wind from other directions, the 50-year wind will generate a wave height of 3.2 feet and a wave period of 2.7 seconds. When approaching perpendicularly to the docks, waves reflect at the wall, superimpose on the incident waves and become standing waves. Wave heights of the standing waves can be up to double of the original wave height. Wave heights in the table, however, do not include the reflected wave effects.

TABLE II-6

PREDICTED FETCH-LIMITED STORM WAVES IN APRA INNER HARBOR

(A) Wind Direction = North
Fetch Length = 2.8 miles
Water Depth = 40 feet

Fastest Mile Wind (mph)	Wind-Stress Factor (mph)	Wave Height (feet)	Wave Period (sec)	Minimum Duration (hours)
60	69	3.3	3.1	0.4
70	82	3.9	3.3	0.4
80	96	4.5	3.4	0.4
90	109	5.1	3.6	0.3
100	123	5.7	3.7	0.3

(B) Wind Direction = other directions
Fetch Length = 1.0 mile
Water Depth = 35 feet

Fastest Mile Wind (mph)	Wind-Stress Factor (mph)	Wave Height (feet)	Wave Period (sec)	Minimum Duration (hours)
60	69	2.2	2.3	0.2
70	82	2.6	2.5	0.2
80	96	3.0	2.6	0.2
90	109	3.4	2.7	0.2
100	123	3.8	2.8	0.2

Stillwater Level Rise In Apra Inner Harbor

The astronomical tide and storm surge are factors determining the rise in stillwater level along the dock in Inner Apra Harbor during extreme wind and wave events.

Astronomical Tide: A tide level of +2.2 feet above MLLW, equal to mean high water is considered an appropriate design tide due to its frequency of occurrence.

Storm Surge: The storm surge is a combination of the pressure setup and the wind setup. The water level rise due to reduction of atmospheric pressure associated with a storm is determined by:

$$S_p = 1.14\ \Delta P$$

where S_p is pressure setup, and ΔP is pressure reduction from the normal atmospheric pressure in inches of mercury. For a 50-year pressure reduction of 2.2 inches mercury, the pressure setup is 2.5 feet. For a 100-year pressure reduction of 2.5 inches mercury, the pressure setup is 2.9 feet.

The rise in water level along a dock due to wind blowing over the water surface can be estimated by:

$$\Delta S_u = 540\ K\ U^2\ \Delta x/d$$

where,

ΔS_u	=	wind setup increments in feet
K	=	3.0×10^{-6}
U	=	wind speed in knots
Δx	=	increment of horizontal distance in n.m.
d	=	average depth in feet over Δx

Estimated fastest mile wind speeds for the return periods of 50 years and 100 years are 84 mph and 93 mph, respectively. The corresponding wind stress factors are 101 mph and 113 mph, or 88 knots and 98 knots. Respective wind setups range from 0.7 to 0.9 feet when the winds blow from the north.

The combined storm surge is defined as the sum of the pressure and wind setup. For the 50-year storm the combined storm surge is 3.2 feet and for the 100-year storm event 3.8 feet. The total stillwater level rise is then computed by adding the astronomical tide level to the storm surge. In Inner Apra Harbor the total stillwater level rise is estimated to be 5.4 feet above MLLW for the 50-year storm and 6.0 feet for the 100-year storm.

CURRENTS

In Vicinity of Guam

The Island of Guam is in the zone of the North Equatorial Current, which flows to the west. The tradewinds and the tidal currents also contribute to the current patterns. The prevailing northeast trade winds result in a surface flow to the southwest. The tidal currents off Guam are reversing, with the flood tide off Apra Harbor reportedly flowing north to northeast and the ebb current setting southwest (Note C, NOAA Chart 81054, "Apra Harbor").

Outside the Entrance of Apra Harbor

Current meter was been collected on Calalan Bank outside the harbor entrance channel by Sea Engineering, Inc. (1981) for a seven-day period in November 1980. The data indicated a persistent water movement to the southwest, particularly during ebb tide. There was some reversal of flow toward the north and northeast during flood tide, but the predominant flow was still to the southwest. The current speed was consistent throughout the tidal cycle, with an average speed of 1.0 ft/sec (31.0 cm/sec) for ebb tide and 0.9 ft/sec (28.3 cm/sec) for flood tide. The current speeds ranged from zero to a maximum of 2.3 ft/sec (70 cm/sec). Water depth at the meter location was 55 feet and the meter depth was 30 feet. During the field study period, winds were 10 to 20 mph from the northeast and east-northeast.

CE Maguire, Inc. and R.M. Towill Corp. (1977) completed drogue studies outside the harbor in October 1976. The drogue tracks outside the Apra Harbor entrance showed that the open ocean currents were very strong with speeds over 1.7 ft/sec. The flood currents flowed to the northeast, while ebb currents reversed and flowed to the southwest. Winds during the measurement were moderate easterly trade winds with speeds of 10 to 15 mph.

At Apra Harbor Entrance

CE Maguire, Inc. and R.M. Towill Corp. deployed a current meter array in 120 feet of water off Orote Peninsula at the main entrance of Apra Harbor in October 1976. The meters recorded current data continuously for three days at depths of 60 and 90 feet. The range of speeds recorded by the current meters varied from 0 to 1.15 ft/sec. The median value for the 60-foot meter was 0.24 ft/sec while that for the 90-foot meter was 0.38 ft/sec.

The direction of flow was predominantly to the north and northeast. The current data showed little correlation with the tidal phases. However, just at high tide the speed readings increased and the direction of flow became highly variable, indicating the possibility of an eddy formation in the harbor entrance area.

In Outer Apra Harbor

CE Maguire, Inc. and R.M. Towill Corp. also conducted drogue studies in Outer Apra Harbor in October 1976. Surface and subsurface (15 and 30 feet) drogues were released at various points in the harbor. These were tracked over one ebb and one flood tide cycle.

The drogue tracks in Outer Apra Harbor showed very little evidence of tidal influence. The majority of the drogues moved in the direction of the wind, at speeds ranging from 0 to 0.71 ft/sec. The current speeds in the harbor and the harbor entrance were moderate, with the wind-driven surface layers reported to extend down approximately 30 feet.

Drogue current measurements conducted by Sea Engineering, Inc. in November 1980 showed that the wind influence during typical tradewind conditions extended to a depth of at least 35 feet. The drogues were set at 0-10 foot, 25-35 foot and 50-60 foot water depths. During an ebb tide, both the surface and mid-depth drogue moved toward the harbor entrance. Speeds of the surface drogues were approximately 0.33 to 0.78 ft/sec (10 to 24 cm/sec). The mid-depth drogues moved at slower speeds, averaging 0.13 to 0.39 ft/sec (4 to 12 cm/sec), about one-half the speed of the surface drogues. During the last stages of a strong flood tide, drogues again moved west toward the harbor entrance at very slow speeds of 0.07 to 0.13 ft/sec (2 to 4 cm/sec). The deep drogues generally moved into the harbor despite the tidal phase at average speeds of about 0.2 ft/sec (6 to 7 cm/sec).

During a strong flood tide, the surface drogues moved toward the harbor entrance at average speed of 0.30 to 0.36 ft/sec (9 to 11 cm/sec). The mid-depth drogues also moved down wind, but at average speeds of only 0.13 to 0.23 ft/sec (4 to 7 cm/sec). The deep drogues moved northeast into Apra Harbor at an average speed of 0.16 ft/sec (5 cm/sec) despite the tide phase. The speed of the deeper current did not vary from ebb to flood tide. Apparently, as the trade winds move the surface layers out of the harbor, the water loss is balanced by the inward moving deeper layers.

No evidence of eddy formation was found in Outer Apra Harbor during the November 1980 field study. Localized eddies may form at Orote Point and the tip of Glass Breakwater due to a strong tidal shear across the harbor mouth during extreme flood or ebb tides. Such eddies, however, should remain localized. The general circulation in the outer harbor appears independent of these effects.

In the Commercial Port Area

Current studies in the Commercial Port area were conducted by University of Guam Marine Laboratory (1977) using drogues at three depths (3-foot, 20-foot and 40-foot) in December 1976 and January 1977. Drogues at the 3-foot and 20-foot were strongly influenced by the prevailing wind, which was from the east at 10-15 knots. Directions of the 3-foot drogues were approximately the same as wind direction; the wind carried these drogues toward Western Shoals. There was no evidence of a tidal effect on the directions of movement of the 3-foot drogues. The observations indicated a continuously strong outward (westward) flow of surface waters.

The 20-foot drogues moved generally in the direction of the wind, but patterns were more variable and complex than for the 3-foot drogues. As the drogues passed from the confines of the narrow docking area into the wider stretch of water just east of Gorco Pier, they tended to veer either north or south. The movement was more uniform outside (west) of the pier. The changes in the direction of drogue movement during rising tides suggest a reversal of subsurface flows or possibly a complex system at the 20-foot depth.

The 40-foot drogues moved outward directly toward Western Shoals and showed no changes in direction of movement with tidal changes. Speeds of the drogues ranged from 0.10 to 1.1 ft/sec (0.03 to 0.33 m/sec) for the 3-foot sets, 0.10 to 0.33 ft/sec (0.03 to 0.10 m/sec) for the 20-foot sets, and 0.07 to 0.23 ft/sec (0.02 to 0.07 m/sec) for the 40-foot. The 3-foot drogues showed no definite pattern of change with tidal changes, but the 20-foot and 40-foot drogues moved significantly slower on rising tides than on falling tides.

Water temperature patterns in Piti Channel, the adjacent tidal flats, and the Commercial Port area were observed by University of Guam Marine Laboratory in 1974 (Marsh, J. and Holloman, J., 1974). The Piti Power Plant and the Cabras Power Plant pump their heated condenser effluent water into a common receiving area in the outfall lagoon, which is located on the east side of Piti Channel. Isotherm plots showed that the temperature patterns in the Commercial Port area changed at tidal phases. The results of the water temperature measurements indicate that the general currents move into (eastward) the Commercial Port area during a flood tide, and move out (westward) of the Commercial Port area during an ebb tide.

CURRENTS IN APRA INNER HARBOR

Methodology and Approach

For this current study, current drogues were used to obtain data on current speeds and directions, and general circulation patterns in Apra Inner Harbor and in the channel entrance to the inner harbor. Current meters were not a feasible option because of ship traffic.

Current drogues are designed to lock into the water mass at the depth of the drogue, and to move with the same speed and direction as the current. The system is tracked using a surface float attached to the underlying drogue. The ideal drogue system is one in which the ratio of the drogue surface area to the float surface area is infinitely large, thus minimizing deflection of the system by wind and surface currents. For this study, we used window shade type drogues. The surface drogues had a surface area of roughly 30 square feet, while the subsurface drogues had a surface area of 40 square feet. A diagram of the drogue system is presented in Figure II-3.

During the study, a surface drogue and a subsurface drogue were typically released together. After release, the drogue positions were measured at regular intervals. The latitude and longitude at each position fix was determined with a handheld GPS receiver. Position errors were corrected by recording at regular intervals (every 30 to 60 minutes) the GPS reading of a location where the latitude and longitude were known. The calculated correction factor was then applied to the position fixes of the drogues.

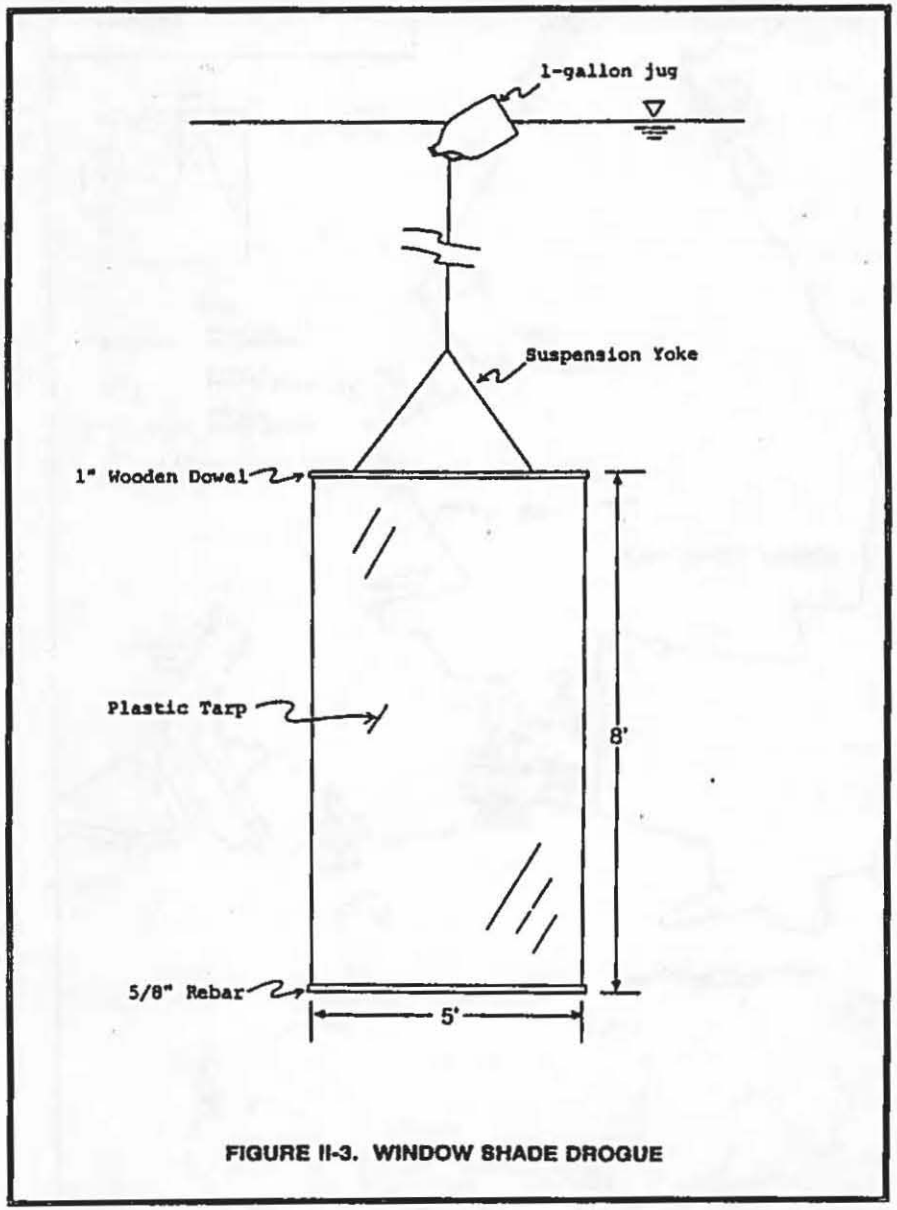

FIGURE II-3. WINDOW SHADE DROGUE

Drogue Tracking Results

Drogues were released and tracked on four consecutive days from May 19 to May 22, 1992. The results of the drogue measurements are presented in Figures II-4 to II-11, Table II-7, and in Appendix A. The figures show surface and subsurface drogue tracks, the time of the first and last position fixes, and the average speed of the drogue during that interval. Table II-7 summarizes the average speeds of the surface and subsurface drogues in the channel, inner harbor and overall for each day in the field. The table also presents the combined average speeds for the four days of measurements. The appendix contains tables of data from each day in the field showing the time of each position fix, total time since release, distance from previous position, total distance from release point, speed between position fixes, and average speed since release. Surface drogues extended from the surface to the 10 foot depth. Subsurface drogues released in the inner harbor extended from 15 to 25 feet below the surface, while those released in the channel to the outer harbor extended from 20 to 30 feet below the surface. The average speeds are presented in feet per second. For reference, 1 knot is 1.69 ft/s and 30 cm/s is 1 ft/s.

	Surface Speeds (ft/s)			Subsurface Speeds (ft/s)		
Date	Channel	Inner	Total	Channel	Inner	Total
5/19	.09	.21	.12	.10	.10	.10
5/20	.17	.19	.17	.08	.12	.09
5/21	.40	.19	.36	.20	.08	.14
5/22	.26	.19	.23	.06	.07	.07
Average	.22	.19	.21	.11	.10	.10

Table II-7 - Average Surface and Subsurface Drogue Speeds

The drogue study was conducted to address two question: first, what are the general circulation patterns and approximate current speeds in the inner harbor; and second, what are possible transport paths of the dredging turbidity plume from the inner harbor to the outer harbor. The drogues, therefore, were released within the area to be dredged (Figure II-12). Because environmentally sensitive corals and recreational areas exist in the outer harbor, most of the drogues were released in the entrance channel to the inner harbor during ebb tide with aim of describing currents out of the inner harbor towards environmentally sensitive areas in the outer harbor. Surface and subsurface drogues were usually released simultaneously from the same location.

The drogue movements observed on each day are described below:

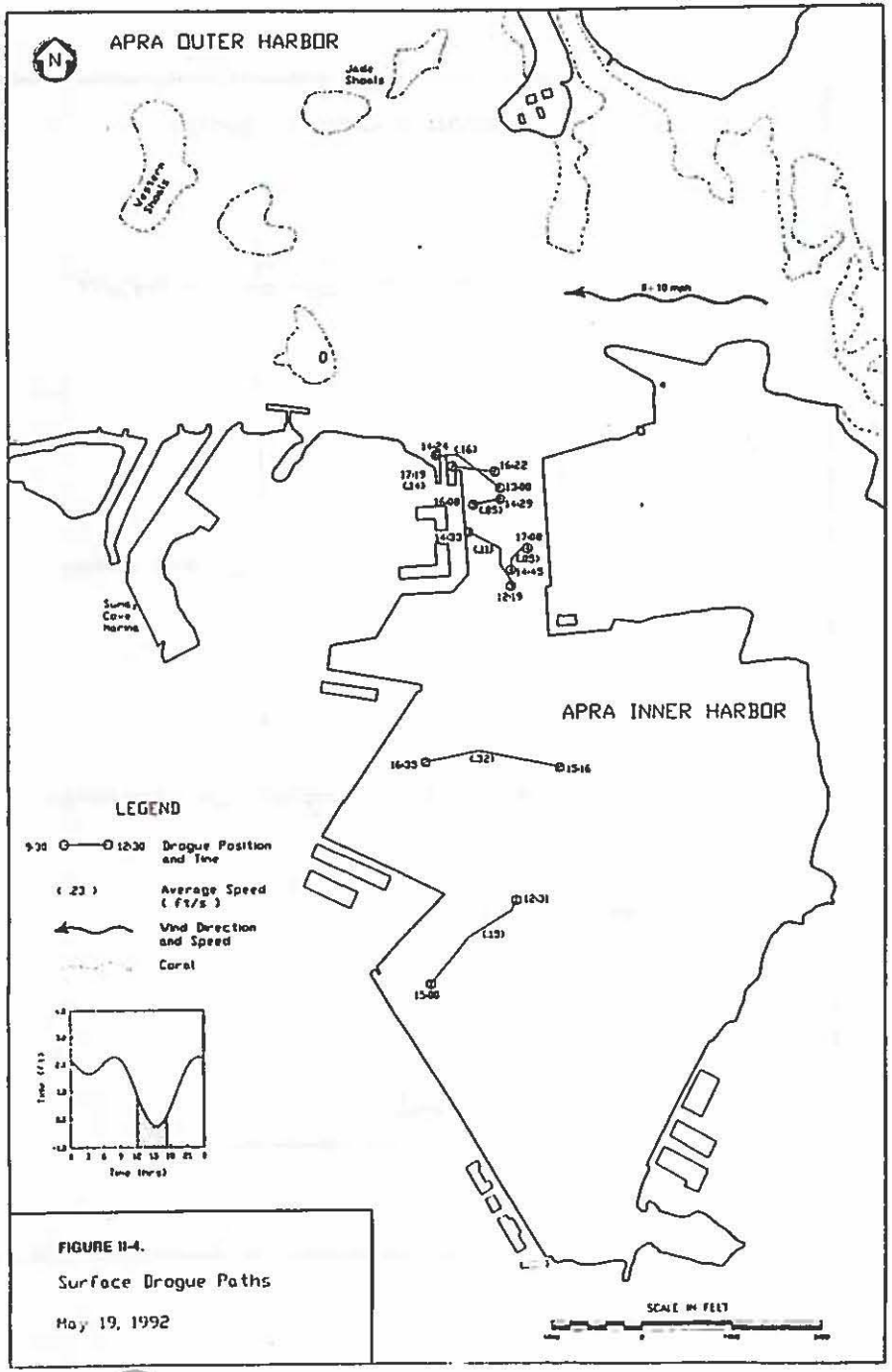

FIGURE II-4.
Surface Drogue Paths
May 19, 1992

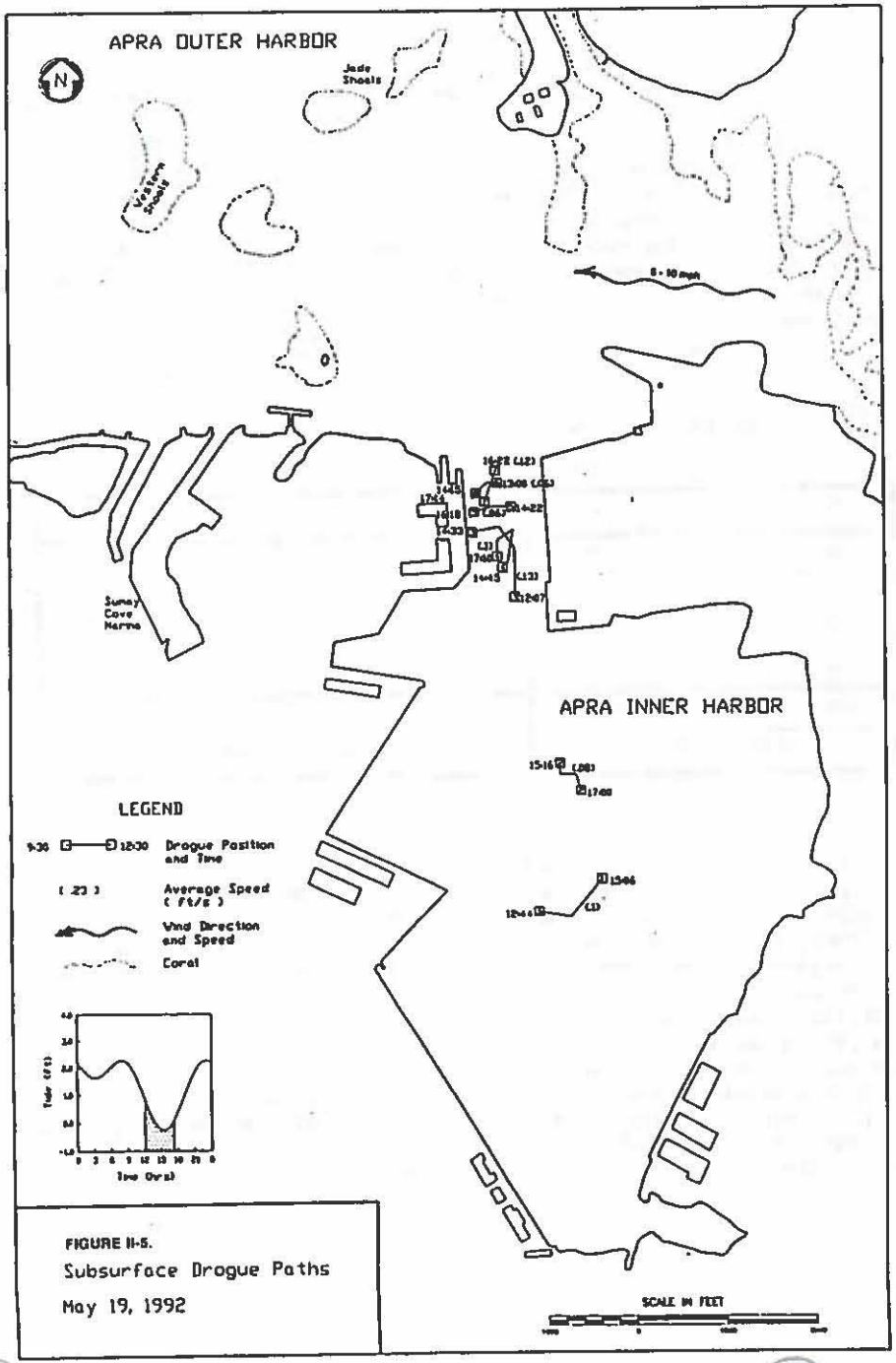

FIGURE II-5.
Subsurface Drogue Paths
May 19, 1992

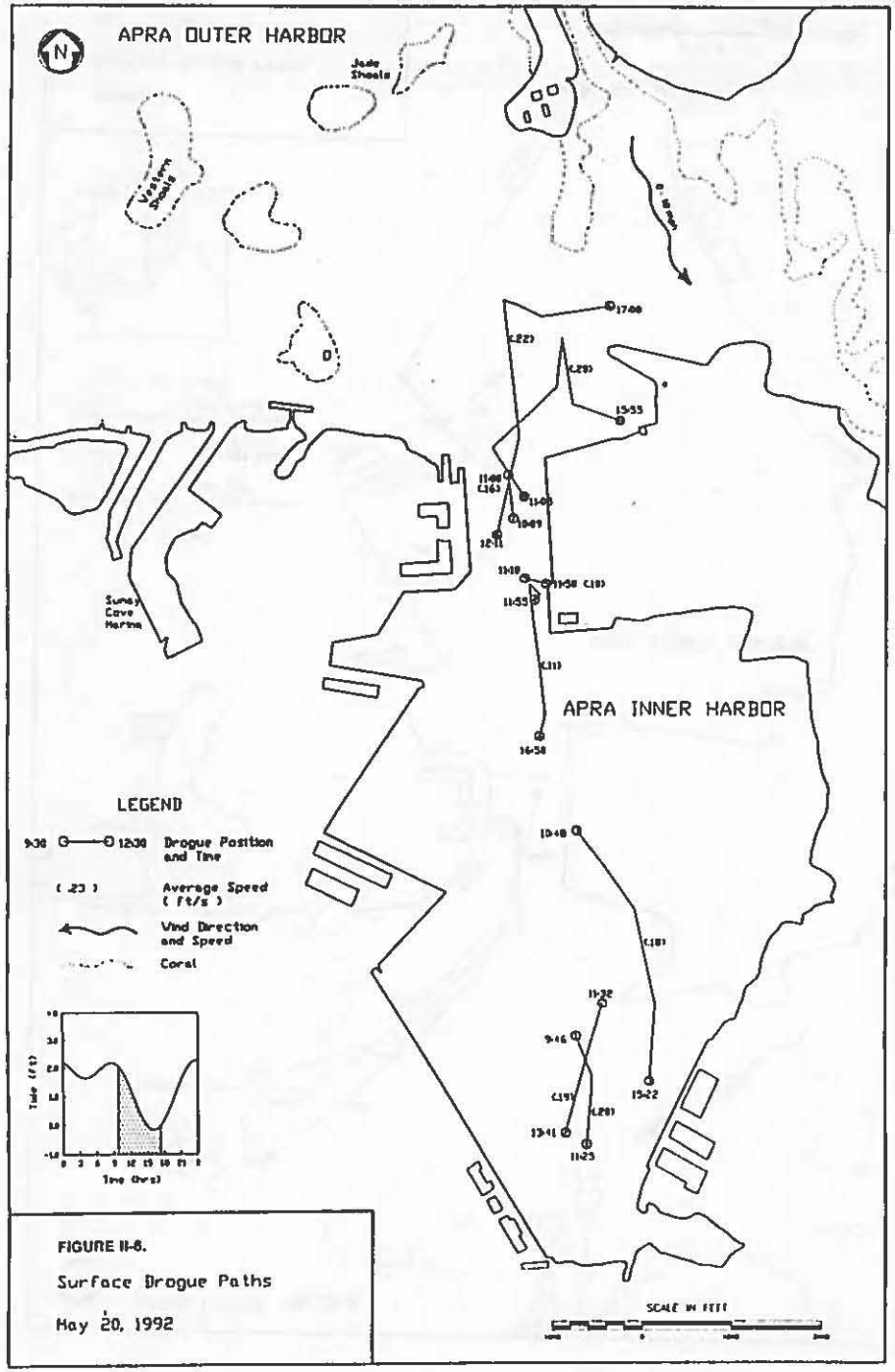

FIGURE II-6.
Surface Drogue Paths
May 20, 1992

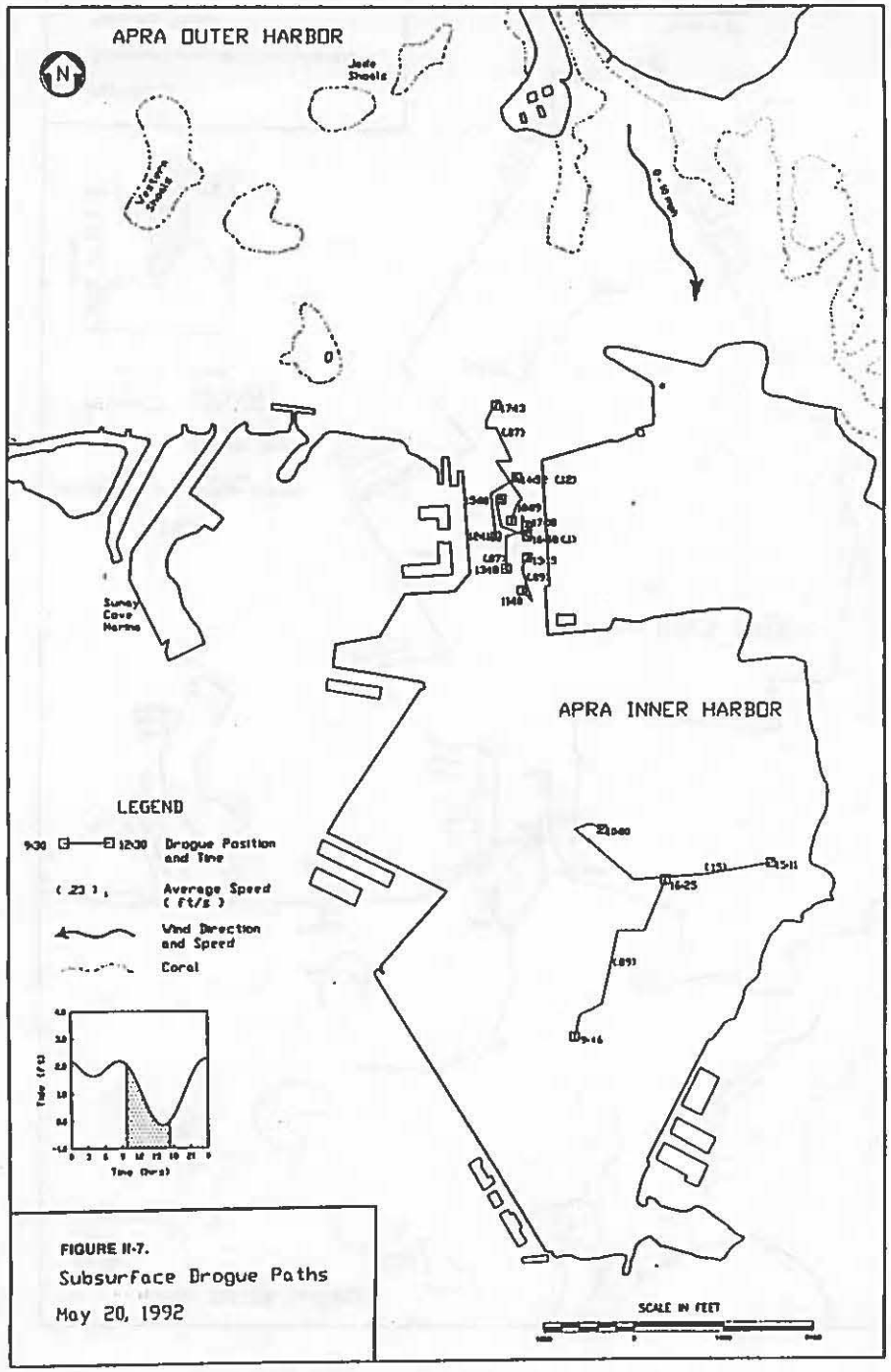

FIGURE II-7.
Subsurface Drogue Paths
May 20, 1992

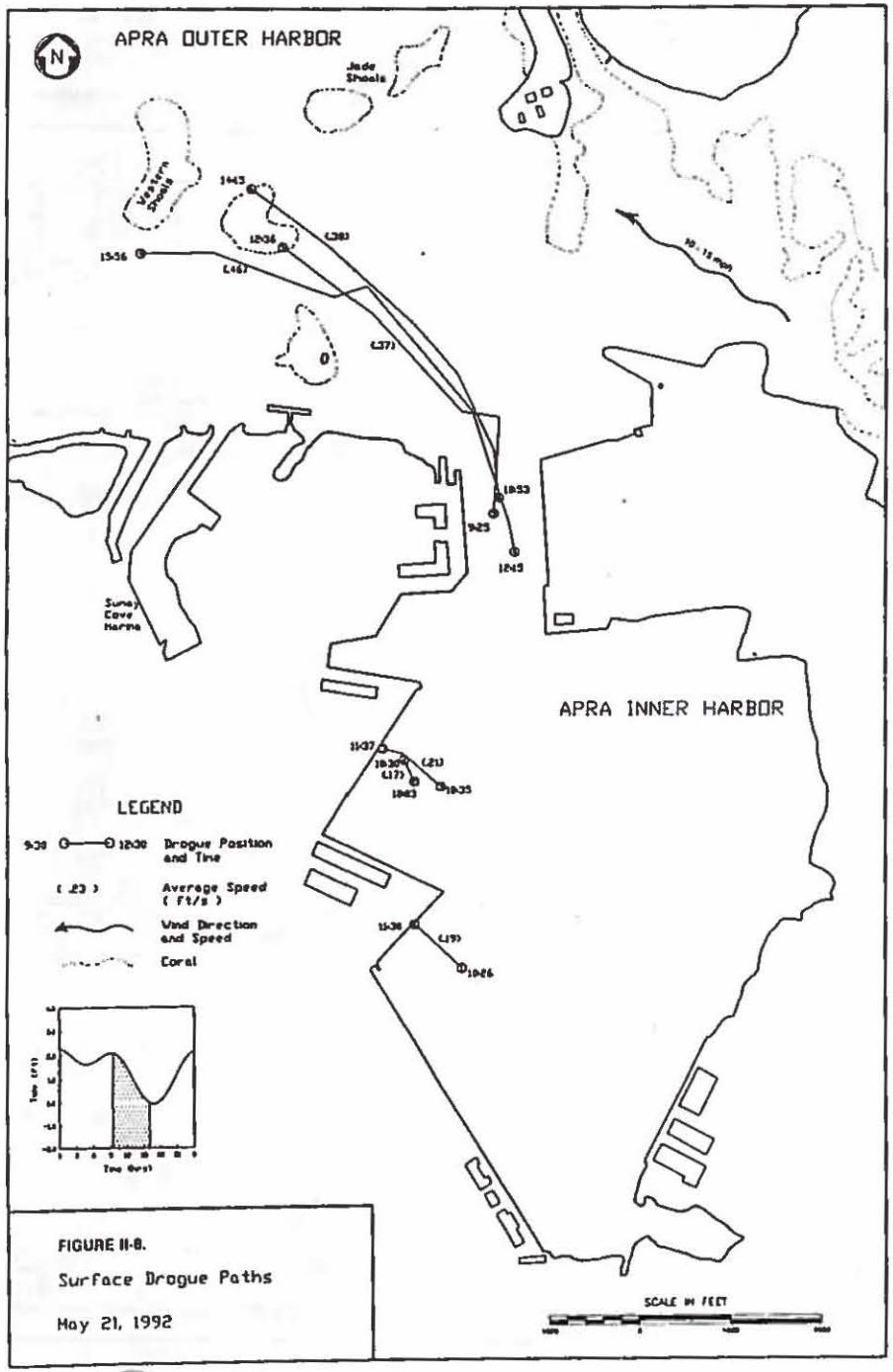

FIGURE II-8.
Surface Drogue Paths
May 21, 1992

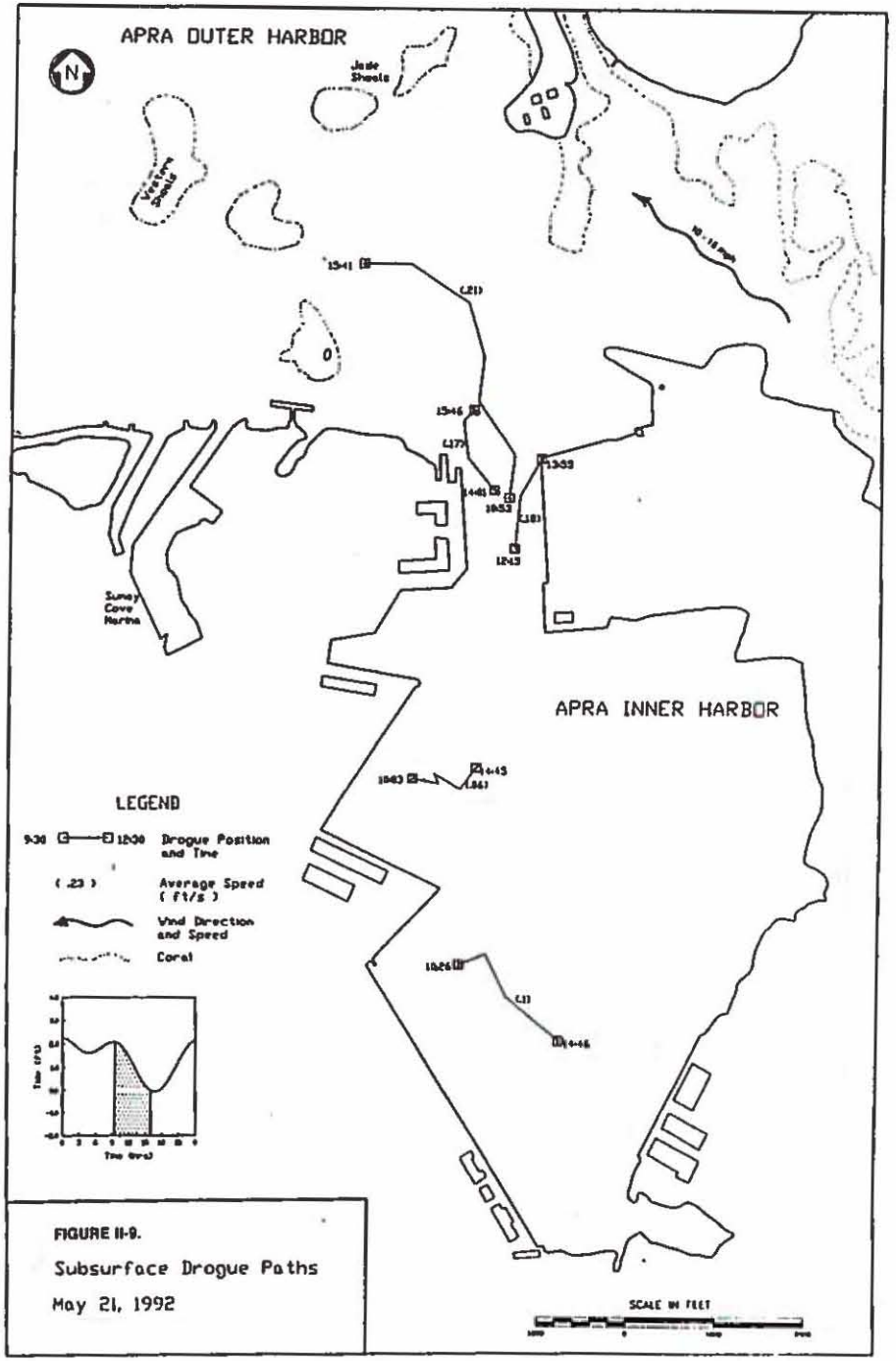

FIGURE II-9.
Subsurface Drogue Paths
May 21, 1992

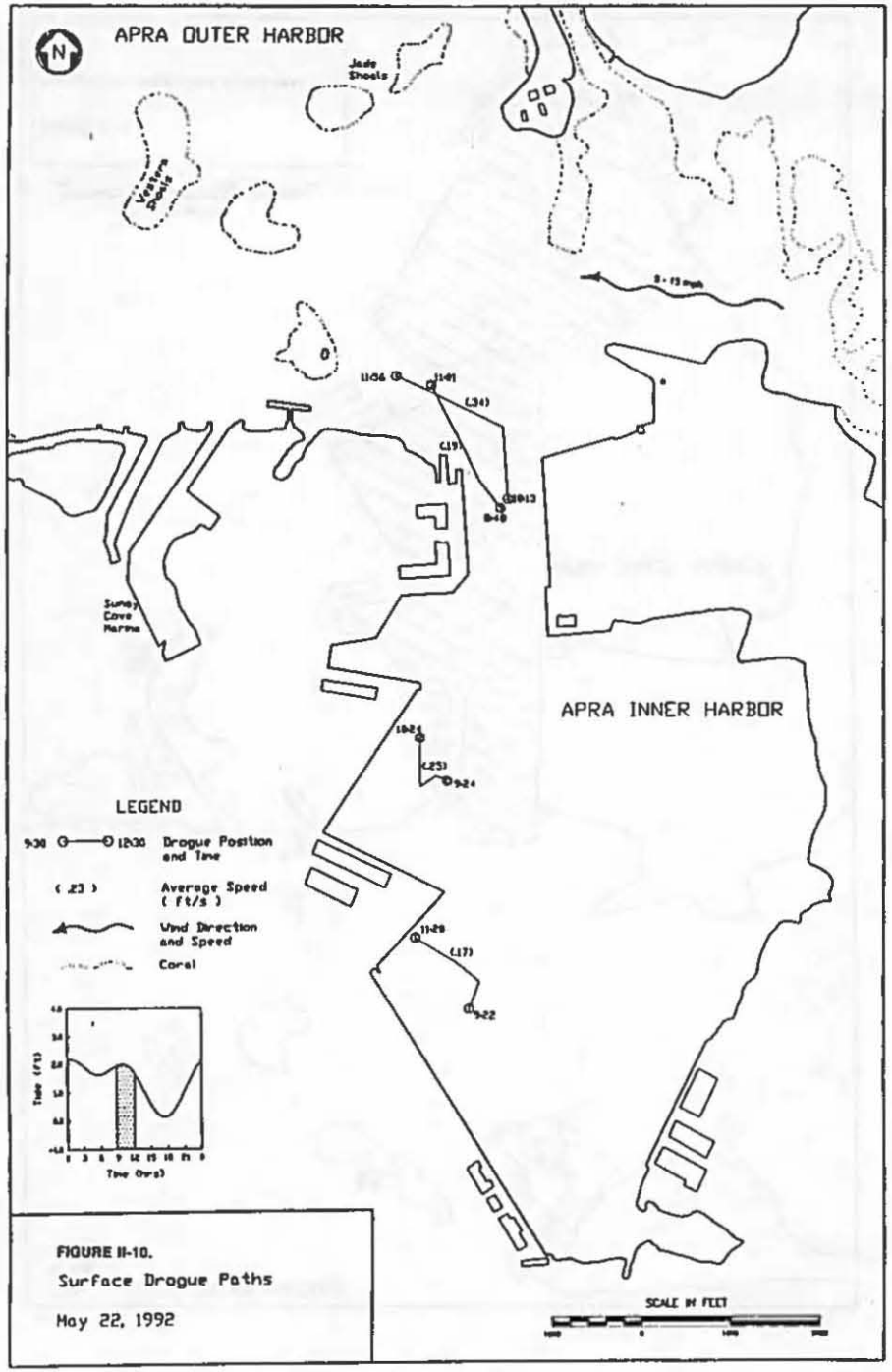

FIGURE II-10.
Surface Drogue Paths
May 22, 1992

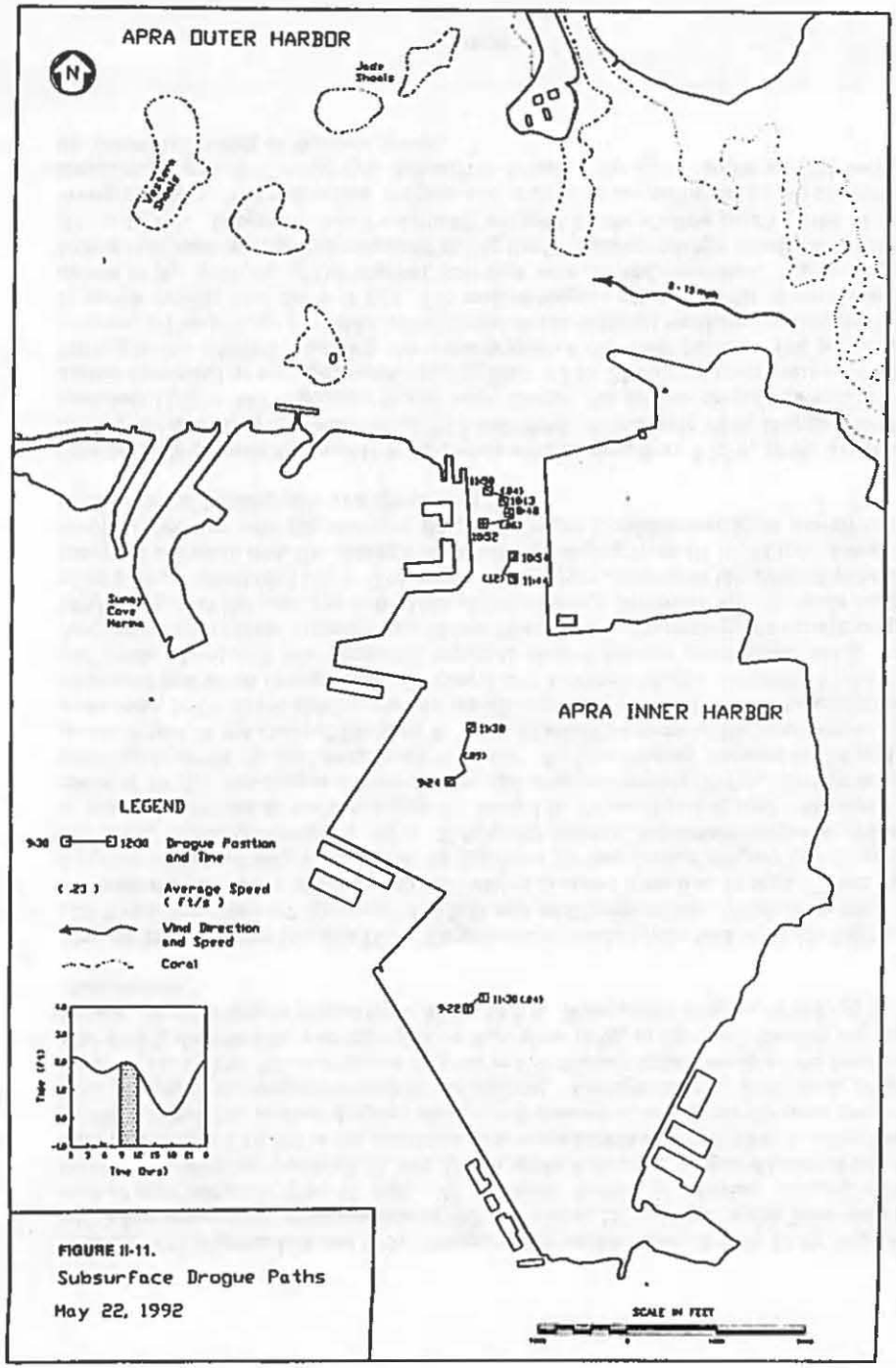

FIGURE II-11.
Subsurface Drogue Paths
May 22, 1992

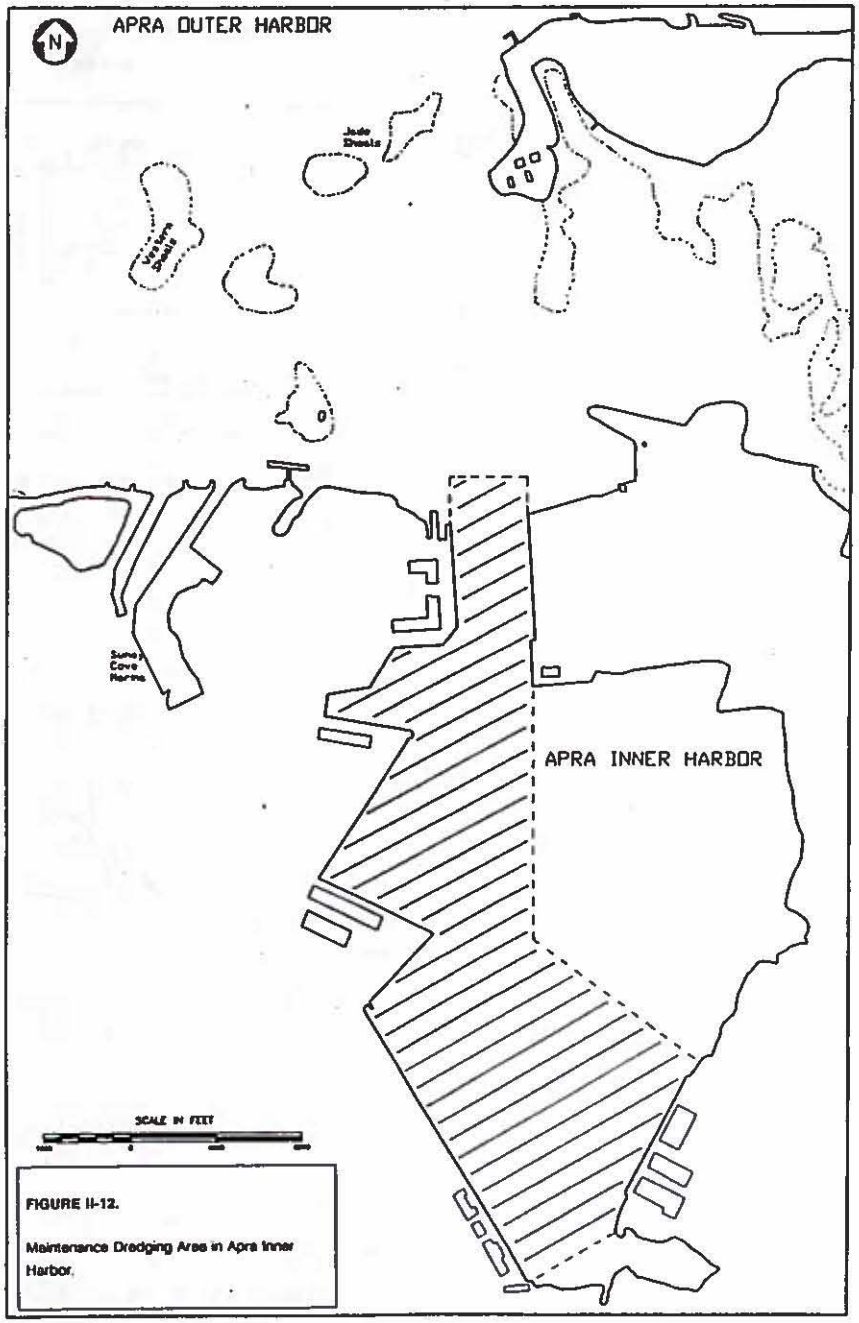

FIGURE II-12.

Maintenance Dredging Area in Apra Inner Harbor.

May 19, 1992 (Figures II-4 and II-5): Drogues were tracked from 12:00 to 17:30. High tide of 2.3 feet was at 8:03, while low tide of -0.3 feet was at 15:30. Light winds blew from the east at approximately 5 to 10 mph. In the inner harbor, the surface drogues moved downwind at average speeds of .32 and .15 ft/s, while subsurface drogue #1 moved into the wind and drogue 2 moved to the southeast, at average speeds of .1 and .08 ft/s, respectively. In the channel, the surface drogues also moved downwind, and generally were retrieved after drifting to the western margin of the channel. Average currents were weak, ranging from .05 to .16 ft/s. The subsurface drogues in the channel drifted slowly to the north and east during the ebb tide, and during flood tide, after 16:00, to the south towards the inner harbor. Average speeds ranged from .06 to .13 ft/s. None of the drogues moved out of the channel area.

May 20, 1992 (Figures II-6 and II-7): Drogues were tracked from 9:46 to 17:15. High tide (2.2 ft) and low tide (-0.2 ft) occurred at 8:38 and 16:07 respectively. Winds were from the north-northwest (320 to 350 degrees), and varied in speed from 0 to 10 mph. There were frequent periods of little or no wind. In the inner harbor, surface drogues (#1-3) moved downwind at average speeds of .18 to .20 ft/s. By contrast, subsurface drogue 1, released in the same position as surface drogue 1, moved to the northeast against the wind at a speed of .09 ft/s, and drogue 2 moved to the east at approximately .15 ft/s. Surface drogue movements in the channel were more complex. Surface drogues released in the mid to northern part of the channel (drogues 6, 7 and 8) initially moved to the north against the weak wind, but with the ebbing tide. In the afternoon, as the influence of the ebbing tide weakened and winds strengthened, drogues 6 and 8 drifted roughly downwind to the east and south. Drogue 8 was eventually retrieved near a military recreational beach area. Average speeds of these drogues ranged from .16 to .22 ft/s. Conversely, the surface drogue (#4) released at the southern end of the channel moved downwind into the inner harbor at an average speed of .11 ft/s. The subsurface drogues released in the channel generally moved to the north with the ebbing tide, at speeds ranging from .07 to .12 ft/s. Drogue 4 reversed direction with the changing tide, and drogue 5, released at 15:00 moved to the south with the flooding tide at a speed of .1 ft/s.

May 21, 1992 (Figures II-8 and II-9): Drogues were tracked from 9:25 to 16:00. High tide (2.1 ft) and low tide (-0.1) occurred at 9:17 and 16:46. Winds were 10 to 15 mph from the southeast (110 to 145 degrees). In the inner harbor, the surface drogues (#1, 2 and 3) moved downwind at average speeds ranging from .17 to .21 ft/s, and were retrieved after drifting to the wharves bounding the western side of the inner harbor. The subsurface drogues (#1 and 2), on the other hand, moved to the east and southeast against the wind at speeds ranging from .06 to .1 ft/s. The surface drogues released in the channel initially moved to the north out of the channel, and then were carried downwind. These drogues attained the maximum speeds measured during the field study; average speeds ranged from .37 to .46 ft/s. Drogues 5 and 6 eventually snagged on the shallow corals to the east of Western Shoals. The subsurface drogues also moved to the north out of the channel at speeds ranging from .17 to .21 ft/s. Subsurface drogue 4 was carried by the current towards the corals to the east of Western Shoals.

May 22, 1992 (Figures II-10 and II-11): Drogues were tracked from 8:48 to 12:00. Tides were as follows: low tide of 1.6 ft at 5:31, high tide of 2.0 ft at 9:59, and low tide of 0.1 ft at 17:26. Currents, therefore, were measured during an interval of slight tidal change. Winds were approximately 5 to 15 mph from the east (70 to 120 degrees). In the inner harbor, surface drogues moved downwind at speeds of .17 and .25 ft/s. Subsurface drogues slowly moved to the north and northeast. Average speeds were .04 and .09 ft/s. Surface drogues released in the channel moved to the northwest out of the channel and downwind. Average speeds were .19 ft/s for drogue 3 and .34 ft/s for drogue 4. Subsurface drogues released in the channel did not move in a consistent manner: drogue 5 moved to the northwest, drogue 4 to the west, and drogue 3 to the south. Speeds were generally weak, and averaged .06 ft/s in the channel. These slow, inconsistent movements are likely a reflection of the small tidal variation that occurred during the measurement interval.

CIRCULATION IN INNER APRA HARBOR

The drogue data discussed above suggests that circulation in the inner harbor is primarily controlled by wind, and that tidal currents are weak and are important only in the channel between the inner and outer harbor. The surface drogues in the inner harbor basin all moved downwind, while the subsurface drogues often moved in a direction opposite to the surface drogues. This suggests that the wind drives water in a surface layer downwind until it reaches the margin of the harbor. Water in the subsurface layer is then forced to flow in an opposite direction to replace water flowing in the surface layer. This is similar to the observed circulation patterns in the outer harbor.

The existence of this wind driven circulation cell is also supported by drogue speeds, and salinity and temperature profiles in the inner harbor. In this circulation cell, conservation of mass requires that the volume flow in the surface layer equal the volume flow in the subsurface layer. The subsurface drogues in the inner harbor extended from water depths of 15 to 25 feet, and the surface drogues to approximately 10 feet. The data indicates, therefore, that the surface layer thickness was 10 to 15 feet, and given an average harbor depth of 35 feet, the subsurface layer was 20 to 25 feet thick. The subsurface layer is approximately twice as thick as the surface layer. Average speeds in the surface layer should therefore be roughly twice those in the subsurface layer. Measured drogue speeds are consistent with this; average surface speeds in the inner harbor were .19 ft/s, while average subsurface speeds were .10 ft/s (Table II-7).

Temperature and salinity profiles measured in the inner harbor during the same period as the drogue study (Dollar, 1992), show little variation in these parameters with depth. The characteristics of the water are relatively uniform, and indicate that the basin is not stratified. This is consistent with a wind driven circulation cell in the inner harbor that would cycle the surface water to the subsurface and then back to the surface. The time required to complete a cycle in the east-west direction consistent with prevailing trade winds, would be approximately one day, assuming average surface and subsurface layer current speeds of .2 and .1 ft/s, respectively.

The second factor characterizing circulation in the inner harbor is that tidal currents are weak, and are significant only in the channel between the inner and outer harbor. Drogue movements in the inner harbor showed no relation to tides, but rather were controlled by the wind, as described above. In the channel, however, movement of subsurface drogues was controlled by tidal currents, while movement of surface drogues was controlled by both winds and tides. The subsurface drogues moved north out of the channel during an ebbing tide, and in the opposite direction during a flood tide. Surface drogues, in general, moved north out of the channel during an ebbing tide, and once out of the channel, moved downwind.

Drogue speeds observed in the channel are consistent with theoretical calculations of current velocities in tidal inlets. A method for calculating the average cross-sectional velocities in an inlet channel is presented in the Shoreline Protection Manual (U.S. Department of the Army, 1984). Important parameters for these calculations include the following:

Inner harbor surface area	=	24,944,280 sq ft
Channel width	=	890 ft
Channel length	=	1500 ft
Channel depth	=	37 ft
Tidal period	=	12.4 hr
Mean tidal range	=	1.7 ft
Mean diurnal range	=	2.4 ft

The equations for calculating the average and maximum tidal current velocities in the channel are the following:

where, V_m = maximum flow velocity in the channel
A_c = cross-sectional area of the harbor entrance below MSL
A_b = harbor surface area (use 25,000,000 ft^2)
L = channel length (use 1,500 ft)
B = channel width (use 890 ft)
d = water depth in the channel (use 37 ft)
T = tidal period (use $12.4x(60)^2$ sec)
α_s = tidal amplitude in open ocean
α_b = tidal amplitude in the harbor
g = gravitational acceleration
F = $k_{en} + k_{ex} + fL/(4R)$
k_{en} = entrance-loss coefficient (use 1.0)
k_{ex} = exit-loss coefficient (use 1.0)
f = friction coefficient (use 0.03)
R = hydraulic radius at the channel

The dimensionless maximum channel velocity, V_m', and the ratio of bay to sea tidal amplitude, α_b/α_s, are graphically given in Shore Protection Manual (U.S. Department of the Army, 1984) as functions of a friction coefficient, K_1, and a frequency coefficient, K_2.

For a mean diurnal range of 2.4 ft, calculated average current velocities in the channel are .09 ft/s, and peak current velocity is .13 ft/s. For a mean tidal range of 1.7 ft, calculated average current velocity is .06 ft/s and peak velocities are .09 ft/s. Our field study was almost exclusively during the diurnal ebb tide. The calculated diurnal velocities of .09 and .13 ft/s are consistent with the average velocity of .11 ft/s that we measured for the subsurface drogues in the channel (Table II-7). The average velocities of the surface drogues are higher probably because of the wind.

Strong sustained winds directed along the north-south axis of the inner harbor may overcome tidal effects in the channel. Sustained net transport in the surface layer to the north or south could result in a compensating flow in the opposite direction in the subsurface layer that could overprint tidal currents. This is the case in Outer Apra Harbor, where tradewinds drive surface flow out of the harbor, resulting in sustained flow into the harbor in the deeper layers. Winds from the north and south, however, are not common in Guam (Table II-1).

In summary, circulation in Apra Inner Harbor is controlled by the wind, while in the channel between the inner and outer harbor, tidal effects are significant. In the inner harbor, the wind drives the surface layer of water downwind, causing a return flow in roughly the opposite direction in the subsurface layer. In the channel, however, subsurface currents flow to the north out of the inner harbor during ebb tide and to the south into the harbor during flood tide. The surface currents in the channel are affected by both tides and winds. Currents in both the inner basin and the channel are relatively weak, averaging .2 ft/s in the surface and .1 ft/s in the subsurface layer. Both maximum surface and subsurface drogue speeds were measured on May 21: .46 ft/s and .21 ft/s, respectively. On May 21, moderate winds from the southeast combined with an ebbing tide to produce stronger currents out of the harbor.

It should be noted that the field data is restricted to four days from May 19 to May 22, 1992. During this period, winds were relatively light and from variable directions. There are, therefore, no field current measurements for the prevailing conditions of sustained tradewinds from the east. We expect that during sustained tradewinds, the circulation patterns discussed above would pertain; in the inner harbor, the surface currents would flow to the east while subsurface currents would flow to the west, and in the channel, weak tidal currents would prevail in the subsurface layer. Additional field measurements, however, would be needed during sustained tradewinds to verify these conclusions.

III. POTENTIAL IMPACTS OF DREDGING IN THE INNER HARBOR

Two points concerning possible impacts of dredging in Apra Inner Harbor stem from the drogue data and circulation assessment discussed above. First, turbidity generated by dredging within the inner harbor basin during prevailing tradewind conditions will likely remain within the inner harbor, although it will probably spread to the eastern side of the basin. Our data indicated that tidal currents are not important in the inner harbor, and that the wind drives a circulation cell oriented primarily east-west during prevailing tradewinds. Winds from south, however, could transport turbidity in the surface water layer out of the inner harbor and into the outer harbor.

Second, turbidity generated in the vicinity of the channel from the inner to the outer harbor can be transported into the outer harbor, and could impact the coral shoals. On May 21, when winds were from the southeast, drogues in the surface layer were transported onto or past Western Shoals, and the subsurface drogues moved towards the shoals. Furthermore, on May 22, when winds were from the east, surface drogues were transported to the north into the outer harbor during the ebbing tide, and then downwind. This suggests that during prevailing tradewinds, turbidity and suspended sediments could be transported into the outer harbor during ebbing tide and then downwind toward coral reef areas.

To evaluate further these possible impacts, a numerical model of turbidity plume transport that accounts for dispersion and particle settling was completed. For the dispersion calculations a Brooks-type model was used, while the effects of particle settling were calculated using particle fall velocity.

NUMERICAL MODEL

The Brooks Model estimates plume spread and centerline concentration reduction (Grace, 1978; Fisher et al., 1979) by mixing in a uniform current flow. The analysis assumes that vertical mixing and mixing in the direction of the current are negligible, the effluent plume has the same density as the ambient water body and moves with the current system, and mixing in the lateral direction can be described by the diffusion process with diffusion coefficient K. The assumption of uniform current flow is important because it restricts application of the model to the water layers characterized by uniform flow, or to time periods between tidal current reversals, less than six hours for diurnal tides.

The rate of decrease of the centerline concentration (C_x) and the spread of the turbid plume (L_x) is calculated using the following equation (Grace, 1978):

$$\frac{C_x}{C_i} = erf\left\{\left[\frac{3}{2}\beta\left[(1+\beta\frac{x}{B})^2 - 1\right]\right]^{1/2}\right\}$$

$$\frac{L_x}{B} = \left[1+\beta\frac{x}{B}\right]$$

where, β = $12K/UB$
U = current speed
B = initial plume width
x = a distance from the dredging point.

The diffusion coefficient, K, in the diffusion equation is given by $K = \alpha B^n$, where α is an empirically derived constant, B is the initial width of the turbid plume and n is an exponent of the length scale of the turbid field which determines the rate of diffusion. Values of n are typically 0 for small confined coastal areas or estuaries, 1 for coastal situations and 4/3 for open ocean situations. Since Inner Apra Harbor is large enough to be typical of a coastal situation, we have used n=1. The ocean field measurements by Okubo (Noda & Associates, 1990) give a range of the coefficient α in the horizontal diffusion coefficient as:

$$0.33 \le \alpha \le 1.67 \text{ m}^{2/3}/\text{hr}.$$

It is reasonable to select the middle point of the range of data as a nominal representative value for this study.

$$\alpha = 1.0 \text{ m}^{2/3}/\text{hr} = 2.2 \text{ ft}^{2/3}/\text{hr}.$$

The plume width, L_x, is defined as 2/3 times of the standard deviation of the concentration profile at a distance x.

The reduction in plume concentration due to particle settling can be estimated by the following equation (Noda & Associates, 1990):

$$C_x/C_i = \exp(-wt/h)$$

where, C_x = peak concentration at a distance x
C_i = initial concentration at x=0.
w = fall velocity
h = depth of the plume
and t = time.

This equation assumes that suspended material is uniformly distributed over the vertical by turbulence. The key value is this equation is the particle fall velocity. Fall velocity depends primarily on particle diameter, and can be approximated by using following equation (U.S. Department of the Army, 1984):

$$w = (\gamma_s/\gamma - 1)\, g\, d^2_{50}/(18\, \nu)$$

where, γ_s = specific gravity of suspended sediment (use 2.72 for calcite)
γ = specific gravity of sea water (use 1.022)
g = acceleration of gravity
d_{50} = median grain size
ν = kinematic viscosity of sea water (use $8.5\text{x}10^{-3}$ cm^2/s)

The key variables for the modeling analysis are suspended sediment diameter, initial plume concentration, and current speed and water depth, and are described below.

Suspended sediment diameter and fall velocity: Sediment samples from the channel and inner harbor were collected during the same period as the drogue study (Dollar, 1992). The average size distribution of these samples was the following:

	Coarser than .063mm	Finer than .063mm
% by weight	80 %	20 %

The grain diameter of .063 corresponds to the boundary between sand and silt in the Wentworth Classification. The turbidity plume concentration was modelled for 2 grain sizes: .063mm and .02mm. The calculations using .063 were intended to evaluate the bounds of impact of the coarse portion of the sediment that settles rapidly, while calculations using .02mm represent the transport of the fine particles that characterize a turbidity plume. In a similar analysis, Edward K. Noda and Associates (1990) selected .02 mm as a representative particle diameter of a turbid plume.

The computed fall velocities for .063 mm and .02 mm grains are .014 ft/s and .0013 ft/s. Because the fall velocity is related to the square of the grain diameter, reducing the particle diameter by 1/3 reduces the fall velocity by nearly an order of magnitude.

Initial plume concentration: Reported values of turbidity plume concentrations caused by dredging operations vary widely, and depend on dredge type, location in the water column, distance from the dredge and ambient conditions. Noda and Associates (1990) used a value

of 40 mg/l based on turbidity measurements taken 500 feet downstream of the source during the construction of Barbers Point Harbor. Herbich (1992) indicates that suspended solids concentrations may range from 30 to 80 mg/l at a distance of 200 feet from an enclosed clamshell dredge. Sustar and others (1976) report suspended solids of 70 mg/l along the centerline of a clamshell dredge. For our analysis, we have assumed that Sustar's reported value of 70 mg/l is representative of suspended solid concentration at the source. The initial plume width of 30 feet is also estimated for the use of a clam-shell dredge (Noda & Associates, 1990).

The modelling analysis includes two cases: 1) a suspended solids concentration of 70 mg/l and a grain size of .063 mm, and 2) a suspended solids concentration of 14 mg/l and a grain size of .02 mm. As mentioned above, 70 mg/l is assumed to be the suspended solids concentration at the source, and therefore includes coarser sediments that may settle quickly. Roughly 80 % by weight of the sediment in the inner harbor is coarser than .063 mm. A modeling run using a concentration of 70 mg/l and a grain size of .063 mm will therefore yield a conservative estimate of the maximum extent of impact of the coarse 80 % of the suspended sediment. On the other hand, approximately 20 % by weight of the sediment is finer than .063 mm. We have chosen a grain diameter of .02 mm as representative of this silt-sized portion of the sediment. Assuming the coarser fraction settles rapidly, we can approximate the suspended silt concentration as 20 % of the total concentration of 70 mg/l, or 14 mg/l. A modelling run using an initial concentration of 14 mg/l and a grain size of .02 mm will estimate the range of impacts of the fine sediments that typically constitute a turbid plume.

Current velocity and water depth: Using data obtained from this drogue study, and from previous studies of the commercial port area and the outer harbor, .33 ft/s was selected as an average surface layer velocity and .15 ft/s as an average subsurface layer velocity during typical tradewind conditions. Assumed surface layer thickness was 15 feet, and the underlying layer 25 feet thick in the area between the channel entrance and the coral shoals. For the modelling analysis, the average selected velocity for the water column was 0.2 ft/s.

MODEL RESULTS

Two processes act on the turbid plume: dispersion and suspended sediment fallout. These processes are assumed to be independent. The final plume concentrations are therefore computed by multiplying the concentration reductions from sediment settling and dispersion with the initial plume concentrations. Tables III-1 and III-2 present the results for the case of initial plume concentration of 70 mg/l and sediment size of .063. Tables III-3 and III-4 present the results for an initial plume concentration of 14 mg/l and sediment size of .02 mm.

Tables III-1 and III-3 show only the dilution expected by sediment settling. Tables III-2 and III-4 illustrate the decrease in the peak concentration of suspended solid in the plume with time and distance transported.

TABLE III-1

RELATIVE CONCENTRATION AND DILUTION
DUE ONLY TO THE FALLOUT OF SUSPENDED SEDIMENTS
(CASE 1: SUSPENDED GRAIN SIZE (d_{50}) OF 0.063 mm)

Initial Plume Width (B) : 30 ft
Depth of the Plume (H) : 40 ft
Sediment Fall Velocity (W): .014 ft/s

Time (hours)	Relative Concentration (C_x/C_i)	Dilution
1	2.837e-1	3.525e+0
2	8.046e-2	1.243e+1
3	2.282e-2	4.382e+1
4	6.474e-3	1.545e+2
5	1.836e-3	5.446e+2
6	5.209e-4	1.920e+3
7	1.477e-4	6.768e+3
8	4.191e-5	2.386e+4
9	1.189e-5	8.412e+4
10	3.372e-6	2.966e+5

TABLE III-2

TURBIDITY CONCENTRATION FOR A CONTINUOUS DREDGING OPERATION
(CASE 1: SUSPENDED GRAIN SIZE (d_{50}) OF 0.063 mm)

Initial Sediment concentration (C_i): 70.000 mg/l
Depth of Water Column (h) : 40.00 ft
Initial Plume Width (B) : 30.00 ft
Sediment Fall Velocity (W) : 0.0140 ft/s
Current Speed (U) : 0.2 ft/s
Initial Diffusion Coeff. (K_o) : 66.00 (ft^2)/hr
Traverse Diffusion Coefficient ($K=ab^n$)

Time (hrs)	Distance (ft)	Peak Concentrations (mg/l) Nonsettling	Settling
1	720	5.064e+1	1.436e+1
2	1440	3.495e+1	2.812e+0
3	2160	2.655e+1	6.060e-1
4	2880	2.139e+1	1.385e-1
5	3600	1.791e+1	3.289e-2
6	4320	1.540e+1	8.023e-3
7	5040	1.351e+1	1.996e-3
8	5760	1.203e+1	5.042e-4
9	6480	1.084e+1	1.289e-4
10	7200	9.871e+0	3.329e-5

TABLE III-3

RELATIVE CONCENTRATION AND DILUTION
DUE ONLY TO THE FALLOUT OF SUSPENDED SEDIMENTS
(CASE 2: SUSPENDED GRAIN SIZE (d_{50}) OF 0.02 mm)

Initial Plume Width (B) : 30 ft
Depth of the Plume (H) : 40 ft
Sediment Fall Velocity (W): .0013 ft/s

Time (hours)	Relative Concentration (C_x/C_i)	Dilution
1	8.896e-1	1.124e+0
2	7.914e-1	1.264e+0
3	7.040e-1	1.420e+0
4	6.263e-1	1.597e+0
5	5.571e-1	1.795e+0
6	4.956e-1	2.018e+0
7	4.409e-1	2.268e+0
8	3.922e-1	2.550e+0
9	3.489e-1	2.866e+0
10	3.104e-1	3.222e+0

TABLE III-4

TURBIDITY CONCENTRATION FOR A CONTINUOUS DREDGING OPERATION
(CASE 2: SUSPENDED GRAIN SIZE (d_{50}) OF 0.02 mm)

Initial Sediment concentration (C_i): 14.000 mg/l
Depth of Water Column (h) : 40.00 ft
Initial Plume Width (B) : 30.00 ft
Sediment Fall Velocity (W) : 0.0013 ft/s
Current Speed (U) : 0.2 ft/s
Initial Diffusion Coeff. (K_o) : 66.00 (ft^2)/hr
Traverse Diffusion Coefficient ($K=ab^n$)

Time (hrs)	Distance (ft)	Peak Concentrations (mg/l) Nonsettling	Settling
1	720	1.013e+1	9.009e+0
2	1440	6.989e+0	5.531e+0
3	2160	5.310e+0	3.738e+0
4	2880	4.279e+0	2.680e+0
5	3600	3.582e+0	1.996e+0
6	4320	3.081e+0	1.527e+0
7	5040	2.702e+0	1.191e+0
8	5760	2.406e+0	9.438e-1
9	6480	2.169e+0	7.567e-1
10	7200	1.974e+0	6.127e-1

To define the potential range of impacts of the dredging turbidity plume, the computed concentrations of suspended solids must be compared with the background turbidity in the harbor and established water quality standards. Turbidity is an optical property that is typically measured in nephelometric turbidity units (NTU). The relationship between NTUs and suspended solids depends on the particular environment. No data is available on this relationship in Apra Harbor. In this analysis, therefore, an equation developed from measurements in Barbers Point Harbor (Noda and Associates, 1990) was used:

Suspended Solids (mg/l) = 0.54 + 1.93 Turbidity (NTU)

Measurements taken in Apra Harbor show the range in turbidity in the inner harbor was .1 to .23 NTU, and in the outer harbor, .13 to .16 NTU. This corresponds to suspended solids concentrations ranging from .73 to .98 mg/l in the inner harbor and .79 to .85 mg/l in the outer harbor. The Hawaii Department of Health water quality standards specify that the mean turbidity should not exceed .4 NTU within embayments, or roughly 1.3 mg/l suspended solids according to the Barbers Point equation. For further comparison, actual measurements of suspended solids concentrations in marine environments include 0.7 mg/l in nearshore waters off Keahole Point, 1.4 mg/l in offshore waters near Barbers Point, and 4.2 mg/l in nearshore waters near Barbers Point. For this analysis, we have chosen the Department of Health standard of 1.3 mg/l to define the potential range of impacts caused by dredging in Apra Inner Harbor.

Tables III-2 and III-4 illustrate that the turbidity plume may be transported roughly 1900 feet in Case 1 and 4800 feet in Case 2 before the peak concentration of suspended solids in the plume drops below 1.3 mg/l. These distances are plotted in Figure III-1 to define the range of potential impact of a turbidity plume emanating from the entrance to the channel to the inner harbor. The curves in Figure III-1 do not represent the boundaries of the turbidity plume, within which suspended solids concentrations exceed the standard of 1.3 mg/l. Rather, they represent the distance that a turbidity plume generated at the entrance to the channel may be transported by an average current of .2 ft/s before the peak concentration in the plume drops below 1.3 mg/l. In fact, for Case 1, the plume at a distance of 1900 feet is calculated to be less than 100 feet wide. and for Case 2, the plume at a distance of 4800 feet is calculated to be less than 200 feet wide. The computed values in Tables III-2 and III-4 correspond only to the peak values in the center of the plume.

The modelling results for Case 1 suggest that the coarse 80% of the sediment suspended by dredging operations will settle out within 1900 feet - well before reaching environmentally sensitive corals in the outer harbor (Figure III-1). This distance is also conservative because it was calculated using a grain size of .063 mm. The size of .063 is the bottom margin for 80 % of the sediment; most of the sediment is actually coarser that .063 mm, and therefore will settle out substantially closer to the source than indicated in Figure III-1. In addition, the distances were plotted from the entrance to the channel, which represents the extreme northern margin for the dredging. The bulk of the dredging will occur to the south of this point, thereby limiting transport of the sediment into the outer harbor.

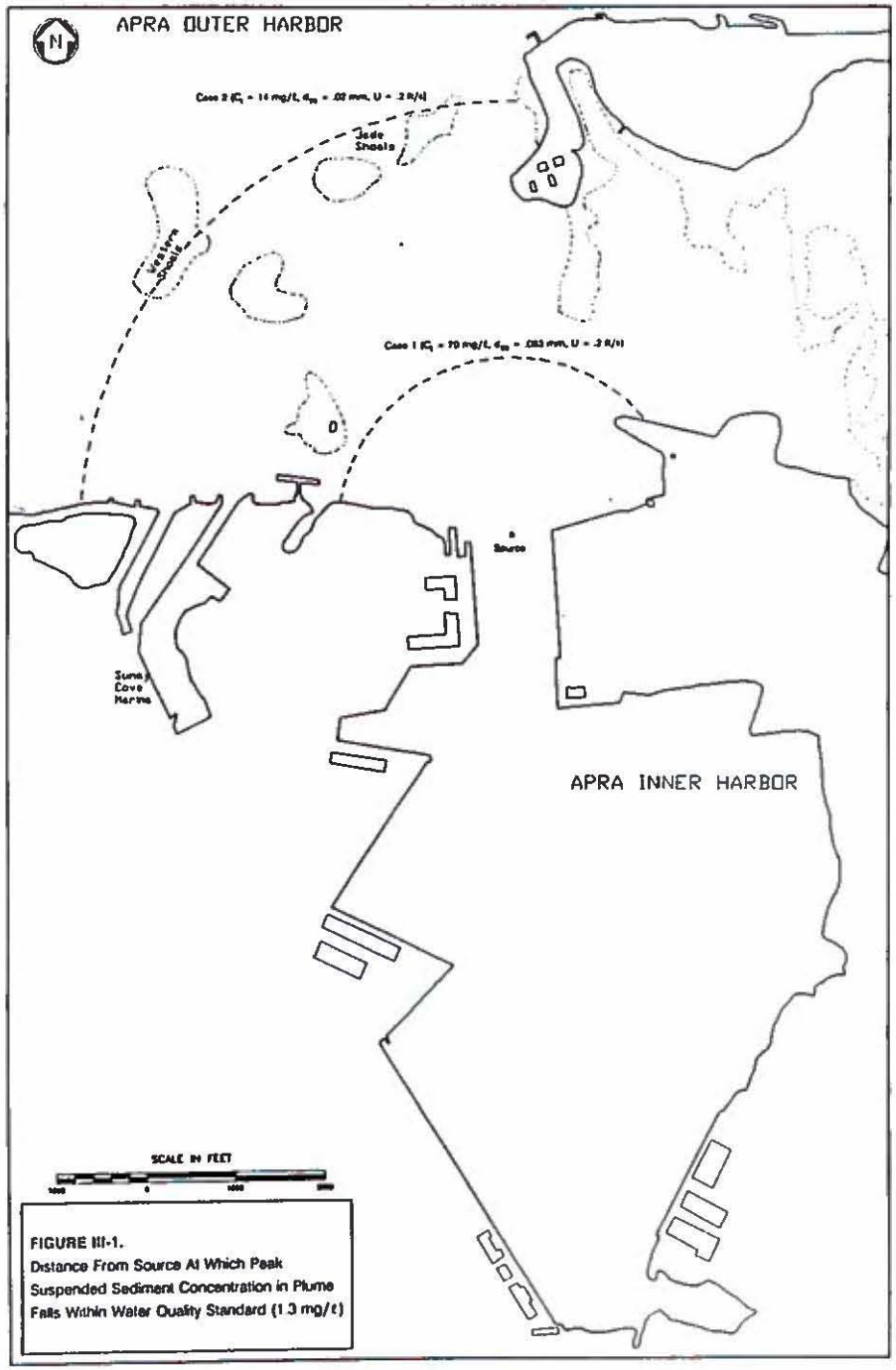

FIGURE III-1.
Distance From Source At Which Peak Suspended Sediment Concentration in Plume Falls Within Water Quality Standard (1.3 mg/ℓ)

The modelling results for Case 2 indicate that a turbidity plume composed of the silt-sized fraction of the sediment may reach the coral shoals before the peak concentration in the plume is diluted to less than 1.3 mg/l. Again, this assessment is conservative because it is for a source at the entrance to the channel. Most of the dredging will occur within the inner harbor and channel, which will limit the possibility of turbidity affecting the corals.

IV. APRA HARBOR WASTEWATER TREATMENT PLANT EXPANSION

EXISTING CONDITIONS

Sewage from the Apra Harbor Naval Complex is presently treated at the Apra Harbor Sewage Treatment Plant and then discharged through the North Tipalao Ocean Outfall. The outfall is located at the northwest end of Tipalao Bay, as shown in Figure IV-1. The present average discharge is approximately 1.7 MGD. The increased activities associated with the military relocation from the Philippines is expected to increase the average discharge by 0.5 MGD.

The initial North Tipalao Outfall handled raw sewage from the adjacent military housing complex, and consisted of a concrete conduit which terminated at the edge of the cliff (approximately 80 feet above sea level) in the notch west of Tantapalo Point. The waste water treatment plant was constructed in the early 1960's, and at the same time the outfall was extended down the cliff face to the waterline.

In 1974, the sewage treatment plant was upgraded and construction initiated to extend the outfall to a depth of 60 feet. The plans specified a 600 foot long outfall, terminating in a diffuser section paralleling the bottom contours in 60 feet of water. The 24 inch diameter concrete pipe was to be placed directly on the bottom and anchored by a continuous series of trapezoidal shaped concrete saddles placed over the pipe and filled with cast in place concrete. The T-shaped diffuser was to consist of a 16 inch diameter steel pipes supported 2 to 3 feet above the bottom by precast concrete pedestals.

The outfall has been subject to repeated damage by waves generated by tropical storms and typhoons. In 1974, prior to completion of the outfall, the inshore 200 foot length was destroyed by a tropical storm. In June of 1975, it was severely damaged by Typhoon Pamela. The outfall pipe between the cliff face and the 20 foot water depth, a distance of approximately 200 feet, was again completely destroyed.

In 1978, C.E. Maguire, Inc. conducted an engineering evaluation of reconstruction of the existing outfall. They determined that the notch in the cliff where the outfall is located is geologically unstable, and that the notch formation magnifies wave energy during storm conditions. Maguire concluded that stabilization of the outfall would be very costly due to the need to stabilize the cliff and the ocean bottom along the route, and that even then, the outfall would have a relatively high risk damage due to wave action or cliff erosion. After consideration of several alternatives, Maguire recommended relocation of the outfall to a point 700 feet to the east, through Tipalao Bay. They concluded that there were no other feasible sites along the south coast of Orote Peninsula between Neye Island and Orote Point. The recommended configuration was a trenched pipe through the surf zone, backfilled to the natural bottom elevation with tremie concrete.

The condition of the outfall was investigated in May, 1992, as part of the field work for this project. The condition of the outfall was as described in the 1978 Maguire report, except

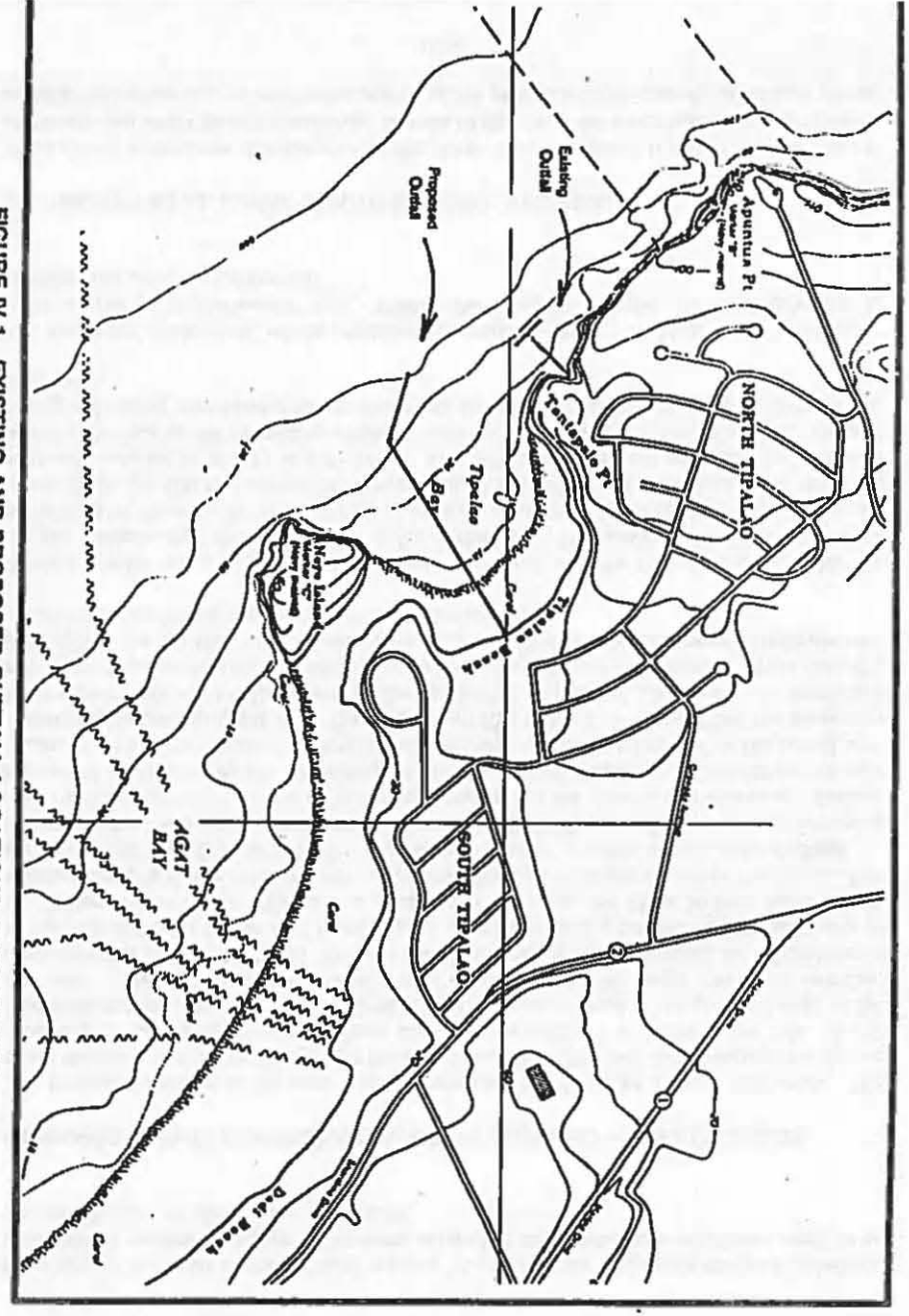

FIGURE IV-1. EXISTING AND PROPOSED OUTFALL LOCATIONS, TIPALAO BAY

for some apparent deterioration of the outfall pipe at the cliff face. In 1978, the outfall pipe extended to a point 5 feet below the water surface. At present, the pipe terminates approximately 10 feet above the water surface.

STATUS OF PROPOSED IMPROVEMENTS

The existing sewage treatment plant on the naval base will be upgraded as part of this project, and the effluent will be discharged through a new outfall that is presently being designed as part of the combined Agat-Santa Rita (Area IV) Wastewater System. The prime consultant is Duenas and Associates (formerly Duenas and Swavely) and they are working for the Public Utilities Administration of Guam (PUAG).

The entire system will have approximately 18,500 feet of force main sewer pipe, two pump stations, and 2270 feet of outfall pipe line. Approximately one half of the new sewer lines and the proposed outfall will be constructed inside the Naval Station. Figure IV-1 shows the new outfall location. The design flows for the new combined system are summarized below. The effluent will receive secondary treatment.

Flow Contribution (MGD)

Flow Parameter	PUAG	USN	Total
Dry weather minimum	1.0	0.5	1.5
Dry weather average	2.94	1.5	4.44
Dry weather peak	7.85	4.03	11.88
Wet weather storm infiltration	1.26	0.65	1.91
Wet weather storm inflow	2.56	1.32	3.88
Total capacity required	11.67	6.0	17.67

The Navy contribution to the overall flow was established by a Memorandum of Understanding, dated July 30, 1987, between the Navy and PUAG. The PUAG flows were determined by Duenas & Swavely in a 1987 planning study. At present, the limiting hydraulic capacity of the pipe is 17.67 MGD, generated by standard hydraulic design curves.

The ocean portion of the proposed outfall will be a 30 inch diameter, 1800 feet long pipeline, including a 300 foot long diffuser section. The diffuser will extend from the 90 to 120 foot depth, and will be designed for an initial dilution of 100:1.

Work completed to date on the outfall includes a seismic reflection survey of sub-bottom conditions along the proposed route, offshore borings, and current and biological studies. Actual design of the outfall has not yet started. The outfall will be either conventional cut and cover, with the outfall embedded in a shallow trench, or one constructed by the directional drilling, or whipstock method, where the outfall is located deep below the ocean

floor until it daylights at the diffuser section. A study of the whipstock design feasibility is presently 85 percent complete. Concerns related to the sub-bottom conditions need to be resolved before an alternative is selected.

OCEANOGRAPHIC CONDITIONS ALONG PROPOSED OUTFALL ROUTE

The proposed route is in the area recommended by C.E. Maguire in their 1978 study. The route crosses a narrow sand beach at the shoreline, and a 300 foot wide fringing reef before dropping off into deeper water. Water depth on the reef is 1 to 2 feet at low tide. A 200 foot wide reef margin, with water depths of 2 to 4 feet, is located at the seaward edge of the reef flat. The seaward edge of the reef margin is cut by surge channels, oriented perpendicular to the reef front. There is a vertical drop to approximately the 20 foot depth at the seaward edge of the reef front, then a gently undulating bottom sloping gradually to the 50 foot water depth. There is a pronounced break at the 45 to 50 foot water depth, approximately 800 feet offshore, with a seaward slope of 25 degrees beyond the break. The bottom in this area is relatively flat, with some scattered patches of thin sand deposits.
Ocean currents in the area are a combination of the North Equatorial Current and reversing tidal currents, modified by the offshore bathymetry and the coastal configuration. Surface layers are influenced by the prevailing winds. The North Equatorial Current moves past Guam in a westerly direction, diverging off the north or northeast corner of the island, and theoretically converging off Apra Harbor. According to the U.S. Coast Pilot, the maximum flood current off Apra Harbor sets to the north with a speed of 1.5 knots. The maximum ebb current sets to the south with a speed of 3 knots. Typical maximum currents during a tidal cycle are on the order of one knot. Current flow to the southwest predominates, occurring more frequently than flow to the northeast.

Reversing tidal currents are common around the island, and the limited data available for the site indicate that this is the case at the outfall site. Two days of current studies were completed by Duenas & Swavely (1991) in support of the outfall design. Measurements taken during an ebb tide showed all current drogues moving to the southwest and offshore, at speeds ranging from 0.11 to 0.33 knots. The offshore movement was apparently caused by the influence of the prevailing offshore wind on the surface drogues. Drogues released during a flooding tide moved to the northwest and offshore, at speeds ranging from 0.11 to 0.42 knots.

The northeast tradewinds, which predominate from November to May, result in offshore winds at the proposed outfall site. During the summer months, the wind direction is variable and calms are frequent.

ENVIRONMENTAL IMPACTS AND UNRESOLVED ISSUES

The existing wastewater discharge from the North Tipalao Outfall is in violation of federal and territorial water quality standards. In spite of this, both the water quality measurements and the field observations conducted as part of this project indicate that the discharge plume

is quickly dispersed, and that there is no apparent degradation of the area, other than the water quality conditions within the plume. This site is directly exposed to frequently occurring storm and typhoon waves, and due to the wave induced scour, there is little coral growth in the outfall vicinity. The additional 0.5 MGD of flow should not have a significant additional effect on the environment.

Outfall damage is common on Guam, due to the severity of the typhoon generated waves. A 1977 study by the Water Resources Research Center, University of Guam evaluated the effect of effluent from the Agat Sewage Treatment Plant on the coastal waters. The Agat outfall had been damaged in 1975, and 0.5 MGD of secondary treated effluent was discharging near shore in 8 feet of water. The study concluded that the effluent discharge had little effect on the benthic biota. The effluent was usually quickly dispersed by the combined effects of the winds, waves and currents. The primary concern was transport of the plume toward the shoreline. In the case of the Tipalao Outfall, the coastline on one side is a steep cliff and on the other a beach with no public access.

Potential options are limited, given the ongoing design process for a new ocean outfall. In any case, construction of the new outfall is the obvious best choice of action. At this time, it is not practical to undertake even emergency, temporary repairs due to the frequent occurrence of severe storm waves along this coastline. A temporary extension would probably be destroyed on a yearly basis.

The primary adverse effect is the water quality degradation within the effluent plume. Certain wind and tide conditions could transport a relatively undispersed plume to the shoreline of Tipalao Bay. Any recreational activities along the shoreline should be evaluated in light of the possible hazards until the new outfall is completed. If necessary, a water quality monitoring program could be established.

Any action that can be taken to expedite the design and construction of the outfall will be beneficial. Given the total design flow of 17.67 MGD, and the relative uncertainties associated with the wet weather inflow and infiltration, the addition of another 0.5 MGD does not pose a technical or environmental problem. At the most, the pipeline diameter might have to be increased by approximately two inches. Since the design process is underway, the Navy should revise the 1987 Memorandum of Understanding with PUAG as soon as possible.

V. EXPLOSIVE ORDNANCE DISPOSAL MOBILE UNIT FIVE (EODMU FIVE)

EXISTING CONDITION

The EODMU FIVE site is located along the banks of Sumay Cove, a small channel located 3,000 feet west of the entrance to Inner Apra Harbor. The location is shown in Figure V-1. The length of the cove is approximately 3,000 feet, with the width varying from 125 to 400 feet. Much of the cove shoreline has been stabilized with vertical steel sheetpile bulkhead. The sheetpiles along the EOD FIVE facility extend from approximately 8 feet above sea level into the channel bottom. Water depths along the seaward face of the bulkhead range from 5 to 15 feet. The channel, at least that part fronting the facility, appears to have been dredged, and has an average depth of 15 feet. There is typically a 10 to 15 foot wide, 5 to 10 foot deep, shelf at the base of the bulkhead. The shelf typically terminates in a vertical drop to the channel bottom at 15 feet. Where the shelf is absent, the water depth at the base of the bulkhead is 15 feet. The water depth along the south (inshore) face of the facility is less than that along the west face.

ENVIRONMENTAL CONDITIONS

Sumay Cove has been highly modified by past shoreline stabilization and dredging. The modifications probably occurred in the late 1940's, when many of the Inner Apra Harbor facilities were constructed.

Observed and measured currents during the May, 1992 field trip were very weak. Currents were measured in mid-channel off the EODMU FIVE facility on May 20, 1992, in the early and middle stages of an ebbing tide. Water moved seaward toward Outer Apra Harbor at an average speed of 0.05 feet per second. The channel is protected from the prevailing tradewinds, so under most conditions the tide will be the primary driving force for the circulation in the channel, and the measured current speed can be condsidered representative.

PRESENT USAGE AND CONDITION

The Sumay Cove Marina, a small recreational marina for Navy personnel, is located across from the EODMU FIVE facility. Marina facilities consist of an office/restaurant, a one lane boat ramp, and several boat slips. Water and power are available. The marina frontage is stabilized by a steel sheetpile bulkhead. The bulkhead is in poor condition from the top to the -2 foot elevation. There is extensive corrosion of the steel sheetpiles, some voids in the bulkhead, and corresponding sinkholes behind the bulkhead.

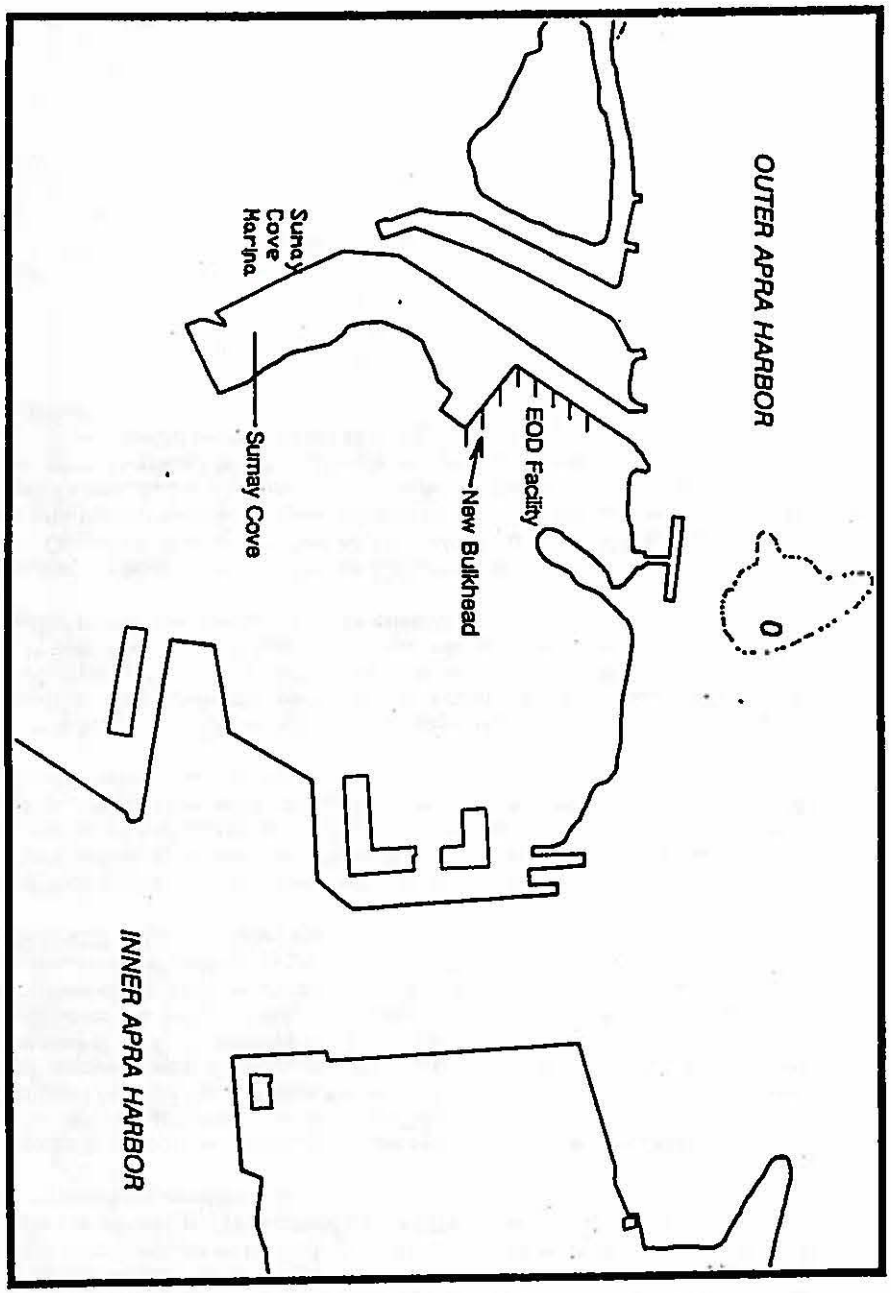

FIGURE V-1. LOCATION OF EODMU FIVE FACILITY AND NEW BULKHEAD

The EOD site has a few storage sheds, but is lightly utilized at present. There are no docks or loading platforms along the bulkhead. As at Sumay Cove Marina, the sheetpile is in poor condition from the top of the bulkhead to just below the waterline. The top horizontal waler, located at about the +2 elevation, is severely corroded, and has fallen into the water in some areas. The underwater portions of the bulkhead are in relatively good condition. No damage was observed during a brief swim by of the bulkhead. However, an engineering inspection team from the Chesapeake Division, Naval Facilities Engineering Command was on site at the same time performing a detailed underwater inspection of all facilities, and they noted some underwater holes in the bulkhead.

PROPOSED USAGE

EOD personnel presently launch and recover their boats at the Sumay Cove Marina. Their vessels are all trailerable, and less than 28 feet long. The relocation from the Philippines will result in an estimated 10 percent increase in vessel operations. No launch ramp is planned for the EOD facility, so they will continue to use the Sumay Cove ramp. During operations, vessels transit through the channel, for training operations in the outer harbor or beyond. There will be no work with explosives, either in Sumay Cove or in the outer harbor. Operations in the outer harbor will at times involve "helicasting", the deployment of personnel into the water from helicopters by jumping, repelling, or parachuting.

REQUIRED MARINE CONSTRUCTION ACTIVITIES

If the sheetpile bulkhead is not repaired or replaced, the vertical bank will probably be considered "unstabilized", and facilities located a safe distance (approximately 50 to 100 feet) inshore. Repair of the bulkhead would probably consist of embedding the top several feet of deteriorated sheetpile in a concrete cap. This would retard further corrosion in the splash zone, which is the most susceptible area. Construction of a new wall would entail driving new sheetpiles just seaward of the existing wall, then backfilling the space in between.

There is some debris in the water along the existing bulkhead, most of it concentrated along the south bulkhead. The debris will have to be removed to provide navigable depths along the bulkhead. The EOD plans to moor a causeway section along the bulkhead to facilitate loading operations.

ANTICIPATED IMPACTS AND CONFLICTS

The proposed construction and operational activities related to this facility do not pose any significant environmental impacts. Repair or replacement of the bulkhead will generate temporary turbidity, but it will not be extensive, and given the extremely slow currents, most of the suspended solids will settle in the immediate area. Given the relatively low level of increased activity, the EOD operations should not interfere with the recreational marina.

VI. SEAL TEAM/SPECIAL WARFARE OPERATIONS

PROPOSED OPERATIONS

The SEAL Team marine operations will be based in Inner Apra Harbor, along a 780 foot long section of Wharves V-1 and V-2. Their vessels will include several inflatable boats, two 36 foot light landing craft, three 65 foot PBR's, one or two 170 foot coastal patrol boats, and several smaller vessels in the 24 to 35 foot size range. They will also have two 90 foot floating causeway sections moored to the wharves. During normal conditions, the causeways will be moored to the bulkhead, and the other vessels moored to either the causeway sections or the bulkhead.

The SEALS will conduct some dive training operations in Outer Apra Harbor. Other than that, they will pass through the harbor in route to other destinations.

During typhoon alerts, the coastal patrol boats, the PBR's, and most probably the causeway sections will be moored to designated typhoon buoys in either the Inner or the Outer harbor. The SEALS have requested that additional typhoon moorings be assigned to them to accommodate their requirements. All other vessels will be lifted out of the water and secured on land. The SEALS will have their own crane on site to perform this operation as required.

DIRECT MARINE IMPACTS

No marine construction will be required for the SEAL facility, except for the possible installation of additional typhoon moorings in Inner Apra Harbor. Placement of the anchors and mooring chains for the buoys will generate temporary turbidity, but it will be minor and confined to the inner harbor.

VII. GANTRY CRANE

A gantry crane, if brought to Apra Harbor, will be installed on Wharves S-1 and S-2. Crane rails and electrical components will be installed on the aprons of the wharves. No underwater work should be required. A brief inspection was conducted during the field work for this project in May, 1992 and the two wharves are in good condition. This evaluation concurs with that of the Chesapeake Division, Naval Facilities Engineering Command underwater engineering inspection team that completed a thorough survey of Inner Apra Harbor facilities in May, 1992. The team rated these wharves as "Good", with no major repairs required.

The two wharves consist of one-half inch thick steel sheetpile bulkheads, with tie-backs to deadmen. The sheetpiles are topped with a concrete cap extending from approximately the +8 foot elevation to one foot below Mean Lower Low Water. The wharves were built in the late 1940's.

Since no marine construction work is required, the installation and operation of a gantry crane should have no impact upon the marine environment of Inner Apra Harbor.

During severe typhoons, there is some wave runup onto the flat aprons behind the wharf bulkheads. Both the wave height calculations in Section II of this report and interviews with Port Operations personnel indicate that the wharf aprons are overtopped during severe typhoons. The overtopping is not extensive, and the associated wave forces acting on objects on the aprons should be minor. However, mechanical or electrical components on the aprons should be designed to withstand inundation.

VIII. NAVAL STATION OPERATING PROCEDURES

TYPHOON PROCEDURES

The Apra Harbor Naval Station has four standard operating conditions:

Condition 4: Normal weather
Condition 3: Typhoon expected within 72 hours
Condition 2: Typhoon expected within 24 hours
Condition 1: Typhoon imminent (within 12 hours)

The Navy sorties on Condition 2. All large, capable ships go to sea. Small craft are removed from the water and secured on land. Intermediate vessels, such as barges, fuel barges, harbor service craft, and in some cases, larger ships, are moored to typhoon buoys in the inner and outer harbors. There are presently eleven typhoon mooring buoys in the outer harbor and eight in the inner harbor.The fleet tugs remain underway during storm conditions, usually in the harbor. Large ships undergoing repair and unable to get underway are, as a last resort, secured alongside one of the wharves in the inner harbor.

There are typically two to five sorties per typhoon season, and an average of one typhoon hits the Guam/Saipan area each year.

CHANGES DUE TO THE RELOCATION

The relocation will increase the number of vessels and support craft in the harbor, but the operating conditions will remain the same. There will be more visiting ships, but they will go to sea during Condition 2. Few additional large vessels will be homeported at Apra Harbor. One new addition, the Spika, a civilian AFS, will be homeported at Apra, but will be underway 90 percent of the time during normal operating conditions. Two fleet tugs will be added to those in the harbor, but they will also remain underway in the harbor during storms.

The Navy is adding four more typhoon moorings in the inner harbor, to accommodate the increase in intermediate vessels and support craft. The eleven typhoon mooring buoys in the outer harbor will remain in place. Six months ago, there was consideration given to eliminating some of the buoys in the outer harbor, but with the increased operations due to the relocation, all eleven buoys will be kept in service.

POTENTIAL OUTER APRA HARBOR CONFLICTS

In recent years, the commercial, recreational and military uses of Outer Apra Harbor have all increased. One of the biggest observed changes in the past ten years has been the increase in recreational diving in the outer harbor. At the present time, there is even a

commercial submarine operating off Gab Gab Beach. Correspondingly, an increased awareness of the resources of the harbor, particularly the coral reef areas, has developed. There are twelve recognized dive sites in Outer Apra Harbor, and they are identified in Appendix B of this report.

The recreational dive industry and the Navy dive training operations (SEAL Team and EOD) should be able to coexist with little or no conflict. Additional ship traffic will stay in the marked navigation channels, and should have no impact on other uses of the harbor. Navy ships presently use the outer harbor for precision anchor drills, and there is a need for that training to continue. Areas that avoid sensitive coral areas and dive sites should be specified for the anchor drills.

The eleven typhoon moorings in the outer harbor present a potential conflict. The Guam EPA would like the moorings removed, however, all buoys are utilized during typhoons. The Navy is even adding additional moorings in the inner harbor to accommodate the increased activity associated with the relocation.

Each mooring is rated for a particular holding capacity, depending upon the number and configuration of the mooring anchors. Some of the spread moorings may have as many as 16 anchors, and are rated for ships up to 500 feet long. The Navy Public Works Center is responsible for maintenance of the buoys. The buoys are refurbished at approximately 15 year intervals, with new anchors and chains installed. Some of the moorings are located near areas of extensive coral growth, and the anchor chains in some instances cross the coral areas. The removal of the old anchor chains and placement of new ones can result in destruction of some of the coral. A refurbishment of the moorings is presently underway, and a new chain was placed across Western Shoals, a popular dive site with prolific coral growth. The incident was described on the front page of the Pacific Daily News, indicating the sensitivity of the community to this issue.

This is one of the marine environmental issues of the relocation that needs to be resolved. Outer Apra Harbor is under the jurisdiction of the Navy, and sufficient typhoon moorings are required to accommodate the vessels based at Apra Harbor. An insufficient number of moorings may result in vessel damage during typhoons, with all the associated adverse environmental effects, such as fuel spills. A mooring location plan and maintenance procedure that minimizes the impact on environmentally sensitive areas may help minimize the conflict.

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APPENDIX A

DROGUE MEASUREMENT DATA

Note: *time = minutes*
distance = feet
velocity = feet/second

SURFACE DROGUE PATHS, MAY 19,1992

drogue	time	total time	distance	total dist	velocity	ave vel
3	1219.	0.	.00	.00	.000	.000
3	1302.	43.	60.41	60.41	.023	.023
3	1323.	64.	216.05	276.46	.171	.072
3	1413.	114.	181.25	457.71	.060	.067
3	1433.	134.	396.59	854.31	.330	.106
0	0.	0.	.00	.00	.000	.000
4	1445.	0.	.00	.00	.000	.000
4	1522.	37.	120.84	120.84	.054	.054
4	1604.	79.	252.90	373.74	.100	.079
4	1708.	143.	60.42	434.15	.016	.051
0	0.	0.	.00	.00	.000	.000
1	1231.	0.	.00	.00	.000	.000
1	1243.	12.	134.36	134.36	.187	.187
1	1313.	42.	559.00	693.36	.311	.275
1	1500.	149.	634.80	1328.17	.099	.149
0	0.	0.	.00	.00	.000	.000
2	1516.	0.	.00	.00	.000	.000
2	1559.	43.	900.32	900.32	.349	.349
2	1635.	79.	600.20	1500.51	.278	.317
0	0.	0.	.00	.00	.000	.000
6	1300.	0.	.00	.00	.000	.000
6	1332.	32.	593.83	593.83	.309	.309
6	1424.	84.	235.17	829.00	.075	.164
0	0.	0.	.00	.00	.000	.000
5	1429.	0.	.00	.00	.000	.000
5	1608.	99.	300.10	300.10	.051	.051
0	0.	0.	.00	.00	.000	.000
7	1622.	0.	.00	.00	.000	.000
7	1719.	57.	474.19	474.19	.139	.139

SUBSURFACE DROGUE PATHS, MAY 19,1992

drogue	time	total time	distance	total dist	velocity	ave vel
3	1207.	0.	.00	.00	.000	.000
3	1302.	55.	543.75	543.75	.165	.165
3	1324.	77.	299.17	842.93	.227	.182
3	1433.	146.	300.10	1143.02	.072	.130
0	0.	0.	.00	.00	.000	.000
4	1445.	0.	.00	.00	.000	.000
4	1544.	59.	84.29	84.29	.024	.024
4	1605.	80.	367.24	451.53	.291	.094
4	1628.	103.	213.80	665.33	.155	.108
4	1710.	145.	181.25	846.59	.072	.097
0	0.	0.	.00	.00	.000	.000
1	1244.	0.	.00	.00	.000	.000
1	1316.	32.	357.87	357.87	.186	.186
1	1506.	142.	550.72	908.60	.083	.107
0	0.	0.	.00	.00	.000	.000
2	1516.	0.	.00	.00	.000	.000
2	1556.	40.	120.82	120.82	.050	.050
2	1644.	88.	176.37	297.19	.061	.056
2	1700.	104.	190.55	487.74	.198	.078
0	0.	0.	.00	.00	.000	.000
6	1300.	0.	.00	.00	.000	.000
6	1325.	25.	117.59	117.59	.078	.078
6	1415.	75.	168.58	286.17	.056	.064
0	0.	0.	.00	.00	.000	.000
5	1422.	0.	.00	.00	.000	.000
5	1524.	62.	235.17	235.17	.063	.063
5	1618.	116.	186.43	421.60	.058	.061
0	0.	0.	.00	.00	.000	.000
7	1622.	0.	.00	.00	.000	.000
7	1714.	52.	381.09	381.09	.122	.122

SURFACE DROGUE PATHS, MAY 20,1992

drogue	time	total time	distance	total dist	velocity	ave vel
1	946.	0.	.00	.00	.000	.000
1	1028.	42.	458.22	458.22	.182	.182
1	1037.	51.	120.84	579.05	.224	.189
1	1125.	99.	607.01	1186.06	.211	.200
0	0.	0.	.00	.00	.000	.000
2	1132.	0.	.00	.00	.000	.000
2	1341.	129.	1449.25	1449.25	.187	.187
0	0.	0.	.00	.00	.000	.000
3	1048.	0.	.00	.00	.000	.000
3	1118.	30.	466.70	466.70	.259	.259
3	1135.	47.	598.37	1065.08	.587	.378
3	1337.	169.	1053.66	2118.73	.144	.209
3	1522.	274.	847.88	2966.62	.135	.180
0	0.	0.	.00	.00	.000	.000
7	1009.	0.	.00	.00	.000	.000
7	1100.	51.	486.90	486.90	.159	.159
0	0.	0.	.00	.00	.000	.000
8	1105.	0.	.00	.00	.000	.000
8	1205.	60.	648.14	648.14	.180	.180
8	1310.	125.	969.22	1617.36	.249	.216
8	1410.	185.	546.92	2164.28	.152	.195
8	1445.	220.	734.46	2898.74	.350	.220
8	1555.	290.	559.31	3458.05	.133	.199
0	0.	0.	.00	.00	.000	.000
5	1110.	0.	.00	.00	.000	.000
5	1150.	40.	242.81	242.81	.101	.101
0	0.	0.	.00	.00	.000	.000
4	1155.	0.	.00	.00	.000	.000
4	1300.	65.	84.31	84.31	.022	.022
4	1400.	125.	168.61	252.92	.047	.034
4	1504.	189.	486.91	739.82	.127	.065
4	1538.	223.	426.98	1166.80	.209	.087
4	1621.	266.	546.92	1713.72	.212	.107
4	1650.	295.	248.71	1962.43	.143	.111
0	0.	0.	.00	.00	.000	.000
6	1211.	0.	.00	.00	.000	.000
6	1308.	57.	1112.64	1112.64	.325	.325
6	1413.	122.	1520.68	2633.32	.390	.360
6	1448.	157.	186.43	2819.75	.089	.299
6	1550.	219.	264.39	3084.14	.071	.235
6	1708.	297.	773.79	3857.93	.165	.216
0	0.	0.	.00	.00	.000	.000

SUBSURFACE DROGUE PATHS, MAY 20,1992

drogue	time	total time	distance	total dist	velocity	ave vel
1	946.	0.	.00	.00	.000	.000
1	1041.	55.	248.72	248.72	.075	.075
1	1132.	106.	264.40	513.12	.086	.081
1	1347.	241.	804.97	1318.09	.099	.091
1	1517.	331.	293.98	1612.06	.054	.081
1	1625.	399.	592.42	2204.48	.145	.092
0	0.	0.	.00	.00	.000	.000
2	1000.	0.	.00	.00	.000	.000
2	1020.	20.	132.20	132.20	.110	.110
2	1048.	48.	186.43	318.63	.111	.111
2	1138.	98.	844.93	1163.55	.282	.198
2	1334.	214.	825.29	1988.85	.119	.155
2	1511.	311.	715.77	2704.62	.123	.145
0	0.	0.	.00	.00	.000	.000
7	1009.	0.	.00	.00	.000	.000
7	1059.	50.	190.55	190.55	.064	.064
7	1105.	56.	84.30	274.84	.234	.082
7	1205.	116.	515.04	789.88	.143	.113
7	1307.	178.	176.39	966.27	.047	.090
7	1407.	238.	403.13	1369.41	.112	.096
7	1451.	282.	117.59	1487.00	.045	.088
7	1546.	337.	60.42	1547.41	.018	.077
7	1705.	416.	134.38	1681.80	.028	.067
7	1713.	424.	84.29	1766.09	.176	.069
0	0.	0.	.00	.00	.000	.000
3	1110.	0.	.00	.00	.000	.000
3	1155.	45.	168.61	168.61	.062	.062
3	1302.	112.	381.09	549.70	.095	.082
3	1315.	125.	134.38	684.08	.172	.091
0	0.	0.	.00	.00	.000	.000
4	1318.	0.	.00	.00	.000	.000
4	1402.	44.	362.50	362.50	.137	.137
4	1500.	102.	186.43	548.93	.054	.090
4	1543.	145.	181.25	730.18	.070	.084
4	1700.	222.	134.38	864.57	.029	.065
0	0.	0.	.00	.00	.000	.000
6	1211.	0.	.00	.00	.000	.000
6	1304.	53.	486.89	486.89	.153	.153
6	1404.	113.	345.34	832.24	.096	.123
0	0.	0.	.00	.00	.000	.000
5	1500.	0.	.00	.00	.000	.000
5	1542.	42.	58.80	58.80	.023	.023
5	1615.	75.	307.76	366.56	.155	.081
5	1658.	118.	317.82	684.39	.123	.097
0	0.	0.	.00	.00	.000	.000

SURFACE DROGUE PATHS, MAY 21,1992

drogue	time	total time	distance	total dist	velocity	ave vel
5	925.	0.	.00	.00	.000	.000
5	1045.	80.	1089.09	1089.09	.227	.227
5	1104.	99.	415.95	1505.04	.365	.253
5	1154.	149.	1477.02	2982.07	.492	.334
5	1236.	191.	1234.71	4216.78	.490	.368
0	0.	0.	.00	.00	.000	.000
6	1053.	0.	.00	.00	.000	.000
6	1107.	14.	546.92	546.92	.651	.651
6	1152.	59.	940.63	1487.56	.348	.420
6	1227.	94.	718.94	2206.49	.342	.391
6	1305.	132.	1265.02	3471.51	.555	.438
6	1415.	202.	1104.26	4575.77	.263	.378
0	0.	0.	.00	.00	.000	.000
2	1003.	0.	.00	.00	.000	.000
2	1030.	27.	268.75	268.75	.166	.166
0	0.	0.	.00	.00	.000	.000
3	1035.	0.	.00	.00	.000	.000
3	1119.	44.	548.42	548.42	.208	.208
3	1137.	62.	242.81	791.23	.225	.213
0	0.	0.	.00	.00	.000	.000
1	1026.	0.	.00	.00	.000	.000
1	1130.	64.	716.65	716.65	.187	.187
0	0.	0.	.00	.00	.000	.000
4	1215.	0.	.00	.00	.000	.000
4	1222.	7.	307.75	307.75	.733	.733
4	1311.	56.	1333.83	1641.58	.454	.489
4	1407.	112.	1820.31	3461.89	.542	.515
4	1422.	127.	372.88	3834.77	.414	.503
4	1518.	183.	1435.99	5270.76	.427	.480
4	1556.	221.	823.08	6093.84	.361	.460

SUBSURFACE DROGUE PATHS, MAY 21,1992

drogue	time	total time	distance	total dist	velocity	ave vel
2	1003.	0.	.00	.00	.000	.000
2	1035.	32.	300.10	300.10	.156	.156
2	1121.	78.	134.39	434.48	.049	.093
2	1332.	209.	345.36	779.85	.044	.062
2	1445.	282.	299.18	1079.03	.068	.064
0	0.	0.	.00	.00	.000	.000
4	1053.	0.	.00	.00	.000	.000
4	1150.	57.	486.89	486.89	.142	.142
4	1204.	71.	216.04	702.94	.257	.165
4	1225.	92.	515.04	1217.98	.409	.221
4	1309.	136.	486.90	1704.88	.184	.209
4	1404.	191.	629.39	2334.27	.191	.204
4	1510.	257.	772.72	3106.98	.195	.201
4	1541.	288.	529.13	3636.11	.284	.210
0	0.	0.	.00	.00	.000	.000
3	1215.	0.	.00	.00	.000	.000
3	1314.	59.	607.02	607.02	.171	.171
3	1355.	100.	483.90	1090.93	.197	.182
0	0.	0.	.00	.00	.000	.000
5	1401.	0.	.00	.00	.000	.000
5	1506.	65.	466.71	466.71	.120	.120
5	1527.	86.	426.98	893.69	.339	.173
5	1546.	105.	168.61	1062.30	.148	.169
0	0.	0.	.00	.00	.000	.000
1	1026.	0.	.00	.00	.000	.000
1	1133.	67.	317.82	317.82	.079	.079
1	1340.	194.	537.51	855.33	.071	.073
1	1446.	260.	761.08	1616.41	.192	.104

SURFACE DROGUE PATHS, MAY 22,1992

drogue	time	total time	distance	total dist	velocity	ave vel
1	922.	0.	.00	.00	.000	.000
1	950.	28.	324.16	324.16	.193	.193
1	1032.	70.	380.54	704.70	.151	.168
1	1120.	118.	477.25	1181.95	.166	.167
0	0.	0.	.00	.00	.000	.000
4	1013.	0.	.00	.00	.000	.000
4	1100.	47.	787.61	787.61	.279	.279
4	1156.	103.	1295.48	2083.09	.386	.337
0	0.	0.	.00	.00	.000	.000
3	848.	0.	.00	.00	.000	.000
3	933.	45.	382.83	382.83	.142	.142
3	1005.	77.	403.13	785.96	.210	.170
3	1101.	133.	752.40	1538.36	.224	.193
0	0.	0.	.00	.00	.000	.000
2	924.	0.	.00	.00	.000	.000
2	944.	20.	132.20	132.20	.110	.110
2	956.	32.	213.79	345.99	.297	.180
2	1024.	60.	543.75	889.74	.324	.247

SUBSURFACE DROGUE PATHS, MAY 22,1992

drogue	time	total time	distance	total dist	velocity	ave vel
1	922.	0.	.00	.00	.000	.000
1	951.	29.	168.61	168.61	.097	.097
1	1035.	73.	84.29	252.89	.032	.058
1	1130.	128.	60.41	313.30	.018	.041
0	0.	0.	.00	.00	.000	.000
5	1013.	0.	.00	.00	.000	.000
5	1109.	56.	60.42	60.42	.018	.018
5	1150.	97.	186.45	246.87	.076	.042
0	0.	0.	.00	.00	.000	.000
4	848.	0.	.00	.00	.000	.000
4	935.	47.	84.31	84.31	.030	.030
4	1004.	76.	242.81	327.12	.140	.072
4	1052.	124.	117.59	444.71	.041	.060
0	0.	0.	.00	.00	.000	.000
3	1054.	0.	.00	.00	.000	.000
3	1112.	18.	216.05	216.05	.200	.200
3	1144.	50.	132.20	348.25	.069	.116
0	0.	0.	.00	.00	.000	.000
2	924.	0.	.00	.00	.000	.000
2	957.	33.	213.81	213.81	.108	.108
2	1040.	76.	134.37	348.19	.052	.076
2	1138.	134.	381.10	729.29	.110	.091

APPENDIX B

OUTER APRA HARBOR DIVE SITES *

* Taken from "Diver's Guide to Guam and Micronesia, by Tim Rock, 1990.

Outer Apra Harbor Dive Sites

1. The Scotia: Located in approximately 20 feet of water just outside the harbor near the tip of Glass Breakwater. The cable ship ran aground on Calalan Bank in 1904 while trying to enter the harbor. The wreck has been largely destroyed, but some of the features still remain.

2. Harbor Tug: An old harbor tug located just off the seaplane ramp. Superstructure is above water and the hull extends down to 20 feet deep. The tug is used for practice wreck diving.

3. Dogleg Reef: Accessible from shore at a site called Family Beach or Hobie beach. The site consists of a shallow shelf with a dropoff to a sand bottom at -25 feet. The site is noted for the soft and hard coral growths.

4. American Tanker: Big barge or tanker that was sunk as part of the Glass breakwater construction about 40 years ago. Used to train novice divers for wreck diving. The depth ranges from 40 to 130 feet.

5. Val Bomber: One of the more accessible World War II airplane wrecks on Guam. The depth is 90 feet, and it is accessible from the road along the breakwater.

6. Breakwater Tip: Remnants of several ships that have foundered at the mouth of the harbor. Depth range is 20 to 50 feet. The site is accessible from the end of the breakwater.

7. Western Shoals: This diving area is known for its corals, sponges and reef fish. Dive depths are 10 to 80 feet. Access is by boat.

8. Hourglass Reef: This site is located across a narrow deep channel from Western Shoals. It is rated as one of the best dive sites on Guam. Attractions are the growths of coral and sponges. Access is by boat and dive depths are 50 to 100 feet. Dive boats are requested to set their anchors carefully to avoid damaging the corals. There has been past buoy anchor chain damage at this site.

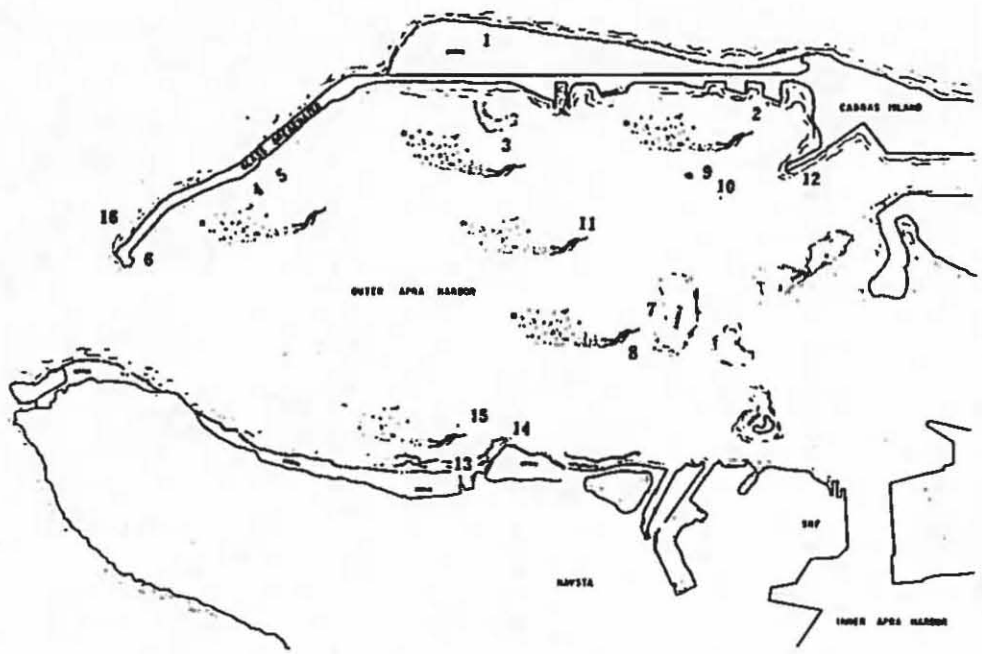
9. Tokai Maru: World War II shipwreck that is a popular dive site. Access is by boat and depths are 50 to 110 feet.

10. The Cormoran: German ship that was scuttled at the start of World War I. It is located just below the Tokai Maru. This ship is protected by law, and it is illegal to remove artifacts from the ship. Access is by boat and depths are 70 to 130 feet.

11. Ki Tsu Gawa Maru: Japanese freighter, sunk by air strikes in World War II. The ship rests upright in the shipping channel of the harbor. Access is bu boat. The top of the ship is at 60 feet, with the bottom of the hull at 160 feet.

12. Nichiyu Maru: Japanese freighter, sunk by naval gunfire prior to the invasion of Guam in 1944. The hull is intact, but the bridge and superstructure were leveled to provide draft clearance for oil tankers at the GORCO fuel pier. Access is by boat or from shore, and dive depths are 40 to 100 feet.

13. Gab-Gab Beach, Gab-Gab Tip, and Gab-Gab II: Three dive sites all located in the immediate vicinity of the Navy's recreational beach. The reefs are known for their coral formations. Access is from boat or shore, and dive depths are 20 to 130 feet.



1. Luminao Reef
2. Harbor Tug
3. Dogleg Reef
4. American Tanker
5. Val Bomber
6. Breakwater Tip
7. Western Shoals
8. Hourglass Reef
9. Tokai Maru
10. The Cormoran
11. Ki Tsu Gawa Maru
12. Nichiyu Maru
13. Gab-Gab
14. Gab-Gab Tip
15. Gab-Gab II
16. The Scotia

FIGURE B-1
DIVE SITES,
APRA HARBOR, GUAM

MARINE ENVIRONMENTAL ASSESSMENT IN THE VICINITY OF THE U. S. NAVAL STATION, GUAM MARIANAS ISLANDS (APRA HARBOR AND TIPALAO BAY)

Prepared for

Belt, Collins & Associates
680 Ala Moana Blvd.
Honolulu, HI 96813

by

Marine Research Consultants
4467 Sierra Dr.
Honolulu, HI 96816

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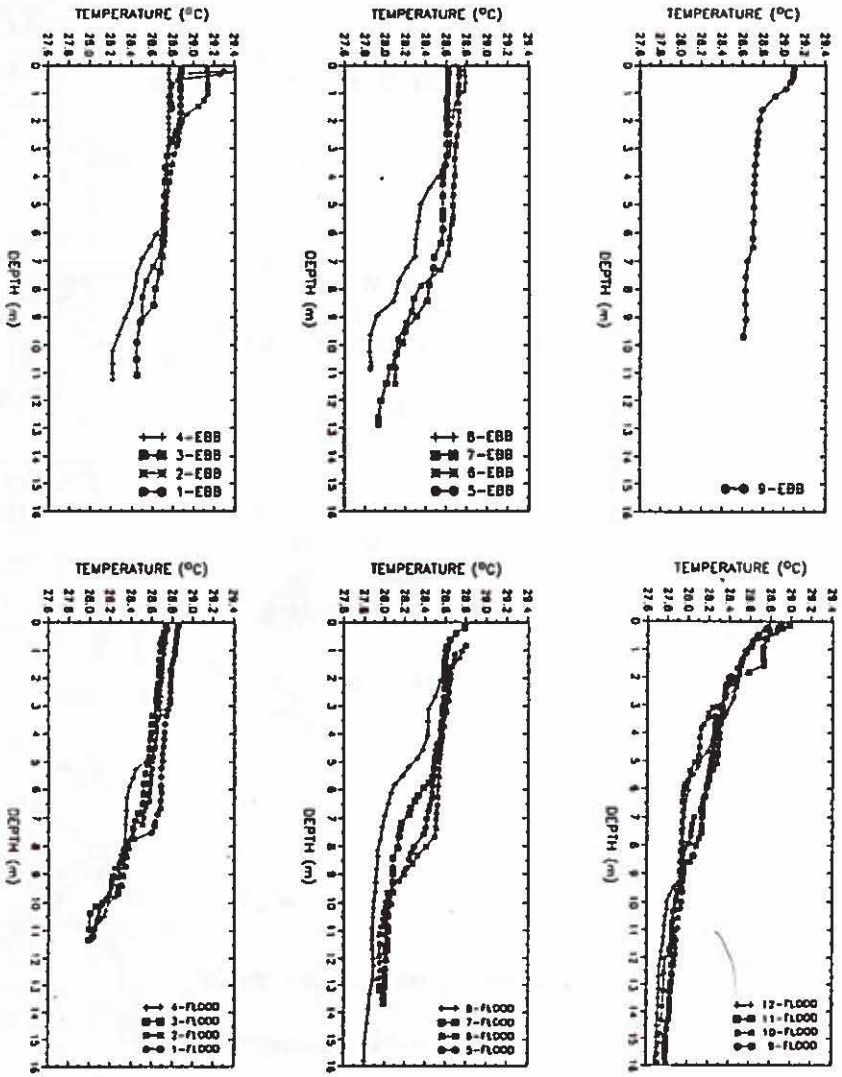

Figure 5. Vertical profiles of temperature (°C) at sampling sites in Apra Harbor measured on May 20, 1992. For station number locations, see Figure 2.

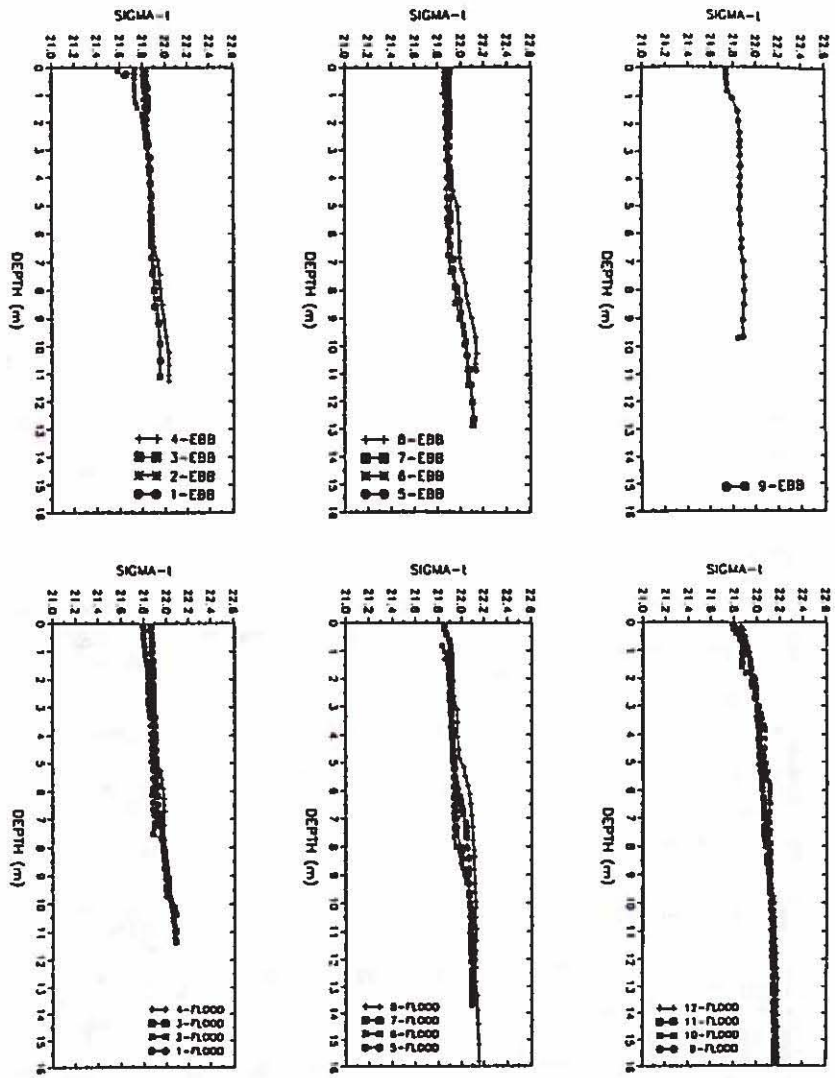

Figure 6. Vertical profiles of Sigma-t at sampling sites in Apra Harbor measured on May 20, 1992. For station number locations, see Figure 2.

FIGURE 7. Map of Apra Harbor showing locations of sediment sampling.

FIGURE 8. Plots showing concentrations of metals in Apra Harbor sediments. Sampling stations are plotted according to location in Harbor, beginning at inner harbor (Station 3) and extending through the outer harbor (Station 2). At each station, plotted concentrations of surface and deep samples are connected with a line, with the surface sample plotted at the left and the deep sample at the right of each pair. For sampling station locations, see Figure 7.

I. INTRODUCTION

Guam is a beneficiary of the relocated missions and personnel from the military withdrawal from the Philippines. Apra Harbor Naval Complex, in particular will be the site of a major build-up of shore support facilities. As a result of the planned build-up, several maintenance and construction projects are planned that have the potential to affect the marine environment in the vicinity of the Naval Station. These projects include maintenance dredging of inner Apra Harbor, temporary expansion of the Apra Harbor Sewage Treatment Plant (STP), and replacement of sheet piles along the banks of a channel bounding the Explosives Ordinance Disposal (EOD) Operations Facility.

Because there is a potential for these actions to result in alteration of the marine environment, field studies have been conducted to assess the existing physical, chemical and biological conditions. Based on such existing conditions, and the projected scope of work associated with the planned expansion projects, it is possible to provide a estimation of the degree of change that can be anticipated under the future scenario. Presented below are the methods, results and conclusions regarding potential environmental status for the three projects at the Guam Naval Station. It is important to note that the scope of the present assessment is considered a preliminary assessment to characterize overall conditions at one point in time, rather than a comprehensive, intensive investigation. As a result, the work does not include such parameters as long-term evaluations of physical processes that would reflect seasonal variability, or comprehensive species lists and quantitative evaluations of community structure. Such studies, which may be implemented at a later date for specific purposes are beyond the scope of the present investigation.

II. MAINTENANCE DREDGING OF INNER APRA HARBOR

A. PURPOSE

In order to ensure safe navigation and berthing operations of increased fleet operations, it is proposed to dredge selected areas of Inner Apra Harbor, including the short channel that connects the inner and outer harbors. The dredged depth will be 40 feet (12.2 meters) below mean lower low water (MLLW) datum. Approximately one million cubic yards of sedimentary materials will be removed by clamshell operation and disposed in an

approved disposal area. Dredging shall be restricted to the western side of the inner Harbor in areas beyond 25 feet off the toe of wharves Alpha, Bravo, Lima,

B. MARINE ENVIRONMENTAL STRUCTURE

Physical and biological community structure of Apra Harbor and vicinity have been described in detail in numerous technical reports, largely in response to addressing environmental impacts of the Piti and Cabras Power Plants located along the northern shoreline of the Harbor (see Amesbury et al. 1977, Department of the Navy 1977, Marsh and Doty 1975, Marsh et al 1977, Naval Ocean Systems Center 1978, Randall and Eldredge Randall and Holloman 1974, Stoikovich 1977). For the present survey, a qualitative reconnaissance survey was conducted of the biotic assemblages in inner and outer Apra Harbor. The purpose of the survey was not to compile an exhaustive species list, but rather to characterize the physical and biotic setting with respect to potential changes that might result from the planned maintenance dredging of the inner harbor.

1. Inner Harbor

The inner Harbor is bounded on the east by a narrow alluvial shoreline several meters wide which supports various vegetation including mangroves. The entire western side of the inner harbor consists of Naval harbor facilities, mostly cement docks and wharfs. Most of the inner Harbor is altered by dredging, although narrow lagoon fringing reef flats are found at the Atantano River and at Abo Cove. Composition of the sediment in the area is a combination of mud, sand and mud intermixed with coral-algal-mollusk rubble. Bottom sediments were marked by numerous burrow holes probably from burrowing crustaceans.

2. Outer Harbor

Outer Apra Harbor is characterized by a variety of environmental settings from clearly degraded areas in dredged areas to relatively pristine, and well developed coral reefs in the outer reaches of the Harbor. The eastern side of the outer Apra Lagoon consists of two extensive land-filled peninsulas, a complex fringing reef and extensive dredged areas. South of Dry Dock Island Peninsula to Polaris Point the fringing reef platform is very irregular and consists primarily of a complex of holes and coral patch reefs and ridges, ranging in depth from emergence at low tide to about 15 m in channels. Tops of the patch reef are covered with fine sand as well as numerous small corals of a variety of species,

and various reef fish and motile invertebrates. Benthic algae, primarily *Halimeda* are also abundant on the reef surfaces. Sloping sides of the patch reefs are covered with a carpet of coral rubble fragments that extend down to sand-filled channel floors. The extensive layer of coral rubble fragments attests to exposure of the area to intermittent periods of high intensity storm waves capable of physical disruption of the reef.

The south side of Apra Lagoon is bounded by Orote Peninsula. A fringing reef platform borders the entire shoreline except a the land-filled eastern end. The reef flat platform is widest on the down-faulted platform at Orote Island. A well-developed reef front extends from the east end of Orote Island to Adotgan Point, where wave assault is high at the mouth of Apra Harbor Channel. Since the construction of Glass Breakwater, the remainder of the fringing reef east of Adotgan Point receives considerably less wave and swell action. In spite of the protection afforded by the breakwater, coral cover on the fringing lagoon reef platform is low at the shallowest depths, likely owing to intermittent wave stress.

The lagoon slope in the outer harbor is steep and well pronounced except where the perimeter has been disturbed by dredging and filling. The steep lagoon slope levels out onto the lagoon floor in the outer harbor, the deep area being bounded by the Calahan Bank on the west, Luminao Reef on the north, Orote fringing reef on the south, and by a series of patch reefs known as Western Shoals and Jade Shoals on the east. The lagoon floor in the outer harbor averages deeper than 30 m, maximum depth being about 50 m at the western end near the deep Apra Harbor Channel. The depth in the channel itself is slightly less than the maximum lagoon depth.

Jade and Western shoals are elongate submarine ridges that are nearly emergent at low tide. The patch reefs rise up from the lagoon floor about 35 m deep on the northwest side and about 25 m deep on the southeast side. At the lower sides and base of the patch reefs, deposits are mostly coral rubble. The lower patch reef slopes are rubbly with algal areas consisting predominantly of sand, rubble, and rocky outcrop. Such substratum grades upward into a region with more rocky outcrops with cliffs and overhanging ledges at the upper margins.

The upper surface of the patch reefs form shallow platforms which, on the southwest sides, have local areas that expose during low tides. In general, these intertidal regions are composed of sand, gravel, rubble, and rubble which thinly veneer an underlying reef rock pavement. Corals are mostly absent in the rubbly areas. The remaining upper

platform surface is somewhat undulatory, ranging in depth from 1 to 2 m, and is predominantly composed of reef rock pavement studded with knobs and knolls populated predominantly with colonies of *Millepora dichotoma*.

Coral growth and development is rich along the lagoon slope and on the sides of the patch reefs. While living coral cover on the lagoon slopes is high, diversity is relatively low with much of the living cover composed of only several species, primarily of the genus Porites. Diversity on the tops the patch reefs and fringing lagoon reefs is higher, but living cover is lower than on the steep sloped areas. A predominant characteristic of all of the patch reefs is a uniform covering of fine sediment on most living and non-living surfaces.

C. WATER CHEMISTRY

1. Methods

Figure 1 shows a map of inner and outer Apra Harbor located on the central western shoreline of the Island of Guam. Also shown are the locations of twelve water chemistry and CTD sampling stations in the inner and outer harbor. All fieldwork was conducted on May 20-21, 1992 working from a small boat. Fieldwork was conducted during a period of calm to light northeasterly winds. At all stations, water was collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) of the water surface, and a bottom sample was collected within 1 m of the Harbor bottom. Water samples were collected by opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice until returned to the laboratory.

Water quality parameters evaluated include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-), hereafter referred to simply as NO_3^-, ammonium (NH_4^+), total phosphorus (TP), chlorophyll a (Chl a), turbidity, temperature, and salinity. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) were reported.

Analyses for NH_4^+, PO_4^{-3}, and NO_3^- + NO_2^- were performed using a Technicon Autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). Total nitrogen (TN) and total phosphorus (TP) were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic

N, and TP and dissolved inorganic P, respectively.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with $HgCl_2$ to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU). Chl a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -20° C for 12-24 hours. Fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001 °/oo. In-situ field measurements of water temperature were taken with a hand-held mercury thermometer with readability to 0.05°C. Continuous profiles of temperature and salinity were acquired with an Ocean Sensors Model 100 CTD.

Water chemistry analyses were performed in two laboratories on Oahu, Hawaii. Dissolved nutrients, turbidity and salinity were analyzed by Marine Analytical Specialists; Chl a were performed by OI Consultants, Inc. Both labs are certified by the State of Hawaii Department of Health for the appropriate analysis.

2. Results

Tables 1 and 2 show results of water chemistry analyses of samples collected at twelve stations in inner and outer Apra Harbor (see Figure 1 for station locations). Table 1 shows results of dissolved nutrient analyses in micromolar (μM) units, while Table 2 shows results in units of micrograms per liter (μg/L). Figures 2 and 3 show histograms of twelve water chemistry constituents in surface and deep samples at each of the twelve sampling sites.

In Figures 2 and 3, inner harbor samples are comprised of Stations 1-8, while outer harbor samples are Stations 9-12. It can be seen in Figure 2 that several constituents exhibit a decreasing pattern of concentration moving from the back of the inner harbor toward the mouth of the outer harbor. Si exhibits the most constant decrease in value with the highest value (4.8 μM) in the deep sample at Station 1, and the lowest value (1.9 μM) in the surface sample of Station 12. Dissolved NO_3^- exhibited slightly higher values (0.04 μM) in the inner harbor landward of Station 5, and uniformly low values near the limits of detection (0.02 μM) at all remaining stations. NH_4^+ exhibited one anomalously high value

(0.77 μM) in the deep sample at Station 2; otherwise concentrations of NH_4^+ did not display a clear pattern of distribution.

Phosphate phosphorus (PO_4^{-3}), DON, DOP, TN and TP all display relatively uniform across the sampling regime from the inner to outer harbor (Figure 2). None of the dissolved nutrients displayed any recognizable pattern with respect to surface and deep samples suggesting that the water column is well mixed.

Salinity displayed a slight, but consistent pattern of increasing values moving from the inner to outer harbor. The range of salinity values through the whole harbor varied by only 0.055°/oo, from 34.562 to 34.617°/oo.

Chl a and turbidity displayed similar patterns, with the highest values in the surface samples at Station 1, lower values in the back region of the inner harbor and higher values toward the channel connecting the inner and outer harbor. Chl a was somewhat higher at Stations 9 and 10 in the outer harbor than within the inner harbor. As with dissolved nutrients, there is not discernible relationship with respect to surface and deep waters for turbidity and Chl a. In addition, the values of turbidity and Chl a are considered extremely low for harbor water.

Temperature (Figure 3) is the only constituent that demonstrated a clear relationship between surface and deep waters. In all cases, surface water was warmer than deep water, likely as a result of solar warming. Within the inner harbor (Stations 1-8), all surface temperatures were similar, and all deep samples were also similar. In the outer harbor, temperatures in surface waters were warmer than in the inner harbor, while bottom waters were substantially cooler. In the outer harbor, it is likely that the cooler deep water is a result of inland movement of deep oceanic water.

Figures 4-6 show vertical profiles of salinity, temperature, and sigma-t at sampling stations shown in Figure 1 during ebbing and flooding tides. With respect to salinity (Figure 6), there is little difference between profiles at the same station at different tidal stages, and at different stations throughout the inner and outer harbor at the same tidal stand. At both states of tide, there is a indication of a surface layer about 1 m thick of less saline water, suggesting input of groundwater or streamflow from the most landward end of the estuary.

Profiles of temperature (Figure 5) all display a cooling trend with depth in the water column. As with the discrete temperature measurements, the largest gradient of temperature, as well as the warmest temperatures occurred in the outer harbor at Stations 9-12. From the structure of the temperature profiles, it appears that the temperature gradients are a result of surface warming by solar insolation and possibly inland movement of oceanic water. Plots of sigma-t reveal consistent density gradients through the water column.

Based on discrete sampling and continuous vertical profiling, it appears that the water column of Apra Harbor is essentially homogeneous. With the exception of temperature gradients caused by solar warming, there is little differentiation between surface and deep waters, nor of waters from the inner and outer harbor. Such uniformity is apparently a result of lack of inputs of freshwater or streamflow for some relatively long period preceding sampling. In addition, lack of wind during the sampling period also results in a lack of stratification from current shear.

C. APRA HARBOR SEDIMENT ANALYSES

1. Methods

Ten sediment cores from inner and outer Apra Harbor were collected by divers using 5 cm diameter Plexiglas coring tubes 1 m in length (see Figure 7 for sampling locations). Where possible, core tubes were carefully inserted into the sediment to a depth of 80 cm, stoppered and carefully extracted. In areas where bottom composition prevented insertion for the full 80 cm, cores were taken from as deep as possible without compacting the core.

Upon return to the surface, sediment was extracted from the core tubes using a piston plunger. Sediment sections 10 cm long from the upper and lower 10 cm of the cores were sliced upon extraction and placed in plastic bags. One sample (#8) was sufficient in quantity for only one sample, resulting in a total of nineteen sediment samples for size fraction analysis and for determination a variety of heavy metals of environmental concern.

In the laboratory, samples were rinsed free of seawater by multiple washings with distilled and deionized water followed by centrifugation. Because of an interest in determining elements that can be potentially lost through volatilization, sediments were

freeze-dried rather than oven dried prior to homogenization. Size fractionation of samples into $>63\ \mu m$, 2-63 μm, and $<2\ \mu m$ fractions was performed by sieving through a 63 μm standard ASTM screen followed by a centrifugation procedure to separate the $<2\ \mu m$ fraction; individual fractions were then weighed.

Approximately 0.25 gram splits of the bulk (not size fractionated) samples were weighed and placed in microwave digestion vessels. Nitric and hydrochloric acids were used to perform a digestion analogous to the EPA method 3050. This procedure is a corrosive attack on the sample which does not completely solubilize all the material. It is, however, intended to release weakly to strongly bound metals in the sample without completely destroying the matrix. The procedure was carried out in closed digestion vessels to minimize contamination and loss of volatiles during digestion. Replicates of three samples were carried through all analytical procedures as was a procedural blank. Elemental analysis was performed by ICP/AES, except Hg which was determined by cold vapor atomic absorption spectrometry.

2. Results

Size fractions by weight are shown in Table 3. For all samples, the largest component of sediment was sand sized particles larger than 63 μm. Sand comprised from 53 to 90% of sediments. Likewise, for all samples the second largest component is silt, comprising from 9 to 39% of sediment. Clays comprised the smallest component of sediment with percentage composition ranging from 1 to 8%. There is only a modest pattern with respect to size composition of sediment and location in the Harbor. Samples from the landward end of the inner Harbor appear to contain greater proportions of sand than samples from the outer Harbor. There is no apparent relationship between depth in the core and size distribution.

Elemental concentrations of the harbor sediments are shown in Table 4. For comparative purposes typical values from a variety of other sediments are also shown in Table 4. Overall, heavy metal concentrations in the Apra Harbor samples are elevated relative to natural crustal abundances, soils, and deep-sea sediments, but are not particularly enriched when compared to sediments from Pearl Harbor or the Ala Wai Canal. Figure 8 presents the elemental abundance data as a function of station position within the harbor, beginning in the innermost harbor near the U.S. Coast Guard Buoy Depot, and progressing outward toward the ocean (see Figure 7 for sampling locations). Generally,

elements of environmental concern exhibit decreasing concentrations moving seaward, reflecting a lesser influence of anthropogenic activity from land.

There are, however, some interesting deviations from the general trend described above. Cadmium (Figure 8) is more enriched in the deep sediments of stations 3, 5, 6, and 7 than in the corresponding surface sediments, suggesting that the Cd flux to the sediments is currently lower than in the past. Stations 4 and 8 display significantly lower Cd concentrations than observed at neighboring inner harbor sites. As will be shown subsequently, sediments from Station 8 are anomalous in all respects. Station 8 was located in the channel between the inner and outer Harbor, and was located on a low rise of more consolidated bottom compared to the surrounding softer sediment that characterized most of the Harbor floor.

Lower Cd levels at Station 4 may result from its position further from the inner Harbor and/or (more likely) further from the docks. At Stations 9 and 10, deep sediments display lower Cd contents than at the surface and concentrations at the latter approach those at Stations 8, 1, and 2. The highest Cd level of 3.8 ppm found in Apra harbor sample 3-D is similar to 3.4 ppm Cd found in Pearl Harbor, but lower than the 4.9 ppm found 32 cm below the sediment surface in the Ala Wai canal. The lowest Cd level in Apra Harbor, however, is a factor of two or more elevated than soils, and both deep-sea and river sediments (see Table 4).

Copper concentrations in Apra harbor (Figure 8) span an order of magnitude between 255 ppm (7-S) and 22 ppm (10-D). Again, a generally decreasing trend is observed towards the ocean except that samples from Stations 7 and 9 exhibit concentrations of approximately a factor of two higher than in the inner harbor (3). The low end of this range is in line with natural sediments but below deep-sea clay. The high end is similar to Ala Wai canal sediments (185 ppm) and likely reflects the use of copper oxide in antifoulant bottom paints for ships. Station 7 is located closest to high ship-activity docks; the high levels at Station 9 in the outer harbor are more difficult to explain.

Cobalt concentrations (Figure 8) also display a decreasing trend towards the ocean with no significant anomalies, except at Station 8 where the lowest levels are observed. Overall contents are in line with those of soils and other sediments, but from three to ten times lower than in sediments from the Ala Wai canal.

The plot of Pb in Apra harbor sediments (Figure 8) shows a trend very similar to that exhibited by Cu with Stations 7 and 9 exhibiting maxima relative to other harbor areas. As observed for Cu, near background concentrations are observed beyond Station 9. The Pb content of the outer stations is, however, more elevated than average sediments, soils, or lake sediments, although it is similar to that found in deep-sea clays and river sediments. Sediments from Pearl Harbor display similar levels to those observed in Apra Harbor, but those from the Ala Wai canal are nearly an order of magnitude higher, probably as a result of street runoff of Pb halides decomposition products from gasoline additives.

Nickel and Mo (Figure 8) also exhibit a decreasing trend toward the ocean. No significant surface/deep trends are apparent, except at Station 5 where Ni concentrations are significantly higher in the deep sediments. Sediments of Station 8 display the lowest Ni values, but Mo contents are not significantly different than those observed further towards the ocean. Nickel contents in Apra harbor are typical of soils, lower than those of river sediments, and nearly an order of magnitude lower than in deep-sea clays and sediments from the Ala Wai canal. However, Mo levels are nearly an order of magnitude higher in Apra harbor sediments than in the average sediment, are twice those in river sediments, similar to concentrations observed in deepsea clays and soils, and approximately half those in Ala Wai canal sediments.

Generally deep sediments exhibit lower Zn concentrations than those at the surface; Stations 7 and 9 again display particularly higher concentrations, whereas Zn at Station 8 is somewhat more elevated than at Station 6 and the outer Stations 10, 1 and 2. The abundance of Zn at Stations 7 and 9 may be attributable to the use of sacrificial Zn anodes on boats or to enhanced street runoff at these sites (Zn is used in the vulcanization of rubber); the former explanation appears more plausible. Overall, Zn levels are within the range of soils and sediments, but much lower than river sediments or the Ala Wai canal. Concentrations of V decrease steadily outward, with particularly low levels observed at Station 8, and slightly higher levels at Stations 1 and 2 than at Station 10. The highest levels in Apra Harbor (Stations 3 and 4) are a factor of two lower than in sediments from the Ala Wai canal, but very much in line with soils and other sediments.

Chromium concentrations (Figure 8) exhibit trends similar to those of Cu, Pb, and Zn, with high values at Stations 7 and 9, and low values at Stations 8, 10, 1, and 2. Concentrations are approximately two to three times those of the average sediment,

typical of soils and other sediments including Pearl harbor, and two to four times lower than observed in sediments from the Ala Wai canal.

Extremely low Ba concentrations were observed in Apra Harbor sediments; these are approximately two to three orders of magnitude lower than in soils and sediments and an order of magnitude lower than in the Ala Wai canal sediments. The low concentrations may result from non-release of Ba from source minerals in the digestion procedure employed in this study. This also indicates a very low abundance of anthropogenic Ba in Apra harbor sediments.

Tin concentrations (Figure 8) exhibit the same general trend as observed for other environmentally interesting elements. Peak concentrations of approximately 1000 ppm occur in the innermost sites and concentrations drop to a few hundred ppm in the outer harbor. Again Station 8 is anomalous with values substantially below all other inner Harbor samples. Of interest is the low level at Stations 10 and 2 relative to Stations 9 and 1. Despite the trend of decreasing Sn content seaward, harbor sediments are enriched by approximately two orders of magnitude over background levels (see Table 4), however, they are a factor of three lower than found in the Ala Wai canal. The Sn in sediments likely results from compounds such as tributyl tin and other alkyl tin compounds used as antifoulant for boat hulls.

Concentrations of Sr in Apra harbor sediments can be used as a proxy for the amount of $CaCO_3$ in the sediments. Generally the Sr content of the sediments increases seaward, with a particularly elevated content at Station 8 that matches closely that at Station 2.

Overall, metal concentrations in sediments in Pearl Harbor, Hawaii, are generally similar to those observed in Apra Harbor, but more variability is apparent in the current data set, possibly reflecting a greater number of samples analyzed in the current study. Although many metals determined in Apra harbor sediments exhibit concentrations above those found in deep-sea sediments and average soils, they are not particularly elevated in terms of posing a pollution hazard. Globally, most harbor sediments are typically contaminated with metals from land runoff. Note for example that the 32-36 cm deep interval of sediments from the Ala Wai canal, Honolulu, Hawaii are much more influenced by anthropogenic activity than those of Pearl or Apra harbors. The sediments in the Ala Wai water body reflect a greater extent of non-point source metal contamination because the (saltwater) canal drains a highly urbanized portion of Honolulu in addition to being a

back basin to a small-craft harbor. Data provided for comparison purposes for river sediment, deep-sea sediment, and deep-sea clays, etc. are from Lantzy and Mackenzie (1979) and Salomons and Forstner (1984).

E. CONCLUSIONS

Maintenance dredging of the inner harbor will likely produce temporary increased sediment loading to the water column. Transport of sediment-laden water out of the inner harbor could increase levels of sediment deposition in the outer harbor. Evaluation of water quality in the inner and outer harbor indicated that there are only minor differences between the two areas, and that the water throughout the harbor is essentially non-stratified. While it is likely that such a situation is not typical of the entire spectrum of weather and season, it provides some indication that circulation between the inner and outer harbor is limited during periods of low wind stress. Thus, it appears that trasport of sediment-laden water from the inner harbor to the outer harbor will be minimal during periods of low wind velocity.

Chemical characteristics of sediment samples collected throughout the inner and part of the outer harbor indicate that while there is a detectable gradient moving seaward there are no extreme differences between composition in the proposed dredge area and other regions of the harbor. In addition, the lack of distinct vertical gradients in chemical constituents in the top meter of sediment indicates that removal of the surface sediment layer will result in exposure of material with substantially different composition that presently exists at the surface.

A consistent characteristic of outer harbor environments was a predominance of sediment, both deposited on the floor of the lagoon, and on the surface of patch and fringing reefs. In addition, patinas of fine sediment were apparent on the surfaces of most benthic organisms, including many corals and algae. It is apparent that these reefs are periodically exposed to severe storm stress capable of breaking coral skeletons and resuspending sediments. Thus, the communities inhabiting the outer harbor are exposed to periodic sediment stress from natural causes.

The environmental composition within the inner harbor is presently a function of previous dredging operations that were considerably more extensive than the proposed action. The outer harbor appears to be consistently subjected to resuspension of sediments

by natural factors. Resuspension of dredged material should not be qualitatively different than resuspension from natural factors. Quantities of resuspended material originating from the dredging action should be controllable by silt curtains, or other mechanical controls. All of these factors suggest that if the proper precautions are employed (e.g. silt curtains) there appears to be little potential for permanent, or irreversible impacts to harbor environments as a result of maintenance dredging.

III. APRA HARBOR SEWAGE TREATMENT PLANT

A. PURPOSE

Because of the increase in homeported ships and tempo of fleet operations that could significantly impair the integrity of the existing sewage collection, treatment and disposal system. Expansion of the Apra Harbor Sewage Treatment Plant (STP) is necessary to accomodate and ensure proper treatment and disposal of the wastewater generated within the Apra Harbor Naval Complex. Expansion will consist of construction of a new secondary clarifier, solids contactor, and drying beds, as well as modification of existing treatment, chlorination and dechlorination equipment. In addition, construction is planned for a new offshore diffuser to replace the existing structure.

At the present time, primary treated effluent flows from a open pipe at the shoreline into the Philippine Sea just to the north of Tipalao Bay (see Figure 9). Underwater diffusers previously functioned to disperse the effluent offshore, but the diffuser and the discharge pipe are no longer connected owing to breakage by impact from typhoon waves. The present authorization to discharge under the National Pollutant Discharge Elimination System is based upon a design capacity of 12,112 m^3 day^{-1} (3.2 million gallons per day). Conditions of the NPDES permit do not require monitoring of receiving waters, and there is no designation of a specific Zone of Mixing (ZOM). It is anticipated that effluent discharge volume may increase by 0.5 mgd as a result of expansion. While a new diffuser is in the planning stages, it is apparent that the increased effluent volume will, at least temporarily, be discharged on the shoreline through the existing system. Understanding the existing effects of the effluent discharge to water quality is essential for evaluating potential impacts from the proposed expansion of the wastewater discharge facility.

B. METHODS

Figure 9 shows a map of the Tipalao area from Apuntua Point to Neye Island showing the location of the sewage outfall in a small notch in the limestone shoreline just north of Tipalao Bay. Also shown are the locations of 15 water chemistry, indicator bacteria and CTD sampling stations in the vicinity of the outfall. A 16th open ocean sampling station was located approximately 2 km offshore beyond the boundaries of the map.

All fieldwork was conducted on May 20-21, 1992 working from a small boat. Fieldwork was conducted during a period of calm to light northeasterly winds. With the exception of sampling Station 1 and the open ocean sample, water was collected at two depths at each of the locations shown in Figure 9; a surface sample was collected within approximately 10 cm of the water surface, and a bottom sample was collected within 1 m of the Harbor bottom. Water samples were collected by opening 1-liter polyethylene bottles at the desired depth. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice until returned to the laboratory.

Water quality parameters evaluated included those constituents which are influenced by inputs of organic material from land. These constituents include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-), hereafter referred to simply as NO_3^-, ammonium (NH_4^+), total phosphorus (TP), chlorophyll a (Chl *a*), turbidity, temperature, and salinity. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) were reported because these parameters are sensitive indicators of sewage effluent and freshwater input.

Analyses for NH_4^+, PO_4^{3-}, and NO_3^- + NO_2^- were performed using a Technicon Autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). Total nitrogen (TN) and total phosphorus (TP) were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) were calculated as the difference between TN and dissolved inorganic N, and TP and dissolved inorganic P, respectively.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with $HgCl_2$ to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Monitek Model 21 nephelometer, and reported in nephelometric turbidity

units (NTU). Chl a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -20° C for 12-24 hours. Fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001 °/oo. In-situ field measurements of water temperature were taken with a hand-held mercury thermometer with readability to 0.05°C. Continuous profiles of temperature and salinity were acquired with an Ocean Sensors Model 100 CTD.

Viable indicator bacteria were evaluated in each of the water samples. Water samples were collected in 150 ml specimen cups, and chilled on ice. Upon return to the laboratory samples were filtered through 0.4 μ sterile membrane filters. Culture and counting were performed according to procedures in American Public Health Association (1986). Filters from fecal coliform samples were placed on a sterile medium of M-FC agar and incubated at 44.5°C. Enterococci filters were incubated at 41°C on ME agar. The number of bacteria colonies in the coliform filter were counted following a 24-hour incubation. The enterococci filters were incubated for 48 hours, then transferred to a sterile medium of Esculin indicating agar and incubated another 20 minutes at 41°C. After this treatment, enterococci colonies were counted as brown or black spots on the underside of the filter paper. For both types of bacteria, the number of colonies is reported per 100 ml of water.

Water chemistry analyses were performed in two laboratories on Oahu, Hawaii. Dissolved nutrients, turbidity and salinity were analyzed by Marine Analytical Specialists; Chl a and bacterial analyses were performed by OI Consultants, Inc. Both labs are certified by the State of Hawaii Department of Health for the appropriate analysis.

C. RESULTS

1. Description of the Receiving Environment

Prior to the water sample collection, a reconnaissance of the outfall pipe and surrounding area was conducted by SCUBA divers. As described above, the outfall terminated in an open pipe several meters above sea level at the shoreline. At the location of the outfall terminus, the effluent stream entered the ocean after flowing out of the open pipe. On the surface, the effluent was evident as a distinct plume marked by floating particulates and foamy residues. From underwater, the location of the effluent stream was

clearly evident by a surface layer of effluent. The surface effluent layer was approximately 1 m thick, and was distinctly evident owing to difference in color and refractive index in comparison to underlying ocean water. While the surface layer was evident for a distance of approximately 100 m from the outfall, at no point was it apparent that the plume extended through the entirety of the water column.

The ocean floor in the vicinity of the outfall consisted of smooth, rolling limestone surfaces that terminated at the shoreline in near vertical limestone bedded cliffs that extended from approximately 20-30 m above sea level to 5-10 m below sea level. In many areas the shoreline cliffs were undercut with ledges, and indented with caves. In the area directly fronting the notch where the diffuser emptied into the ocean, large boulders were scattered on the smooth limestone sea floor. In the vicinity of the outfall, the bottom was strewn with a variety of debris including pipes, cables, and machinery. Approximately 50 m from of the shoreline, the diffuser structure stretched seaward. While heavily armored, it was evident on inspection that the diffuser was not sufficient to withstand the force of storm waves.

2. Horizontal Contour Profiles

Tables 5 and 6 show results of all marine water chemistry analyses from waters in the vicinity of the Guam Naval Station STP, with dissolved nutrient concentrations expressed in micromolar units (μM) micrograms per liter (μg/L), respectively. In addition to the samples collected in the vicinity of the diffuser, a surface sample was also collected approximately 2 km from shore. This sample represents open coastal ocean conditions, and provides a comparison to water quality within the influence of the outfall.

Because of the gridded sampling pattern, a useful method of exhibiting the horizontal patterns of distribution of various chemical constituents is with contour plots. Figures 10 through 21 show contour plots of each constituent in surface and deep samples. Contour plots of surface salinity (Figure 10) reveal a distinct zone of decreased salinity in the vicinity of the discharge that extends off shore in the downwind northwest direction. At stations near the shoreline to the southeast (upwind) of the diffuser (#'s 2 and 3), surface salinity is similar to open ocean conditions (34.6°/oo) suggesting little influence from the discharge or other inputs from land. Contours of deep salinity values do not indicate decreased values in the vicinity of the diffuser. Such a pattern reflects relatively rapid dilution of the effluent plume in surface waters, with little or no mixing with waters below the surface layer.

The contour plot for Si (Figure 11) shows very similar patterns as salinity with a concentrated area of influence directly over, and downcurrent from the outfall. As with salinity, the pattern of influence is present only in surface waters, and is not evident in deep waters.

Contour plots of inorganic nitrogen, NO_3^- (Figure 12), and NH_4^+ (Figure 13) and inorganic phosphorus, PO_4^{3-} (Figure 14) all reveal similar patterns as described above for salinity and silica. The area of influence in surface waters is restricted to a region within approximately 100 m of the downwind side of the outfall. Beyond this distance surface values are not substantially different than concentrations in open ocean water collected approximately 1 mile from shore (see Table 5). At all stations, bottom water samples are not noticeably different in dissolved inorganic nutrient composition than open ocean waters. The lack of gradients in deeper waters indicates that the sewage plume is maintained as a surface layer owing to differential density of the effluent.

Contour plots of dissolved organic nitrogen and phosphorus (Figures 15 and 16) do not display the same zonal pattern as inorganic nutrients. Both of these constituents display similar gradients of gradually decreasing values with distance from the shoreline throughout the sampling grid. For both DON and DOP, maximum values were not measured in the sample taken from the effluent jet (#1), but from stations downwind (#'s 5, 6 and 7). Contrary to inorganic nutrients which displayed distinct vertical partitioning, concentrations and patterns of distribution of organic N and P are similar in surface and deep samples. Concentrations of DON and DOP in the sample collected from directly under the outfall (#1) are approximately 3-fold higher than open ocean water (Table 5).

Contours of turbidity (Figure 19) reveal a slight increase in the surface layer directly under the diffuser and at the downwind stations within 200 m of the outfall. In surface waters there was a slight indication of a decreasing gradient with distance from the shoreline, while the opposite trend was evident in deep waters. Except for the sample collected in the sewage jet (#1), no values of turbidity exceeded 0.17 n.t.u.

Contour plots of Chl a (Figure 20) display no apparent pattern with respect to distance from the outfall in either surface or deep samples. Temperature also showed no recognizable gradients as a function of the outfall (Figure 21). Water temperature from the sample collected in the effluent jet was the same as measured in the open ocean control sample (see Table 5).

3. Vertical Profiles

Figures 22-24 show vertical profiles of salinity, temperature and sigma-t at the thirteen stations shown in Figure 9. Profiles of salinity reveal steep gradients in the upper 1 m at Stations 1, 4, 5, 6 and 14. The largest magnitude of the surface gradient was 1.25‰, from 33.25 and 34.50‰. Below the 1-m thick surface layer at these stations, and throughout the entire water column at the remaining stations, salinity was invariant at about 34.5‰.

Temperature profiles (Figure 21) do not display the same pattern of surface stratification as did salinity. The majority of stations displayed gradually cooler temperatures with depth. The single exception was Station 4 which exhibited a distinctly cooler layer in the upper 1 m of the water column. The maximum excursion of temperature from the entire set of profiles was 0.45°C, from 27.50° to 27.95°. As the temperature measured in the water sample collected directly under the outfall did not display substantially different temperature than receiving waters, it is not surprising that the vertical profiles do no display a distinct pattern with respect to proximity to the discharge. Vertical profiles of sigma-t (Figure 24) are virtually identical to salinity, indicating that density of the water column is primarily a function of salinity, rather than temperature.

4. Bacterial Indicators

Tables 5 and 6 lists colony counts of fecal coliform and enterococci bacteria at stations shown in Figure 9. Figure 25 shows histograms of colony abundance at each sampling site for surface and deep samples. It can be seen in Figure 25 that the highest colony counts (4 colonies) of enterococci were measured in the outfall jet (#1) and in the surface and bottom samples at Station just upwind of the outfall. Two colonies of enterococci were also measured in surface samples at Station 3, 6 and 12.

The pattern of fecal coliforms counts was similar to enterococci. Forty-four colonies were measured in the effluent plume at Station 1, while from 2 to twelve colonies were observed at Stations 2, 4, 5, 6 and 12 (see Table 5).

The pattern of abundance of indicator bacteria suggests that there is little potential for public health concerns or environmental impacts from the Guam Naval Station Sewage Treatment Plant. The relatively low counts at only several of the sampling stations

suggests that few viable cells were present in the effluent during the sampling, and that the cells are rapidly dispersed and/or inactivated during initial mixing with seawater. As a means of comparison of the extent of contamination, State of Hawaii water quality standards place limits of seven counts of enterococci and two hundred counts of fecal coliform for geometric means of five samples collected in a thirty-day interval for recreational waters. While the sampling protocol for the Guam Sewage Treatment Plant did not conform to the multiple sampling strategy over a fixed interval of time, it can be seen that the number of viable cells at all stations (including the effluent stream) can be considered below the potentially hazardous level.

5. BIOTIC COMMUNITY STRUCTURE

Reconnaissance surveys of the area in the vicinity of the Sewage Treatment Plant discharge revealed an extremely depauperate biological setting. Destruction of the heavily fortified diffuser pipe attests to the extreme wave stress that impacts the area as a result of typhoons and tropical storms. Because most long-lived sessile fauna and flora are not able to withstand such physical forces, the submerged shoreline and offshore sea floor is largely devoid of macrobenthos. In the region of the diffuser, small encrusting colonies of corals of the genera *Porites*, *Pocillopora*, *Montipora* and *Leptastrea* were observed, primarily on the sides of boulders. No branching species were observed. In Tipalao Bay, stands of macrothalloid algae, predominantly of the genus *Padina* was observed. Such algal beds did not extend beyond the mouth of the bay to the region of sewage discharge.

C. CONCLUSIONS

Investigation of the Guam Navy Station Sewage Plant were conducted over two days. Thus, in drawing any conclusions based on survey results, it must be remembered that physical environmental setting during other conditions of wind, current, or wave climate may result in a different set of results. However, because the present survey was conducted during a period of low wind and wave mixing, results may represent a "worst case" scenario in that dispersion of the effluent by advective forces was minimal, allowing the plume to maintain a maximum of integrity.

Based on the survey results, the effects of the sewage effluent discharge of approximately 3 mgd from the severed discharge pipe on the shoreline is minimal to receiving waters. Increase in dissolved inorganic nutrients (N and P) that are contained in the effluent stream are confined to a surface layer approximately 1 m thick that extended

approximately 150 m along the shoreline in a downwind direction. Effects were limited to within 100 m of the shoreline. Little effect was detectable in deeper waters below the surface layer. As a result, there appeared to be virtually no areas other than the submerged cliffed shoreline adjacent to the area where the effluent jet enters the ocean where the effluent plume is in contact with the seafloor.

At the time of sampling, direction of movement of the effluent plume was dictated by surface winds; with the prevailing easterly winds there was no evidence of the plume in Tipalao Bay. During periods of northerly or westerly winds, however, it would be expected that the plume would travel in a southeasterly direction toward Tipalao Bay. While the surface plume did was visible owing to surface slicks, testing for indicator bacteria indicated that the chlorination process, as well as mixing with ocean water, is effective in minimizing potential public health problems.

It goes without saying that the present situation of sewage discharge from a broken pipe onto the shoreline represents a sub-optimal situation. However, it does not appear from the survey results that the present scenario is resulting in substantial environmental impacts. Owing to the same extremely harsh environmental conditions that preclude a workable offshore diffuser, biotic components of the area are extremely limited in abundance. Owing to the differential density of the effluent (whether discharged from the shoreline or from an offshore diffuser) and ocean water, there is little opportunity for contact of benthos with the effluent. As a result, other than visual and odor impacts, there appears to be virtually no negative environmental effects. It does not appear that proposed increase in flow capacity of approximately 0.5 mgd should not result in any different situation as was observed during the present survey. With completion of a new offshore diffuser structure and upgraded treatment facilities, it is also likely that the increased flow will have virtually no negative environmental impacts.

IV. EOD BULKHEAD

The EOD facility is located along the banks of a small channel leading to a recreational boating marina that is approximately 1 km west of the entrance to inner Apra Harbor. Most of the channel shoreline has been stabilized with vertical steel sheetpile bulkheads. The sheetpile extend from approximately 2.5 m above MLW into the channel bottom. Water depths along the seaward face of the sheetpiles range from 1.5 m to 5 m. The channel, at least the part fronting the EOD facility appears to have been dredged, and has an average depth of 5 m. In some areas there is a narrow shelf at the base of the

bulkhead that terminates in a vertical drop to the channel floor. In other areas, the water depth at the base of the bulkhead is similar to the depth of the channel floor. The water depth along the south face of the facility is typically less than that along the west face.

Biological communities inhabiting the bulkhead consist primarily of two groups, corals and sea urchins. Dense stands of several species of "fire coral" *Millepora* (*M. dichotoma, M. latifolia, M. platyphlla*) are the most common colonizer of the vertical wall. In many areas, thickets of *Millepora* were also growing on the sediment comprising the floor of the channel. Owing to the scattered distribution, it appeared that the colonies on the channel floor were broken off from original points of attachment on the vertical bulkhead.

The other dominant colonizer of the bulkhead were large encrustations of *Porites spp*. These corals formed large (up to 1 m in diameter) hemispherical coverings of the vertical surfaces. Other than corals, the dominant fauna on the bulkhead and the channel floor were the long-spined sea urchins, *Diadema sp.* Numerous urchins were observed on the soft sediment channel floor, often in dense aggregations of several hundred individuals. It does not appear that any of the biotic components inhabiting the area represent rare or unique resources, and pending restoration or repair work on the bulkhead, recolonization should restore the area to the present state.

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TABLE 1. Water chemistry measurements in Apra Harbor collected on May 20, 1992. Abbreviations as follows: S = surface; D = deep; BDL = below detection limit. For sampling site locations, see Figure 1.

STATION NO.	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	TEMP (deg.C)
APH-1 S	0.06	0.05	0.07	4.57	0.23	6.16	0.29	6.28	0.23	34.570	0.46	28.8
1 D	0.07	0.04	BDL	4.76	0.24	6.92	0.31	6.96	0.17	34.588	0.21	28.7
2 S	0.04	0.05	0.33	4.22	0.20	7.69	0.24	8.07	0.15	34.591	0.12	28.7
2 D	0.05	0.06	0.77	4.10	0.31	9.52	0.36	10.35	0.14	34.596	0.11	28.6
3 S	0.04	0.05	0.22	3.78	0.31	7.38	0.35	7.65	0.18	34.598	0.14	28.7
3 D	0.05	0.05	0.22	3.82	0.22	6.67	0.27	6.94	0.15	34.593	0.15	28.6
4 S	0.06	0.03	0.19	3.82	0.24	6.13	0.30	6.35	0.10	34.599	0.13	28.7
4 D	0.07	0.03	0.23	4.33	0.22	6.61	0.29	6.87	0.18	34.594	0.21	28.6
5 S	0.08	0.06	0.53	4.39	0.25	8.66	0.33	9.25	0.16	34.602	0.16	28.8
5 D	0.08	0.02	0.29	3.28	0.23	7.36	0.31	7.67	0.18	34.591	0.13	28.6
6 S	0.05	0.01	0.51	3.91	0.21	7.51	0.26	8.03	0.19	34.600	0.22	28.8
6 D	0.05	0.01	0.20	3.96	0.14	6.77	0.19	6.98	0.21	34.597	0.17	28.6
7 S	0.05	BDL	0.28	3.52	0.23	7.13	0.28	7.41	0.18	34.602	0.21	28.8
7 D	0.05	0.01	0.25	3.53	0.23	6.28	0.28	6.54	0.16	34.600	0.19	28.6
8 S	0.05	BDL	0.25	3.34	0.19	6.10	0.24	6.35	0.18	34.601	0.12	28.7
8 D	0.05	0.01	0.20	3.22	0.24	7.00	0.29	7.21	0.18	34.593	0.18	28.5
9 S	0.05	0.02	0.19	2.92	0.22	6.13	0.27	6.34	0.15	34.562	0.26	29.0
9 D	0.05	0.01	0.17	2.94	0.21	5.73	0.26	5.91	0.14	34.604	0.21	28.3
10 S	0.05	0.01	0.14	2.33	0.17	5.30	0.22	5.45	0.13	34.606	0.25	29.0
10 D	0.04	0.01	0.19	2.56	0.20	5.26	0.24	5.46	0.16	34.605	0.22	28.2
11 S	0.03	0.02	0.24	2.09	0.19	7.47	0.22	7.73	0.15	34.617	0.19	28.9
11 D	0.04	0.01	0.16	2.18	0.18	6.35	0.22	6.52	0.12	34.610	0.19	28.1
12 S	0.04	0.01	0.16	1.88	0.19	5.49	0.23	5.66	0.11	34.611	0.16	28.8
12 D	0.03	0.02	0.11	1.94	0.18	6.10	0.21	6.23	0.11	34.605	0.12	28.1

TABLE 2. Water chemistry measurements (in µg/L) in Apra Harbor collected on May 20, 1992. Abbreviations as follows: S = surface; D = deep; BDL = below detection limit. For sampling site locations, see Figure 1.

STATION NO.	PO4 (µgP/L)	NO3 (µgN/L)	NH4 (µgN/L)	Si (µgSi/L	DOP (µgP/L)	DON (µgN/L)	TP (µgP/L)	TN (µgN/L)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	TEMP (deg.C)
APH-1 S	1.86	0.70	0.98	128	7.13	86.24	8.99	87.92	0.23	34.570	0.46	28.8
1 D	2.17	0.56	BDL	134	7.44	96.88	9.61	97.44	0.17	34.588	0.21	28.7
2 S	1.24	0.70	4.62	119	6.20	107.66	7.44	112.98	0.15	34.591	0.12	28.7
2 D	1.55	0.84	10.78	115	9.61	133.28	11.16	144.90	0.14	34.596	0.11	28.6
3 S	1.24	0.70	3.08	106	9.61	103.32	10.85	107.10	0.18	34.598	0.14	28.7
3 D	1.55	0.70	3.08	107	6.82	93.38	8.37	97.16	0.15	34.593	0.15	28.6
4 S	1.86	0.42	2.66	107	7.44	85.82	9.30	88.90	0.10	34.599	0.13	28.7
4 D	2.17	0.42	3.22	122	6.82	92.54	8.99	96.18	0.18	34.594	0.21	28.6
5 S	2.48	0.84	7.42	123	7.75	121.24	10.23	129.50	0.16	34.602	0.16	28.8
5 D	2.48	0.28	4.08	92	7.13	103.04	9.61	107.38	0.18	34.591	0.13	28.6
6 S	1.55	0.14	7.14	110	6.51	105.14	8.06	112.42	0.19	34.600	0.22	28.8
6 D	1.55	0.14	2.80	111	4.34	94.78	5.89	97.72	0.21	34.597	0.17	28.6
7 S	1.55	BDL	3.92	99	7.13	99.82	8.68	103.74	0.18	34.602	0.21	28.8
7 D	1.55	0.14	3.50	99	7.13	87.92	8.68	91.56	0.16	34.600	0.19	28.6
8 S	1.55	BDL	3.50	94	5.89	85.40	7.44	88.90	0.18	34.601	0.12	28.7
8 D	1.55	0.14	2.80	90	7.44	98.00	8.99	100.94	0.18	34.593	0.18	28.5
9 S	1.55	0.28	2.66	82	6.82	85.82	8.37	88.76	0.15	34.562	0.26	29.0
9 D	1.55	0.14	2.38	83	6.51	80.22	8.06	82.74	0.14	34.604	0.21	28.3
10 S	1.55	0.14	1.96	65	5.27	74.20	6.82	76.30	0.13	34.606	0.25	29.0
10 D	1.24	0.14	2.66	72	6.20	73.64	7.44	76.44	0.16	34.605	0.22	28.2
11 S	0.93	0.28	3.36	59	5.89	104.58	6.82	108.22	0.15	34.617	0.19	28.9
11 D	1.24	0.14	2.24	61	5.58	88.90	6.82	91.28	0.12	34.610	0.19	28.1
12 S	1.24	0.14	2.24	53	5.89	76.86	7.13	79.24	0.11	34.611	0.16	28.8
12 D	0.93	0.28	1.54	55	5.58	85.40	6.51	87.22	0.11	34.605	0.12	28.1

TABLE 3. Percentage by weight of sand, silt and clay size classes of sediment from Apra Harbor, Guam. For sample locations, see Figure 7.

SAMPLE	SAND >63μm	SILT 2-63μm	CLAY <2μm
1-S	65.7	32.3	2.0
1-D	53.3	38.7	8.0
2-S	62.6	36.3	1.1
2-D	70.7	28.1	1.2
3-S	89.6	8.9	1.4
3-D	66.5	27.5	6.0
4-S	83.4	13.3	3.3
4-D	72.6	19.9	7.4
5-S	78.7	18.9	2.4
5-D	85.5	11.7	2.7
6-S	90.1	8.8	1.0
6-D	80.7	15.8	3.5
7-S	61.2	36.0	2.9
7-D	78.3	19.5	2.2
8-S	82.9	16.2	0.1
9-S	62.5	35.4	2.1
9-D	74.0	24.3	1.7
10-S	61.2	37.3	1.6
10-D	63.2	34.7	2.1

TABLE 4. Concentrations of metals in sediments from Apra Harbor, Guam. For comparison, concentrations in various other sediments are also shown. For sample locations, see Figure 7. "S" indicates surface sample; "D" indicates deep sample in core. All concentrations are in p.p.m.

SAMPLE	Sn	Cd	Cu	Co	Ni	Mo	Pb	V	Ba	Zn	Sr	Cr	Hg
1-S	349	2.13	37.1	9.1	14.4	14.0	50.5	88.5	4.73	49.8	6618	76.1	n.d.
1-D	415	2.14	37.2	11.4	189.5	17.6	56.5	99.7	4.96	46.4	5993	84.9	n.d.
2-S	200	1.88	30.1	6.0	10.3	15.2	56.3	66.2	5.46	36.3	8216	62.2	n.d.
2-D	256	2.05	35.4	7.9	12.6	16.2	57.5	74.3	5.61	39.0	7950	63.9	n.d.
3-S	994	3.44	95.3	28.1	36.9	18.6	105.2	146.5	4.35	127.5	2627	113.0	0.64
3-D	917	3.76	73.6	28.3	36.7	19.7	96.4	135.3	4.70	102.2	2514	106.0	1.12
4-S	1055	2.63	70.4	25.9	36.2	17.5	67.7	143.6	3.33	77.1	3150	105.0	1.44
4-D	751	2.59	32.2	21.8	32.4	19.2	54.3	135.4	4.07	29.5	3929	105.0	1.68
5-S	875	3.23	118.5	20.1	30.6	17.9	92.4	124.1	4.88	127.6	4582	107.0	1.68
5-D	967	3.47	47.1	29.1	40.6	20.1	67.0	150.7	3.93	39.7	2942	113.0	0.79
6-S	856	3.01	41.0	24.9	33.3	21.0	58.4	125.5	4.08	38.3	3985	94.4	1.35
6-D	908	3.34	37.3	27.2	31.6	19.4	56.6	126.2	4.89	33.7	3814	99.4	1.64
7-S	826	3.02	254.6	18.6	27.1	16.9	138.8	111.7	9.17	278.5	4675	129.0	1.70
7-D	726	3.08	176.1	17.4	24.1	15.5	122.6	106.4	6.96	208.0	4656	112.0	2.40
8-S	148	1.93	52.3	5.2	7.6	13.6	42.8	51.1	7.34	51.9	8324	64.0	0.14
9-S	535	3.12	210.8	14.5	21.4	15.5	131.8	97.8	7.17	222.9	5289	113.0	0.99
9-D	522	2.88	238.4	13.0	20.9	15.3	138.1	91.2	7.29	235.6	5516	126.0	1.74
10-S	245	2.41	34.9	8.7	11.5	14.9	56.8	73.5	5.87	34.1	6886	68.9	0.27
10-D	184	2.02	21.6	7.5	8.8	12.8	45.9	68.3	5.67	16.2	7218	59.8	n.d.
Ala Wai Canal	3713	5.73	206.5	65.9	204.4	34.9	772.7	228.0	43.57	375.5	571	279.0	–
Average Soil	5	0.62	25.8	12.0	33.7	11.3	29.2	108.0	568	59.8	278	84.0	0.10
Lake Sediment	–	0.40	45.0	16.0	66.0	–	34.0	–	–	118.0	–	118.0	0.35
Deepsea Red Clay	1.5	0.42	250.0	74.0	250.0	13.0	80.0	120.0	2300	165.0	110	90.0	0.08
River Sediment	–	1.00	100.0	20.0	90.0	5.0	150.0	170.0	600	350.0	150	100.0	–
Average Sediment	4.6	0.17	33.0	14.0	52.0	2.0	79.0	105.0	460	–	–	–	–
Pearl Harbor													
FT1S-1		3.40					67.5			377		88.2	1.60
FT1S-2		1.20					68.3			371		83.6	1.20
FT1D-1		2.17					90.9			256		88.8	3.80
FT1D-2		1.83					93.9			256		89.3	4.70
FT2S-1		1.63					65.5			263		99.1	1.40
FT2S-2		1.26					64.3			247		94.1	1.40
FT2D-1		1.74					131.0			276		97.7	3.10
FT[illegible]		1.69					133.0			277		[illegible]	3.00

ABLE 5. Water chemistry measurements in the vicinity of the Guam Naval Station Sewage Treatment Plant collected on May 21, 1992. Abbreviations as follows: S = surface; D = deep; O.O. = open ocean; FC = fecal coliforms; ENT = Enterococcus. For sampling site locations, see Figure 7.

STATION NO.	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	DOP (µM)	DON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	TEMP (deg.C)	ENT (col/100ml)	FC (col/100ml)
GNS-1 S	0.31	0.25	30.58	16.29	0.23	8.37	0.54	39.20	0.36	31.917	0.12	27.9	4	44
2 S	0.07	0.07	0.21	1.00	0.29	8.42	0.36	8.70	0.17	34.566	0.08	27.8	0	0
2 D	0.09	0.10	0.15	1.13	0.32	7.08	0.41	7.33	0.12	34.568	0.10	27.7	0	2
3 S	0.08	0.02	0.21	1.34	0.30	6.82	0.38	6.85	0.09	34.572	0.04	27.8	2	0
3 D	0.08	0.02	0.17	1.00	0.19	6.25	0.27	6.44	0.09	34.568	0.10	27.7	0	0
4 S	0.13	0.22	5.25	3.90	0.22	7.08	0.35	12.53	0.15	34.107	0.07	27.6	0	8
4 D	0.08	0.04	0.36	1.49	0.31	6.58	0.39	6.98	0.12	34.529	0.08	27.8	0	0
5 S	0.17	0.17	7.51	4.76	0.21	7.59	0.38	15.27	0.17	33.974	0.08	27.8	4	12
5 D	0.10	0.05	0.73	1.63	0.40	7.63	0.50	8.41	0.13	34.506	0.11	27.7	4	6
6 S	0.10	0.11	0.71	1.57	0.43	6.63	0.53	7.45	0.13	34.510	0.09	27.9	2	4
6 D	0.09	0.11	0.23	1.32	0.24	7.17	0.33	7.51	0.11	34.518	0.11	27.9	0	0
7 S	0.13	0.11	3.94	3.27	0.30	8.86	0.43	12.91	0.12	34.234	0.10	27.7	0	0
7 D	0.09	0.03	0.39	1.57	0.26	6.56	0.35	6.98	0.09	34.535	0.07	27.7	0	0
8 S	0.12	0.10	3.01	3.07	0.29	5.98	0.41	9.09	0.09	34.300	0.07	27.9	0	0
8 D	0.09	0.02	0.25	1.51	0.29	5.86	0.38	6.13	0.08	34.576	0.09	27.7	0	0
9 S	0.10	0.05	0.27	2.00	0.26	6.24	0.36	6.56	0.10	34.575	0.09	27.7	0	0
9 D	0.11	0.07	0.34	1.38	0.21	4.39	0.32	4.80	0.11	34.572	0.06	27.7	0	0
10 S	0.11	0.08	0.29	2.06	0.19	3.76	0.30	4.13	0.11	34.576	0.07	27.8	0	0
10 D	0.10	0.15	0.25	1.37	0.17	3.55	0.27	3.95	0.10	34.572	0.08	27.7	0	0
11 S	0.10	0.03	0.31	1.41	0.18	3.50	0.28	3.84	0.09	34.586	0.06	27.8	0	0
11 D	0.09	0.05	0.36	1.49	0.17	3.19	0.26	3.60	0.18	34.581	0.09	27.7	-	-
12 S	0.09	0.04	0.34	1.54	0.16	4.63	0.25	5.01	0.11	34.577	0.10	27.7	2	2
12 D	0.08	0.03	0.24	1.57	0.18	3.51	0.26	3.78	0.14	34.580	0.07	27.7	-	-
13 S	0.10	0.05	0.31	1.61	0.15	3.82	0.25	4.18	0.13	34.578	0.08	27.9	0	0
13 D	0.09	0.04	0.36	1.66	0.21	4.36	0.30	4.76	0.16	34.577	0.25	27.8	-	-
14 S	0.09	0.02	0.28	1.68	0.15	3.59	0.24	3.89	0.12	34.586	0.07	27.9	0	0
14 D	0.10	0.13	0.32	1.76	0.15	3.19	0.25	3.64	0.19	34.578	0.06	27.8	-	-
15 S	0.10	0.05	0.33	1.72	0.16	2.75	0.26	3.13	0.11	34.573	0.04	27.9	0	0
15 D	0.09	0.09	0.37	1.73	0.16	2.75	0.25	3.21	0.14	34.581	0.89	27.7	-	-
O.O. S	0.10	0.02	0.33	1.78	0.17	2.58	0.27	2.93	0.09	34.586	0.03	27.9	0	0

TABLE 6. Water chemistry measurements (in µg/L) in the vicinity of the Guam Naval Station Sewage Treatment Plant collected on May 21, 1992. Abbreviations as follows: S = surface; D = deep; O.O. = open ocean; FC = fecal coliforms; ENT = Enterococcus. For sampling site locations, see Figure 7.

STATION NO.	PO4 (µgP/L)	NO3 (µgN/L)	NH4 (µgN/L)	Si (µgSi/L	DOP (µgP/L)	DON (µgN/L)	TP (µgP/L)	TN (µgN/L)	TURB (NTU)	SALINITY (o/oo)	CHL a (µg/L)	TEMP (deg.C)	ENT (col/100ml)	FC (col/100ml)
GNS-1 S	9.61	3.50	428.12	458	7.13	117.18	16.74	548.80	0.36	31.917	0.12	27.9	4	44
2 S	2.17	0.98	2.94	28	8.99	117.88	11.16	121.80	0.17	34.566	0.08	27.8	0	0
2 D	2.79	1.40	2.10	32	9.92	99.12	12.71	102.62	0.12	34.568	0.10	27.7	0	2
3 S	2.48	0.28	2.94	38	9.30	92.68	11.78	95.90	0.09	34.572	0.04	27.8	2	0
3 D	2.48	0.28	2.38	28	5.89	87.50	8.37	90.16	0.09	34.568	0.10	27.7	0	0
4 S	4.03	3.08	73.50	110	6.82	98.84	10.85	175.42	0.15	34.107	0.07	27.6	0	8
4 D	2.48	0.56	5.04	42	9.61	92.12	12.09	97.72	0.12	34.529	0.08	27.8	0	0
5 S	5.27	2.38	105.14	134	6.51	106.26	11.78	213.78	0.17	33.974	0.08	27.8	4	12
5 D	3.10	0.70	10.22	46	12.40	106.82	15.50	117.74	0.13	34.506	0.11	27.7	4	6
6 S	3.10	1.54	9.94	44	13.33	92.82	16.43	104.30	0.13	34.510	0.09	27.9	2	4
6 D	2.79	1.54	3.22	37	7.44	100.38	10.23	105.14	0.11	34.518	0.11	27.9	0	0
7 S	4.03	1.54	55.16	92	9.30	124.04	13.33	180.74	0.12	34.234	0.10	27.7	0	0
7 D	2.79	0.42	5.46	44	8.06	91.84	10.85	97.72	0.09	34.535	0.07	27.7	0	0
8 S	3.72	1.40	42.14	86	8.99	83.72	12.71	127.26	0.09	34.300	0.07	27.9	0	0
8 D	2.79	0.28	3.50	42	8.99	82.04	11.78	85.82	0.08	34.576	0.09	27.7	0	0
9 S	3.10	0.70	3.78	56	8.06	87.36	11.16	91.84	0.10	34.575	0.09	27.7	0	0
9 D	3.41	0.98	4.76	39	6.51	61.46	9.92	67.20	0.11	34.572	0.06	27.7	0	0
10 S	3.41	1.12	4.06	58	5.89	52.64	9.30	57.82	0.11	34.576	0.07	27.8	0	0
10 D	3.10	2.10	3.50	38	5.27	49.70	8.37	55.30	0.10	34.572	0.08	27.7	0	0
11 S	3.10	0.42	4.34	40	5.58	49.00	8.68	53.76	0.09	34.586	0.06	27.8	0	0
11 D	2.79	0.70	5.04	42	5.27	44.66	8.06	50.40	0.18	34.581	0.09	27.7	-	-
12 S	2.79	0.56	4.76	43	4.96	64.82	7.75	70.14	0.11	34.577	0.10	27.7	2	2
12 D	2.48	0.42	3.36	44	5.58	49.14	8.06	52.92	0.14	34.580	0.07	27.7	-	-
13 S	3.10	0.70	4.34	45	4.65	53.48	7.75	58.52	0.13	34.578	0.08	27.9	0	0
13 D	2.79	0.56	5.04	47	6.51	61.04	9.30	66.64	0.16	34.577	0.25	27.8	-	-
14 S	2.79	0.28	3.92	47	4.65	50.26	7.44	54.46	0.12	34.586	0.07	27.9	0	0
14 D	3.10	1.82	4.48	49	4.65	44.66	7.75	50.96	0.19	34.578	0.06	27.8	-	-
15 S	3.10	0.70	4.62	48	4.96	38.50	8.06	43.82	0.11	34.573	0.04	27.9	0	0
15 D	2.79	1.26	5.18	49	4.96	38.50	7.75	44.94	0.14	34.581	0.89	27.7	-	-
O.O. S	3.10	0.28	4.62	50	5.27	36.12	8.37	41.02	0.09	34.586	0.03	27.9	0	0

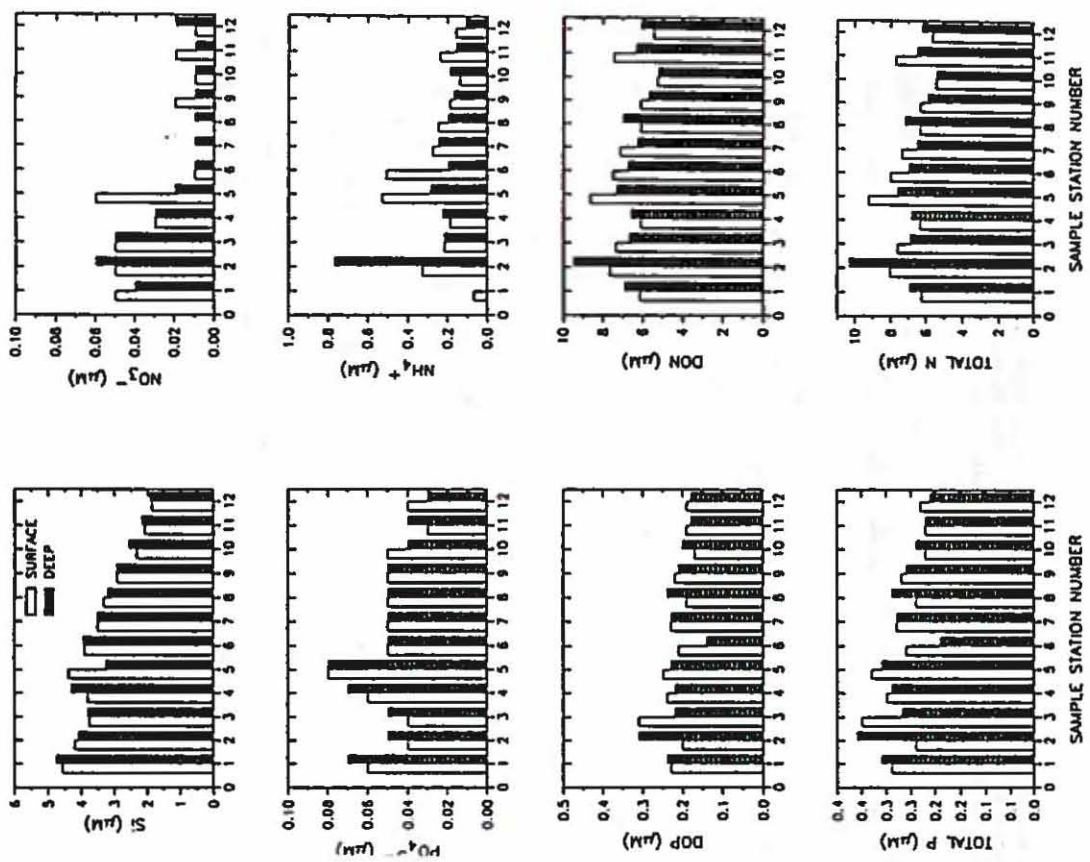


FIGURE 2. Histograms showing concentrations of water chemistry constituents in surface and deep waters of inner (Stations 1-8) and outer (Stations 9-12) Apra Harbor. For station locations, see Figure 1.

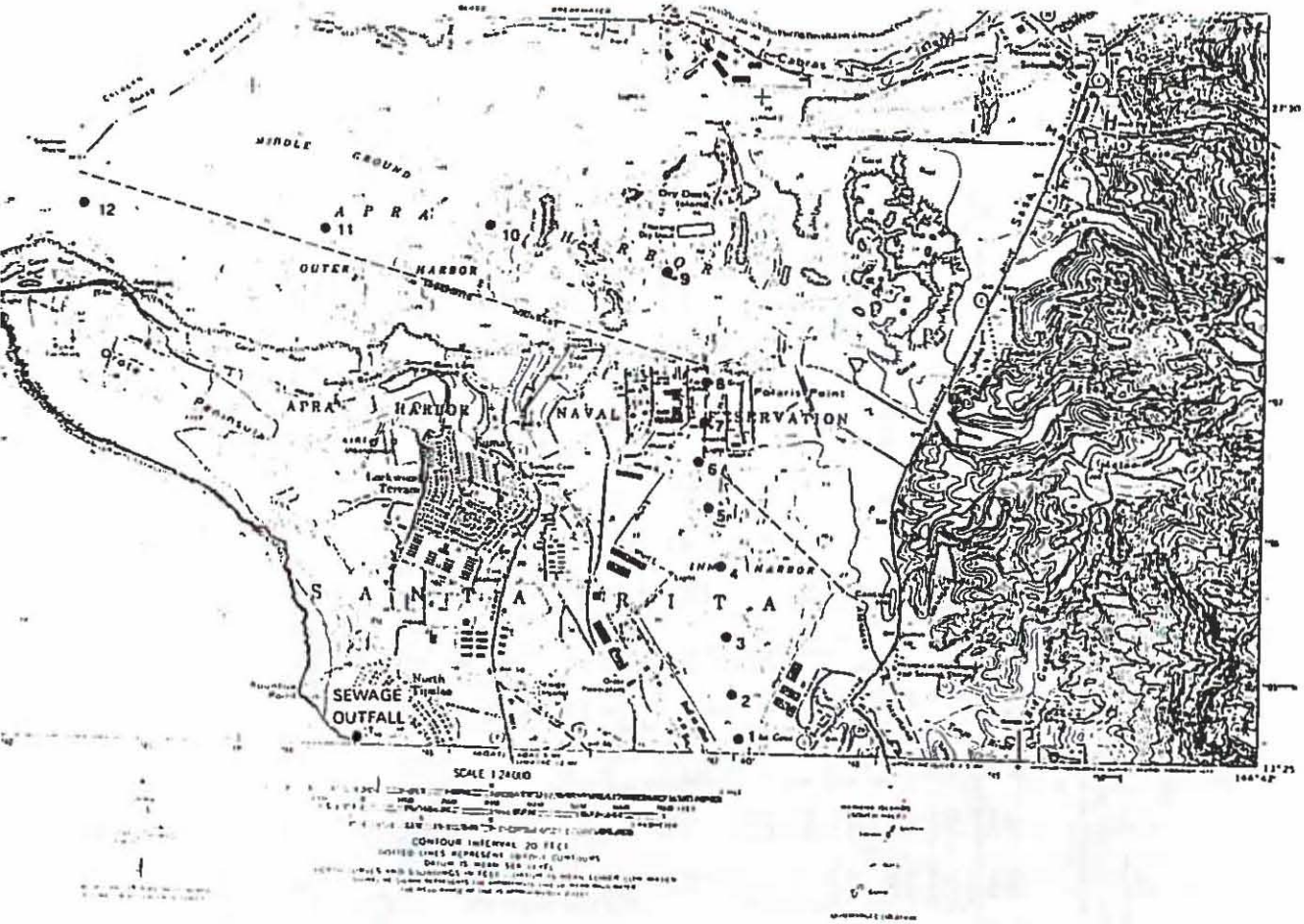


FIGURE 1. Map of Apra Harbor showing locations of water sampling, indicator bacteria, and CTD sampling stations. Also shown is location of Guam Naval Station sewage outfall near Tipalao Bay

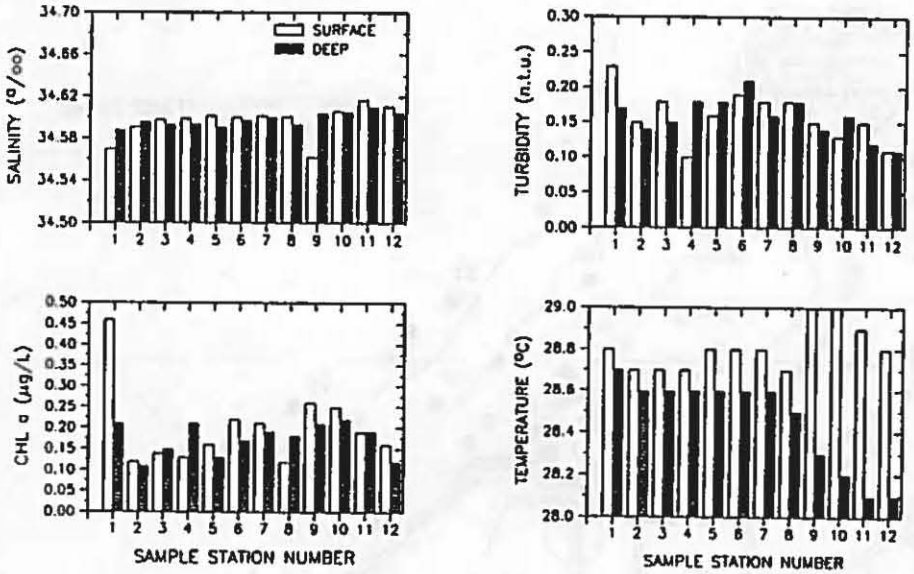


FIGURE 3. Histograms showing concentrations of water chemistry constituents in surface and deep waters of inner (Stations 1-8) and outer (Stations 9-12) Apra Harbor. For station locations, see Figure 1.

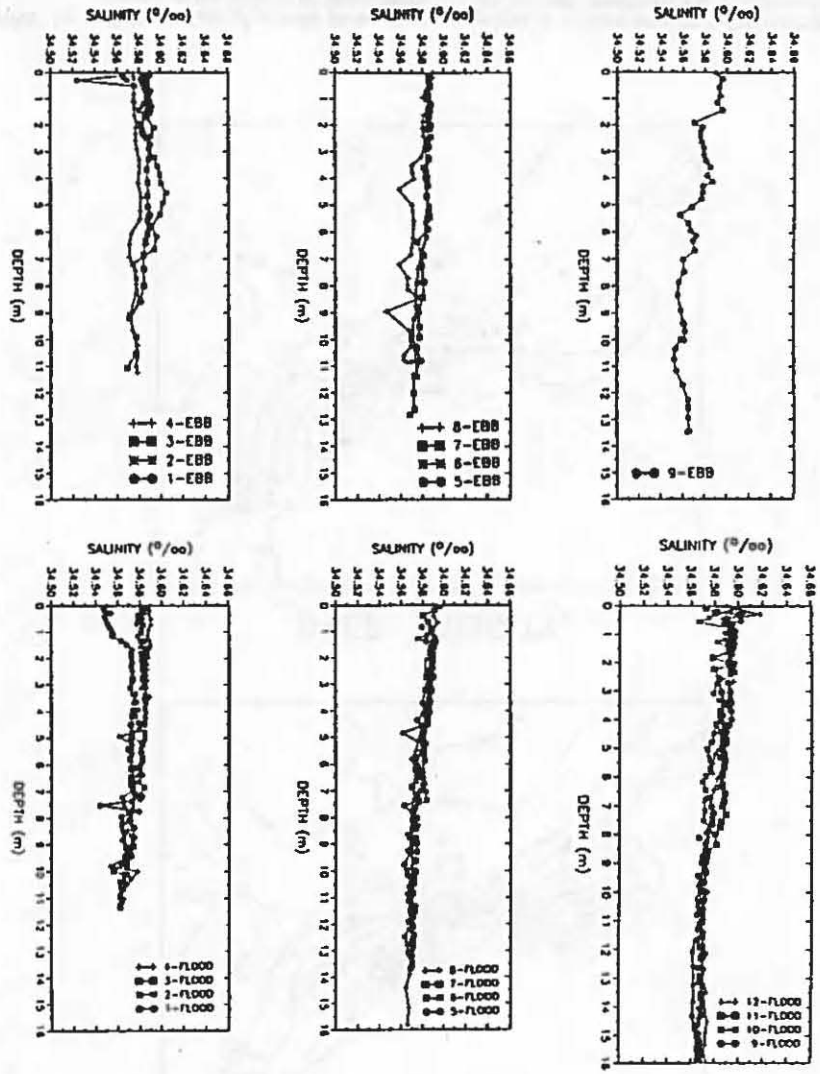


Figure 4. Vertical profiles of salinity (in parts per thousand) at sampling sites in Apra Harbor measured on May 20, 1992. For station number locations, see Figure 2.

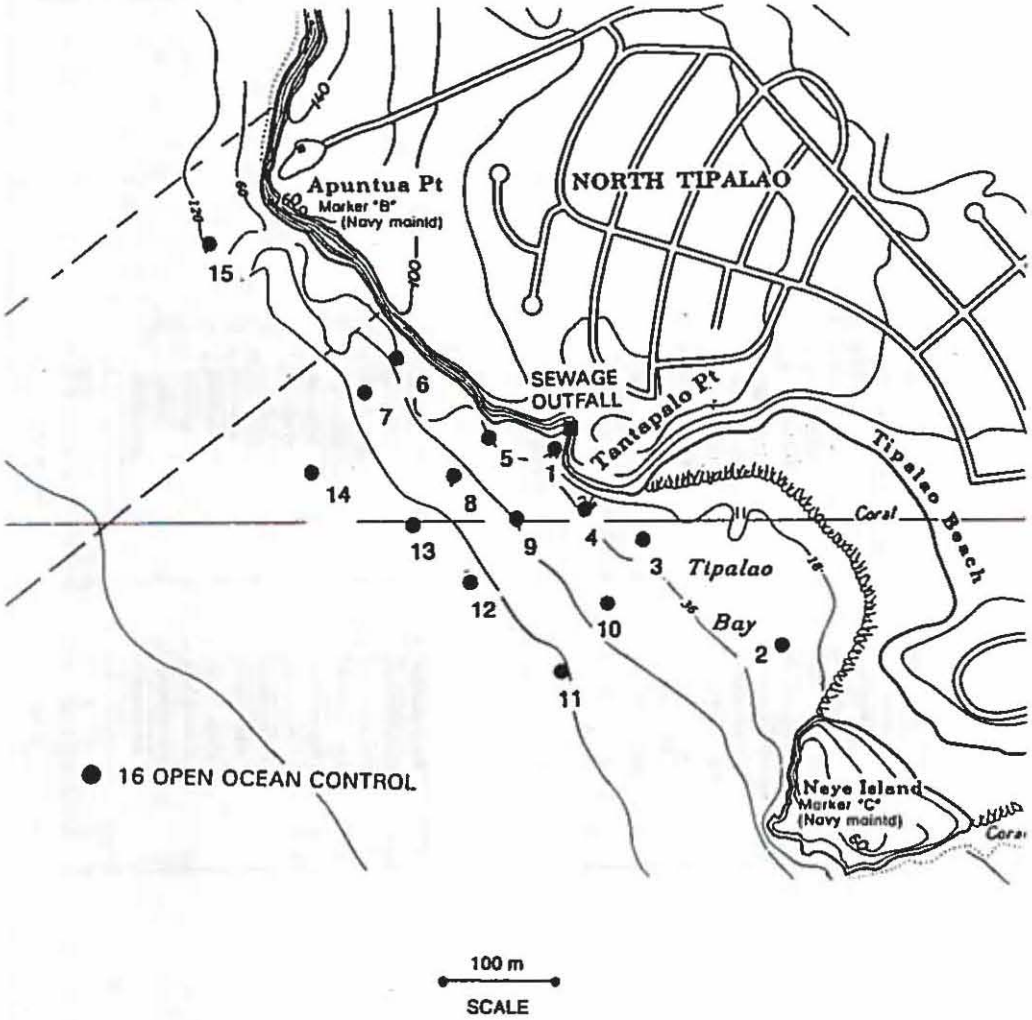


FIGURE 9. Map of Tipalao Bay and nearby shoreline showing location of Apra Harbor Guam Naval Station Sewage Treatment Plant Outfall. Also shown are numbered stations sampled for water chemistry and indicator bacteria. Station 16 is an open ocean sample collected approximately 1 mile from the shoreline.

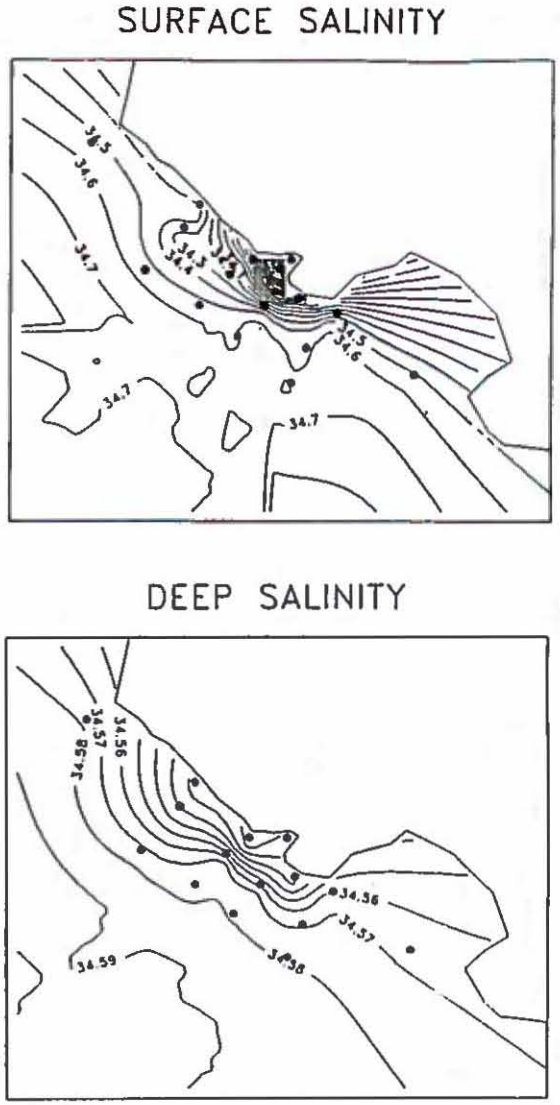
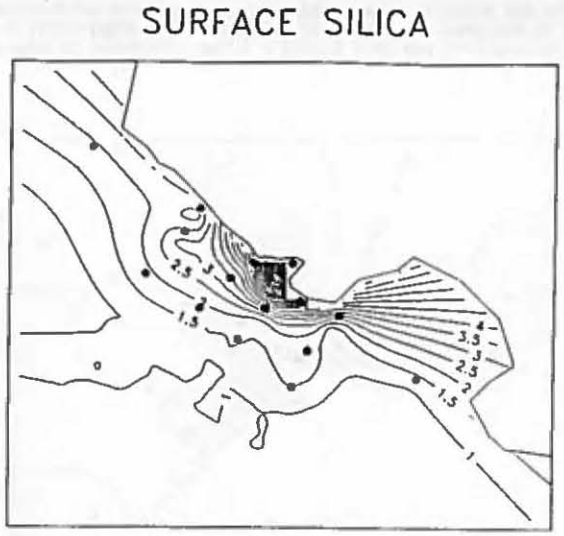


FIGURE 10. Contour plots of salinity (in parts per thousand) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.



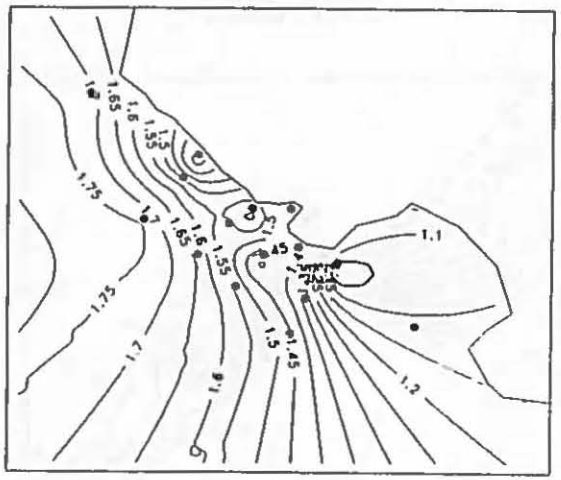
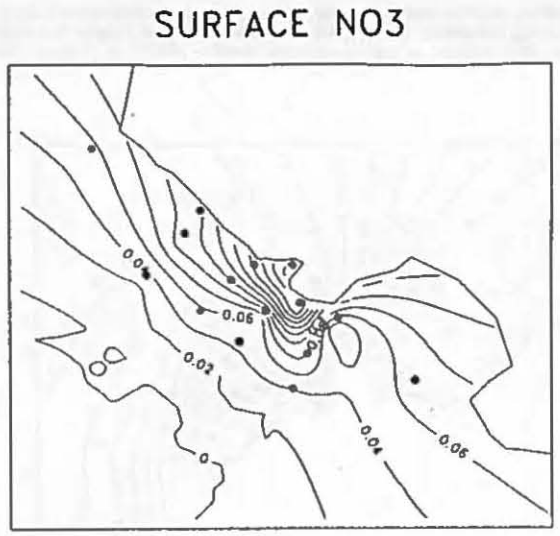


FIGURE 11. Contour plots of silica (Si) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.



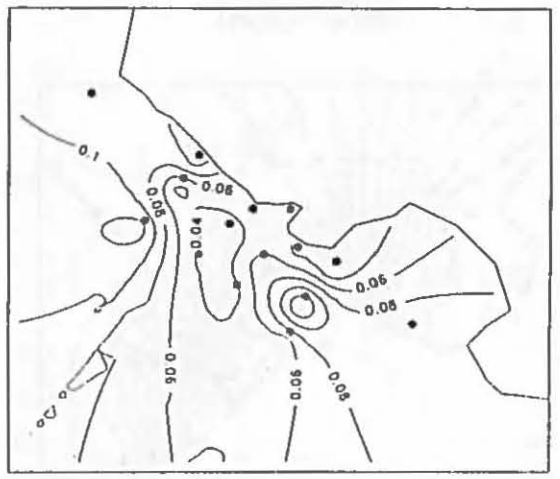


FIGURE 12. Contour plots of nitrate (NO_3^-) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.

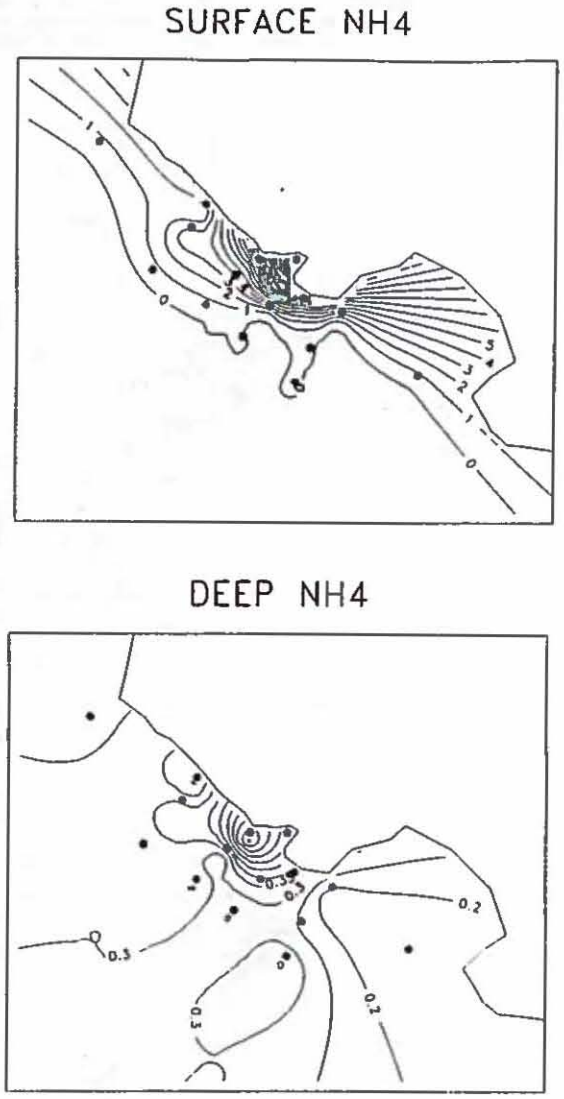


FIGURE 13. Contour plots of ammonium (NH_4^+) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.

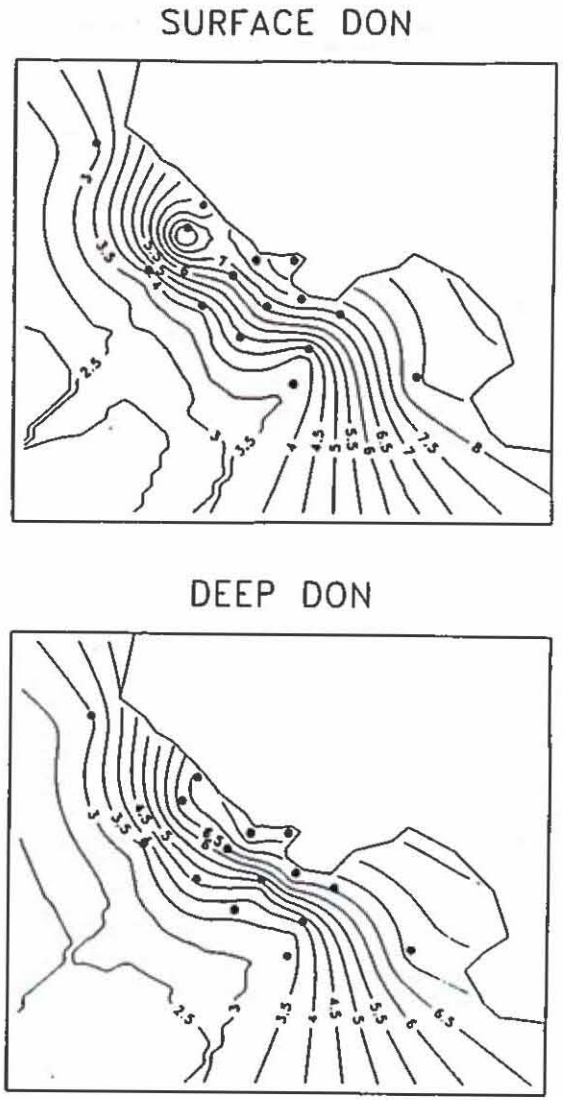
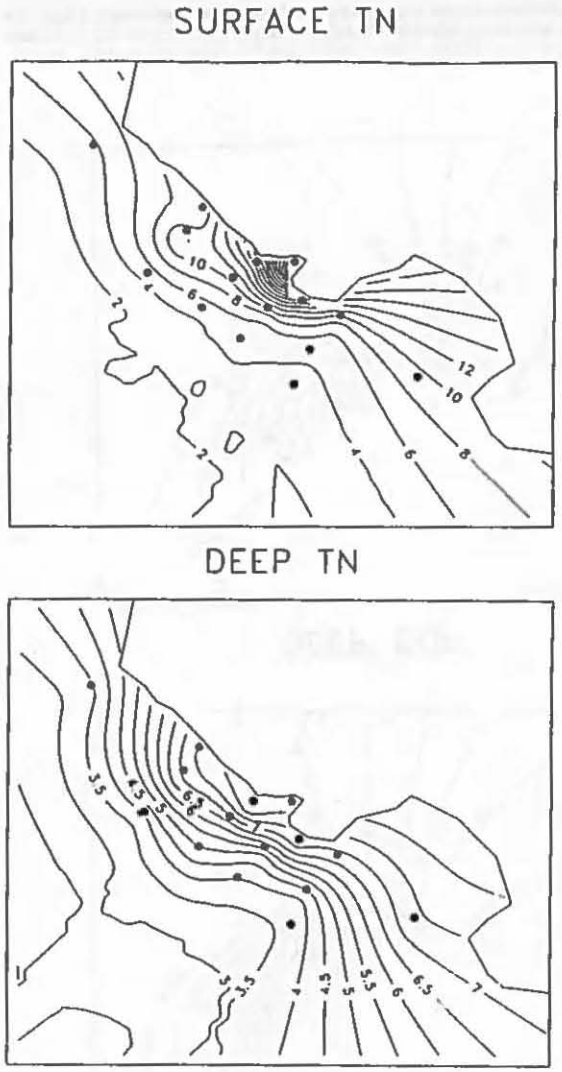


FIGURE 14. Contour plots of dissolved organic nitrogen (DON) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.



GURE 15. Contour plots of total nitrogen (TN) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.

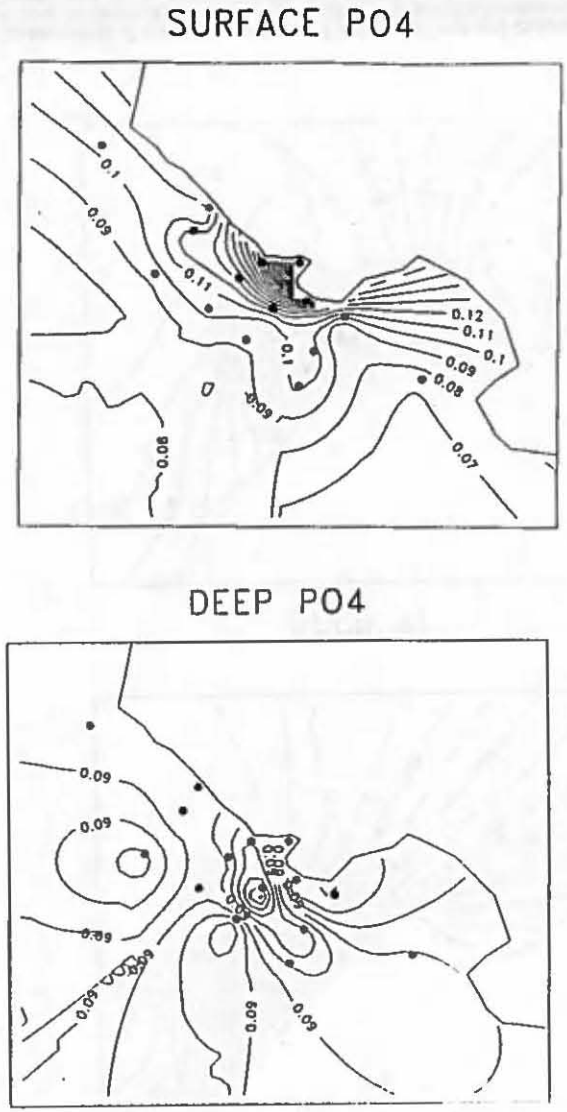


FIGURE 16. Contour plots of phosphate (PO_4^{3-}) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.

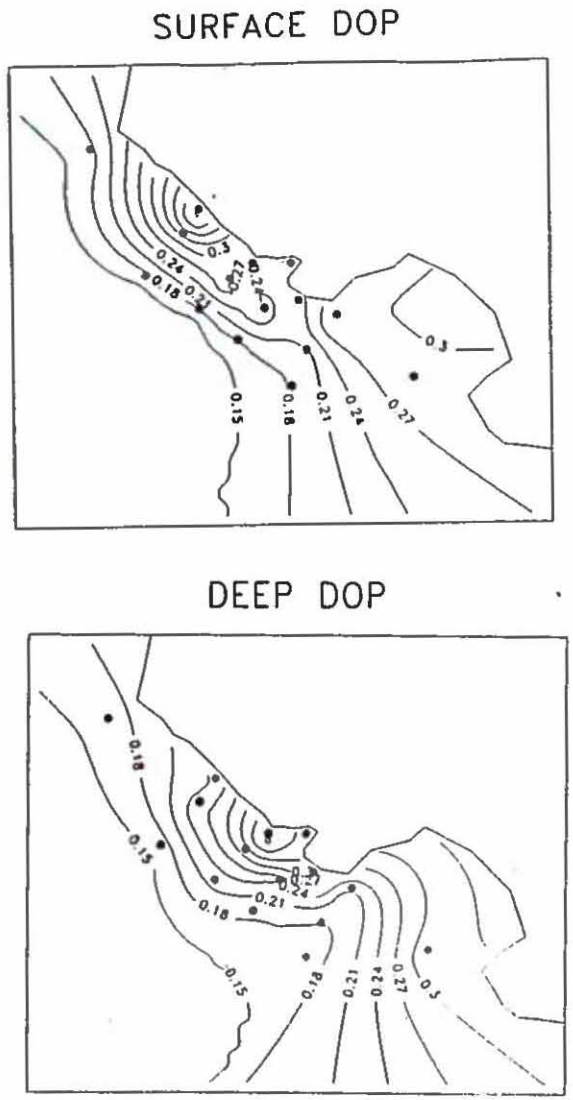


FIGURE 17. Contour plots of dissolved organic phosphorus (DOP) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.

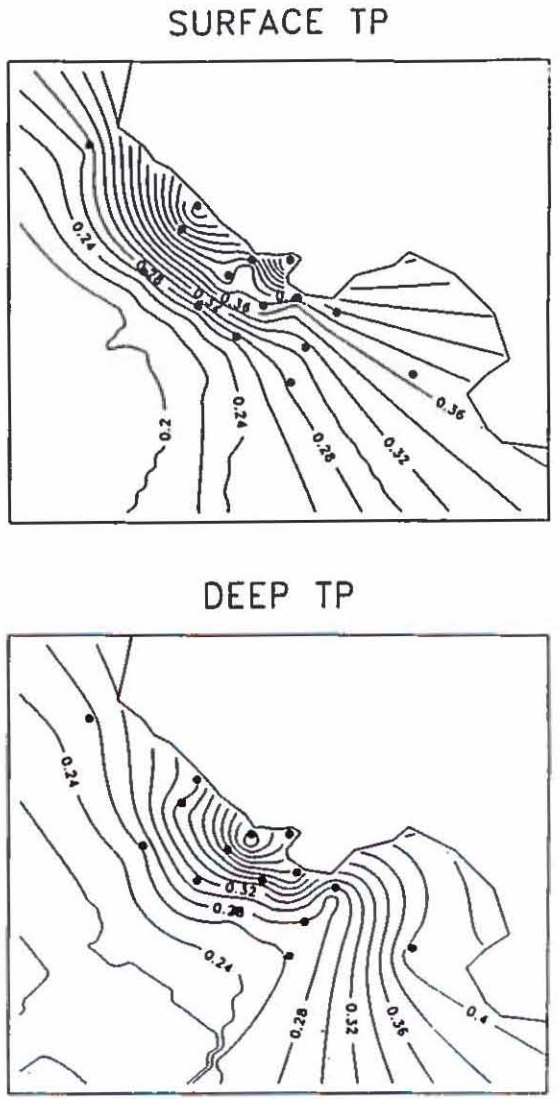
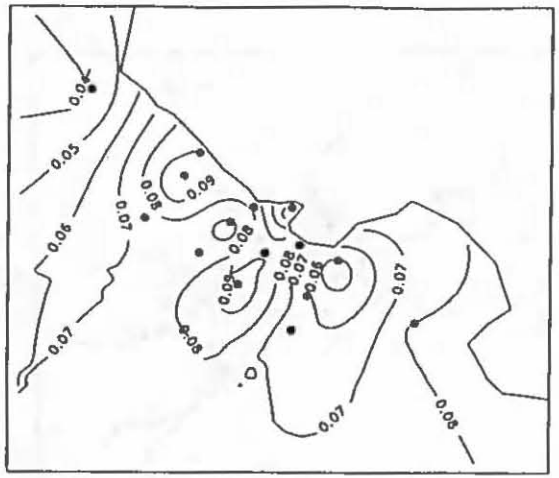
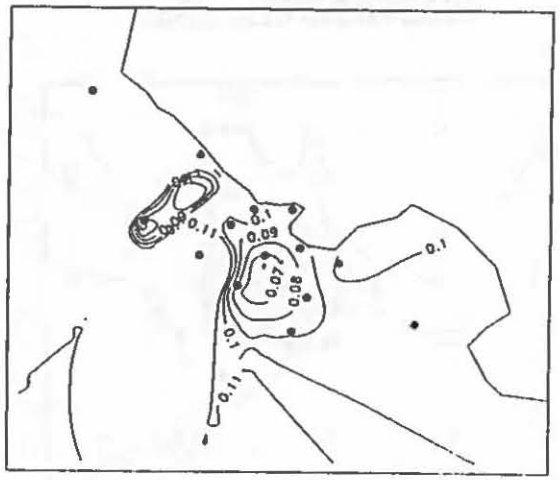


FIGURE 18. Contour plots of total phosphorus (TP) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. Concentrations are reported in μM. For station number locations, see Figure 7.

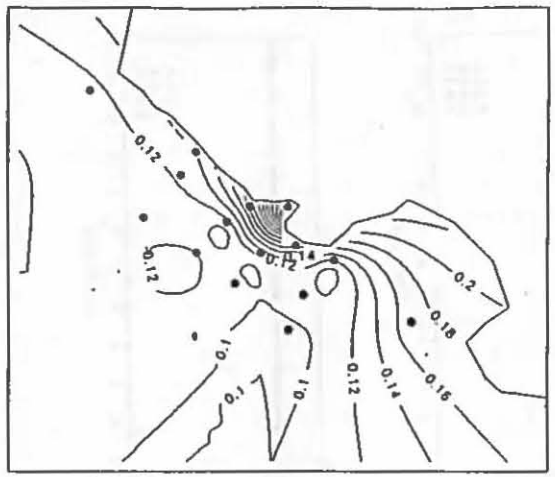
SURFACE CHLOROPHYLL



DEEP CHLOROPHYLL



SURFACE TURBIDITY



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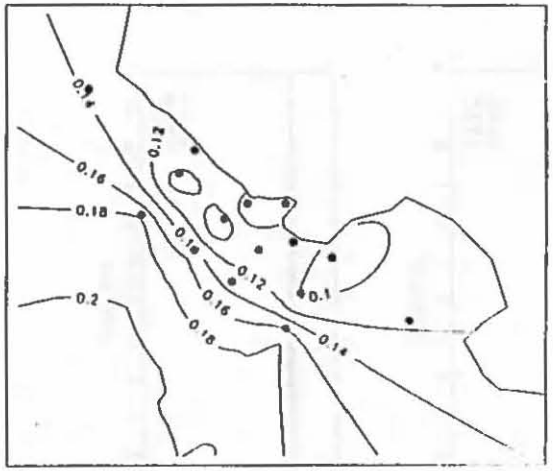


SURE 19. Contour plots of chlorophyll *a* (µg/L) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. For station number locations, see Figure 7.

FIGURE 20. Contour plots of turbidity (reported as n.t.u.) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. For station number locations, see Figure 7.

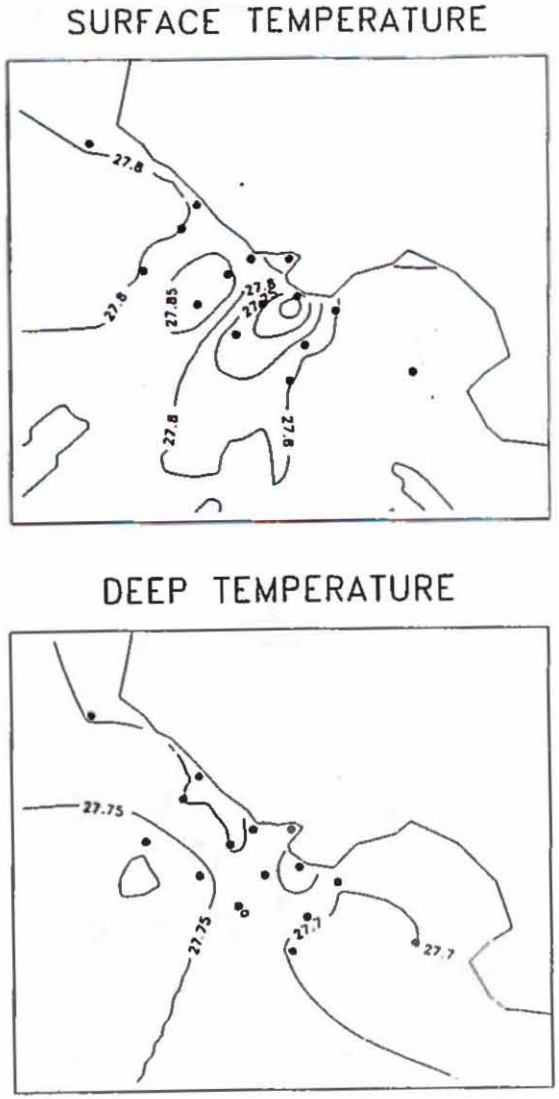


FIGURE 21. Contour plots of temperature (°C) in surface (top) and deep (bottom) waters in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. For station number locations, see Figure 7.

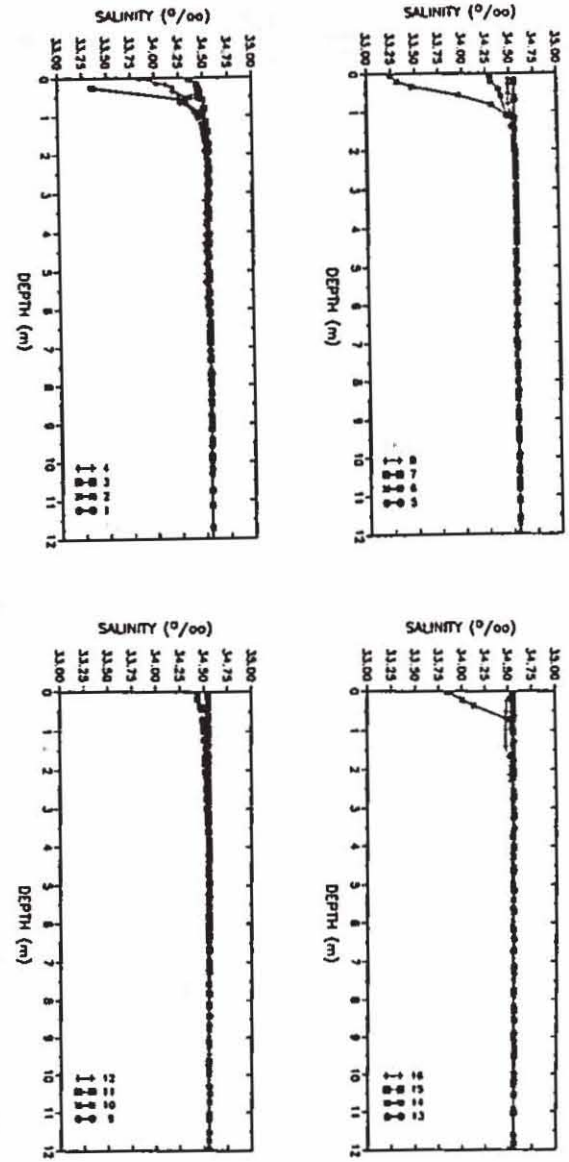


FIGURE 22. Vertical profiles of salinity (in parts per thousand) at sampling sites in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. For station number locations, see Figure 8.

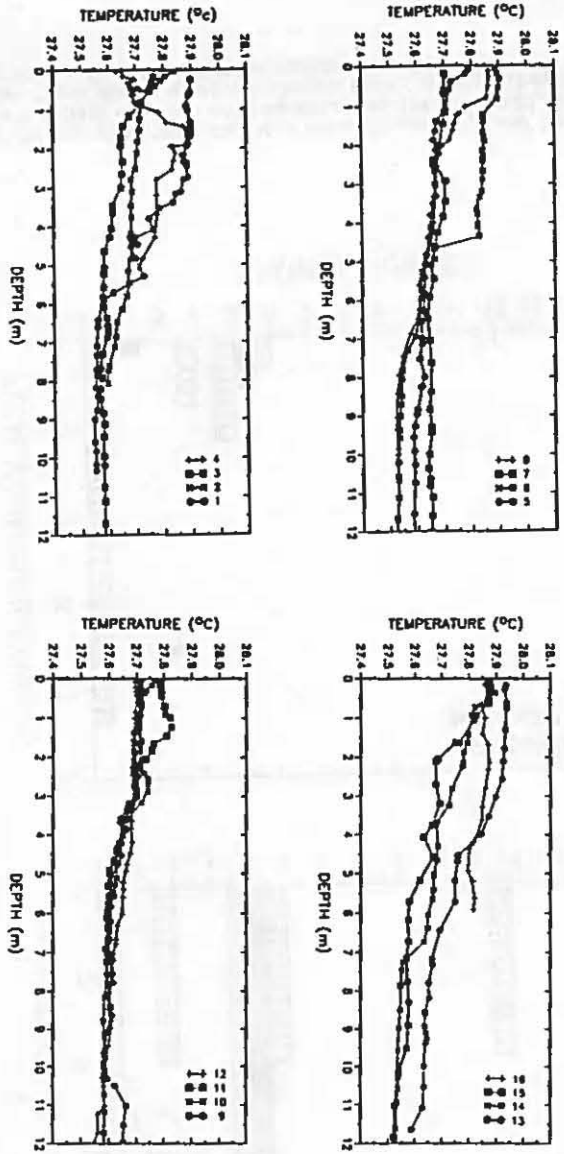
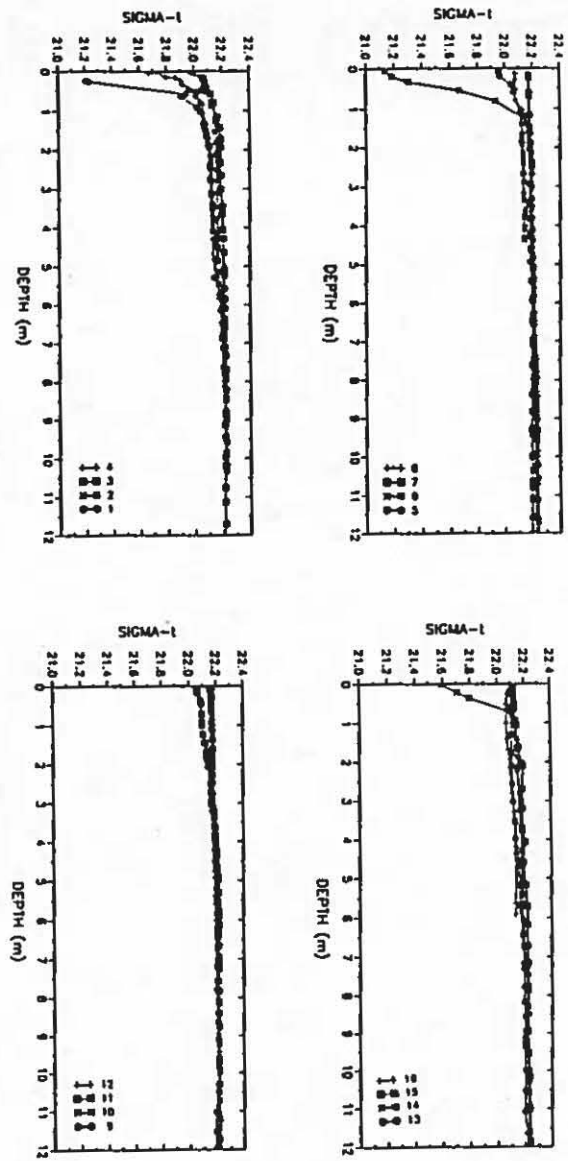


FIGURE 23. Vertical profiles of temperature (°C) at sampling sites in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. For station number locations, see Figure 8.



IGURE 24. Vertical profiles of Sigma-t at sampling sites in the vicinity of Guam Naval Station Sewage Treatment Plant measured on May 21, 1992. For station number locations, see Figure 8.

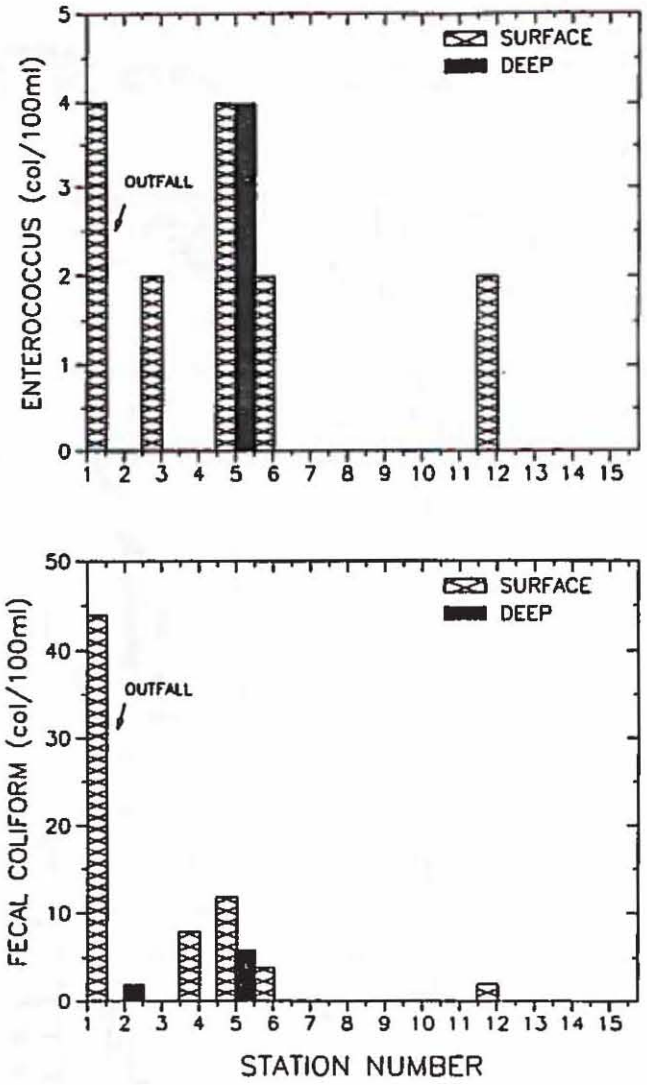


FIGURE 25. Histograms showing colony counts of enterococcus (top) and fecal coliform (bottom) bacteria in surface and deep water samples collected on May 21, 1992 in the vicinity of the Guam Naval Station Sewage Treatment Plant. Location of outfall diffuser is shown with an arrow. For station number locations, see Figure 9.

Appendix G

Air Quality Impact Report

AIR QUALITY IMPACT REPORT

OROTE POWER PLANT
PWC MCON P-234

August 31, 1992

PREPARED FOR

Belt Collins & Associates

and

Pacific Division
Naval Facilities Engineering Command

PREPARED BY

J. W. MORROW
ENVIRONMENTAL MANAGEMENT CONSULTANT
KAILUA, HAWAII

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4	Piti and Cabras Power Plants, August 1992

1. INTRODUCTION

The U. S. Navy (USN) is proposing to construct a new power plant at its Public Works Center (PWC) on Orote Point, Guam. The existing islandwide power generating capability, including both Navy and Guam Power Authority (GPA) units, only marginally meets current demand. The relocation of shore installations and fleet units from the Philippine Islands to Guam will further degrade the system's ability to meet demand. The proposed facility is necessary to meet critical requirements in the Apra Harbor Complex where power must be in sufficient quantity, high quality and very reliable [1].

Due to the necessity to comply with the federal Clean Air Act [2] and local Guam air pollution control requirements [3], analysis of the quality impacts associated with the proposed project was deemed necessary. It is the purpose of this study, therefore, to assess those impacts and identify mitigation measures which may be necessary to insure compliance with regulatory requirements.

2. EXISTING AND PROPOSED FACILITIES

The locations of the existing and proposed power plants are depicted in Figure 1.

The existing power plant (UTM 246.50, 1484.80) is intended to be a peaking facility but due to the ongoing islandwide power

problems, has been operating approximately 18 hours per day [4]. The high variability of its usage can be seen in recent fuel consumption data depicted in Figure 2. It consists of ten Worthington 600 kW diesel generating units, only eight of which are currently operating. Its current condition can be seen in Figure 3.

A site adjacent to the existing plant (UTM 246.52, 1484.75) has been tentatively identified for siting the proposed facility (see Figure 3). The new plant will consist of three 6 MW Stork-Wartsila diesel generator sets originally intended for Subic Bay in the Philippines [1, 5].

Two other large oil-fired power plants located some five kilometers northeast of the Orote plant also affect air quality in the area. The U.S. Navy Piti Power Plant and GPA Cabras Power Plant (Figure 4) are presently surrounded by a 3.5 kilometer non-attainment area for sulfur dioxide (SO2) [6].

3. LOCAL METEOROLOGY

3.1 Temperature, Humidity and Rainfall. As evidenced by the data in Table 1, temperature and humidity display expected diurnal variability but are relatively stable throughout the year. Rainfall, however, exhibits a significant seasonal variation with a dry season from January to June and a wet season from July to

December.

3.2 Surface Winds. Winds in Guam are dominated by easterly trade winds. This predominance is clearly indicated in the directional distribution for the period 1968-72 (Table 2) as reported by the Guam EPA (6); however, no location for the collection of those data was indicated. Due to complex terrain in some parts of the island, there are likely to be some differences among various wind data summaries. Wind data studied for this report (1987-91) were from the National Weather Service Site No. 41406 (Agana). Those data appeared to have a more northerly component than did the 1968-72 data noted above.

4. EXISTING AIR QUALITY

There are no air monitoring stations in the immediate vicinity of the Orote Power Plant. The nearest monitors for SO2 and PM are several kilometers northeast of the plant in the Piti - Cabras area [6]. Recent data from a USN-operated station near Piti are presented in Table 3. These data show no violations of NAAQS but do indicate violations of the Guam 24-hour particulate standard.

5. APPLICABLE STANDARDS

5.1 Ambient Air Quality Standards

5.1.1 National Ambient Air Quality Standards. The U.S. EPA has promulgated national ambient air quality standards (NAAQS) pursuant to the federal Clean Air Act [7,8,9]. The NAAQS are divided into primary and secondary standards. Primary standards are intended to protect public health with an adequate margin of safety while secondary standards are intended to protect public welfare through the prevention of damage to soils, water, vegetation, man-made materials, animals, wildlife, visibility, climate, and economic values. It is also important to note that the short-term (less than annual) NAAQS may be exceeded once per year (see Table 4).

5.1.2 Guam Ambient Air Quality Standards. The Guam EPA has also promulgated ambient air quality standards [3] which are similar but not identical to the NAAQS (Table 5). SO2 and NO2 standards are expressed as sulfur oxides (SOx) and nitrogen oxides (NOx), but the text of the standards suggests that they are in fact meant to be the same as the NAAQS. The annual SO2 and 1-hour photochemical oxidants standards are more stringent than NAAQS, but the annual NO2 is less stringent. There is a 3-hour standard for hydrocarbons which no longer exists in NAAQS. The particulate matter (PM) standard appears to be a total suspended particulate matter (TSP) although it is not defined as such. Additionally, the 24-hour and annual PM standards are the same as the old NAAQS TSP standards. An 8-hour PM standard has also been included.

5.2 Prevention of Significant Deterioration. New major sources being proposed in attainment or unclassified areas are subject to pre-construction review under the Prevention of Significant (PSD) provisions [10] and thus to ambient air increments for PM, SO2, and NO2 [11,12]. Unless subsequently redesignated, all attainment areas were initially established as Class II areas by the Clean Air Act and thus subject to Class II increments (see Table 4).

The rules also require one-year of pre-construction continuous air monitoring [13] if certain "de minimus" levels are exceeded. These values are listed in Table 6.

5.3 Emission Standards. It should also be noted that the EPA has previously proposed new source performance standards (NSPS) for stationary internal combustion (IC) engines which limit NOx emissions. When these standards are finalized, any new, modified, or reconstructed IC engine that commenced construction after January, 1982, will have to be in compliance with them [14].

In addition, pursuant to PSD provisions [15], a new major source must employ best available control technology (BACT) for each regulated pollutant that it would have the potential to emit in significant amounts (Table 7).

6. ANALYSIS METHODOLOGY

6.1 Fuel Use and Emission Factors. Historical fuel use data were obtained from the U.S. Navy for the Orote, Piti, and Cabras power plants [16]. The Orote plant fires diesel fuel with a maximum sulfur content of 1%. A recent test (22 Apr 91) indicated sulfur content of 0.58% [4]. While there is an intermittant control strategy (ICS) in effect which requires the burning of low sulfur fuel oil (LSFO) at the Piti and Cabras plants under certain wind conditions [6], such fuel was burned less than 1% of the time in 1991 [16]. LSFO is procured by the USN and provided to GPA as needed. The high sulfur fuel oil (HSFO) with sulfur content up to 2.84% is procured by GPA and fired in both Piti and Cabras units.

The 1991-92 fuel use data were used to generate emission rates for both the emissions and the ambient air quality analyses. EPA emission factors [17] were used for carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), and sulfur dioxide (SO2). In the case of SO2, the EPA factor was adjusted to account for the use of diesel fuel with 1% sulfur content.

6.2 Meteorology. Surface and upper air data from 1991 for Agana, Guam (NWS Site No. 41406) were obtained from the National Climatic Data Center and processed into a form usable with EPA

dispersion models.

6.3 Plant Parameters. Plant design and operating parameters necessary for modelling are summarized in Table 8. Due to limited data availability, the following assumptions were made:

- exit gas temperature and flow volume for Orote units were based on similar-size diesel units.
- 18-hr/da operations were assumed for Orote units.
- mean and maximum emission rates were based on historical fuel use for existing units.
- maximum emission rates for proposed Orote units were based on 125% of mean fuel rate.

6.4 Dispersion Modelling. EPA's Industrial Source Complex - Short Term (ISCST) model [18] was selected for use in this analysis for several reasons. It is a flat terrain model which can accomodate multiple sources, variable hourly emissions, a large number of receptor locations, hour-by-hour sequential meteorological data, aerodynamic downwash, and a variety of time-averaged pollutant concentrations. It is also an EPA-recommended "guideline" model [19].

Because of the relatively short stack heights at the existing and proposed Orote Power Plants as compared to the building height

(27 feet), building wake effects (downwash) were anticipated. Downwash is of interest because it results in high pollutant concentrations in close proximity to the source. A stack height which would theoretically prevent this effect is referred to as "good engineering practice" (GEP) stack height [20]. GEP was a concept defined by EPA pursuant to Section 123 of the Clean Air Act [1] to preclude sources from using very tall stacks for dispersion instead of installing continuous emissions controls. For a 27-foot, GEP stack height would be about 68 feet.

Ambient standards for regulated pollutants are time-averaged; thus, in order to make valid comparisons, a model must produce concentration estimates which are averaged over those same time periods. For this reason, the output from the ISCST model is presented as 1-hour, 3-hour, 8-hour, 24-hour, and annual average concentrations to correspond with the NAAQS.

In a modeling analysis such as this, a receptor array must also be established. These are simply the locations around the source at which the model will compute pollutant concentration estimates for the time periods specified. In this case, an initial circular receptor grid with 10-degree radials and 100-meter spacing was established around the existing and proposed power plants to identify areas of high concentration. Once such areas were found, a secondary 100-meter grid was then used to locate

the points of maximum impact.

6.5 NOx-to-NO2 Conversion. As recommended by EPA [19], the Ozone Limiting Method (OLM) was employed to estimate NO2 concentrations. In this case, given the remote mid-ocean location of Guam and the low likelihood of significant ozone concentrations being present, NOx-to-NO2 conversion is assumed to be limited to thermal conversion, i.e., approximately 10% [22].

7. RESULTS

7.1 Estimates of Annual Emissions. Estimates of annual emissions from the existing and proposed plants are presented in Table 9. Also shown is the net emissions should the new plant replace the existing one. These emissions indicate that the proposed plant would be considered a new "major source" [23] because SO2 and NOx emissions exceed 250 T/yr or a "major modification" [24] (if it replaces the old plant) because net emissions of CO, SO2, NOx, and PM are "significant" (see Table 7). In either case, it would appear to be subject to PSD review [10].

7.2 Ambient Air Quality.

7.2.1 NAAQS/Guam AQS. As indicated in Table 10, both NAAQS and Guam AQS were complied with in the area of maximum impact for both short- and long-term standards. Carbon monoxide (CO) is not shown because it was determined early in the modeling analysis to

have minimal impact, i.e., < 2 mg/m3 1-hr concentration. Due to the prevailing northeasterly winds and the short stacks at Orote, the area of maximum impact is located approximately 100 meters southwest of the plant site.

7.2.2 PSD Increments. Compliance with the PSD Class II increments appears problematic. Modeling of the proposed new plant by itself and then again with credited offsets due to the assumed shutdown of the existing plant still resulted in exceedance of the 24-hr PM and SO2 increments (see Table 11).

7.2.3 Non-Attainment Area Impacts. The proposed new plant also appears capable of impacting the Piti non-attainment area "significantly" [25]. Twenty-four hour SO2 concentrations ranged 5.2 - 16 ug/m3 at distances up to 3 kilometers into the non-attainment area, exceeding the 5 ug/m3 significance level. Similarly, 3-hour SO2 concentrations ranged 30 - 53 ug/m3, well over the 25 ug/m3 significance level.

It should be noted that the winds would have to be blowing predominantly from the southwest in order to cause these impacts. Under such wind conditions, the two large power plants which cause the non-attainment area would not even be impacting that area to their southwest where the Orote Plant would be impacting.

8. CONCLUSIONS AND MITIGATION

The proposed new power plant appears capable of complying with NAAQS and Guam AQS even with the existing plant remaining in operation and the two large power plants to the north.

Emissions analysis indicates that the proposed new plant is a "major source" in an attainment area and thus subject to PSD review. The modeling analysis indicates that de minimus levels will be exceeded and thus pre-construction monitoring is required.

The apparent problem with PSD increment compliance for SO2 and PM and SO2 non-attainment area impacts can be dealt with by some combination or all of the following:

- limiting sulfur content of fuel oil fired
- raising stack heights to reduce downwash effects
- using manufacturer-specific emission rates for PM instead of industry-average EPA values (assuming they are lower)
- implementing enforceable limitations on operating hours or fuel consumption
- installation of emission controls.

REFERENCES

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2. Clean Air Act of 1963, 42 USC 7401 et seq.
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10. 40 CFR 166, Prevention of Signficant Deterioration.
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12. 53 FR 40656, 17 Oct 88.
13. 40 CFR 51.166(i)(8)
14. U.S. Environmental Protection Agency. Proposed Rule: Stationary Internal Combustion Engines; Standards of Performance for New Stationary Sources, Federal Register, Vol. 44, No. 142, p. 43152, July 23, 1979.
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16. U.S. Navy Public Works Center, Guam. Utilities Department, Monthly Fuel Oil Report, Jan-Dec 91.

17. U. S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, Fourth Edition, AP-42, September 1985.

18. U. S. Environmental Protection Agency. Industrial Source Complex (ISC) Model User's Guide, Second Edition, June 1986 (computer code updated July 1988)

19. U. S. Environmental Protection Agency. Guideline on Air Quality Models (Revised), EPA-450/2-78-027R, July 1986.

20. U. S. Environmental Protection Agency. Good Engineering Practice Stack Height: Final Rulemaking, Federal Register, Volume 50, p. 27892, July 8, 1985.

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22. Cole, H. S. and J. E. Summerhays. A Review of Techniques Available for Estimating Short-Term NO2 Concentrations.

23. 40 CFR 51.166(b)(1)(i)(b)

24. 40 CFR 51.166(b)(2)(i)

25. 40 CFR 51.165(b)(2)

TABLES

TABLE 1

SUMMARY OF CLIMATOLOGICAL DATA
FINEGAYAN, GUAM

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (F)													
Daily Maximum	83.4	83.4	84.4	85.7	86.5	86.9	86.4	86.0	85.8	85.7	85.3	84.2	85.3
Daily Minimum	71.0	71.1	71.2	72.4	72.9	73.1	72.5	72.2	72.2	72.4	73.1	72.6	72.2
Relative Humidity (%)													
4:00 a.m.	88	88	88	90	92	92	94	96	96	95	91	88	92
4:00 p.m.	75	74	72	71	72	74	78	80	80	80	80	77	76
Precipitation (inches)	5.4	4.8	4.2	4.1	6.4	5.5	10.3	13.9	14.2	13.9	9.0	6.0	97.9

SOURCE: National Weather Service
Station No. 41415

TABLE 2

FREQUENCY DISTRIBUTION OF WIND DIRECTION
GUAM

Direction	Frequency (%) 1968-72(1)	1991(2)
N	1.9	2.5
NNE	3.1	6.3
NE	8.6	16.0
ENE	21.2	28.5
E	35.9	17.4
ESE	10.7	7.3
SE	5.2	4.8
SSE	3.8	4.1
S	3.2	3.6
SSW	1.1	2.1
SW	0.7	0.9
WSW	0.9	1.6
W	1.3	1.6
WNW	0.7	1.2
NW	0.7	0.8
NNW	1.0	1.4

SOURCES: 1. Reference 6.
2. National Weather Service, Station No. 41415

TABLE 3

AIR QUALITY MONITORING DATA
PITI AREA
1990

Concentrations (ug/m3)

	SO2		TSP	
Month/Year	Range	Mean	Range	Mean
Mar 90	5 - 348	42	15 - 190	82
Apr 90	3 - 86	47	13 - 199	71
May 90	3 - 167	60	8 - 203	78
Jun 90	3 - 131	44	33 - 124	75
Jul 90	3 - 42	10	8 - 146	41
Aug 90	3 - 42	10	15 - 181	84
Sep 90	0 - 63	18	24 - 101	55
Oct 90	0 - 31	8	18 - 97	44
Nov 90	0 - 50	21	18 - 140	64

SOURCE: USN PWC-Guam, Quarterly Summaries of SO2 and TSP Air Monitoring Data.

TABLE 4

SUMMARY OF NATIONAL AMBIENT AIR QUALITY STANDARDS AND PSD INCREMENTS

Concentrations (ug/m3)

Pollutant	Averaging Period	NAAQS	Class II PSD
SO2	Annual	80	20
	24-hr	365	91
	3-hr	1,300	512
PM-10	Annual	50	--
	24-hr	150	--
TSP	Annual	--	19
	24-hr	--	37
NO2	Annual	100	25
CO	8-hr	10,000	--
	1-hr	40,000	--
Pb	Quarterly	1.5	--

TABLE 5

SUMMARY OF GUAM AMBIENT AIR QUALITY STANDARDS

Concentrations (ug/m3)

Pollutant	Averaging Period	Standard
SOx	Annual	60
	24-hr	365
	3-hr	1,300
	4-hr	650
PM	Annual	60
	24-hr	150
	8-hr	360
NOx	Annual	160
HC	3-hr	160
CO	8-hr	10,000
	1-hr	40,000

TABLE 6

PSD PRE-CONSTRUCTION AIR MONITORING
DE MINIMUS LEVELS

Pollutant	Concentration	Averaging Period
Particulate matter	10 ug/m3	24-hr
Sulfur dioxide	13	24-hr
Nitrogen oxides	14	24-hr
Carbon monoxide	575	8-hr
Ozone	see note	
Lead	0.1	3-month
Mercury	0.25	24-hr
Beryllium	0.001	24-hr
Fluorides	0.25	24-hr
Vinyl chloride	15	24-hr
Total reduced sulfur	10	24-hr
Hydrogen sulfide	0.2	1-hr
Reduced sulfur compounds	10	1-hr

* No ambient concentration specified; if source emits > 100 TPY of VOC, then air monitoring must be conducted.

Reference: 40 CFR 51.166(i)(8)(i)

TABLE 7

SIGNIFICANT EMISSION LEVELS

Pollutant	T/yr
CO	100
NOx	40
SO2	40
PM	25 15 (PM10)
Ozone	40 (as VOC)

Reference: 40 CFR 51.166(b)(23)(i)

TABLE 8

POWER PLANT DESIGN AND OPERATING PARAMETERS

	Orote		Piti		Cabras
	Existing	New	2-3	4-5	1-2
No. Units:	8	3	2	2	2
Stack height (m):	10.7	13.1	61	61	61
Stack I.D. (m):	0.3	1.0	2.4	2.4	2.6
Exit gas velocity (m/sec):	55.6	28.0	12.8	19.7	15.0
Exit gas temperature (K):	788	687	433	414	422
Plant fuel rate					
-max (gal/hr):	234	1,311	1,407	2,905	8,227
-mean (gal/hr):	144	1,050	913	1,515	7,389
Building height (m):	8.2	8.2	21.2	21.2	30.0
length (m):	65.8	65.8	101.3	101.3	75.0
width (m):	25.6	25.6	45.7	45.7	52.1

TABLE 9

ESTIMATES OF ANNUAL EMISSIONS
OROTE POWER PLANTS
(Existing and Proposed)

Pollutant	Tons/Year Existing	Proposed	Net
CO	61	448	388
NOx	233	1,735	1,492
SO2	70	517	447
PM	23	172	149
VOC	6	45	39

TABLE 10

RESULTS OF MODELING TO
DETERMINE COMPLIANCE WITH AIR QUALITY STANDARDS

Pollutant	Averaging Period	Second Highest Concentration (ug/m3)
SO2	3-hr	520
	24-hr	243
	Annual	27
PM10	24-hr	51
	Annual	7
NO2	Annual	6

TABLE 11

RESULTS OF MODELING TO
DETERMINE COMPLIANCE WITH PSD INCREMENTS

Pollutant	Averaging Period	Second Highest Concentration (ug/m3)
SO2	3-hr	632 (373)
	24-hr	211 (125)
	Annual	15
PM10	24-hr	70 (42)
	Annual	5
NO2	Annual	5

NOTE: Values in parentheses indicate concentration with credit for shutdown of existing plant.

FIGURES

FIGURE 1

PROJECT LOCATION

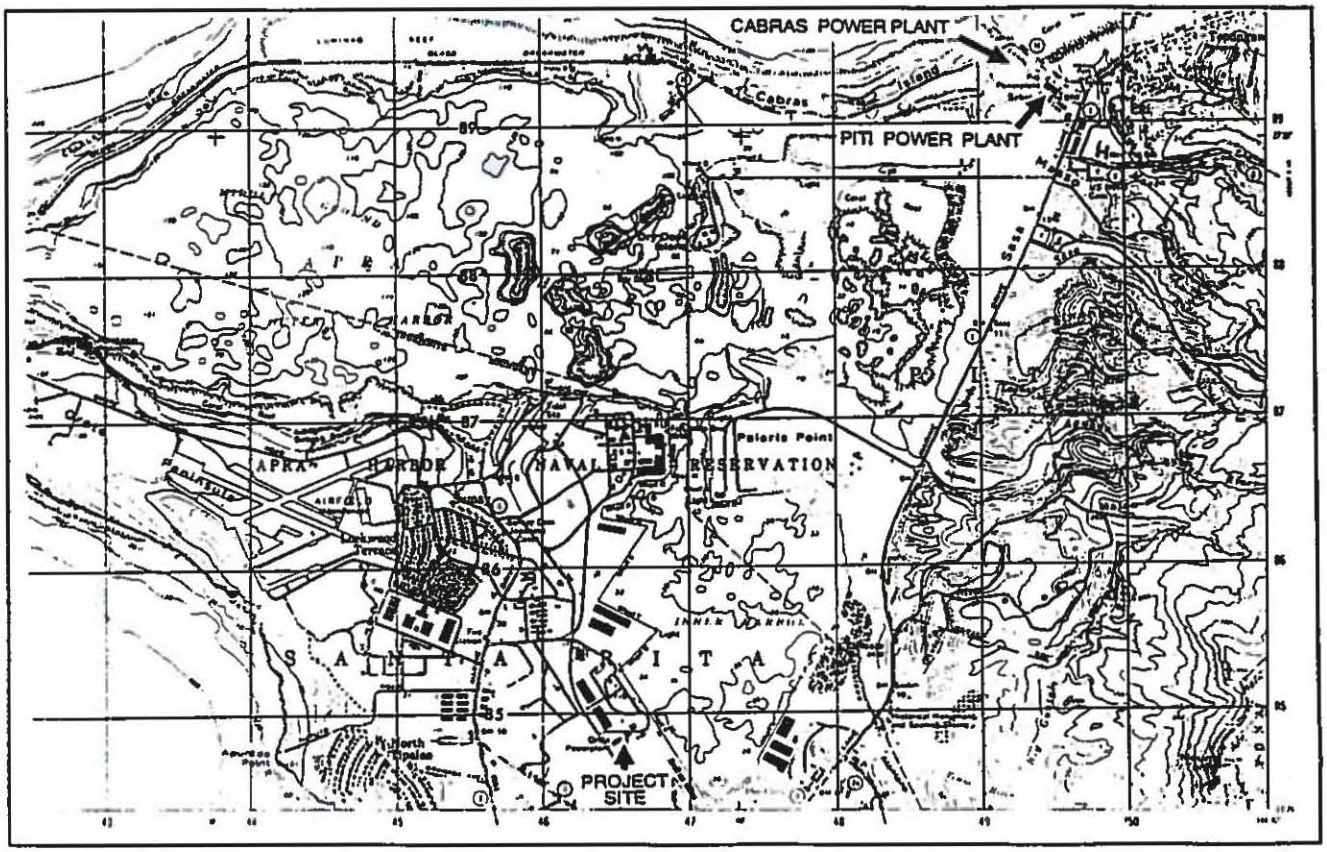


FIGURE 2

MONTHLY FUEL USE
OROTE POWER PLANT
OCT 90 - JUN 92

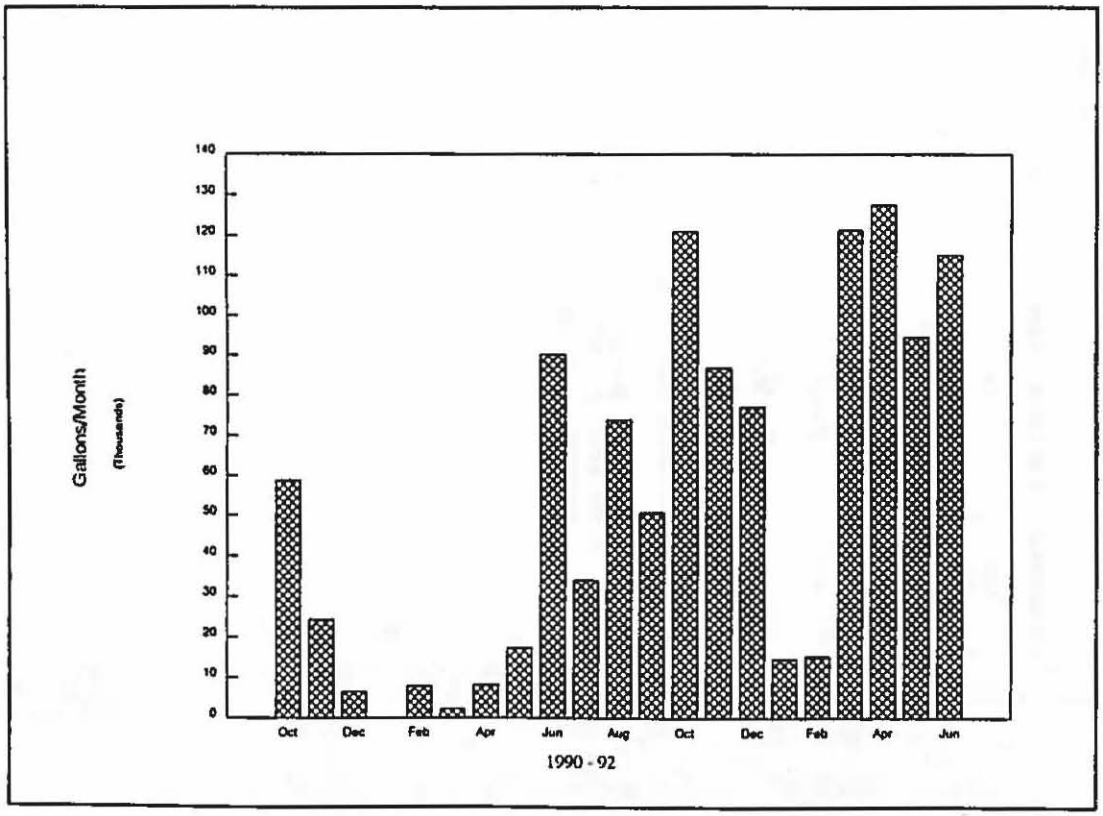
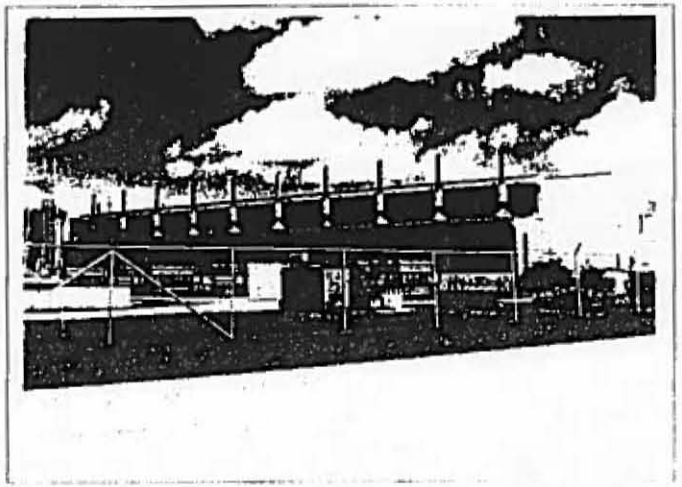
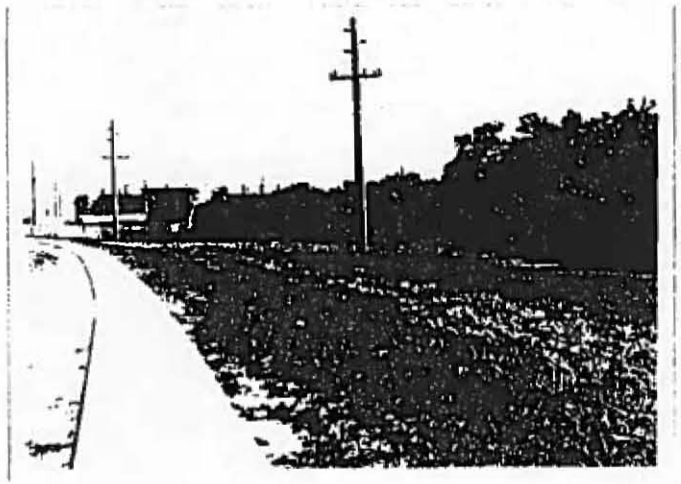


FIGURE 3

OROTE POWER PLANT
AUGUST 1992



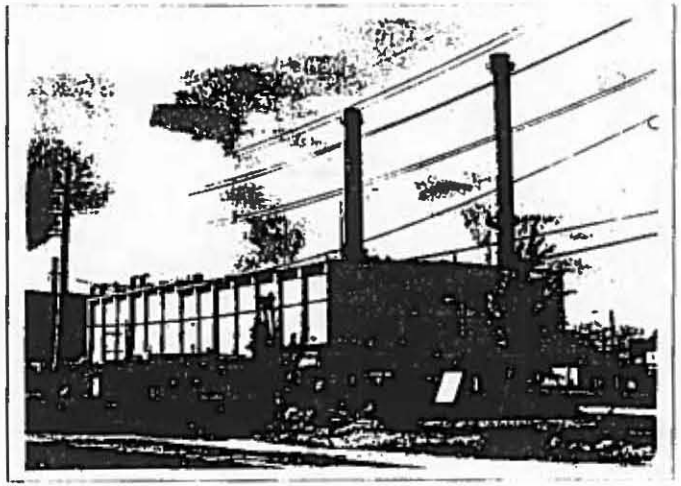
Existing Facility



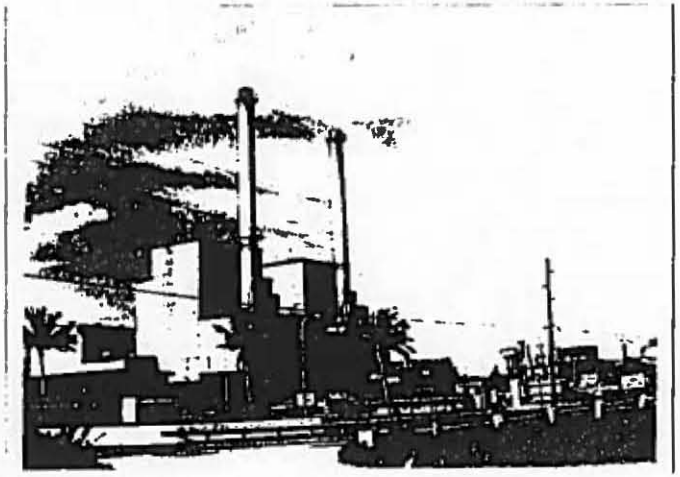
Proposed Site of New Plant

FIGURE 4

PITI AND CABRAS POWER PLANTS
AUGUST 1992



U.S. Navy
Piti Power Plant



Guam Power Authority
Cabras Power Plant

Appendix H

Archaeological Inventory Survey and Section 106 Consultation Letter

DEPARTMENT OF PARKS AND RECREATION
GOVERNMENT OF GUAM
PEDRO PALASYO ROAD
Agana Heights, Guam 96919
Telephone: (671) 477-9620/1

RECEIVED
1993 JUL 19 A 11:31
BELT COLLINS & ASSOCIATES

JOSEPH F. ADA
Governor

FRANK F. BLAS
Lt. Governor

ANTHONY C. MARIANO
Director

DENNIS M. ZERMENO
Deputy Director

JUL 16 1993

Ms. Susan S. Rutka
Senior Planner
Belt Collins & Associates
Suite 200
Honolulu, HI 96813

Dear Ms. Rutka:

In comment on the EIS for the relocation of facilities and programs from Subic Bay to Naval Station, Guam, we are impressed with the thoroughness of the identification of cultural resources in the potential areas of effect, and with the careful evaluation of significance of the cultural resources.

We are also in agreement that the proposed measures of documentation, interpretation, and care during construction phases are appropriate means to avoid or mitigate the potential adverse effects of the project.

It is our understanding that in these circumstances, the most appropriate and most straightforward means for providing opportunity for the Advisory Council on Historic Preservation and opportunity to comment would be a determination of "Adverse Effect" coupled with a two party memorandum of agreement (MOA) per 36 CFR 800.8 stipulating the measures already identified in the EIS.

It is our unde:standing that either the Navy or Belt Collins and Associates will draft teh MOA on behalf of the Navy in the near future.

Sincerely,

Richard D. Davis

RICHARD D. DAVIS
State Historic Preservation
Officer

Commonwealth Now!

MEMORANDUM OF AGREEMENT

between the U.S. Department of the Navy, Guam State Historic Preservation Officer, and Advisory Council on Historic Preservation concerning Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

WHEREAS, the U.S. Navy has consulted with the Guam State Historic Preservation Officer (SHPO), pursuant to 36 CFR Part 800 regulations implementing Section 106 of the National Historic Preservation Act (16 U.S.C. 470f), and Section 110(f) of the same act (15 U.S.C. 470h-2(f), regarding proposed facilities development and relocation of Navy activities to the Territory of Guam from the Republic of the Philippines; and

WHEREAS, the U.S. Navy has determined that no direct effects are expected as a result of the proposed actions; and

WHEREAS, the U.S. Navy has also determined that there is a potential for short-term and long-term indirect effects in the vicinity of the proposed Tipalao family housing project, but that these effects can be mitigated;

NOW THEREFORE, the U.S. Navy, the Guam SHPO, and the Advisory Council on Historic Preservation (Council) agree that the Tipalao family housing project shall be implemented in accordance with the following stipulations in order to take into account the effect of the undertaking on historic properties.

STIPULATIONS

The U.S. Navy shall ensure that the following measures are carried out:

1. Flagging. In consultation with the Guam SHPO, prior to commencement of construction, archaeological sites located in the vicinity of construction activities will be flagged as needed to prevent accidental damage to the sites.

2. Monitoring. A qualified professional archaeologist will monitor construction, as determined necessary in consultation with the Guam SHPO.

3. Signage. Prior to occupancy of the Tipalao family housing, signs will be installed to alert residents and other area users about the presence and significance of historic resources. The wording of the signs and their locations will be determined in consultation with the Guam SHPO.

4. Inspections. The Guam SHPO will be allowed to conduct periodic inspections of the sites and make recommendations in order to enhance preservation of the sites.

5. Dispute Resolution. Should a signatory to this Agreement object within thirty (30) days of receiving any plan, proposal, report, or correspondence presented in compliance with this Agreement's requirements, the Navy will consult with the

objecting party to resolve the objection. If the Navy finds that the dispute cannot be resolved after a reasonable period, it will request the further comment of the Council, pursuant to 36 CFR Section 800.6(b). Any Council comment provided in response to such a request will be taken into account by the Navy in accordance with 36 CFR Section 800.6(c)(2), with reference only to the subject of the dispute. The Navy's responsibility to carry out all actions under this Agreement that are not the subjects of the dispute will remain unchanged.

6. Amendments. Any party to this Agreement may request that it be amended, whereupon the parties shall consult in accordance with 36 CFR Section 800.5(e)(5) to consider such an amendment.

Execution of this Memorandum of Agreement and implementation of its terms evidence that the Navy has afforded the Guam SHPO and the Council an opportunity to comment on the proposed actions and its effects on historic properties, and that the Navy has taken into account the effects of the undertaking on historic properties.

In recognition of the requirements of the Anti-Deficiency Act, 31 U.S.C. §1341, nothing in this Memorandum of Agreement or derived from it obligates the expenditure of funds in excess or in advance of appropriations.

COMMANDER U.S. NAVAL FORCES MARIANAS

By:_____ Date:_____

GUAM STATE HISTORIC PRESERVATION OFFICER

By:_____ Date:_____

ADVISORY COUNCIL ON HISTORIC PRESERVATION

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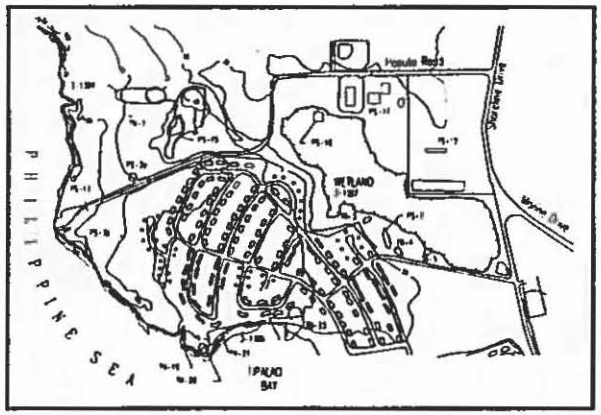
THE ARCHAEOLOGY OF OROTE PENINSULA:

PHASE I AND II ARCHAEOLOGICAL INVENTORY SURVEY OF AREAS PROPOSED FOR PROJECTS TO ACCOMMODATE RELOCATION OF NAVY ACTIVITIES FROM THE PHILIPPINES TO GUAM, MARIANA ISLANDS



by
James Carucci

with contributions by
H. David Tuggle
D. Colt Denfeld
J. Stephen Athens
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and with the assistance of
Jolie Liston
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Wendy L. Goodman

INTERNATIONAL ARCHAEOLOGICAL RESEARCH INSTITUTE, INC.
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James Carucci, Ph.D.

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H. David Tuggle, Ph.D.
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J. Stephen Athens, Ph.D.
Jerome V. Ward, Ph.D.
Stephen K. Wickler, M.A.

and with the assistance of

Jolie Liston, M.A.
Richard K. Olmo, M.A.
Wendy L. Goodman, B.S.

prepared for:

Belt, Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

International Archaeological Research Institute, Inc.
949 McCully Street, Suite 5
Honolulu, Hawaii 96826

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This document is printed on acid-free, archival bond paper. It is intended to provide a long-term record of Guam's cultural resources.

ABSTRACT

Between 1 June and 25 September, 1992, International Archaeological Research Institute, Inc. (IARII) conducted Phase I survey and Phase II testing and recording of archaeological sites in portions of three United States military bases on Guam. This fieldwork was done for the Navy, and was made necessary by the planned relocation of United States military forces from the Philippines to Guam. In order to assess any cultural resources which may be impacted by planned construction projects, several small parcels were surveyed and tested on the Naval Magazine, and two discrete areas were examined at Anderson Air Force Base. No archaeological deposits were found in any of these locations. The bulk of the areas surveyed, amounting to over 250 acres, was located on the Naval Station.

Field surveys of the designated Naval Station areas identified 30 sites and 18 potential sites. One prehistoric rockshelter with deep, stratified deposits was identified and tested using controlled excavations. The very disturbed cultural deposits of a second prehistoric/historic site, probably the remains of the village of Tuparao, were also tested. In the case of Tuparao, testing involved a mixed strategy of controlled excavations, power auger tests and backhoe trenches. A number of World War II-era sites were also identified, many of which are Japanese defensive caves. Two of these caves, which had been modified into bunkers, held sandy sediments which were tested. Little stratification and no intact cultural deposits were found. Eight defensive caves are eligible for the National Register of Historic Places. Two other locations also appear to be eligible based on both archaeological and natural environmental criteria. One of these is a sinkhole and the other a large solution structure; both are located in the karst limestone landscape of the Haputo Point area. At each, two or three underground caverns open off of the larger geologic structure.

In all, 15 sites are considered to be eligible for the National Register, and should be listed on the Guam Register as well.

Ten charcoal samples from the rockshelter were radiocarbon dated. The dates calculated suggest the occupation of the area began around A.D. 700, or possibly as early as A.D. 600. A small sample of late Pre-Latte ceramic material was recovered from the rockshelter, as well as a much larger collection of Latte Period ceramics. Two other sites provided several radiocarbon dates and small ceramic samples, and an extensive paleoenvironmental record was recovered from Tipalao Marsh.

Analysis of the faunal materials recovered from the rockshelter indicates a dependence on small and medium inshore fish, and bivalve molluscs. There are also the remains of larger offshore fish, sea turtle, lizards, chicken, and fruit bat which were all presumably eaten. Midden materials from controlled excavations at Tuparao Village and a third site were sparse. However, several small pieces of human bone were recovered from the Tuparao Village excavations. While these fragments are provenienced, their context and age are not clear. This bone could be from either World War II or from prehistoric/protohistoric contexts. Further work to evaluate the possibility of disturbed or intact human burials in the Tipalao Bay area is required.

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The field crew for the Phase I-A project work included Joan Clarke, B.A., Laura Prishmont, B.A., and Coral Rasmussen, B.A. During the Phase I-A survey, Wendy Goodman, B.S., served as field supervisor to Dr. H. David Tuggle. For subsequent phases of the project (I-B, II-A, and II-B), members of the field crew included Tim Coleman, B.A., Chris Descantes, M.A., Wendy Goodman, B.S., Coral Rasmussen, B.A., David Russell, B.A., and Richard Olmo, M.A. During these surveys Julie Liston, M.A., was field supervisor to Dr. James Carucci. Michael W. Kaschko, M.A., the principal investigator, was present in the field and assisted during the Phase I-B survey.

Many individuals in the Honolulu area also supported and assisted this project. First, the staff of the Bishop Museum Archives are recognized for their help. Second, the constant support of Ms. Susan Rutka of Belt, Collins & Associates was very much appreciated. Third, the archaeologists at PACNAVFACENGCOM are acknowledged for their able assistance. While in the field on Guam, the weekly telephone consultations with Drs. W. Bruce Masse and Robert J. Hommon were eagerly anticipated. And finally, the entire office staff of International Archaeological Research Institute Inc. are to be thanked; but especially Steve Athens, Mikk Kaschko, and David Welch for worrying about us as we were pounded by Typhoon Omar; David Welch for his expert interim management; Judith McNeill for formatting the tabular data; Roger Blankfein for preparing the maps and figures; and Rona Ikehara for her assistance with the faunal bone. Thank you all.

PART I

I: INTRODUCTION

This document is the final report concerning fieldwork conducted on Guam necessitated by the planned relocation of Navy personnel from the Philippines to the Naval Station, Guam. Presented in this document are descriptions of the areas surveyed, detailed reports of archaeological sites and properties identified, accounts of sites and areas tested, discussions of artifactual materials recovered, and summaries of all archival research. Figures 1 and 2 depict the general project areas.

The coverage and content of the present document is based in part on the two previous letter reports (Tuggle 1992, Carucci 1992c), and the interim report of the project findings (Carucci 1992b). Although the present document does not contain the entire text of the earlier reports, whole, virtually unedited sections from them are included here. Additionally, the observations and tentative conclusions of the earlier reports are superseded by this final report. The present document constitutes the latest and most accurate summary of findings and recommendations concerning the sites and properties identified and tested in the project areas.

A copy of this report is on file at the Guam Historic Preservation Office. In addition, copies have been deposited at the Micronesian Area Research Center, the Nieves Flores Memorial Library, and the Commonwealth of the Northern Mariana Islands Historic Preservation Office. The official Guam Inventory Forms describing the HPO designated sites are not included in this document. These forms, required by the overall scope of work, are on file at the Guam Historic Preservation Office.

Organization of the Report

This report is organized into two main sections. Part I includes this introduction, and also discusses the survey phases, dates spent in the field, and the scope of work. The historical setting and archaeological background of the project area are then reviewed, and the fieldwork methods used during the project are described. This is followed by descriptions of the small parcel surveys conducted in developed areas of Andersen Air Force Base, the Naval Station, and the Naval Magazine. Next, general descriptions of the main parcels of the Naval Station survey are given which characterize the geology, soils, topography, and vegetation. These descriptions are keyed by letter (A through K) to areas in Figures 4 through 8 of this report. Note that the maps and verbal descriptions are intended to convey roughly defined natural environmental zones, and approximate the areas surveyed.

Part I also includes a summary of archival research and supporting recommendations provided by D. Colt Denfeld, Ph.D., a military historian and consultant

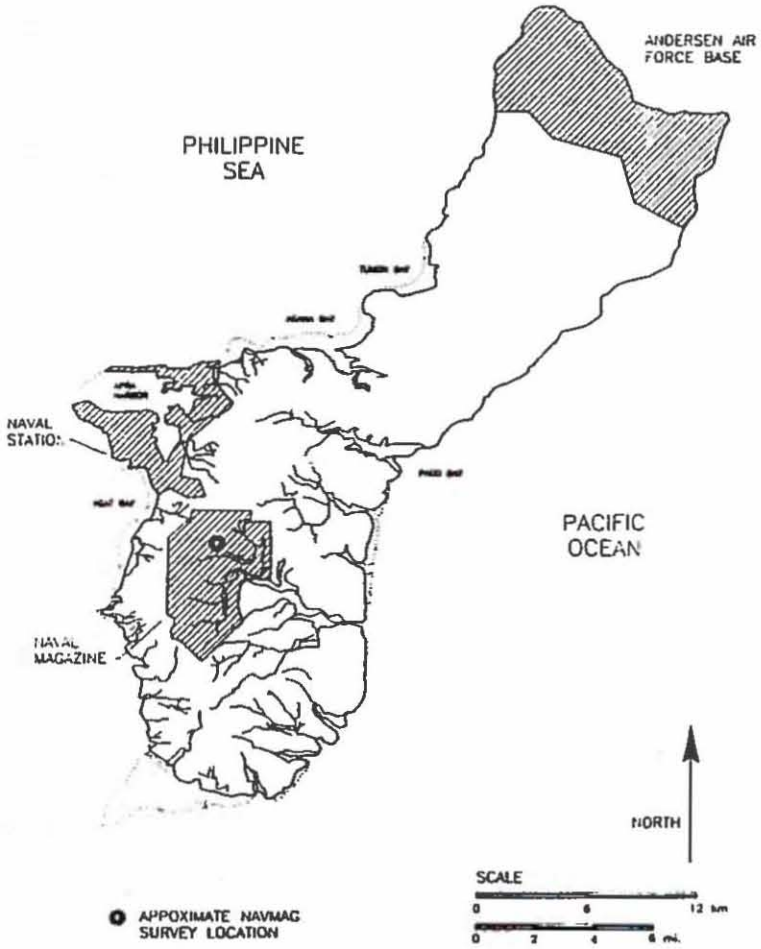


Figure 1. **Map of Guam showing project locations.**

Figure 2. Naval Station general project area and vicinity.

for this project. This document also includes a discussion concerning the mass burial of Japanese dead in the World War II Pacific theater, with a focus on the Mariana Islands.

The remainder of Part I presents the findings of the fieldwork and summarizes the results of several laboratory analyses. This section characterizes the bone, shell, and artifacts recovered, and the samples submitted for radiocarbon dating and pollen analysis. Finally, the overall project is assessed, findings are summarized, and recommendations are presented. Recommendations for specific sites and general long term recommendations are discussed.

Part II is a descriptive inventory of identified sites organized in three sections. The first section describes 14 properties which have official names and file numbers assigned by the Guam Historic Preservation Office. Thirteen of these sites are newly identified; the fourteenth had an existing site number (66-03-1129) but no site forms could be found in the Guam HPO files. The second section describes the sites and potential site areas which received Phase II testing. The third section is a summary of the remaining sites and potential site areas identified during Phase I survey but not subsequently tested during Phase II. Every site description in the inventory includes a summary interpretation, statement of significance, and summary recommendation.

Explanation of Survey Phases

Due to some early archaeological survey findings, and changes to engineering plans, two Phase I components were necessary to complete the overall scope of work on Guam. Two Phase II testing components followed each survey. Except for several recent follow-up visits, all archaeological field activities described in this report took place between 1 June and 25 September, 1992. Phase I-A fieldwork took place between 1 June and 19 June, and was directed by H. David Tuggle, Ph.D. All subsequent fieldwork was directed by James Carucci, Ph.D. Phase I-B fieldwork was from 27 July to 7 August; Phase II-A from 10 August to 4 September; and Phase II-B from 7 to 18 September (Fig. 3 depicts the survey areas by phase). Fieldwork on Guam concluded with five days of archival research, from 21 September to 25 September.

Scope of Work

The purpose of this project was to survey designated areas of Andersen Air Force Base, the Naval Magazine, and the Naval Station in order to produce a comprehensive inventory of archaeological sites. This goal was effectively and efficiently accomplished on Guam by concentrating the fieldwork in two phases. First, Phase I field survey identified the archaeological sites in the designated project areas. Second, Phase II testing evaluated the sites considered to be potentially significant or possibly endangered by planned development. The results of this work are intended to allow the Guam Historic Preservation Office and Belt, Collins & Associates to adequately assess impacts to any significant archaeological properties that may result from the development proposed for the project areas. This assessment is in accordance with the requirements in Section 106 of the National Historic Preservation Act.

Phase I Fieldwork Goals

The Phase I scope of work specified the survey of two small parcels at Andersen Air Force Base, three small parcels at the Naval Magazine, and six small parcels at the Naval Station. In addition, six large parcels on the Naval Station were being considered for new housing. Documents and planning maps supplied by representatives of Belt, Collins & Associates and PACNAVFACENGCOM indicate that the area examined during this first Phase I survey equalled about 146 acres.

Shortly after the completion of the first or Phase I-A survey, fieldwork was suspended by the Navy for a brief period of time. After the suspension, five new areas were identified for survey, and a Phase I-B scope of work was issued. The five new parcels were clustered in the vicinity of Tipalao Bay, and were being considered for the siting of family housing units. Maps and planning documents indicated that the additional areas surveyed during Phase I-B covered about 112 acres.

Both Phase I surveys were designed to locate all archaeological properties in the area and identify them for later evaluation. At the same time, this strategy cleared entire parcels for further development. Areas identified as having been previously built up or completely disturbed had either no intact soils, extremely low probabilities of buried deposits, or no historical features which would be adversely affected.

Phase II Fieldwork Objectives

The primary goal of Phase II was the testing and evaluation of sites identified during the two Phase I surveys (Phase II-A tested the sites from Phase I-A, and Phase II-B tested the sites from Phase I-B). The sites and areas of potential deposits to be tested were specified in the scopes of work. Not all of the sites given temporary field numbers (TN-) were tested; neither were all areas thought to have potential (the PS-numbered series) tested. The final list of sites to be tested, mapped, and recorded was based on the recommendations of the Phase I fieldwork, and took into consideration the time, engineering, and logistical constraints of the project. Consultations between PACNAVFACENGCOM personnel, the archaeological field supervisors and principal investigator, and a representative from Belt, Collins & Associates clarified the level of effort required at each site to be evaluated.

Phase II testing was intended to identify which sites had substantial deposits and which did not. At those sites having deposits, quantities of faunal materials and artifacts sufficient to allow a significance evaluation were collected. Other goals of Phase II included the recovery of charred wood, charcoal and other materials for radiocarbon dating, and the coring of two wetlands thought to contain important paleoenvironmental data. At many other sites, mapping was required in addition to subsurface testing. In particular, the scopes of work specified that the defensive caves and bunkers built by the Japanese be recorded in photographs, mapped, and that site forms be filed with the Guam Historic Preservation Office.

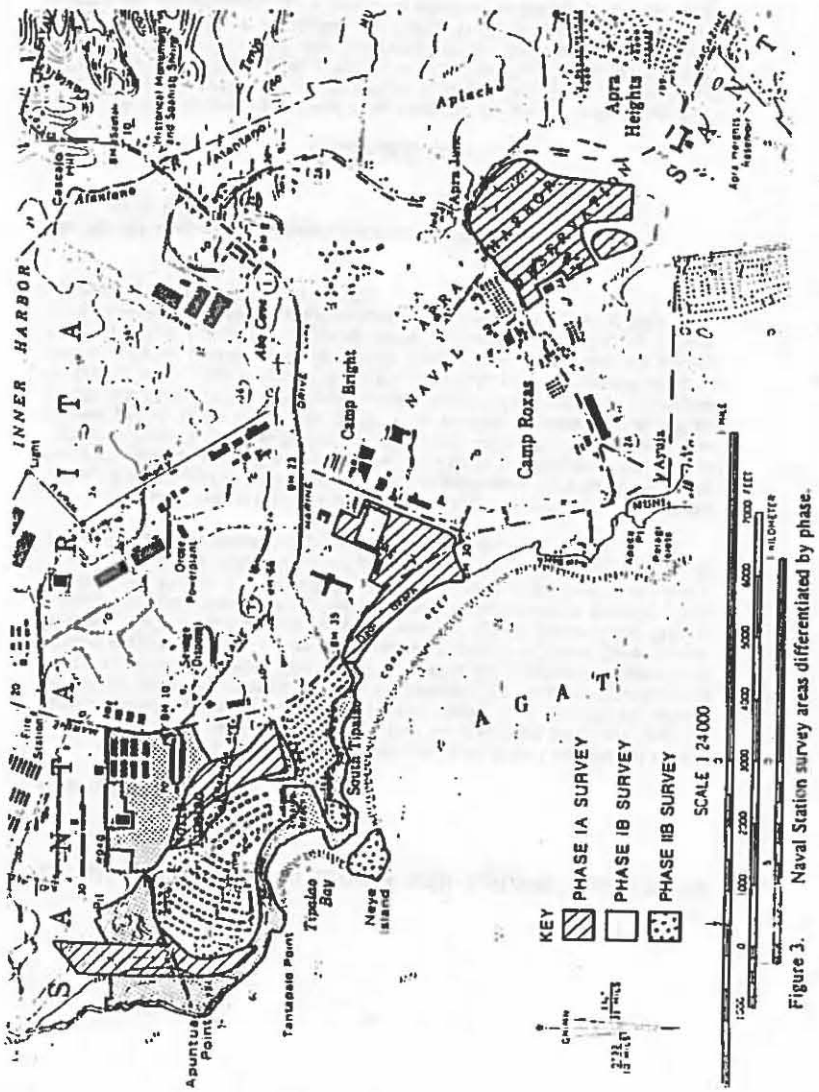


Figure 3. Naval Station survey areas differentiated by phase.

Modifications to the Scope of Work

The brief cessation of work after the Phase I-A survey followed by the Phase I-B survey additions redefined the project areas. After completion of the first survey, the area known as Dadi Beach was removed from consideration as a site for the family housing units and it first appeared no Phase II effort would take place there at all. It was argued, however, that expansion of the family housing area would bring greater numbers of people into the area, creating problems with indirect negative impacts in the Dadi Beach area. Consequently, the sites on Dadi Beach were still test excavated, mapped, and recorded during Phase II-A because the probable effects of increased use of the area had to be assessed. In fact, roughly 40 percent of the new areas surveyed during Phase I-B was in areas defined as being subject to indirect impact.

The scope of work was further modified in late August of 1992. At that time several minor corrections and changes were made in the scheduled submission dates for the interim and final project reports. These changes proposed an interim report in lieu of a third letter report, and clarified the deadlines for the draft final and final archaeological reports.

In mid-December, a brief letter report submitted to Belt, Collins & Associates stated that paleoenvironmental coring originally authorized and required by the Phase II-A scope of work had finally been completed. This work had been postponed by high water and bad weather which accompanied Typhoon Omar (28 and 29 August, 1992). With the coring finished, all archaeological field activities specified in the scopes of work had been completed. The findings of this study are detailed below in a separate section of this report.

II: HISTORICAL BACKGROUND AND KNOWN RESOURCES

Historical Background Summary

The cultural resources likely to be present in the project area can be broadly attributed to one of three temporal eras. First are traditional Chamorro sites and materials from the time before western contact (dating to A.D. 1521 or earlier). Second are Spanish-era sites which reflect the colonial use of Guam and the Marianas by Spain and her allies, from 1521 to 1898. The third and final historical era is from 1898 to the present, and could be considered the American or United States Period. Although this span of years can be divided into the "United States I" and "United States II" historical eras, with the "Japanese Period" sandwiched in between (Craib and Yoklavich 1992b), such detail is not needed. The focus of the third historical era, for purposes of this report, is on the years prior to, including, and just after the Second World War, referred to in this report as the War-era.

A detailed culture-historical discussion of Guam is beyond the scope of this report. It is sufficient to list several representative publications for each historical era. For discussions of early Chamorro culture, see Carano and Sanchez (1964), Reed (1952), Reinman (1968), and Thompson (1932, 1945, 1947). For an overview of the Spanish period, Hezel and Driver (1988) is an excellent resource; see also Plaza (1980), and Schurz (1939), and the cartographic history of the project area discussed by Tuggle, below. The history of World War II on Guam, and descriptions of extant War-era sites are available in Crowl (1960), Denfeld (1982, 1992, and this report), Lodge (1954), and Russell and Fleming (1989). A summary of the history, culture, and previously known historical and archaeological resources of the Naval Station area are given by Craib and Yoklavich (1992b).

The Spanish Context and Cartographic History of the Project Area
by H. David Tuggle

The Spanish Context

Numerous summary accounts of the history of the Spanish in Guam are available, although first-hand sources are difficult to obtain. Summaries include Barrett (1975) Beardsley (1964), Burrus (1954), Carano and Sanchez (1964), Hezel (1989), Schurz (1939), Spoehr (1954), and Underwood (1973). Available primary accounts include García (1883, in translation), Le Gobien (1700 in translation), Sanvitores (1669-1670, in translation), and a number of selections in Burney (1813) and Hezel and Berg (1975).

The first European record of the Marianas comes from the Magellan expedition in 1521. In 1565 Legazpi claimed the islands for Spain and they were subse-

quently used as a supply point for the Manila galleons, whose main anchorages were Umatac and Agana. The first permanent Spanish mission in the Marianas was established at Agana in 1668. The next two decades were turbulent and complex. Cultural change was rapid, given first the missionizing efforts and then common Spanish colonial practice of population relocation and centralization. The Chamorro responded with sporadic attacks on Spaniards as well as large-scale revolts. During this period the Chamorro population declined drastically due to wars, diseases, and dislocation (Underwood 1973).

Following their subjugation and initial acculturation, the Chamorro continued to decline in numbers over the next century, as the mestizo and immigrant populations increased.

Prior to centralization, there were several Chamorro villages on the Orote Peninsula, and people from these villages played a major role in the Chamorro wars, with the result that many of the villages were burned (Le Gobien 1700).

In 1690 five main villages were identified on Guam (Hernandez 1690, quoted in Hezel and Berg 1975:48; Barrett [1975:51] notes seven villages). These were villages with resident priests, undoubtedly primary population centers and consolidation locales (cf. Underwood 1973: 17). People in these centers may have farmed elsewhere, but the number of people living away from them would have been very low.

Of these five villages of 1690, the nearest to the present survey area was Agat, with a population of about 300. The first recorded Spanish installation on Orote was Fort Santiago, begun in 1721; Fort San Luis was constructed in 1734, and Fort Santa Cruz in 1801 (Delgadillo, McGrath, and Plaza 1979; Denfeld 1982; Driver 1987). The Spanish began to call this area the Port of San Luis (see map of 1734), and later the Port or Harbor of San Luis d'Apra, named for the small village and wharf (embarcadero) of Apra. The origin of the Apra Wharf is unknown.

In 1742 the English Commodore Anson ([1748] 1928:78) described Fort San Luis as

> ...intended to protect a road where a small vessel anchors...This fort mounts the same guns as the former [San Angelo, with five eight pounders].

In 1772 French Lt. Crozer (quoted in Carano and Sanchez 1964:109) described the harbor:

> The entrance is very narrow, and protected by a brick battery, which the Spaniards call St. Luis, mounted with eight bronze twelve-pounders of an old pattern. The harbour is capable of holding four vessels...It is dangerous to enter without pilots, because of the numerous rocks and coral reefs.

Population figures from the 19th century combine Agat and Sumay (Underwood 1973:Table 3), and probably represent the population for all of Orote Peninsula. These figures show a steady growth from 222 in 1831 to 1,325 in 1897, representing 4% and 15%, respectively, of the total Guam population.

The nearly 200 years of Spanish occupation of the harbor ended with the American takeover in 1898 (see Denfeld, this report).

This summarizes the primary Spanish activity that was recorded as taking place on Orote Peninsular near the project area. The details of this history as they relate to cultural resources are presented below through a study of historic maps and related documents.

A Cartographic Study of the Project Area

A study of historical maps covering the research area was carried out to obtain information on changes in landscape, cultural features, and place names. Some documentary sources are also included where relevant. This study presents the information based on the chronological order of the maps, which provides a framework for the evaluation of the data. The generalizations are obviously only as good as the collection of sources, and phrases such as "this name appears for the first time" are relative to the archival sources consulted, and are not intended as absolute statements. An excellent summary of the history of Marianas cartography is found in Driver (1987), and listings of Guam maps are in Reid (1939) and Driver (1985).

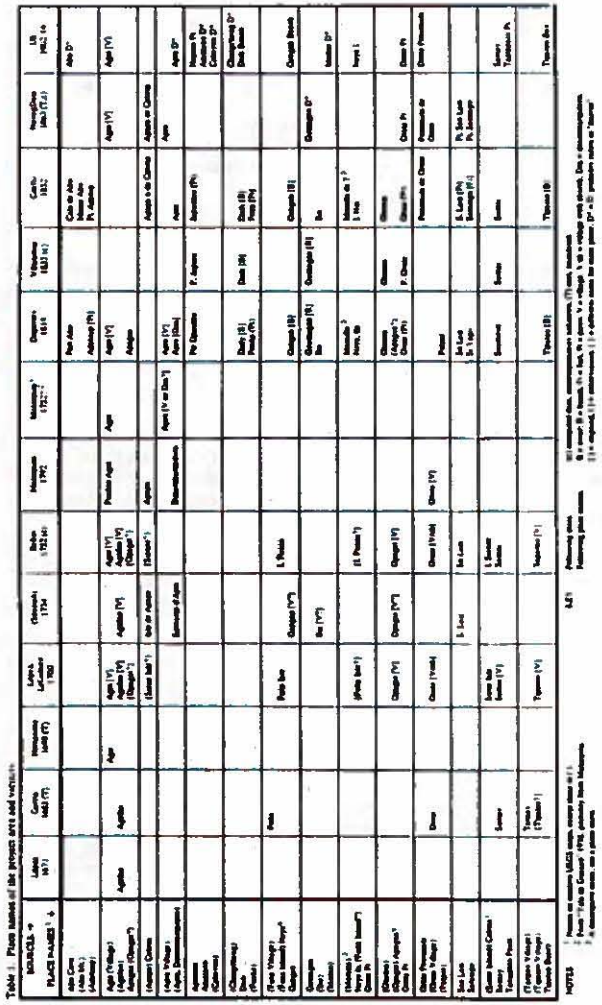
A listing of maps that were consulted is appended (see Map Resources) and the history of place name references is shown in Table 1.

Sanvítores Letters of 1669-1670

The letters of Sanvítores and others of the first Mariana mission were compiled into mission reports. In one of the reports dating to 1669-1670 (Barrett 1975: 15-16), there is a listing of Guam's "seven harbors" and associated villages. This listing does not mention any of the villages of Orote Peninsula or Apra Harbor. The villages named by Sanvítores nearest to the project area are "Agadna" and "Taragrichan".

Lopez Map of 1671

Guam appears on several early maps of the Pacific, such as Mercator's "Insulae Indine", 1595 (Driver 1985:7), but the earliest known map of the island showing any detail was prepared by Padre Alonso Lopez about 1671 (Driver 1985: 16). As far as I know, only one map directly attributed to Lopez has ever been published (Fig. 4). This is in Burney (1813:293), who notes that it was taken from Le Gobien's Historie de Isles Marianes, printed in 1700. Complications regarding the Lopez map are discussed below under "Lopez/Le Gobien".



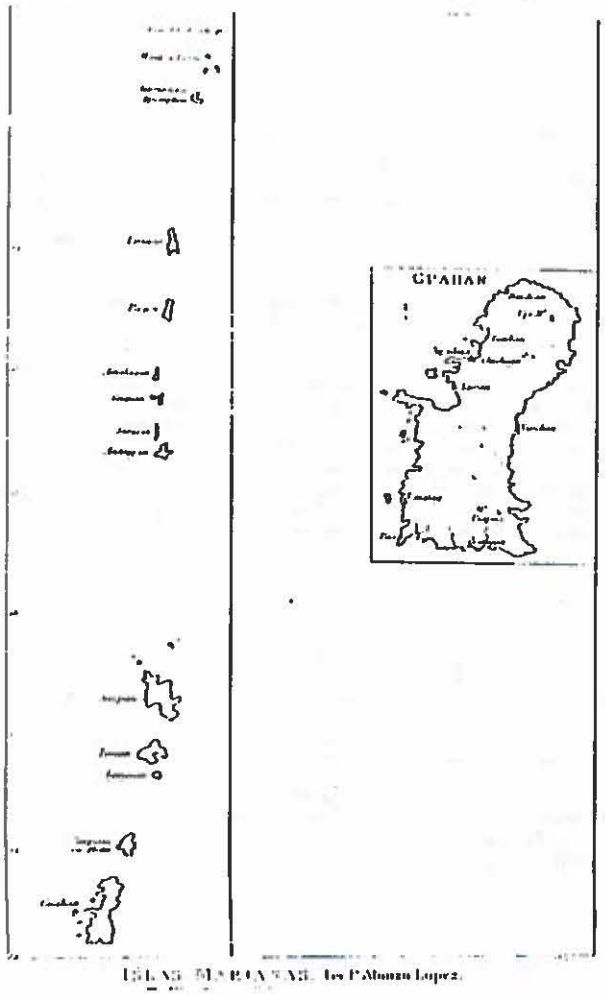


Figure 4. **Map of Guam and the Mariana Islands, attributed to Alonso Lopez, 1671 (from Burney [1813] 293); reportedly first printed in the 1700 edition of Le Gobien.**

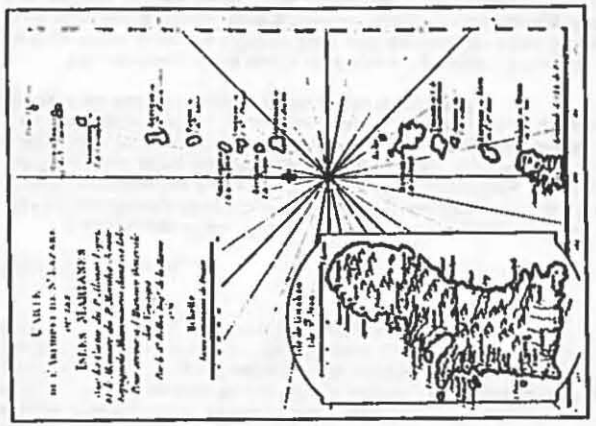


Figure 5. (b) Map of Guam, based on Lopez and Le Gobien map of 1700, redrawn by J. Bellin in 1752 (from Hezel 1989:ii).

Figure 5. (a) Map of Guam (copy in MARC library), attributed to Alonso Lopez; reportedly from the 1700 edition of Le Gobien.

The Lopez map in Burney shows the geographic areas of Orote Peninsula and Apra Harbor, but it provides no place names or other geographic data for the area, except for the village of "Agofan" on the northern side of the harbor. The only other named place anywhere near the project area is "Agadna".

García Document of 1683

Francisco García's 1683 document (García [1683] 1936) describing the Chamorro wars of the previous decade mentions the villages of "Orote", "Tarisay", "Funa", "Sumay", and "Agofan". Le Gobien's text ([1700] 1949:98) refers to these same villages, but this is presumably just part of the García text he copied (cf. Beardsley 1964:122). The 1930s translator of García (Higgins) notes that "Tarisay" is inland from Agat, near Sumay, while "Funa" was near Umatac, although the source of this information is unclear. Carano and Sanchez (1964: 74) implies that Funa was near Agat, on the southern side.

Several points about this list of villages can be considered by reference to the Lopez/Le Gobien map of 1700 (Fig. 5a) and later maps. All of the villages on García's list appear on the 1700 Lopez/Le Gobien map except for "Tarisay" and "Funa". The name "Tarisay" does not appear on any maps, but it is possible that the village "Tuparao" on the Lopez/Le Gobien map may be "Tarisay". The name "Funa" appears on the 1700 map, not as a village, but as an island, apparently Neye Island. This raises the question as to whether Funa Village was near Funa Island, which would place it along Agat Bay.

Lopez/Le Gobien Map of 1700

The histories of the two maps attributed to Alonso Lopez (Figs. 4 and 5a) are not clear, so it is difficult to evaluate the accuracy of village placement. Marjorie Driver (personal communication, 1993) has provided the following information. Both maps are said to be from the first edition of Le Gobien in 1700 (British Library reference 866e7). The base maps in Le Gobien were probably done by Lopez, but it is possible that Le Gobien added some of the place names.

In the apparent absence of original Lopez maps, it may be impossible to establish the reliability of the village locations. The outlines of the two maps are the same, but they are rendered differently, the mountains are drawn differently, and one has typeset lettering (the Lopez/Burney map, Fig. 4), while the other is hand-lettered (Lopez/Le Gobien, Fig. 5a). The critical point is the time period they represent and the information they are based on. If these maps were completely prepared by Lopez, rather than reworked by Le Gobien or others, the information would be more reliable.

All of the villages at harbors mentioned by Sanvitores are present on the Lopez/Le Gobien map (Fig. 5a) and in positions of relative accuracy. However, as discussed above, there are problems with this map and García's list of villages, including the location of "Tarasay" and "Funa". This is the earliest map to show the villages of Orote Peninsula, and if it was actually drawn by Lopez, represents the early

1670s, the period prior to the time of the Orote Peninsula village revolts, village burnings, and centralization. If it was modified by Le Gobien, the validity of the locations and time period is uncertain.

The locations of "Tuparao" and "Orote" villages on the Lopez/Le Gobien map (Fig. 5a) are interpreted by Craib and Yoklavich (1992b: 65, Fig. 11) to correspond to the present locations of Tipalao Bay and Dadi Beach. This is possible, but there are several problems. The cartographic inaccuracy of the coastline provides difficulty in determining position. Inaccuracy of village placement is suggested by the position of "Sumai", unless this village later moved to the location shown on later maps, its known location until WWII. The 1792 Malaspina map shows what may be a village named "Orote" at the end of the peninsula, and this locale was identified as Orote Point at least as early as 1734, as shown on a Spanish harbor map of that date (see below). This raises the possibility that Orote and Tuparao village locations may have been transposed on the Lopez/Le Gobien map. Alternatively, the village could have moved after the 1670s. Similar problems relate to the location of Tuparao, although a transposition with Orote would place it near the area of the beach now named Tipalao, if not at Dadi Beach.

In 1677, Orote village was involved in a serious conflict between the Chamorros and Spaniards, and in 1678, the governor, Captain Juan de Salas, burned several villages, including Orote, Tipalao, Sumay, Punton, and Taleyfac (Carano and Sanchez 1964:77). Two years later Jose de Quiroga renewed village burnings and population consolidation. The village of Sumai survived this period; Tuparao apparently did not. The fate of Orote is not clear. The Malaspina map suggests it may have lasted for another hundred years, but there is no record of the village after 1792.

Map of 1734 (Spanish)

A sketch map of the "Port of San Luis" (MARC collection) was drawn in 1734 by the officers a Spanish vessel taking harbor soundings. This shows very little of the research area, but it does provide several place names (Table 1), including Apra and Sumay, and shows the alignments (pilings?) of the Apra Wharf that are more clearly drawn on the 1819 Duperrey map. This is the earliest reference to Apra as a place name and as a wharf. There is no indication of a village, but it is assumed that a village of this name is the source for the naming of the wharf.

The importance of this map is the evidence it provides for Spanish activity in the inner harbor at least by 1734, ten years after the founding of Fort Santiago. This would almost certainly have involved some settlement and road building in the survey area, plus use of Dadi Beach. The rampart across the isthmus (see discussion of Duperrey map) may also have been constructed about this time.

This map does not show a village at Orote Point, but curiously, neither does it show Fort Santiago, which was built a decade before, in 1721.

Bellin Map of 1752

The 1752 map of J. Bellin (Fig. 5b) is one of the "old maps" of Guam most frequently reproduced, sometimes without attribution, sometimes called the Gobien map, and sometimes attributed to the actual preparer. It is said to have been "originally prepared by Bellin in 1752 from charts of a Jesuit missionary who came to Guam in 1671..." (Reid 1939:80). In other words, this was based on the work of Alonso Lopez (Figs. 4 and 5a). Driver (personal communication, 1993) notes that there are several published versions of the Bellin map, but all apparently redrawn from Lopez/Le Gobien. The caption of the 1752 map (Fig. 5b) states: "Carte...Les Iles Marianes Sur les Cartes du P. Alonso Lopez... por le Sr Bellin Ingr de la Marine" (Hezel 1989:ii; it is assumed that this is the same map listed by Driver, 1985:34, as "Bellin, Jacques. [Paris, 1780]. Source unknown.").

A comparison of the Bellin map with the Lopez/Le Gobien map indicates that it is essentially a redrafting of the latter, with no new information. There is some variation in the spelling of place names (for example Punna versus Funa), but this probably results from error (or French versus Spanish convention), and does not hold any importance for place name history.

Malaspina Map of 1792

The 1792 map from the Malaspina expedition (Fig. 6a; Driver 1985:22) places some villages in identifiable positions. The large village of Agat is shown with a road leading north to a "Desembarcadero" (landing place or wharf), from there to "San Luis", then ending at "Orote". This may be Orote village, although it could also represent Fort Santiago, or both fort and village.

The road from Agat to the Desembarcadero is placed on the map so that it would pass through the present research region, somewhere in the vicinity of survey area J (Fig. 10). However, the more accurate 1819 Duperrey map places this road (assuming it is the same one) about where Exchange Road is today. No other features or place names of the Malaspina map are shown in the research area.

A map (Fig. 6b) reproduced in the *Guam Recorder* in 1938 (titled "Ysla de Guaxan") is said to have been published by Fr. Juan de la Concepcion in a work entitled Historia General de las Filipinas, undated but printed sometime after 1892 ("Old Map of Guam" 1937). This map is reprinted in Beardsley (1964, end paper), attributed to Lopez. The similarity of this map to the Malaspina map (Fig. 6a) indicates that it is probably from the Malaspina expedition of 1792 and is not a Lopez map. The published record of the Malaspina expedition (Malaspina 1984) does not include this map, but it probably exists in the archives of the voyages that were available to Concepcion in Spain.

The importance of this second Malaspina(?) map is that the place name "Apra" appears on it, located at the place of the "Desembarcadero" of the other Malaspina map. On later maps, this is the Desembarcadero d'Apra.

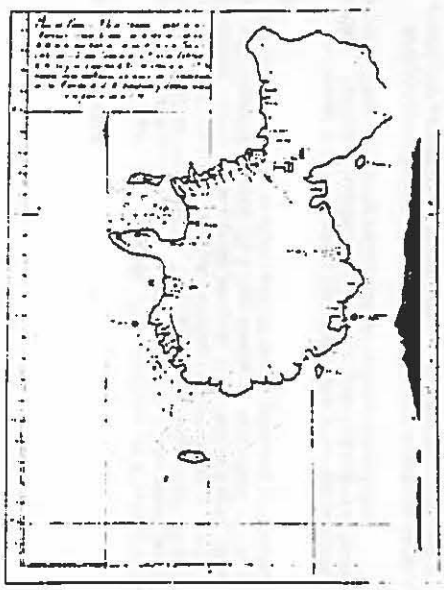


Figure 6. (a) Map of Guam, Malaspina expedition of 1792 (from Driver 1985:22).

Figure 6. (b) Map of Guam, probably from the 1792 Malaspina expedition (from Beardsley 1965, endpaper, noted as Lopez map).

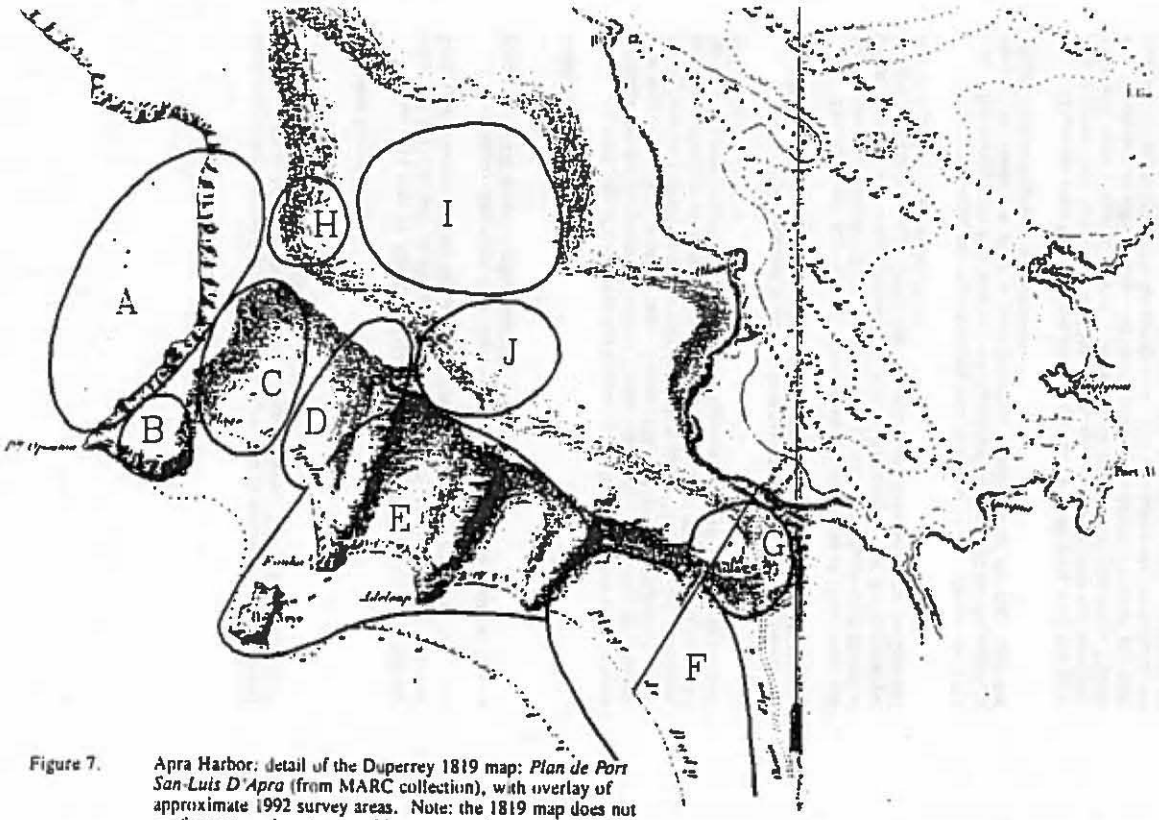


Figure 7. Apra Harbor: detail of the Duperrey 1819 map: *Plan de Port San-Luis D'Apra* (from MARC collection), with overlay of approximate 1992 survey areas. Note: the 1819 map does not conform to modern topographic maps, so the overlays have been estimated based on relative locations.

Duperrey Map of 1819

The 1819 map (Fig. 7; MARC collection) from the Freycinet expedition was prepared by a professional navy surveyor, L. Duperrey, who would later become a ship's captain (Dunmore 1991:91). This map provides a substantial amount of important information for the project area, including (1) the presence of a wall or rampart ("muraille") across the neck of the peninsula, (2) a "Village d'Apra" on the high ground at the center of the neck, (3) a clear drawing of Apra Wharf, (4) the road or path ("chemin") from Apra to Agat, and (5) several previously unrecorded place names.

The rampart is shown running from Dadi Beach across the peninsula to the Apra Wharf. The wall is described in an 1834 manuscript (see below) as "strong" and "thick" and is clearly part of the military defense system of Apra Harbor.

Apra Village is shown just east of the rampart, with at least two houses on the high ground, and perhaps others on the slope. It is interesting to note that the map identifies Apra as a village, but up the coast "Soumaye" (Sumay) is called a farm ("ferme"). During this period the local center or *pueblo* was Agat, and Sumay was one of its *barrios*, a dependent district (Driver 1987:22).

The wharf ("Embarcadaire [?] d'Apra") and the Agat-Apra road are shown more clearly on this map than on the earlier ones. The wharf is two alignments (pilings or rocks?) extending into the bay just to the east of the rampart. This wharf first appears on the 1734 map, but its date of construction is unknown. Spanish construction of Fort Santiago began in 1721, so the wharf was probably built between 1721 and 1734.

The Duperrey map is a primary source for place names for locales within the project: these include Dadi ("Dady") Beach, "Tipalao" Beach, "Neye" Island, and three points: "Opoutou" (now Haputo), "Fouka", and "Adeloup". The name of the river that drained into the harbor near Apra is given as Gumagoa, its drainage just east of the present Exchange complex. The harbor is given the full name of "Port San-Luis D'Apra".

This 1819 map shows no village at Dadi Beach (although the southern portion of the beach is not included), nor is any village shown at Orote Point. However, a road is drawn on the map to Orote Point, where the village may have existed according to the Malaspina map, leading from Sumay and passing by "Fort St Yago" (Santiago).

With the identification of Dadi Beach and an overlay of modern topography, the locations of the features of the Duperrey map can be identified. The wall or rampart's location can be placed in the survey area running from about the middle of Dadi Beach through survey area G (Figs. 7 and 10), the area that is now mostly concrete pads. Apra Village was located just east of the wall and would have been in the center of survey area G, now covered in concrete pads, and near Building 272. This is presently the high ground of the neck (about 40 ft. asl), and corresponds topographically with the 1819 map, even with the modern military modifications. The

north end of the wall and Apra Wharf would have been in the presently undeveloped low area north of Marine Drive and south of Sumay Drive. The Apra-Agat road ran approximately where Exchange Road is today.

Villalobos Map of 1833

An 1833 map by Villalobos (MARC collection) shows the rampart and the village of Apra, as well as additional paths or roads on Orote Peninsula. The road from Apra to Sumay follows the approximate route of Marine Drive today.

Population data from 1831 show the peninsula, including Agat, to have a population of 222 people (Underwood 1973:Table 3).

Coello Map of 1852

An 1852 map of the Port of San Luis de Apra (Driver 1987:16) was produced in Madrid by the geographer Francisco Coello. Inspection shows that the primary base map is the 1819 Duperrey map. Driver (1987:xiv) notes that Coello had numerous sources available to him to prepare the final map. This reworking of an older map raises questions about the contemporaneity of the data. The map thus cannot be taken to represent conditions in 1852, but as a generalization about Guam in the first half of the 19th century.

New information added to the Duperrey base map includes some roadways of the peninsula. Also, the first recording of the name for the peninsula, Orote, appears.

The road from Agat to Apra diverges near the south end of Dadi Beach and runs across the peninsula; this is the approximate location of the present Shoreline Drive. There is also a road shown from Agat to Atantano; this is the approximate location of the present Agat Drive, and Atantano would have been near the intersection of Agat Drive and Marine Drive.

The ridge along the Agat-Atantano road is named Monte Abo on the 1852 map. Thus survey area K is near the old Agat-Atantano road and on the slopes of Mount Abo. (Note that there is some distortion in this area of the map; also that Mount Tenjo is misplaced or misnamed).

There are some houses shown near the divergence of the Agat road; this location is above Dadi Beach, south of the survey area. The map does not decisively indicate if Apra Village still exists. There may be some houses just above Tipalao Bay, but there is no village name. No other structures are shown at Dadi or any other location that would fall within the survey area. The wall across the peninsula shown on earlier maps is still present on this map, identified as "muralla de [illegible]", muralla commonly used in Spanish to mean fort wall or rampart.

The War Years

None of the pre-invasion maps from the US or Japanese military show any military installations in the project area. Defenses are shown inland of Dadi Beach, at Orote, and at Agat. The coastal defenses of Dadi (such as Site 2-1129) were apparently not identified, except for water obstacles.

The pre-invasion "Beach Sketch" (Fig. 9) of Dadi describes the coast as:

> Coconut palms along immediate shore line. Rice fields and cultivated areas inland.
>
> Scrub Growth and Sword Grass on slopes with semi-dense undergrowth in the lower ravines.
>
> Water obstacles along reef edge.

The 1944 US military landing took place just in the Agat area, just south of the project area, then swept north across the isthmus and Dadi Beach. This is well illustrated in the maps of Lodge (1954).

Summary of the Map Data

The historic data about the survey area derived from maps of the peninsula are summarized in Figure 10.

The pre-1800 maps of the peninsula are not definitive because of cartographic distortion and questions about the history of their data. They suggest that the villages of Tuparao (or Tarisay?) and Orote may have been in or near the present project area in the 1670s, particularly at present-day Tipalao Beach and Dadi Beach. However, there are several uncertainties about the data. Orote may have been located at the end of the peninsula and the villages of Funa and Apra also have to be considered as having been located in the Dadi Beach area. Sites 1302 and 1311 may contain remnants of one or more of these early villages.

The 1819 Duperrey map provides much more solid information. In what is now the project area, the Duperrey map shows a rampart, the village of Apra, a road, and a number of place names. The rampart extended across the isthmus, crossing Dadi Beach and the isthmus flat. There is no record of the wall after the mid-1800s, but if any of it survived through WWII, it certainly would have been destroyed by the intensive post-war development.

The village of Apra was located in the survey area on the upper flat of the isthmus, and was in existence at least as early as 1734. The main area of the village lay in the area that was developed after the war and consequently any evidence was obliterated. However, it is possible that rockshelter Site 1302 could hold a part of the history of the village's fringes. The possibility that a remnant of the 18th century Apra Wharf has survived destruction should also be investigated.

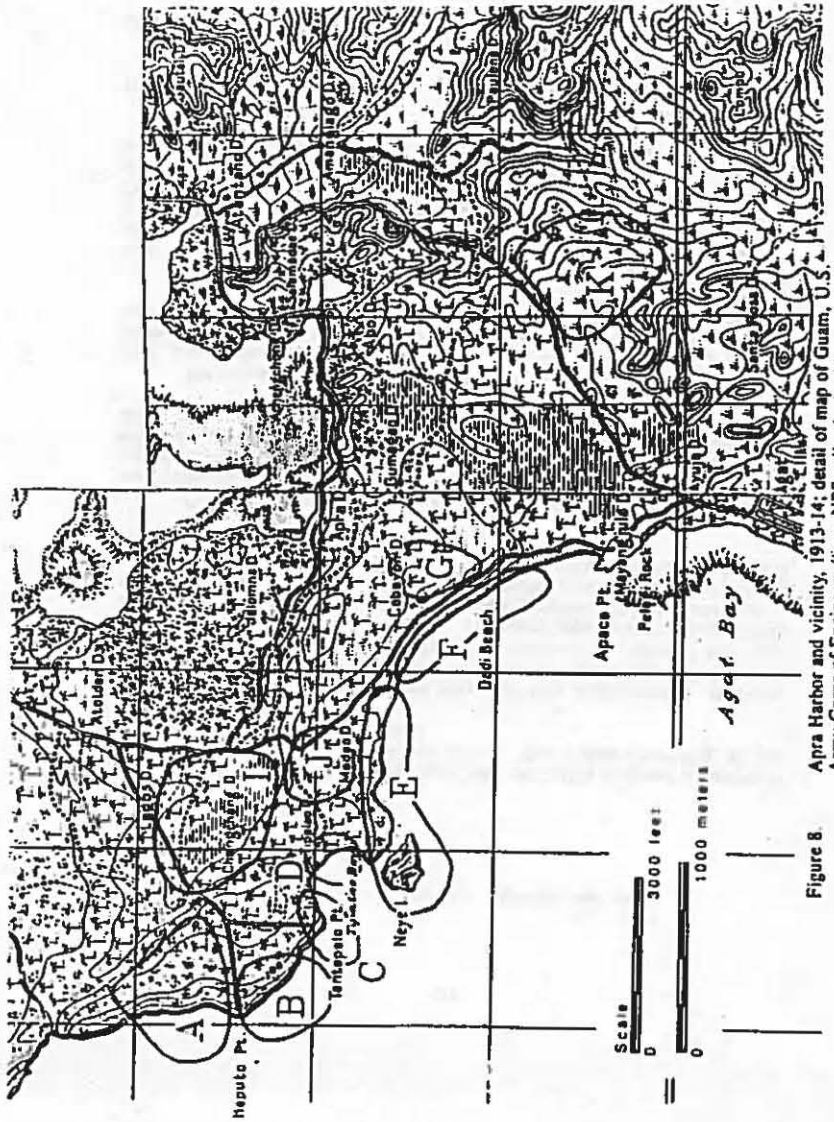


Figure 8. Apra Harbor and vicinity, 1913-14; detail of map of Guam, U.S. Army Corps of Engineers (from NPS collection) with overlay of 1992 survey areas.

Navigational Data Manuscript of 1863

Only two maps of Guam are recorded between 1852 and the turn of the century (Driver 1985:39-42). However, the Spanish Hydrographic Office published a document of geographic data in 1863 (translated by Driver 1987). Unfortunately this was not a first-hand study, but primarily data from the Freycinet expedition, with additional information from unspecified sources (Driver 1987:ix). Thus like the Coello map, this has to be taken as a compilation of information from more than a half century and not a contemporaneous description from 1863.

The following description is the portion of the 1863 text describing pertinent sections of Orote Peninsula (Driver 1987:13-18):

> From Facpi Point, the coast continues north northwest...there are various coves, points, and islets...
>
> The most notable of the coves is at Agat, where the village of the same name and 280 inhabitants nestle at its head. In the vicinity of Agat, the fields are extremely fertile, in contrast to the rest of the island...
>
> By contrast Orote Peninsula, lying beyond, is very sparsely vegetated...
>
> The coast continues [from Orote Point] east by southeast [to] the fort of San Luis, then...as far as the village of Apra...
>
> Orote Peninsula extends southeast to northwest a distance of approximately three miles. It is flat and relatively low, yet inaccessible on the north side as far as San Luis Point. It is also inaccessible on the southwest where there are high cliffs. From the point of San Luis...to the landing place at Apra, the land is low-lying and swampy, fringed by sandy beaches in some places and in others by woodlands that reach to the water's edge.
>
> The isthmus that joins Orote Peninsula to the island is near the village of Apra and is 3,000 feet wide. A strong thick wall constructed across the neck separates the land on the peninsula from that adjoining it.
>
> The entire peninsula of Orote consists of madreporic terrain that is nearly impassible because of its rugged surface, yet there is abundant vegetation. There are several roads, one of which leads from the *barrio* of Sumaye to Fort Santiago...

> The village of Apra has few inhabitants and scarce resources.

United States Maps of 1902-1914

The US Navy, Corps of Engineers and, and USGS produced a number of maps of Guam in the first decade of this century. One is shown here (Fig. 8), and others are listed under Map Resources.

The rampart, Apra Village, and Apra wharf have all disappeared. However, the maps show that the old Spanish road system is now formalized, and these corridors have remained to the present. There is no evidence of habitation or field cultivation in any of the present research areas. The nearest population centers are Sumay to the north and Agat to the south (the combined population of Sumay and Agat in 1897 was 1,325 [Underwood 1973:Table 3]). Atantano, to the east, is under intensive cultivation, probably rice. A single house is shown at the southern end of Dadi Beach and another at Apra.

The present project area is shown under heavy vegetation in virtually every area, primarily a palm forest (although the type of palm is unspecified). Area K is swampy. Dadi Beach has a sandy shore line, and survey area I is shown as a large body of standing water. This area is identified as "Changchang" on the maps, although the place name of "Lagos" (Spanish for "lakes") appears nearby.

The remnant of the body of water at Changchang exists today as a bog (Site 3-1327, area I), which was cored for the project. The maps indicate that this area was a wetland as early as the turn of the century. Earlier maps do not provide any detail about the area, but it can be assumed that this is a natural feature of some antiquity.

Most of the older place names appear on these maps, along with a new set as well. These appear to be locality or district names, but their origin and geographic reference have not been determined. These names can be found on Figure 6, and for the research area include "Changchang", "Madao", and "Cabeyon" (or "Cabayon"). On some maps they are followed with a "D." This "D." series also includes some older names, such as "Tipalao", "Apra", and "Gumagoa" (or "Gumagao"). The "D" probably stands for "district" (Bruce Karolle, personal communication).

United States Maps after 1914

The 1902-1914 map series forms the basis for all of the US and Japanese maps until after the war, when the modern USGS series was initiated.

No significant use of the areas that fall within the survey can be seen in the pre-war maps. Power, water and telephone lines were run through the area prior to 1936 (supporting the development at the end of the peninsula), but there is no evidence of habitation or farming other than the presence of a single house above Tipalao Bay, the house belonging to a "J. Delizama" (Corps of Engineers 1942).

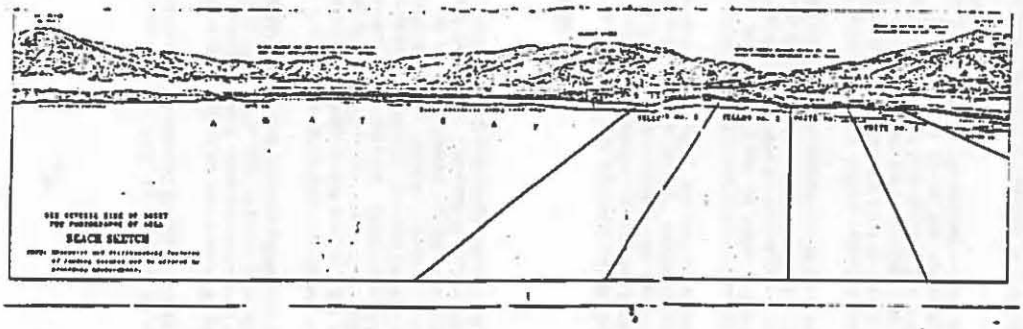


Figure 9. Pre-invasion sketch of Agat Bay and Dadi Beach: 1944 (from NPS collection).

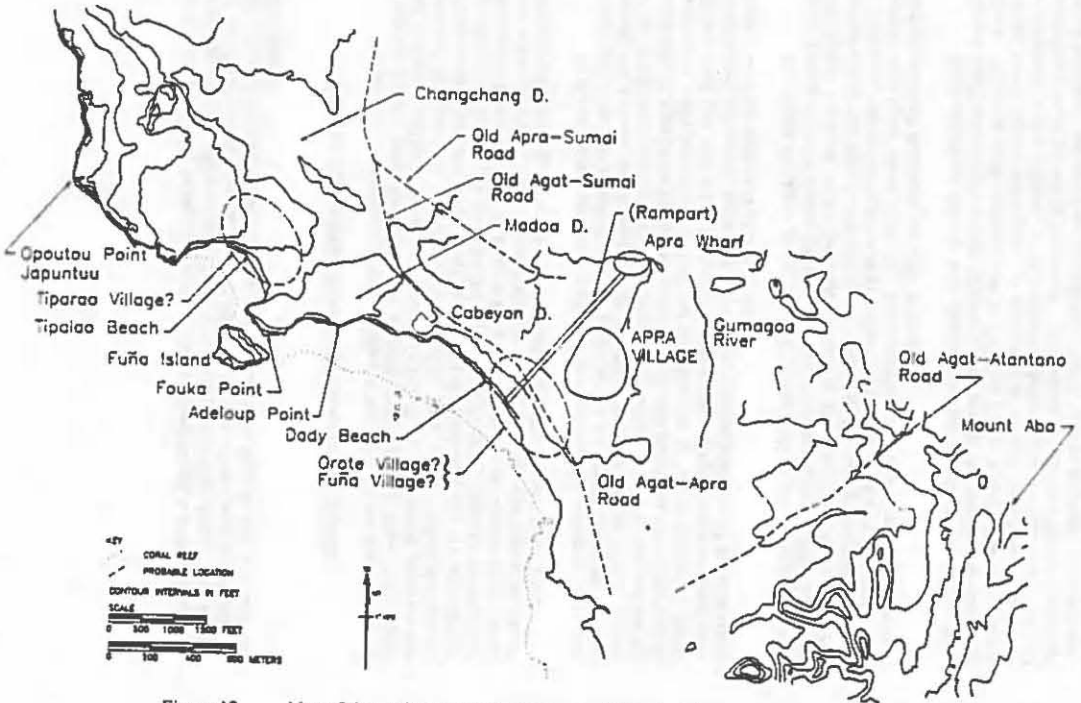


Figure 10. Map of the project area with summary of historical data from cartographic analysis, including variations in place names (see Table 1 for sources of information).

Other than Sites 1302 and 1311, the legacy of the long-term history of the project area may exist in only two domains, the road corridors and the place names.

The corridors or alignments of the main roads of the peninsula today date to at least the turn of the century. In many cases, the roads appear to have existed since the Spanish era of the early 1800s. The maps of earlier times show no roads, but given the terrain, it is probable that the basic corridors extend even further back into time.

The history of place name designation is presented in Table 1. Some names, such as Dadi and Japuntuu were not recorded until the early 1800s, and consequently may be questionable as traditional place names. Some Spanish names have been added to the area, such as Point San Luis. Other names for locales in or near the project area do have significant antiquity, including Orote, Tuparao, Sumay, Gabgab, Ilie, Agat, and possibly Apra. The retention of these place names, the recognition of the old roadways, and the archaeological remains help define the Chamorro and Spanish past as part of the present. These can be added to the more obvious cultural resources from the American period to constitute the total heritage of Orote Peninsula and Apra Harbor.

Archaeological Background

Concerning probable or known archaeological sites likely to be located within the Naval Station, documentary evidence suggests that remains of the 17th century Spanish-era village of Tuparao might be encountered. Remains of the villages of Apra and Orote may also be found in the vicinity. What is known about the locations of these villages as well as the thick wall or "muralla" is discussed by Tuggle, above.

The only other location previously thought to contain prehistoric deposits is the Dadi Beach area. According to Craib and Yoklavich, the Dadi Beach site is listed as "destroyed" (1992b: 65), but the area has been assigned the site number 66-02-143. In addition, the Guam HPO files contain no descriptions of the site, and this lack of information precludes any additional consideration of the site or use of its number.

By far, the largest number of historic properties and deposits in the project area date to the American and Japanese eras prior to, during, and after World War II. However, only two recorded sites were known to exist in the vicinity prior to the start of this project. At the north end of Dadi Beach is Site 2-1129, a bunker and cave complex fortified by the Japanese (Craib and Yoklavich 1992b: 71, Fig. 13). Although there is no known HPO site file or other records, the site is identifiable and the original site number is used here.

The second known property is illustrated by Craib and Yoklavich and is described only as "Masonry Entry Walls Along Shoreline Drive" (1992b: Fig. 13). No site number is given, and the concrete features do not seem to be described in the text. In Table 2 (Craib and Yoklavich 1992b: 53), "Stone Entry" is listed with "Japanese Steps" which are near the Sumay Village location. The Entry Walls are along Shoreline Drive, above Dadi Beach, not in the Sumay area, so this appears to be a confusion of features. Denfeld (this report) notes that these entry walls or gate

posts marked the entry to the Captain's Quarters of Camp Bright, a facility constructed immediately after the recapture of Guam on the bluff over Dadi Beach. (An identical set of entry walls is located about 1,100 meters south of the Camp Bright area, at the corner of Shoreline Drive and the access road to the flagpole area just south of Rizal Beach).

Previous Archaeological Investigations in the Project Vicinity

Systematic archaeological survey within the Naval Station has identified many important historic properties (McCoy et al. 1978, Denfeld 1982, Shun 1988, Craib and Yoklavich 1992b). During the survey of Orote Point, prehistoric ceramics and foodshell deposits were also encountered (McCoy et al. 1978). While the historic properties and prehistoric deposits of Orote Point are important, they are not really in the vicinity of our project area (the Orote Historical Complex, listed on the National Register of Historic Places, is about 4 kilometers northwest of Tipalao Bay). In or near our project area, only two small surveys are known; although several additional archaeological surveys and test excavations have taken place farther to the south.

Of the two small scale surveys known to have occurred within or quite near the project area, one examined a small parcel within the Naval Magazine, and the second was a recent investigation of "the old WESTPAC site" (Craib 1992). Survey of the WESTPAC site took place in December of 1991. This area, located on the south side of Agat Drive just inland from the beach, was developed by the Navy as an automotive repair facility after World War II. This tract of land is outside the Naval Station south gate, and is just north of a wetlands area. No prehistoric deposits were noted during the survey; apparently, the existing concrete platforms of the auto repair facility were not mapped or photographed.

The Naval Magazine survey occurred in late 1987 in the vicinity of several small parcels surveyed during this project. The area investigated in 1987 was about 800 meters northeast of the proposed Tomahawk Magazine (see below), and 760 meters east of the Inert Storehouse parcel. Although the survey covered only about 1.5 hectares, two surface scatters of prehistoric sherds and an isolated "possible basalt pestle" were found (Shun 1988:17). These materials did not define a site, however, and no additional fieldwork was done in the area.

More significant findings were obtained just south of the Naval Station, from several small test trenches placed 50 meters southwest of the bridge over the Namo River. This area, on the seaward side of Shoreline Drive, is about 800 meters south of the Naval Station south gate. A cultural layer of dark brown sandy clay was encountered in two trenches, at 70 centimeters below surface in one trench, and 40 centimeters below surface in the second. This deposit varied from 20 to 40 centimeters in thickness, and contained Latte Period pottery, worked fragments of *Isognomon*, a *Tridacna* adze fragment, Arcid and Venerid shell valves, and charcoal. The ceramic fragments appeared not to be water worn (Hunter-Anderson and Moore 1987).

A larger area just south of the Namo River was recently investigated as part of a waterline replacement project (Moore 1990). The area examined encompassed

portions of Agat and Santa Rita, and the methods used included survey of existing roadways and the placement of 25 test borings. In general, the 30 centimeter diameter auger holes found only disturbed clay soils and fill along the waterline right of way. No cultural deposits were encountered in any of the test holes, and no significant resources were identified during the survey.

The most substantial archaeological fieldwork located south of the project area was completed south of the village of Agat. There on the coast, about 4.3 kilometers south of the Naval Station south gate, a series of surveys and excavations preceded the construction of the Agat Small Boat Harbor. The most recent excavation took place in May of 1987, and the findings of that work are interesting (Hunter-Anderson 1987). The controlled excavations were able to identify and date the in-filling of an estuary, apparently caused by major erosional episodes linked to the recurrent hot dry season, the occurrence of fires, and the return of torrential rains. The cultural materials recovered in the Small Boat Harbor project area indicated that the shoreline had been used for farming and that foraging took place in the nearby lagoon. Furthermore, the prehistoric landscape was neither used intensively nor for residential purposes.

Finally, the fourth known archaeological survey recently completed south of the project area identified several significant properties. This survey was located 6 kilometers south of the Naval Station south gate, in Tailayag, Agat (Ramirez 1990). The parcel surveyed was situated along the coast just south of the Tailayag River; Anae Island lies 900 meters east-southeast. The 14 hectare parcel was surveyed over three days in mid-1990, and eight significant pottery scatters were located. In addition, possible *latte* stones and a possible limestone mortar were found, as well as a Spanish-era bridge and World War II material. The prehistoric materials located in this parcel where not considered to be in primary context (Ramirez 1990:27). Also, from the descriptions, the landscape and vegetation are not at all similar to the Orote Peninsula area, and comparisons between this site and the Naval Station project areas would be problematic.

III: FIELDWORK METHODS

Fieldwork methods varied depending on the project phase and the goals of the fieldwork activities. With one exception, all methods used were those outlined in the original and amended Scope of Work documents.

Phase I Surface Survey Field Methods

The Phase I surface survey of each project area was accomplished by walking systematic transects with crew members spaced every 10 to 20 meters, depending on the local topography and density of ground cover. In some places, straight-line block sweep transects were possible, and the ground was relatively clear of surface vegetation. But in most cases, the transects had to bend and conform to the local terrain, and ground surface visibility was judged less than 20 percent due to vegetation cover. In areas obscured by vegetation, surveyors stopped at regular intervals and cleared a small section of ground, allowing a more careful search for artifacts or cultural debris. Additionally, existing trenches, back dirt piles, erosional features, and soil brought up by downed trees were also examined for evidence of cultural activity.

With few exceptions, artifacts were not collected during survey. When either prehistoric or historic potsherds were located, they were picked up, examined, and then replaced where they were found. During Phase I-A survey, however, the two prehistoric sherds found at TN-17 were collected. During Phase I-B, three isolated artifacts were removed from Site 3-1304, the sinkhole caverns given the field designation PS-1. All three of these items are basalt maul fragments and are discussed in more detail in Part II. In general, other types of historic artifacts encountered during survey were also left *in situ*. The four historic items which were collected include a screw-on cap from an oil storage drum found in the old quarry, site PS-15; a short length of double-twist galvanized solid steel wire found within several meters of a live World War II hand grenade (site PS-11, the grenade was disposed of by experts); and a metal fragment from a fuse assembly (probably from an exploded American naval shell) found on the limestone ground surface roughly midway between the two cavern loci (PS-1 and PS-2) north of Haputo Road. These items, and all other artifacts and materials recovered from the test excavations are being curated temporarily at the Honolulu offices of International Archaeological Research Institute, Inc. The United States Navy has ultimate responsibility for the disposition of these materials.

Site locations were recorded on the Apra Harbor Complex maps (sheets 14, 17, 18, and 19) which offered both topographic and land-use detail. The dimensions, basic descriptions, and hand-compass triangulation data for each site were recorded in field notebooks. Aerial photographs of the project area taken in 1944, 1945, and 1954 were used to make preliminary interpretations of the surface survey findings. USGS topographic maps, Apra Harbor Complex maps, and the aerial photographs were also used to plan and efficiently execute the survey of each project area.

Phase II Site Recording and Subsurface Testing Field Methods

Documentation varied somewhat from site to site because of differing levels of effort specified in the scopes of work. However, minimal documentation of all sites included black and white photographs, sketches of prominent site features, and at least one set of descriptive field notes. Sites requiring more complete documentation were mapped using transit and stadia rod; in special cases, mapping was accomplished using a hand level, Brunton compass, and 30 meter tapes.

Five different methods were used for subsurface testing: hand auger, shovel probes, backhoe testing, a power auger, and controlled excavations. Preliminary assessment of site deposits and definition of site boundaries was usually accomplished using the hand auger (a three inch bucket type) and shovel probes. Deep testing was performed at two sites: TN-16 and the PS-12 area in Tipalao Bay (Tuparao Village, Site 2-1311). The backhoe used for these tests followed standard procedures. A 10 inch (25.5 centimeter) diameter truck-mounted power auger capable of drilling to a depth of two meters was also utilized for testing in the Tipalao Bay area.

Field forms and field notebooks were used to record data from the hand auger, power auger, and shovel probes. The types of data recorded included the presence or absence of artifacts, depths of soil color changes, characteristics of sediments and fill horizons, and other observations of geological and archaeological phenomena. Notes, sketches, soil profiles, and photographs were taken of the backhoe trenches and soil colors were recorded using the standard Munsell soil color charts.

At sites required by the scope of work to have controlled test excavations, units measuring either 50 by 50 centimeters or 50 centimeters by one meter were excavated. All controlled excavations were accomplished using 10 centimeter thick arbitrary levels (within thicker natural levels if such were discernible), removed by hand trowel and shovel. The volume of each excavated level was measured in liter-graduated buckets. All excavated sediments were field screened through quarter inch mesh. During screening, rocks larger than a fifty-cent piece were removed and discarded. All remaining material, including carbonate rock and other debris, was bagged for later analysis. Although some rough sorting of bulk materials took place on Guam, the vast majority of the laboratory analysis took place in Honolulu where all the excavated materials were shipped to be examined, sorted, and weighed. When sufficiently large pieces of charcoal were encountered during excavation, they were collected for possible radiocarbon assay. Charcoal fragments were also picked from the field screens and collected from the bulk midden bags in the laboratory.

The controlled test units and hand excavated trenches were back filled after first placing aluminum cans or plastic trash in the bottom of each pit. These materials are essentially non-biodegradable and should remain as markers of the excavations for an indefinite length of time. Trash markers were also placed in the backhoe trenches before they were machine filled.

Controlled test excavations were documented on standard provenience level forms. At the completion of each excavation, stratigraphic profiles were taken of one or two sidewalls (the single exception to this was a very disturbed and rocky test unit).

Where appropriate, black and white photographs were taken of the controlled excavations and soil samples were removed and saved for future reference.

The field methods used throughout this project are consistent with commonly accepted practices of scientific archaeological field work. With one exception, these methods were also those specified in the scope of work documents. The exception involves the size of screen used to process the excavated sediments; one quarter inch screen was erroneously used instead of the one eighth inch as required by the scope of work. This error was an unintentional oversight on the part of the Phase II project director.

The use of the larger sized screens has some potential for biasing the materials recovered from the controlled excavations. Although it is impossible to know exactly how the excavations were affected, it is possible to generalize how the larger screens may have impacted the recovered data. Of the four sites which received controlled test excavations, the deposits at two (TN-12, the bunker/cave complex now designated 2-1301; and PS-12 or Tuparao Village, now designated 2-1311) exhibited evidence of extreme disturbance. Testing at the third site, TN-17, found few artifacts and no true anthrosols; TN-17 is essentially a "nonsite". The use of eighth inch screen at these three sites would not have added substantially to the data recovery effort because it is unlikely that many small artifacts or faunal materials of interest were there to be recovered.

The one area where data recovery may have been biased by the use of quarter inch screens is the prehistoric rockshelter, Site 2-1302. Deep, basically intact stratified deposits were encountered in three of the four test units at this site. These deposits yielded an impressive number of small osteological (mostly fishbone) remains in addition to the huge numbers of molluscan shells recovered. Although research has shown that screen size does have an effect on the number and variety of identifiable fishbones recovered (Masse 1989), the use of larger inch screens at the rockshelter may not have had a great effect. The quarter inch screens that were used appeared to have recovered a representative sample of cranial and mouth fishbones from the site, although numbers of small vertebrae and spines probably passed unnoticed through the screens. It is also important to note that the marine molluscan shells at the site would not have been substantially biased by the difference in screen size, and it is unlikely that many small artifacts (shell beads, unusually small fishhooks, etc.) were present in the predominantly food-refuse midden of the rockshelter.

Other Field Methods

In addition to the specified surveys and test excavations, the scope of work allowed for a period of archival research to be conducted on Guam. This work was a supplement to that undertaken by the project historian (Denfeld, this report). The majority of the archival research took place on Guam between 21 and 25 September, after fieldwork was completed. Archives consulted during that period included the library of the Navy Public Works Center, the Micronesian Area Research Center of the University of Guam, and the Guam Historic Preservation Office. Aerial photographs, files of historical and archaeological significance, and general source materials

were consulted at these repositories. Short visits were also made to the Nieves Flores Memorial Library of Agana, and the museum and headquarters of War in the Pacific National Historical Park. Several of these archives were also visited prior to the final week of fieldwork. Such visits were short, and generally occurred during the frequent rainstorms which made outdoor work virtually impossible.

The photographic and documentary archives of the Bernice P. Bishop Museum in Honolulu were also consulted. This research was conducted by Drs. Tuggle and Carucci after the Phase I-A survey was completed and before Phase I-B began.

Finally, the sediment cores recovered from the marsh behind Tipalao Bay, Site 3-1327 (PS-6), were removed using a modified Livingstone piston sampler. This fieldwork was accomplished on 8 and 9 December. The samples were analyzed for pollen content, and portions of the sediments have been radiocarbon dated. A more complete discussion of the methods used, and the findings, is presented in a separate section below.

IV: SMALL AND DEVELOPED PARCEL SURVEY AREAS

by

H. David Tuggle

Andersen Air Force Base

The scope of work included two parcels at Andersen Air Force Base for archaeological survey. These parcels were both listed under MCON P-203, maintenance hangar and a fuel storage tank at a separate location. The survey of the two areas was conducted on June 16, 1992. The on-site survey locations were determined in consultation with Heidi Hirsch, environmental officer of Andersen Air Force Base.

The fuel storage tank area was added to the original scope of work. The original scope included a sewer line, but in discussion with Heidi Hirsch and Andersen engineers, it was learned that in reality no line was actually planned, nor had one been surveyed. An engineer also pointed out that the proposed facility would probably have a septic system, and not be attached to a sewer system. Consequently, there was no sewer line to survey.

Maintenance Hangar Area (MCON P-203): 78,000 sq. ft.

The survey area (Fig. 11) is a completely developed and modified parcel immediately adjacent to runways, roads, and revetments. The areas on both the inside and the outside of an existing chain-link fence were surveyed, a total area of about 120,000 sq. ft. The surface is limestone exposures and coralline gravels, with some sparse grass, but no soils, all apparently bulldozed. No cultural material was seen and there is no potential for testing.

Fuel Storage Tank Area (MCON P-203): 240,000 sq. ft.

The survey area is an overgrown slope with a roadway along the eastern side and a telephone line along the northern side. The heavy vegetation includes hibiscus, vines, ferns, and Marianas cane. The surface is a loose coralline gravel on a limestone base, with quantities of modern trash. The area appears to have been bulldozed.

No modern cultural material was seen. There is no potential for testing.

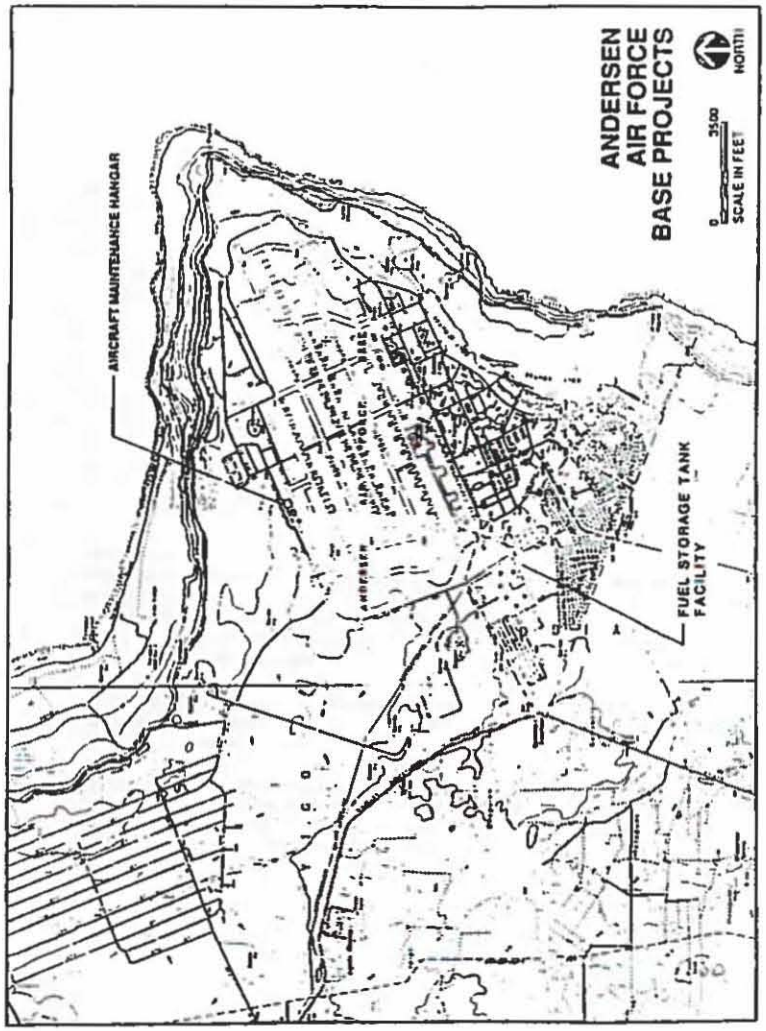


Figure 11. Location of maintenance hanger survey area, and fuel storage tank survey area, Andersen Air Force Base.

Summary of the Andersen Survey

The areas have been modified by recent activities. There are no sites and no potential for sites.

Naval Magazine

Galley Expansion (MCON P-827): 1,535 sq. ft.

The area (Fig. 12) is bulldozed and developed, clay soils, a cut into the hillside, and no vegetation. No cultural material was seen and there is no potential for testing.

Inert Storehouse (MCON P-830): 17,000 sq. ft.

The survey area is a bulldozed and developed area, with clay soils. A nearby carabao wallow was also examined. No cultural material was noted and there is no potential for testing. Personnel of the Naval Magazine on site also indicated that the project would use existing pads, and that no new ground would be broken.

Tomahawk Magazine (MCON P-829): 18,000 sq. ft.

Survey Area 1

The project is on an open bluff with some soil development, predominantly clay. No cultural material was seen. A limited potential for testing was considered, but the project was moved from this area and consequently no testing was conducted.

Survey Area 2

Conversations with Lt. Kelly, and examination of several planning maps Kelly provided confirmed that the proposed location of the Tomahawk Magazine had been changed since the first survey. The new location for the magazine is about 400 meters east of the location surveyed by Tuggle (Fig. 13). Fieldwork at the new location utilized a combined strategy of surface survey and subsurface testing. Since the site was new, it had to be surveyed; to comply with the scope of work, the new location had to be tested as well.

Details concerning the relocation of the proposed P-829 Tomahawk Magazine construction project were reported to PACNAVFACENGCOM. This report was made verbally during the weekly phone consultation mandated in the scope of work.

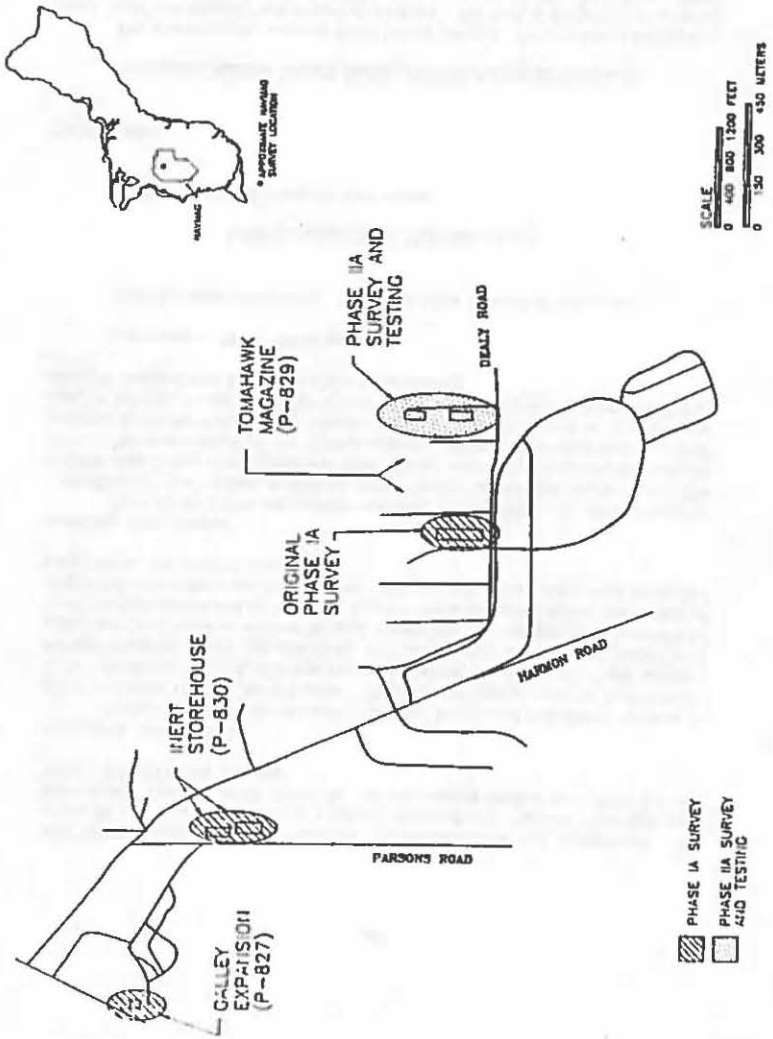


Figure 12. Location of parcels surveyed on the Naval Magazine.

Standing on the new site are two old, dilapidated magazines which will be razed. They are located in partial revetments the excavation of which disturbed the surrounding ground. The area in between the two structures has also been disturbed. A coral concrete road and apron leads up to the doors of the magazines. West of the revetments is low and swampy ground, to the east the ground is slightly elevated and better drained. The entire project area was surveyed in transects, but no prehistoric deposits were found. On the higher ground to the east, four auger tests were placed. A fifth auger was situated between the two existing magazines, and a section of road-bank was shovel faced for stratigraphic detail.

Results of Test Excavations

Auger 1

Placed in the center of the surveyed parcel, just west of the road connecting the two old storage magazines, at the bottom of the road shoulder slope. Total depth 50 centimeters. The upper 20 centimeters consisted of a heavy, moderate brown clay soil. Second layer was 30 centimeters of light brown clay, becoming rusty red sterile clay at the very bottom. Ground water encountered at 48 centimeters below surface; small subrounded to subangular coral pebbles found throughout upper 30 to 40 centimeters. No flecking or artifacts noted.

Auger 2

Located on the higher ground in the east-central part of the site, about 10 meters east of the access road and 20 meters north of the northern end of the southern storage magazine. Total depth reached 29 centimeters. The upper 20 centimeters was a dark brown very plastic clay soil containing some roots and a minor component of humus. Below 20 centimeters below surface, a mottled red-orange sterile clay was encountered. Ground water began entering the auger hole at 22 cmbs; no flecking or artifacts noted.

Auger 3

Also located on the high ground 10 meters east of the access road, roughly opposite the north end of the southern storage magazine. Total depth 54 centimeters. Ground water began filling the auger hole at 2 centimeters below surface making examination of the soils and measurements difficult. Upper 10 centimeters dark brown clay soil, then mottled red and tan sterile clay. No flecking or artifacts.

Auger 4

Approximately 20 meters south of Auger 3, in line with Augers 2 and 3, 15 meters east of the access road. This auger is opposite the south end of the southern storage magazine. Total depth 38 centimeters; ground water reached at 28 cmbs. The upper 20 centimeters consisted of a medium brown heavy clay soil having the same appearance as the other auger tests. From 20 to 38 cmbs, mottled red and tan sterile clay. No flecking or artifacts noted.

Auger 5

Placed in the same line as the previous three augers, about 20 meters south of Auger 4, 10 meters east of the access road, and 20 meters north of Dealy Road. The

total depth reached was 30 centimeters; ground water was not encountered. The upper 20 centimeters consisted of a medium brown heavy clay soil with light roots throughout. From 20 to 30 cmbs, the soil was mottled tan and red sterile clay was noted. No artifacts or flecking.

Road Bank Shovel Facing

A short section of the cut bank above the access road was shovel faced in an effort to further examine the soil strata. This test was located between Augers 4 and 5, but nearer to Auger 4, and was roughly opposite the south end of the southern storage magazine. Only two soil strata were discovered. Layer I consisted of a 15 centimeter thick band of medium to dark brown clay soil containing a good deal of roots but little humus and no flecking. Layer 2 was a variegated dense, sterile clay of bright red with mottles and bands of tan. Both the red and tan clays were moist and very plastic. No artifacts were noted.

Summary Interpretation

None of these tests encountered any artifacts or evidence of cultural activity. Ground water was reached at shallow depths in four of the five auger tests. The shallow dark brown clay topsoil was underlain by dense, plastic, sterile tan and red clays. The construction of the older magazines, earthen revetments and the coral concrete aprons have thoroughly disturbed this area. In addition, it is clear that the area, in general, would have been a poor location for a prehistoric farm or village, although foraging may have taken place in the vicinity.

Significance: None; this is not a site.

Summary Recommendation: No further work is required in this area.

Summary of the Naval Magazine Survey

No sites or cultural materials were located.

Naval Station

Hazardous Material Storage Facility (MCON P-141): 55,000 sq. ft.

The area surveyed measures about 150 by 500 feet. It lies south of the Supply Depot Road and adjacent to a fenced parking lot. The area is flat and it is covered with abandoned concrete pads. Exposed surface areas are coralline gravels and limestone. There are no cultural materials and no potential for testing.

General Warehouse (MCON P-153): 60,000 sq. ft.

The surveyed area is about 150 by 150 feet. It is located north of the Sewage Treatment Plant. The area is flat and covered with *tangantangan*, with a surface of

coralline gravel and some thin patches of soil. Large mounds of dumped and/or bulldozed dirt are in the center of the parcel. There are no cultural materials and no potential for testing.

Child Care Center I & II (MCON P-391/392): 10,350 / 7,500 sq. ft.

These two small adjacent parcels lie about 30 m north of Haputo road. There is a fence on the west and the existing Child Development Center is on the east. The area is flat, probably bulldozed, covered in *tangantangan* and grass, with a coralline gravel surface. No cultural materials were found and there is no potential for testing.

Transportation Parts Storage (MCON P-235): 10,000 sq. ft.

This area is flat, with some *tangantangan*, with a bulldozed surface of coralline gravels. No cultural materials or potential for testing exist.

Wastewater Treatment Plant Expansion (MCON P-239): 3 acres

With the exception of a narrow strip to the northeast, the survey parcel is the developed area of the current wastewater treatment plant. The southeastern area that is marked on the map as vegetated is landscaped lawn.

The northeastern strip of ground, bounded by two access roads, is covered in *tangantangan*. All of the areas are bulldozed, and have exposed limestone or coralline gravels. Much of the non-landscaped areas are strewn with recent debris. No cultural materials were found and there is no potential for testing.

Summary of the Naval Station Small Parcel Surveys

All of the listed areas are in developed areas and appear to have been bulldozed and previously used for military construction or activity. Some are landscaped and others are overgrown in *tangantangan*. All have exposed limestone or gravel surfaces. There is no soil present, except for a few patches two or three centimeters thick. No non-modern cultural material was located in any areas. There is no testing potential.

V: GENERAL DESCRIPTIONS OF NAVAL STATION SURVEY AREAS AND ENVIRONMENTAL ZONES

The following are general descriptions of all the major Naval Station survey areas (Fig. 13). With the exception of Neye Island, each area is identified with a descriptive title and lettered in order from A through K. The lettered areas represent approximate survey areas, broken into natural physiographic zones. The descriptions of these physiographic zones are given in broad environmental terms. The letter-coded parcels are keyed to Figures 14 through 17 and are described from north to south starting along the coast and followed by the inland areas.

A: Coastal Zone North of Haputo Road

The survey area north (as well as south) of Haputo Point contains some extremely rugged terrain (Fig. 14). Topographic data reported on various maps often do not adequately represent the true nature of the ground surface (apparently, the tops of the trees and other vegetation were used to incorrectly interpolate details of the ground surface below). Much of the area is covered by tall, sharp, massive karst solution structures. In other parts of Micronesia (e.g., the "Rock Islands" of Palau), similar areas are termed "pit and pinnacle" topography.

The pit features vary in size, but many average 2 to 3 meters across and 3 to 4 meters long (although many pits are much larger). In general the long axis of each pit is roughly oriented north-south, paralleling the coastline. The depth of the pits (or the height of the sharp, roughly eroded limestone walls) vary considerably based on the amount of accumulated plant litter and other debris they contain. Some pits are at least 10 meters deep, while others are as shallow as a meter or so.

The area north of Haputo Road appears to have more disturbance than the section to the south. In the north, there are numerous bulldozer berms, piles of historic and recent trash, and perhaps more *tangantangan* as well.

Five sites or possible sites were located in this area.

B: Coastal Zone South of Haputo Road

The zone of pit and pinnacle topography south of Haputo Road is possibly more pristine than the comparable topographic area north of Haputo Road (Fig. 14). There is, in general, less trash and a less disturbed vegetation regime. There are large patches of limestone forest with very little grass, *tangantangan*, or other volunteer species. The karst solution features themselves also appear to be more rugged. There are expanses of razor-sharp dogtooth structures that are almost impossible to traverse.

Few coconut crab traps were seen in these virgin areas.

One possible site area was located in this survey parcel.

C: Headland at North end of Tipalao Bay: Tantapalo Point

The beach is littered with piles of wet-poured waste cement, bricks, blocks, and fragments of eroded concrete, and more recent trash (Fig. 15). The reef flat is also littered with trash, most of it rusted masses of steel from the War-era. One area in particular exhibits a huge mass of rusted metal. This is located near the northern edge of the reef in Tipalao Bay. It is not clear if the mass of metal was dumped off the edge of the cliff, or if a barge or other vessel ran aground. A few pieces of aircraft aluminum were noted among the wreckage, including at least two large airplane landing gears.

The top of the cliff is also heavily disturbed. The entire area must have been scraped by bulldozers and subsequently filled. There is little soil development in most areas. Vegetation tends to be heavy *tanganiangan* and other volunteer species. Strand vegetation and *tanganiangan* dominate the beach.

Five sites were recorded in this survey parcel.

D: Central Tipalao Bay: Beach and Backshore Areas

This area represents a complex and changing environment (Fig. 15). In the past the backshore areas were vegetated sand dunes; more recently the area has been filled and the elevation raised by several meters. Some natural changes have occurred as well. Since the prehistoric past, the beach and surrounding area has probably risen relative to sea level by about 20 to 30 centimeters. Near the center of the beach, a band of young beachrock has formed shoreward of two older deposits. The beach also exhibits characteristics indicating that extremely powerful storms have occurred, a process which we observed with the passage of Typhoon Omar.

Two sites were recorded in this survey area.

E: Headland Opposite Neye Island, South Tipalao Bay, and Cliffline of Northern Agat Bay

This section consists of a corridor formed by the beach and the top of the cliff (Fig. 15). The geology, level of disturbance, and commonly occurring vegetation in this area are essentially the same as those described above for the northern Tipalao Bay headland. What is different here is the effort the Japanese military took to make the area defendable. Numerous caves have been excavated in the limestone headland. In some cases, this was accomplished by enlarging natural sea caves.

Altogether, eight sites were recorded in this survey parcel.

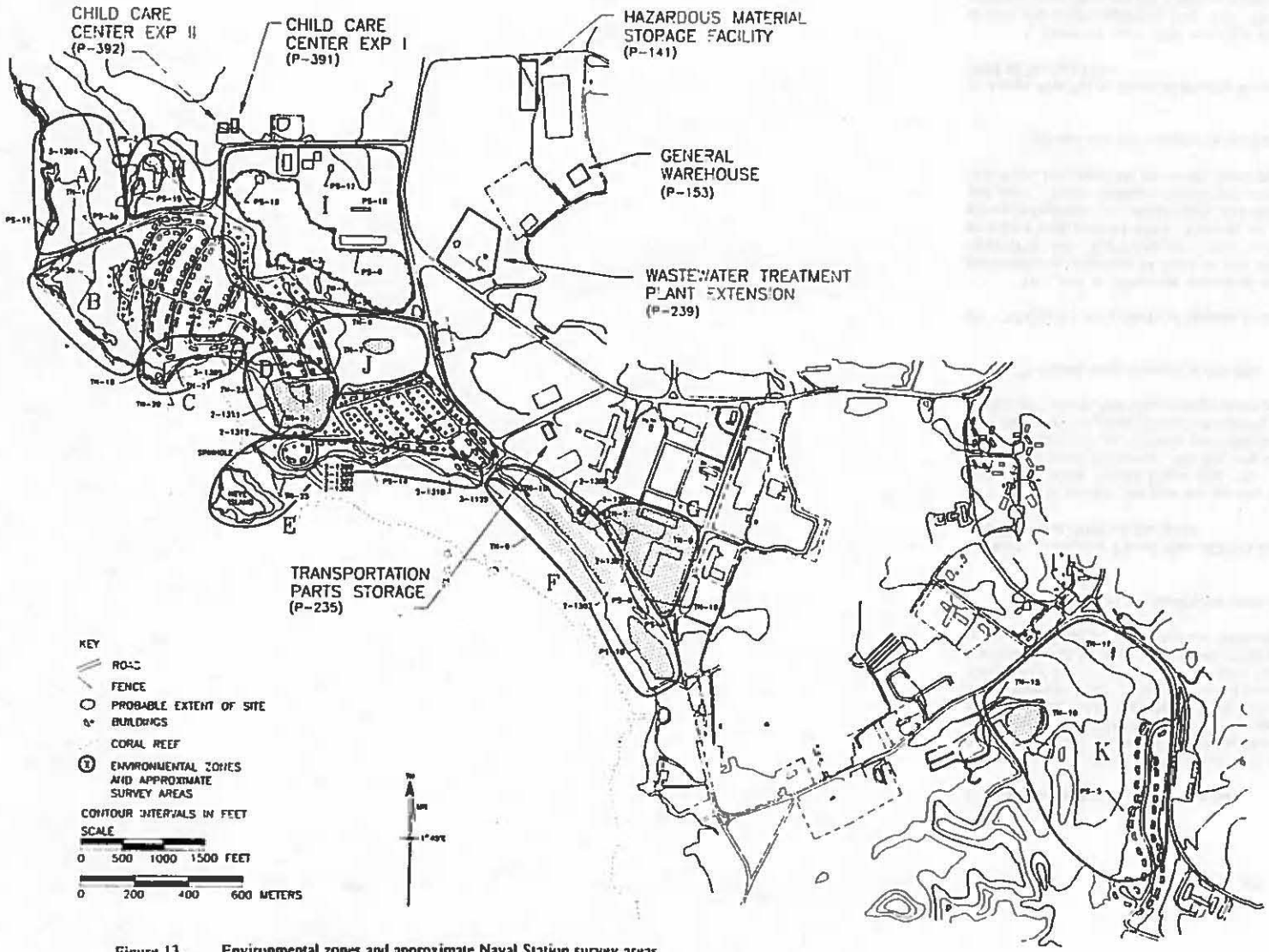


Figure 13. Environmental zones and approximate Naval Station survey areas, keyed by letter.

F: Dadi Beach: Northcentral Agat Bay

A coastal strand heavily impacted by both human activity before, during, and after the war, and by natural storm processes (Fig. 16). Except for the littoral zone of bioclastics and carbonate sands, most of the coastal bench and low backshore areas are now under dense vegetation. Many early 19th century Spanish maps include the name "Playa de Dadi" indicating this is a name of some antiquity. The northern point (location of Site 2-1129) may have been called Adotgan Point. Tipalao Bay, the possible site of Tuparao Village lies to the north. The area immediately above the north end of Dadi is named "Madao" on the early 20th century maps.

Twelve sites or site areas were located in this survey parcel.

G: Flat, Triangular Parcel West of Navy Exchange, Bounded by Exchange Road and Shoreline Drive on the South

In the late war and post war periods this was a completely developed parcel, part of the Naval Supply Depot (Fig. 16). There are flat cement foundations and portions of roads remaining, and the area is bounded by deep, well-built and still active drainage ditches, culverts, and other storm-control features. Most of the area is covered in mowed grass. Early 20th century maps identify this area as "Cabayon" or "Cabeyon", which, like Changchang, seems to be a regional name and not a village.

Two sites were recorded in this area.

H: Old Quarry Area North of Haputo Road and West of Active Quarry

This area is comprised mainly of an abandoned and overgrown quarry pit surrounded by remnants of more or less disturbed karst topography and limestone forest (Fig. 14). The topographic maps are not to be trusted because the old quarry may have been partially filled. Much of the vegetation in and around the quarry has grown to immense size, which might also affect the interpretation of recent air photos and maps. Trash, bulldozer berms, and other evidence of recent use (e.g., coconut crab traps, beer cans) are commonly found throughout the area.

Only one site was recorded in this parcel, and that is the old quarry itself.

I: Large Flat Parcel South of Haputo Road, North of Granada Avenue and West of Marine Drive

A generally level area having a hard, compacted surface, with coralline gravels and dense vegetation (Fig. 14). The place name "Changchang", apparently referring to a region and not a village, occurs on early 20th century maps. The northern portion of this survey parcel is clear, open land which appears to be either extremely hard, machine-compacted crushed coral, or else a large expanse of poorly preserved concrete. Aerial photographs indicate the area was extensively bulldozed

and then used for open storage, Quonset storage huts, and possibly the dumping of rubbish. The western half of the parcel is more densely vegetated and heavily disturbed. To the south is a low marshy wetland which war-era air photos indicate was partly filled and encroached upon. In sum, the whole large parcel has been impacted.

Eight sites and site areas were recorded in this area.

J: Old Quarry Area South of Granada Avenue, West of Shoreline Drive, North of South Tipalao Housing

A flat parcel, except toward the south where the terrain becomes very broken, and the boundary is marked by a high limestone face; heavy vegetation, primarily *tangantangan* and dense ground cover lies over most of the area (Fig. 15). This entire area was a quarry site when the 1944 aerial was taken, and also used for concrete production. The southern end represents the remnant areas of quarrying. The high limestone bluff is covered with moderately dense vegetation, mostly *tangantangan*. In some places, the soil has been disturbed by the placement of fences or by erosional features; other areas are relatively intact.

Two sites were recorded in this survey parcel.

K: Rugged Area South of the Intersection of Agat Drive and Magazine Road

The greater part of this area is a large drainage system, with heavy clay soils, thickly overgrown with Marianas cane, bamboo, swordgrass, *Pandanus*, and *hibiscus* (Fig. 17). Evidence indicates the area is heavily flooded during the rainy season, creating huge quagmires. There are some streamcut exposures, but no cultural material of any kind was noted in the main drainage basin. No early name is known for this locale, but it is the upper drainage for the coastal place named Ayuja.

Outside of the project area, along the central southern portion of this survey parcel, an additional area was examined briefly because of its topographic position and relevance to the adjoining areas. As a bluff in the drainage complex, this area had the best possibility to contain prehistoric remains; however, none were noted; a USGS map also indicates that a tank (water?) was located here in the early 1950s.

Four sites and site areas were identified in this survey parcel.

Neye Island

Survey of Neye Island was not authorized or included in the scope of work until Phase II-B. It was considered highly probable that intact prehistoric and historic resources would be found on the island (see map of Area E). The moderately large, high relief island located just off the headland at the south of Tipalao Bay was probably utilized in some fashion by the Japanese (Photo 1). Certainly, their thorough defense strategy would have assigned some role to the island, even though some re-

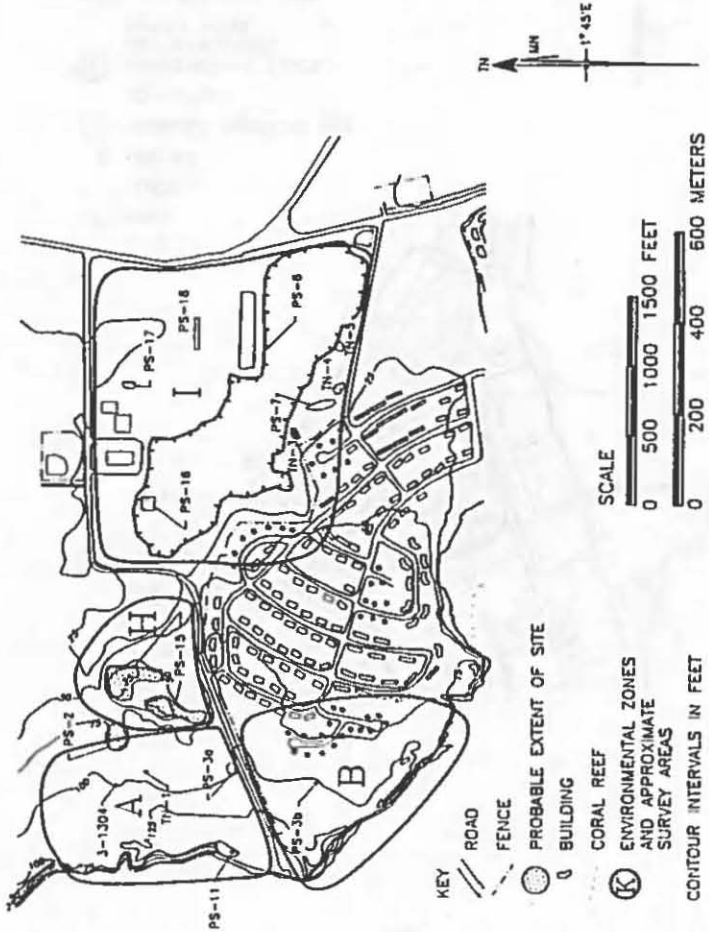


Figure 14. Environmental zones and Survey Areas A, B, H, and I.

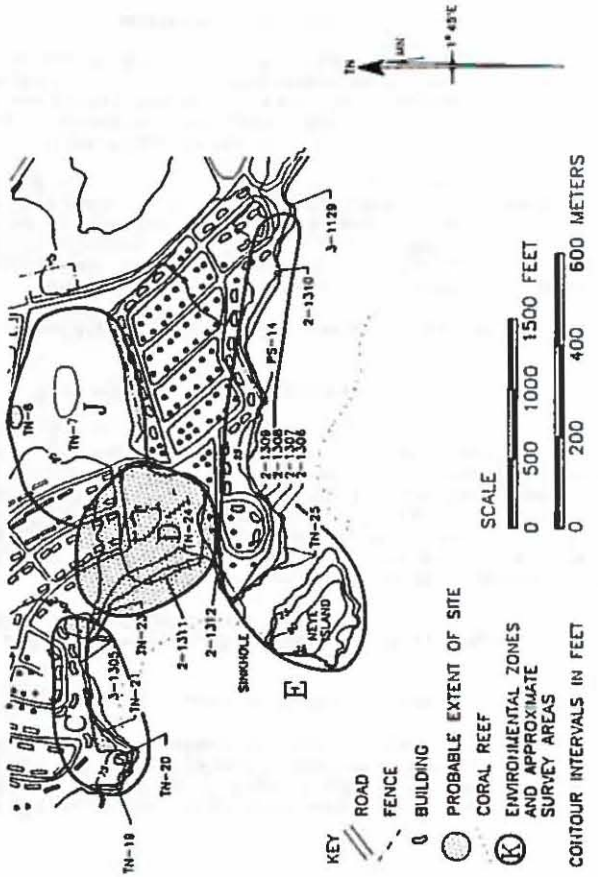


Figure 15. Environmental zones and Survey Areas C, D, E, and J.

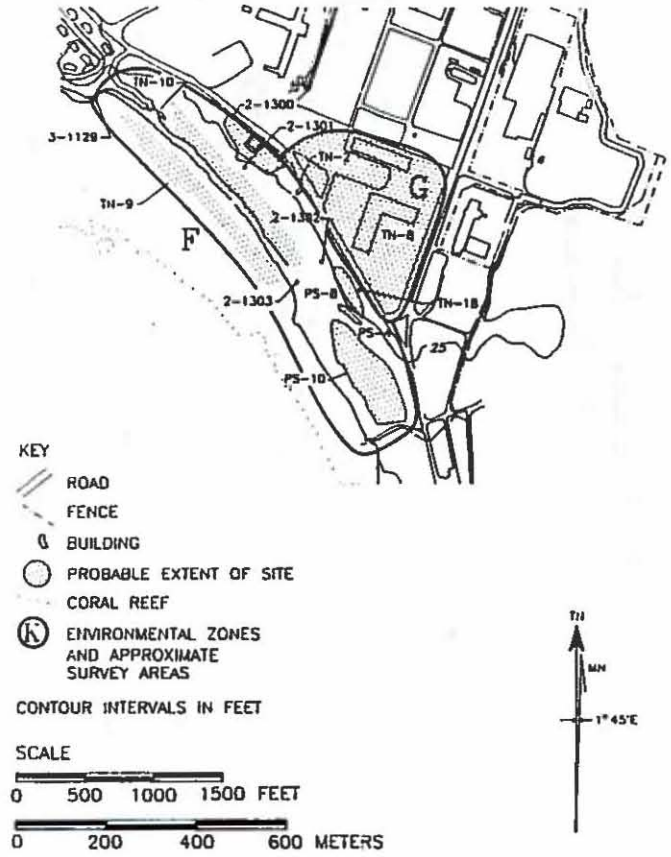


Figure 16. Environmental zones and Survey Areas F and G.

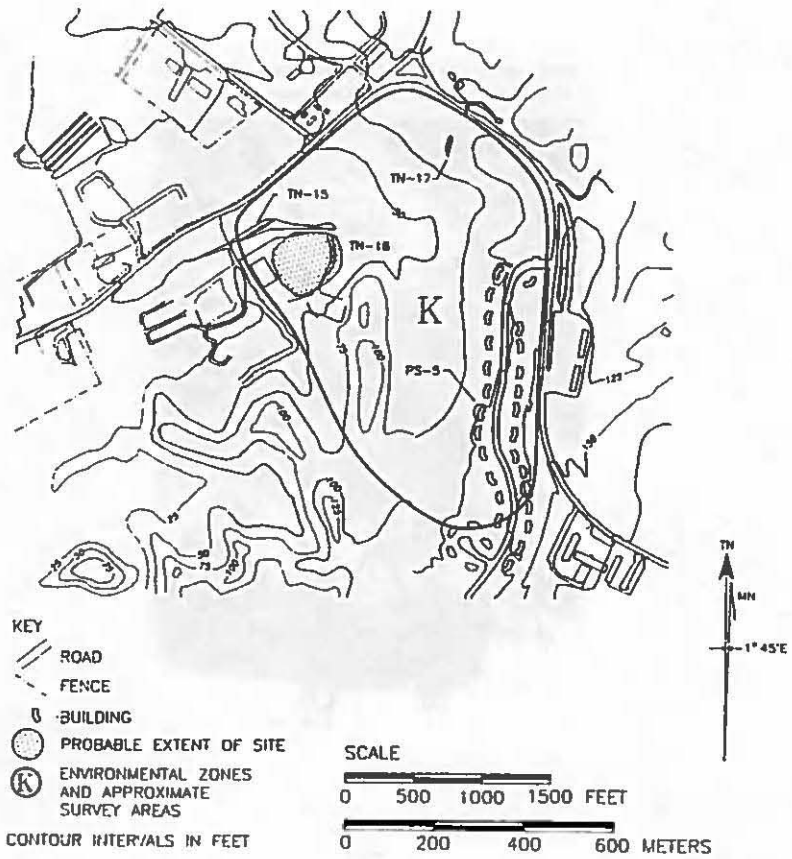


Figure 17. Environmental zone and Survey Area K.

ports suggest that the construction of such defenses had only just begun at the time of the American invasion (Lodge 1954).

The survey was also considered necessary in order to evaluate the island as a biological preserve. Neye Island appeared to exhibit virtually undisturbed native limestone forest, and because of its separation from the shore of Guam, it is possible that endangered native birds and other fauna are also extant. A survey of the island would confirm or deny this, offering important first-hand data to NAVSTA planners.

Survey Results

A brief survey of Neye Island was undertaken on 14 September, about two weeks after Typhoon Omar had passed. Most of the trees and vines on the island had been stripped of their leaves. Many of the larger trees were dead or blown over; only cycads and *Iemondichina* appeared numerous. No coconut palms were seen at all. Wildlife was not plentiful on the island. Only one bird was seen, but several were heard. Many small coconut crabs were seen, and lizards were numerous as well. Also seen was a light brown spider which measured 12 to 15 centimeters long. It was on the underside of a rock, not in or near any web. No prehistoric deposits were found. The only historic materials found related to World War II: several fragments of shrapnel, a 50 caliber machine gun shell casing, and a bullet fragment. Recent trash indicates that people visit the island from time to time perhaps to explore. These recent materials include beer cans, beer bottles, and the cushion and seat back of a padded chair. Four or five coconut crab traps were also noted, as were several plastic gallon jugs. These bottles were found hanging on trees as if marking the location of a trail or crab trap. A few of the plastic jugs contained fresh water.

Visibility of the ground surface was excellent, due in part to the destruction caused by Typhoon Omar. The ground over the entire island is composed of moderate to massive pit and pinnacle karstic limestone. At many locations across the island, small pieces of the sharp limestone ground surface had been broken off, indicating that people had recently traversed the area. Perhaps this was caused by an earlier surveying crew; pink surveyor's flagging tape was seen in several places. Near the center of the island, several vertical shafts or tubes were found. These shafts are about a meter in diameter and seem to extend all the way down to the ocean. Several locations were noted where a deep red soil (colored by iron precipitate from the limestone ?) with a moderate amount of humic material had begun to form. In general, however, the island lacks topsoil and presents a view of what the Guam mainland around Tipalao Bay and Haputo Point looked like prior to development. No cultural deposits were found and it is unlikely that buried prehistoric deposits exist on Neye Island. It is equally unlikely that any substantial World War II emplacements are on the island.

Significance and Recommendations

Neye Island preserves the last example of karstic landscape in the vicinity of Tipalao Bay. This fact imports considerable significance as a natural area, and could possibly qualify the island for the National Register based on environmental criteria.

Photo 1. View southwest from "Echo 12" towards Neye Island. Photo was taken after passage of Typhoon Omar.

The Navy should consider making Neye Island an official nature preserve. A complete wildlife and botanical baseline study is necessary, if one has not already been completed. For safety reasons, and for the protection of the flora and fauna, people should be discouraged from visiting the island.

Environmental Summary of Naval Station Project Areas

Separate botanical and faunal surveys of the project area have been prepared for Belt, Collins & Associates as part of the overall Environmental Impact Study of the project area. The Faunal survey was conducted by Bruner (1992); the botanical survey by Whistler (1992). Other sources which describe the flora of Guam include Raulerson and Rinehart (1991, 1992), and Lee (1985). The common fish and shellfish of Guam are described by Amesbury and Meyers (1982), Amesbury et al. (1986), and Demond (1957). Although detailed discussions are beyond the scope of this report, general summaries of the vegetation and wildlife of the project area are given below.

Vegetation

The vegetation in survey areas A, B, and H in the vicinity of Haputo Point is dominated by limestone forest. Growing on the rugged karst limestone landscape are banyon trees, *Pisonia grandis*, *Pandanus*, and many other canopy tree species which characterize the vegetation regime. Epiphytic ferns and the cycad *Cycas circinalis* are common understory plants. In areas with a thin veneer of soil, *tangantangan* and *lemondichina* (*Triphasia trifolia*) dominate, and may indicate disturbance.

Two rather uncommon trees are also located in the Haputo Point area. The first, *Tristeriopsis acutangula* was only found south of Haputo Road. The second, tree, *Heritiera longipedunculata* is reported from a few localities on the island, but is listed by the government of Guam as an endangered species (Whistler 1992:18).

The cliffs and rocky shoreline of the northern and southern headlands of Tipalao Bay, and the sandy beach flat in the central part of the bay are characterized by disturbed vegetation. Except for Neye Island which exhibits classic, largely undisturbed limestone forest, the rocky beaches and headlands of Tipalao Bay are mostly covered by scrub thickets of *tangantangan* with understories of weeds and sometimes ferns. Also found are scattered groves of ironwood (*Casurina equisetifolia*) which grow in small coves and on rubble-strewn terraces behind the beaches, and on the cliffs overlooking the beach.

In the northern reaches of Agat Bay, the area known as Dadi Beach has three different plant communities. Along the sandy strandline, between the beach access road and the high tide line, the vegetation is dominated by beach morning glory and one or two grasses. A littoral forest and scrub community is found inland of the road and is dominated by ironwood trees, beach hibiscus, often dense *Scaevola taccada*, and many small weedy plants. There may also be dense growths of spiderlily on the forest floor, and *tangantangan* is present throughout the backbeach area. The slopes and terraces at the very back of the beach, and the areas near Shoreline Drive exhibit

species commonly found in very disturbed contexts. The dominant vegetation here is *tangantangan*; wild sugarcane, Mexican creeper (*Antigon leptopus*), grass, and weeds also occur.

Another scrub forest of *tangantangan* is the dominant community in the area of Camp Roxas (Area K). Growing among the *tangantangan* in this poorly drained, sloping area are Indian mulberry (*Morinda citrifolia*) and scattered ironwood trees. A number of herbaceous plants and ferns comprise the understory. In the low marshy portions of Area K, *Phragmites karka* is found; in the swampy area below the New Apra Housing complex, *Hibiscus* thickets are common. Other ground cover species present here indicate that the area is not a true wetland, however.

The one true marsh in the project area, which apparently has some antiquity, is Site 3-1327 (PS-6) located in survey area I. The most significant plant species in the marsh are California grass (*Brachiaria mutica*), marsh fern (*Cyclosorus interruptus*), swamp fern (*Acrostichum aureum*), water chestnut (*Elocharis dulcis*), and a variety of additional grasses and vines (Whistler 1992:21).

Wildlife

Sightings of wildlife in the limestone forest of the Haputo Point area were limited; moreover, of the four animal varieties noted, all but one are late introductions to the island. In the vicinity of the subsidence shaft north of Haputo Road, a large monitor lizard and a Brown Tree Snake (*Boiga irregularis*) were sighted. Throughout the entire project area, but in slightly higher numbers in some areas of the limestone forest, great numbers of the giant African snail (*Achatina fulica*) were seen. These reptiles and land snails are not native to Guam. The only indigenous animal sighted with any regularity was the coconut crab, *Birgus latro*. Numerous trap lines were seen in the area of the abandoned quarry, and in the more accessible portions of the karst pit and pinnacle areas north and south of Haputo Road. The coconut crab is a favorite source of food today, and would have been present in the prehistoric past as well.

Many unidentified shore birds were seen along the beach at Tipalao Bay; several were apparently driven from nests. Birds were also sighted in the area of Dadi Beach, although the numerous feral dogs which live in the caves and drainage culverts probably discourage their nesting there (feral cats are also a problem it seems, and may be present in the Dadi Beach area although none were seen).

During the recent faunal survey, two birds have been reported at the PS-6 wetland. These were the Pacific Reefheron *Egretta sacra*, and the Yellow Bittern *Ixobrychus sinensis* (Bruner 1992:4).

Discussion of Exploitable Prehistoric Natural Resources

Regardless of the paucity of present day wildlife, produce of the land and sea would have been relatively rich in prehistoric times. For purposes of this discussion, seven broad ecological zones or habitats are defined; three are terrestrial, three are marine, and one is transitional between the two. The terrestrial zones of interest are limestone forest, protected beach flats and sandy backbeach areas, and the fresh water wetland. The three marine habitats are inshore coral reef flats, patch reefs in shallow sandy lagoons, and deep coral reefs (including the open ocean). The habitat that is transitional between the land and the ocean is, of course, the mangrove swamp.

The largest terrestrial natural resource zone present in prehistory would have been limestone forest covering a pit and pinnacle landscape. It is likely that the entire project area north of Dadi Beach (indeed, all of Orote Peninsula in fact) was originally karstic limestone. To the southeast, beyond the Naval Station south gate, there is a transition into the clay soils and volcanic tuffs of the uplands, but most of the Naval Station and the project area is located on the solid limestone base of Orote Peninsula.

Some common trees of the limestone forest which provide usable foodstuffs include *Cynometra ramiflora* (the almond-like seeds are edible), *papaya*, *Pandanus* (the seeds or "keys" are edible), and at least two varieties of breadfruit (Craig 1992). Another important understory tree in the typhoon-resistant *Cycas circinalis*. This tree provided hard, lemon-sized seeds and the pith of the trunk which could be processed into starchy food. However, both the seeds and the pith are poisonous and have to be detoxified before consumption (Monmaney 1990, Raulerson and Rinehart 1991).

Foraging and hunting in the limestone forest would have yielded coconut crabs and several varieties of birds. In addition, the Marianas Fruit Bat would also have been available in the prehistoric past even though none were sighted in the limestone forest during our fieldwork, nor found by the survey biologist (Bruner 1992).

In the protected areas behind Dadi Beach, and in the dunes which were likely present behind Tipalao Bay, coconut palms and other plants would grow, stabilizing the shifting sands and providing food. At the base of the limestone cliffs, fresh water seeps would allow the planting of taro, banana, and other foodstuffs. Other plants which flourish on the protected beach flats include *papaya*, *Pandanus*, and breadfruit. The rockshelter location (Site 2-1302) at the base of the cliff behind Dadi Beach would have offered physical protection, a probable supply of fresh water, access to the limestone forest, proximity to the mangrove resources of Apra Harbor, and easy access to a calm reef flat or lagoon environment.

The final terrestrial habitat, the fresh water wetland, is the smallest and most specialized of the three. It is likely that some of the reeds and ferns growing here would have been useful to the prehistoric Chamorro. Possibly, there are edible tubers and roots to harvest, and desirable leaves, stems, and plant fibers to collect. There is no doubt that an expanse of open fresh water or mass of marshy vegetation would have attracted animals, especially birds. This would have been a good area to hunt in.

The two basic differences which separate the three marine habitats are the amount of coral growing in each, and the average ocean depth. The ocean off Dadi Beach is generally lagoon-like, calm and accessible. Much of the Agat Bay reef flat is sand bottomed and supports large populations of psammophilic bivalves and gastropods, fish, sea cucumbers, and other organisms can be found here. At low tide, these animals could easily be collected. The fish, molluscs, crabs, and other animals living on the coral patch reefs strewn throughout Agat Bay could also be harvested, but these are less accessible. Reef fish could be speared, netted, or caught on hand lines; large *Tridacna* could be caught by breath-hold diving.

On the hard shallow reef flat of Tipalao Bay, cryptic organisms such as eels, octopi, crabs, lobster, and certain molluscs could be caught at low tide. However, the configuration of the bay apparently constricts incoming waves and ocean swells. This would make Tipalao Bay moderately to extremely rough when the seas are running from the west, south, or southwest. The reef flat, reef drop-off, and deeper patch reefs in this area could only be frequented during fairly moderate or calm weather. A rich assortment of molluscs, territorial reef fish and foraging pelagic fish could be harvested from the reefs and drop-offs of Neye Island and Tipalao Bay.

Of course, scores of other animals were sought after and hunted in relatively deep water (or open ocean). Sea turtles were prized; flying fish were used as bait when trolling from a canoe for tuna, dolphinfish, marlin, and barracuda.

The habitat transitional between land and sea was the large mangrove swamp of Apra Harbor. This area would have offered very rich resources, in part because a mangrove swamp has characteristics of semi-dry tidal mud flats and a shallow estuary. Scores of species of crabs, marine snails, and bivalves live in the mangrove. Many birds nest in the trees or hunt land snails. Fish forage among the tree roots along the seaward mangrove fringes at high tide, and can thus be caught. Several species of mangrove trees offer useful wood, fruit, sap, and other products. While they are often considered quite uncomfortable, a large, pristine mangrove swamp in prehistoric Apra Harbor would have offered a rich and diverse forage area.

VI: SUMMARY OF FIELD SURVEY FINDINGS AND IDENTIFIED SITES

The findings of the project fieldwork and archival research are summarized below. Two tables have been created for the sake of clarity. Table 2 is a summary of the findings and recommendations from the Phase I survey. Table 3 presents the findings of Phase II fieldwork and summarizes site significance assessments based on those findings. In both tables, the designation "NE" means Not Eligible for listing on the National Register (i.e., "No Property"). In all cases, these are well-informed judgments based on the fieldwork findings and archival research.

Phase I Survey Results and Recommendations

Table 2 is a complete list of findings based on the Phase I fieldwork. Only sites and potential sites are listed, as are the Tomahawk Magazine project location and the previously identified Site 2-1129. The developed parcels of the Naval Station, Naval Magazine, and Anderson Air Force Base are not listed because there were no sites or potential sites in these areas, and no further work was required after the first survey. All sites and potential sites are listed by their original field designations so that the different survey subphases could be preserved and presented clearly. The upper portion of Table 2, nearly the entire first two pages, lists the Phase I-A findings of Tuggle, grouped first by TN and then by PS field numbers. The remainder of the table presents the Phase I-B findings of Carucci, listing first the TN designated sites and then the potential sites. The actual findings, or recommendations summarized in Table 2 led to the specific requirements detailed in the Phase II-A and II-B scopes of work. Note, however, that due to Navy planning modifications not all recommendations from Phase I were included in the Phase II scopes of work.

Phase II Fieldwork Results

A summary of the findings of Phase II fieldwork is presented in Table 3, listed in the same manner as Table 2. The intent of Table 3 is to summarize the action taken to evaluate each site, and to report the significance determination for each site. The codes A, B, C, D, and MP are used to identify significant sites, based on specific criteria relevant to National Register eligibility determination. The eligibility of a site for listing on the National Register is based on the criteria stated in 36 CFR 60.4:

> The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

> (a) That are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (b) That are associated with the lives of persons significant in our past; or
>
> (c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> (d) That have yielded, or may be likely to yield, information important in prehistory or history (Parker et al. 1985:5-6)

None of the sites listed in Table 3 were found to be significant based on criterion B. The significance code MP stands for multiple property and indicates that the site should be viewed as one component part of a group of sites which qualify in part for the National Register based on their unifying theme. In this case, there are ten Japanese defensive sites stretching from TN-22 in north Tipalao Bay to TN-14 in the middle of Dadi Beach. Mr. Richard Davis, Guam Historic Preservation Officer, and Dr. D. Colt Denfeld, the project military historian, concur with the assessment that the MP coded sites are significant and should be added to the already existing "Japanese Defensive Fortifications on Guam" Multiple Property nomination to the National Register. This is discussed in more detail below.

Discussion of Preliminary Significance Evaluations

The documentation justifying the significance of the "Japanese Defensive Fortifications of Guam" multiple property listing already exists. Some time ago, a series of 36 sites was submitted to the National Register. These sites are Japanese pillboxes, gun caves, and other fortifications associated with the recapture of Guam by American military forces. Because this documentation has already been submitted, it is not necessary to rejustify the significance of the ten newly identified defensive sites; rather, forms documenting the new sites can simply be added to the existing catalog of significant sites in the thematic nomination.

Of the ten separate Japanese defensive sites to be included in the thematic nomination, all but one or two are probably eligible for the National Register as single sites. One of these exceptions, PS-14, is listed as a gun emplacement in Table 3, and described as the possible location of a Japanese defensive gun in Part II below. There is no hard evidence that a gun was emplaced at the PS-14 location, but the possibility alone is important and should be included in the documentation for the multiple property nomination. However, by itself, PS-14 is definitely not eligible for the National Register. The other site is TN-22, the smallest of the group of defensive caves located at sea level in the Tipalao Bay and Dadi Beach areas. This cave is the farthest north of the group, and is a generally unremarkable and only slightly modified natural cave. It is not near any of the other caves or features of the network of defensive sites. Be-

Table 2. Summary of Phase I findings and recommendations.

Site (TN) or Potential Site (PS)	Recommendation for Phase II
Tomahawk Magazine	Shovel test
Site 1129: Japanese bunker/caves	Map, test
TN-1: coral outlines	Test, map if cultural
TN-2: coral facing	Recorded; NE; no further work, except research on construction history (POW?)
TN-3: bulldozed military debris	NE; no further work
TN-4: bulldozed military debris	NE; no further work
TN-5: bulldozed military debris, one concrete pad	Re-examine area; determine age and function; shovel test for prehistoric
TN-6: concrete pads, recent	NE; no further work
TN-7: concrete waste dump	NE; no further work
TN-8: concrete pads	NE; no further work
TN-9: offshore features	Future underwater survey should be conducted
TN-10: concrete wall	NE; no further work
TN-11: remains of Camp Bright	Sample clearing and mapping, including section of bluff facing; test for prehistoric occupation in lawn area.
TN-12: Japanese bunker/cave below Camp Bright	Map, test; test beach flat in front of cave with backhoe; remove debris blocking cave with backhoe
TN-13: rockshelter and open deposit	Map, test
TN-14: Japanese bunker	Map, test for prehistoric deposits
TN-15: drain, bridge	NE; no further work on TN-15, but clear drainage bank for facing to test for deposits

Site (TN) or Potential Site (PS)	Recommendation for Phase II
TN-16: concrete pads, debris	NE; no further work on TN-16, but backhoe test in area above CB structure for deposits
TN-17: two sherds	Clear bank, face to determine if deposit is present or only isolated sherds
TN-18: fire debris	Examine artifacts to determine if may be WWII remains
PS-1: cave	Explore for cultural remains
PS-2: cave	Explore for cultural remains
PS-3a and b: sinkholes	Shovel test good example
PS-4: sand embankment	Face, test, examine base for *latte*
PS-5: bluff, bulldozing	Clear, check for *latte*, sherds
PS-6: swamp	Core for stratigraphic data, potential paleoenvironmental data
PS-7: bluff	Clear vegetation, shovel test for deposit
PS-8: low rise	Shovel test for deposit, possible backhoe test
PS-9: beach deposits at Dadi	Backhoe test
PS-10: swamp at Dadi	Core for stratigraphic data if PS-6 is cored

The following sites and potential sites were identified during Phase I-B survey.

TN-19: concrete foundation	Archival research
TN-20: water system	Archival research
TN-21: stone wall, steps	Archival research
TN-22: defensive cave	File Guam HPO site form
TN-23: sewer features	Limited subsurface testing

Site (TN) or Potential Site (PS)	Recommendation for Phase II
TN-24: structure pads	Archival research
TN-25: sewer features	No further work
TN-26: defensive cave	Survey, testing, archival research, and file Guam HPO site form
TN-27: defensive cave	File Guam HPO site form
TN-28: defensive cave	File Guam HPO site form
TN-29: defensive cave	File Guam HPO site form
TN-30: defensive cave	Reexamine carefully and file Guam HPO site form
PS-11: hand grenade	Contact EOD personnel; No further archaeological action.
PS-12: Tuparao Village	Backhoe testing and controlled excavation if necessary
PS-13: rubble filled caves	Survey and test excavate if appropriate
PS-14: gun emplacement	No further work
PS-15: old quarry	No further work
PS-16: hard stand	Archival research
PS-17: lavatory	No further work
PS-18: six tie downs	Archival research

Note: NE indicates that the site has no obvious characteristics that meet criteria of eligibility for the National Register. Sites not recommended as NE may be National Register eligible. Further evaluations were made during Phase II fieldwork.

Table 3. Summary of Phase II findings and significance.

Site (TN) or Potential Site (PS)	Action Taken	Significance
Tomahawk Magazine	Project area surveyed and shovel tested	NE; not a site
Site 1129: Japanese bunker/caves	Shovel and auger tested, mapped, photographed	A, D, MP
TN-1: coral outlines	Shovel tested	NE; not a site
TN-2: coral facing	Photographed; archival research inconclusive	NE
TN-3: bulldozed military debris	No work recommended	NE
TN-4: bulldozed military debris	No work recommended	NE
TN-5: bulldozed military debris, one concrete pad	Shovel tested near concrete pad	NE
TN-6: concrete pads, recent	No work recommended	NE
TN-7: concrete waste dump	No work recommended	NE
TN-8: concrete pads	No work recommended	NE
TN-9: offshore features	Future underwater survey is recommended	Uncertain
TN-10: concrete wall	No work recommended	NE
TN-11: remains of Camp Bright	Phase I recommendations not included in Phase II SOW	A
TN-12: Japanese bunker/cave below Camp Bright	Shovel and auger tested, controlled excavations, mapped, and photographed	A, D, MP
TN-13: rockshelter and open deposit	Shovel and auger tested, controlled excavations, mapped, and photographed	D
TN-14: Japanese bunker	Auger tested, mapped, photographed	A, C, D, MP

Site (TN) or Potential Site (PS)	Action Taken	Significance
TN-15: drain, bridge	Part of drainage bank shovel faced, shovel tested	NE
TN-16: concrete pads, debris	Backhoe trenching for deep cultural deposits	NE
TN-17: two sherds	Part of earthen bank shovel faced, shovel tested, and one controlled excavation	NE
TN-18: fire debris	Phase I recommendations not included in Phase II SOW	NE
PS-1: caves (related to sinkhole structures)	Caves explored, mapped, photographed	D
PS-2: caves (related to sinkhole structures)	Caves explored	D
PS-3a and b: sinkholes	Pick and shovel tests done in two selected solution pits	NE
PS-4: sand embankment	Shovel and auger tested	NE
PS-5: bluff, bulldozing	Vegetation cleared and shovel tested	NE
PS-6: swamp	Coring of sediments	D
PS-7: bluff	Shovel and auger tested	NE
PS-8: low rise	Phase I recommendations not included in Phase II SOW	NE
PS-9: beach deposits at Dadi	Recommend monitoring	(D ?)
PS-10: swamp at Dadi	Re-examined during coring	NE

The following sites and potential sites were identified during Phase I-B survey.

TN-19: concrete foundation	Archival research inconclusive	NE
TN-20: water system	Archival research	NE

Site (TN) or Potential Site (PS)	Action Taken	Significance
TN-21: stone wall, steps	Archival research	A, C, D
TN-22: defensive cave	Mapped and photographed	A, D, MP
TN-23: sewer features	Tested with 10-inch power auger and hand auger	NE
TN-24: structure pads	Archival research inconclusive	NE
TN-25: sewer features	No work recommended	NE
TN-26: defensive cave	Mapped, photographed, shovel tested	A, D, MP
TN-27: defensive cave	No work recommended	A, D, MP
TN-28: defensive cave	No work recommended	A, D, MP
TN-29: defensive cave	No work recommended	A, D, MP
TN-30: defensive cave	Mapped and photographed	A, D, MP
PS-11: hand grenade	Disposed of by EOD personnel	NE, isolated artifact
PS-12: Tuparao Village	Backhoe trenches, power and hand auger, controlled tests	C, D
PS-13: rubble filled cave	Surveyed and photographed	A, D, MP
PS-14: gun emplacement ?	No work recommended	NE, (MP)
PS-15: old quarry	No work recommended	NE
PS-16: hard stand	Archival research inconclusive	NE
PS-17: lavatory	No work recommended	NE
PS-18: six tie downs	Archival research	NE

Note: NE indicates that the site has no obvious characteristics that meet criteria of eligibility for the National Register. See text for descriptions of A, B, C, D, and MP significance designations.

cause it is small, and not in close proximity to the rest of the defensive sites, its significance derives mainly from being a member of a larger group of similar sites. By itself, TN-22 (Site 3-1305) would probably not be significant.

Test excavations at TN-13 have clearly established that intact, well-stratified, deep deposits are preserved in the rockshelter. There is no question that TN-13 is significant and qualifies for nomination to the National Register. It is very likely that the archaeological deposits at the rockshelter will yield important information about the prehistory of Guam. Using this argument, which is criterion "d" for the determination of eligibility, the rockshelter should be nominated for the National Register. Listing TN-13 (Site 2-1302) on the National Register should be part of the long-range management plan for the site.

Assessing the significance of archaeological deposits at PS-9 and at PS-12 is difficult. PS-9 was the designation given during the Phase I-A survey to the entire Dadi Beach area. Although the specific recommendation to backhoe test portions of Dadi Beach was not included in the Phase II scope of work, fieldwork that was conducted in the area confirmed that thin scatters of beach worn sherds were probably present throughout large portions of the beach strand and backshore areas. These are not materials that can be related to any one specific site; rather, they suggest that the beach has been impacted by ocean storms. Results of the excavations at TN-12 (Site 2-1301) at least tentatively support the view that much (if not all) of the Dadi Beach area has been and will continue to be disturbed by ocean storms. In fact, observations made following the passage of Typhoon Omar found that much of the beachflat, tidal berm, and backshore areas had been moderately to heavily disturbed by the waves, rain, and wind of the storm. In sum, while it is unlikely that large, undisturbed cultural deposits remain at Dadi Beach, variations in local topography have probably helped to protect smaller, discrete deposits. Because this interpretation is uncertain, and Dadi Beach remains largely untested, the significance of the area cannot be determined with certainty.

The potential site area of Tuparao Village (2-1311) is a similar situation. In terms of total area, only a very small portion of the site was tested. But the areas that did receive subsurface testing exhibited extremely disturbed soils, which contained both prehistoric and historic materials mixed throughout the excavation column. But the recovery of several small fragments of human bone (see discussion of faunal bone below) suggests the need for caution and further work at this site. Again, there is a very good chance that discrete, isolated pockets of intact prehistoric materials are to be found somewhere in the Tipalao Bay area. The finding of undisturbed cultural materials at this site would be very significant.

A final important point concerning site significance involves environmental considerations. During the project, three areas were identified which may qualify for the National Register under natural environmental criteria. These areas are Neye Island (see Fig. 15), and portions of the pit and pinnacle landscape in Area A north of Haputo Road and in Area B south of Haputo Road. The possibility of treating one or all of these areas as natural preserves is discussed below in the section on long-term recommendations.

VII: SUMMARY REPORT ON MILITARY HISTORIC RESOURCES GUAM EXPANSION SURVEYS NAVAL STATION, OROTE PENINSULA, GUAM

by

D. Colt Denfeld

EXPANSION SURVEYS, HISTORIC FEATURES

Expansion Surveys

In this section the historic features discovered in the two 1992 expansion field surveys are discussed and evaluated for their potential eligibility to the National Register of Historic Places. Consideration is also given to strategies for their protection and interpretation.

The Guam Naval Station, Orote Peninsula, is a unique naval base, one that is busy supporting the fleet in the Pacific but also a historic facility with large areas of undeveloped or formerly used sites now overgrown. The jungle has however served to shield and protect historic objects. Important relics of four cultures, five occupations, and two battles rest in forest areas of Orote Peninsula. There are objects from the prewar historic Chamorro period, the Spanish occupation (1565-1898), American pre-World War II, Japanese World War II, and American since the islands recapture in 1944.

These undeveloped or overgrown sites are potential locations for projects associated with the building expansion program. The field surveys and archival work are intended to identify and preserve historically significant artifacts.

Archival Research

The resources of the Micronesian Area Research Center (MARC), University of Guam, were researched in May 1992 for relevant data. In this collection are some maps and descriptions of Orote Peninsula. The greatest amount of material deals with Sumay village and not the survey areas. Also inspected was the Pacific Collection, Flores Library, Agana. This library has bound volumes of the *Navy News* for the last year of the war and early post war years. This is an excellent source of information on naval activities on Orote Peninsula and island-wide.

Materials were also obtained from the National Archives, Naval Operational Archives, and the U.S. Marine Corps Historical Center. Seabee construction records were acquired from the Naval Construction Battalion Historical Center, Port Hueneme, California.

World War II Intelligence reports of the Joint Intelligence Center, Pacific Ocean Areas (JICPOA), were studied. Reports such as JICPOA 79A-44 (1944) contain information on Japanese gun emplacements on Orote Peninsula (but aerial coverage missed the defensive caves on both the north and south shores of the peninsula).

The Guam Register of Historic Places was consulted and in it was found the nomination of a mass burial site, but this site is outside the survey areas. Field notes and research data collected during a 1982 survey were also consulted (Denfeld 1982).

HISTORY OF THE GUAM NAVAL STATION, OROTE PENINSULA

Military Construction, Orote Peninsula

The strategic military location of Orote Peninsula, guarding Apra Harbor, the most important harbor in the Marianas, was recognized early. The Spanish defenses of Guam included three fortresses to command Apra Harbor. Two were sited on Orote Peninsula, above the harbor. To protect the approach and entrance was Fort Santiago on Orote Point, constructed in 1721.

Within Apra Harbor was Fort San Luis, completed in 1737 on San Luis Point. In the Inner Harbor was Fort Santa Cruz, on a shoal. Fort Santa Cruz was the last constructed, completed in 1801.

When Captain Henry Glass, USN, approached Guam on June 20, 1898 to capture the island and take prisoner the Spanish governor and regular military he was aware of the forts but was unaware that they were unmanned. This made easy the capture of Guam for which Captain Glass had been instructed to accomplish quickly and then steam to Manila to reinforce Commodore George Dewey's blockade of Manila Bay.

War had been only recently declared on Spain, on April 25, and Dewey had destroyed the Spanish fleet in Manila Bay on May 1. Dewey then formed a blockade and awaited reinforcements. A task force of the cruiser *Charleston* and three transports under the command of Captain Glass were dispatched to Manila.

On Guam, the unmanned forts could not challenge the American naval forces nor did they desire to do so as they were unaware of the declaration of war. The island had not received mail in months and the last that they had heard was of negotiations. When Glass fired on Fort Santa Cruz the Spanish command assumed it was a friendly salute. The Spanish sent a party out to the American ships to welcome them.

There followed discussions regarding the surrender of the island delaying its capitulation until the next day. At 1445 on June 21 the U.S. flag was raised over Fort Santa Cruz. The Spanish governor, his staff, and 54 Army troops were loaded aboard the task force ships and departed for Manila.

No provision had been made for the permanent administration of Guam. Captain Glass selected a local American citizen Don Francisco Portasach, as an interim governor until an official governor arrived. It would be over one year before the first permanent commandant-governor arrived.

The first permanent governor, Captain Richard P. Leary stepped ashore on August 7, 1899. Inspecting the island he found the Spanish Governor's Palace, at the Plaza de Espana in the center of Agana to be inadequate as offices and residence so he returned to his ship, the *Yosemite*, and remained aboard while the Palace was rehabilitated as the administrative offices and residence for the governor. The governor was also the commandant of the Naval Station which was the entire island. Guam was to be a coaling station for ships steaming across the Pacific, as such its administration was deemed a Navy responsibility.

In October 1899 a Marine force of five officers and 212 enlisted men arrived and moved into the Spanish barracks on the west side of the Plaza. The Marine duties were to guard the coal stores, ceremonial, and to improve the Guam infrastructure. Marines built roads, schools, and public facilities. The Spanish forts were decayed and left to fall apart. It would be a few years before the Marines would receive any artillery or coastal defense guns.

In 1901 a hospital was built in Agana. The U.S. Navy was continuing the use of Agana as the center of administration and naval activities. A second hospital was completed in 1909 and the expanded hospital facility was named the U. S. Naval Hospital, Island of Guam, Marianas (Governor's Report, 1909, [GR]).

There were no ship docks on Orote Peninsula, there was only a small boat dock at Piti. Here the Spanish had constructed a small wharf, boat shed, coal shed, and store house constructed of local stone. Cargo arriving at Guam had to be lightered to the Piti boat harbor. A ship dock was not built until 1941 at Cabras Island.

An open coal stores was established on Cabras Island in 1900 but this involved little construction. Funding for building at Guam was lean. In 1901 monies were made available for the building of a prison camp, at the Presidio of Asan on Asan Point, to imprison political prisoners from the Philippines. A May 1902 building inventory of the Naval Station Guam listed 36 buildings island-wide, with 15 of them at the Presidio of Asan (Governor's Report 1902).

This is not to suggest that the military value of Guam was unrecognized. Captain John F. Merry, USN, in his military survey of 1901 recommended that the island be defended by 10-inch, 9-inch, and 6-inch guns sited on Mount Tenjo and Orote Peninsula. The Merry Report called for the development of Guam into a first class naval facility. However when it came time to allocate funds they went to bases in the

Philippines which were viewed as more critical.

The first U.S. construction on Orote Peninsula was initiated in 1903 at Sumay village. Here the Pacific Commercial Cable Company built a station with connections to Midway, Yap, the Philippines, and Yokohama (Koerper 1971).

The U.S. Marines also moved onto Orote siting two six-inch guns in temporary emplacements, near the cable station and at the abandoned Spanish Fort Santiago. In 1909 additional six-inch guns arrived and were installed on Mount Tenjo and Cabras Island.

A Marine Detachment for island defense arrived in February 1914. Their arms included four and five-inch guns, and they were to receive six-inch guns removed from the Philippines. The detachment moved into tents in Sumay village and went to work to construct squad housing on the west side of Sumay. The Marine Barracks on the Plaza in Agana was reduced to the band and Headquarters Detachment with duties at the Government House. Six-inch guns to replace the old weapons on Guam were received in 1915 and installed at Orote Point, Tipalao, and Cabras Island (USMC 1921).

In November 1919 construction was started on a new Marine Barracks on the plateau above Sumay. Marines did most of the construction work on this camp. The Marine Barracks was dedicated on January 15, 1921 (U.S. Navy, ONI-99 1944).

As the Marines built their camp they also planned for substantial upgrading of the island defenses. The six-inch gun positions were to be replaced by eight seven-inch pedestal guns (Mark 2, 45-caliber), two eight-inch howitzers, six three-inch anti-aircraft guns, and four 75mm guns (USMC 1921).

These guns arrived in 1921. Three seven-inch were installed at Fort Santiago, three on Mount Tenjo, and one each on Cabras and Tipalao. At Tipalao and Cabras the single seven-inch guns were sited with the existing six-inch to form a battery of one six and one seven-inch gun. Wood barracks were constructed at each battery to have gun crews nearby.

A Marine aviation unit, Flight L, 4th Squadron, moved to Guam on March 17, 1921. The air crews moved into the Marine squad housing on the west side of Sumay. Work was begun on a hangar, sea ramps, and a shop building (Sherrod 1952).

The installation of the coastal defenses was not complete when in 1922 the Naval Limitations Treaty was signed. Following this treaty all the coastal defense guns were removed. The mounting bolts were cut and the guns lifted off the gun plugs (the bolts of the seven-inch guns at Orote Point and Mount Tenjo are extant today). The removed guns were returned to the Washington Navy Yard. No replacement guns would arrive before the start of the War in the Pacific, Guam was largely defenseless in December 1941.

On April 11, 1927 Flight L boarded the station ship *U.S.S. Gold Star*, bound for China to protect endangered foreigners. They returned to Guam the next year.

In 1930 the Marine Air Squadron was comprised of six observation planes. The Marine strength on Guam had reached its peak number of 550, including both the aviators and the Marine Barracks population. As an economy measure in 1931 the air squadron was withdrawn to the continental U.S. and the Marine Barracks reduced to ten officers and 121 enlisted men. The coal station outdated by advances in ship technology was no longer needed so it was closed.

One very important military operation at Guam survived the lean years and that was the radio intercept station. This station was established in 1929 with one operator at the radio station at the Plaza de Espana. However the radio station was poorly sited, on low ground below the Agana cliffs. The next year the station was moved onto the cliffs and seven more operators were added. In late 1933 the station moved to a better site at the former Navy Radio Station on Libugon Hill (today Nimitz Hill).

A significant contribution of the intercept station was tracking the Japanese battle fleet in maneuvers and discovering that the top speeds of the battle ships were higher than believed. The intercept station remained in operation until the Japanese bombing of Guam in December 1941. It was hit by bombs in December 1941 and again in the recapture in 1944 and heavily damaged. There are remains of the station on Nimitz Hill.

Civil aviation came to Guam in 1935 when the Pan American Airways Clipper service acquired rights to use the former Marine Aviation facilities at Sumay. PAA would have to improve the sea lanes, and construct a dock, air terminal, hangar, shop, and hotel. Construction was carried out in 1935 and 1936. The hotel was finished in October 1936. A November 1940 typhoon destroyed the hotel but it was quickly rebuilt. On December 8, 1941 the hotel kitchen was hit by a Japanese bomb, but the building was only slightly damaged. After the Japanese capture naval officers lived here. It was completely destroyed in the battle for Guam in July 1944. Orote Peninsula, with its important airfield, was subjected to carrier aircraft raids, naval bombardment and intense artillery fire during the land battle on the peninsula. When the peninsula was secured on July 29, 1944 there were few standing buildings and all of them heavily damaged.

Guam which had been demilitarized in 1922 was investigated by the Hepburn Board in 1938. This naval study team had been directed by the Secretary of the Navy to determine the Navy needs for bases and ships. The Board, named for its head, Rear Admiral Arthur Hepburn, accomplished its mission in record time. The Board found Guam facilities inadequate and recommended on December 1, 1938, that a major air and submarine base be located at Guam with adequate coastal defenses to withstand all but a major assault. The Navy, however, sensitive to Congressional resistance (Congress did not want to offend Japan), requested only five million dollars for harbor dredging and improvements. Even this modest request was turned down in the House of Representatives on February 23, 1939. Finally in 1941 funding was appropriated for harbor improvements, fuel tank construction, seaplane landing facili-

ties, and airfield surveys (Morison 1982).

Construction of five steel fuel tanks, breakwater improvements, and airfield surveys were started in mid 1941. The commandant of the Naval Station, Captain George McMillin, in a letter report of August 6, 1941 indicated that Orote Peninsula was suitable for a 4,500 foot long and 400-foot wide runway. Construction of this airfield would not be started before the Japanese capture. An airfield here was the first Japanese project, with a construction start of February 1942 and completion one year later.

Apart from the fuel tank and breakwater construction no attempt was made to fortify Guam in the months before World War II. The military dependents were ordered evacuated in October 1941, with last group sailing from Guam on October 17, 1941. Attention then turned to island defense, Captain McMillin assigned the Marines the responsibility to defend Apra Harbor against landings. The Marine commander Lieutenant Colonel William MacNulty, who had available 153 Marines, established fire block positions on the Sumay-Orote Road just above Sumay village.

The local Guam militia of 247 men were to defend the military headquarters in Agana at the Plaza de Espana. The 274 U.S. naval personnel were to assume defense duties on their ships or shore duty sites.

There were no coastal defense guns and only a few .30 caliber machine guns. The largest guns were the 3-inch deck guns on the *U.S.S. Penguin*. However this minesweeper/patrol boat would be no match for the destroyers and cruisers of a Japanese landing force. The rest of the "Guam navy" was little help; there was the station ship *Gold Star*, and an immobilized tanker, the *Robert L. Barnes*, which was used as a vessel to train mess attendants. There were two patrol boats, the YP 16 and YP 17, converted fishing boats which shared patrol duties with the *Penguin*.

The Japanese Capture of Guam

Guam was scheduled for early capture in the prewar Japanese war plans. Its occupation was viewed as necessary to remove U.S. forces which posed a danger to air and naval bases at Saipan and Tinian. The island would also be useful as a submarine and air base for attacks against the U.S. Pacific fleet as it was lured into the Mariana-Bonin Islands to be destroyed by the Japanese fleet.

On December 1, 1941 the Imperial General Headquarters set December 8 (East Longitude date), as X-day for the start of the War in the Pacific. Orders for the attack on Guam were transmitted to Lieutenant General Horii Tomitaro, Commander of the South Seas Detachment, a reinforced regiment of 5,000 Army troops. Additionally the Fourth Fleet was to contribute a Special Navy Landing Force (SNLF) of 500 men. The 5,500 man invasion force had received intelligence reports indicating a Guam defense of 1,800 soldiers and sailors, overstating the actual number by more than one thousand.

On December 6 Captain McMillin received word of the eminent danger of war and he ordered the military on alert status. Two days later at 0545 a radio message was received that Pearl Harbor had been attacked and the start of hostilities. At 0827 that morning nine Japanese bombers from Aslito Field, Saipan, attacked Guam. The first bombs were aimed at the Marine Barracks but missed and hit at the Marine positions to the west of the camp. Some Marines were injured. The last bombs in this string hit the kitchen of the Pan American Airways Hotel in Sumay killing two Guamanian workers, Teddy Flores Cruz and Lorenzo Lujan Pangelinan (Sanchez n.d.).

As aircraft bombed Orote Peninsula others struck at the *Penguin* which was near the entrance of Apra Harbor. The ship fought back but was soon overpowered. Ensign Robert G. White was killed by enemy machine gun fire at his shipboard gun station. The ship was damaged and was unable to steam to safety. The ship captain, Lieutenant James W. Haviland, III, ordered it scuttled. The crew escaped in life boats carrying to shore the wounded and the body of Ensign White.

Marines waited in their defenses on the Sumay Road, where the road climbed over the cliff line and onto the Marine golf course. They helplessly fired their rifles at the planes overhead. After attacking the *Penguin* the Japanese continued east to bomb Piti Navy Yard and attack the *Barnes* in Apra Harbor. One warehouse at the Piti Navy Yard was destroyed. The *Barnes* was hit but not seriously damaged and survived to be returned to sea duty by the Japanese, and finally surrendered by the Japanese (after the war she sailed as a British tanker until she was scrapped in 1949).

That afternoon six seaplanes resumed the attack, they bombed the Libugon intercept station, and the military headquarters area of Agana. One home near the Plaza de Espana was hit, damaging the second floor apartment of Navy radioman George R. Tweed. Also this day three men from Saipan were captured landing at a northern beach. During an interrogation they told of a Japanese invasion scheduled for the next day at Dungca's Beach. Captain McMillin doubted the story and feared it was a trick to get him to divert the Marines from Orote, in order that an unopposed landing could be made in the Apra Harbor area (McMillin 1945:11). The story was correct except the landings came one day later.

The Japanese planes returned at 0845, December 9, to bomb Standard Oil fuel tanks at Sumay village, Orote Peninsula, the intercept station, Piti Navy Yard, Agana and other villages. Damage was limited which would help the invasion forces as they captured an island with its facilities largely intact.

The landings conformed to Japanese amphibious principles of late darkness, 0400. There were unopposed landings at Agat and Dungca's Beach (East Agana). The Special Naval Landing Force (SNLF) coming ashore at Dungca's advanced quickly down the road to Agana. As they neared Agana the SNLF encountered a truck load of civilians escaping Agana. The civilians were shot and bayoneted and then the SNLF resumed its push into the city. They met scattered resistance until they reached the Plaza de Espana. Here the Insular Force Guard had set up effective defensive positions at the narrow street entrances to the Plaza. The local militia was able to halt the Japanese advance, forcing the SNLF to regroup for another attack. Before this

assault Captain McMillin had determined that further resistance would lead to heavy civilian casualties so he decided to surrender Guam.

The South Seas Detachment had landed at Agat and was moving towards Orote Peninsula when the surrender took place at the Government House at the Plaza. A message was sent to the Marine commander LTC MacNulty on Orote Peninsula to surrender his troops. The Marines had yet to be involved in the battle, nor had the Japanese soldiers still en route to Orote Peninsula when the surrender took place. Later that morning the SNLF drove to the Marine Barracks to accept its surrender. The SNLF moved into the Barracks marching the Marine POWs to Agana. Five American sailors were able to escape into the jungle; two were caught and executed on September 11, 1942. Shortly afterwards two more were discovered, but Radioman George Tweed was able to escape detection with the aid of Guamanian civilians. A number of civilians were tortured as the Japanese became frustrated in their long search for Tweed, a few were executed for allegedly aiding Tweed. Tweed was able to signal an American ship offshore before the invasion and was safely recovered.

Supplies and laborers for the construction of an airfield at Orote arrived in early 1942 and clearing of the field was started in February. Two engineer construction battalions, the 217th and 218th Setsuietai, were assigned to the project. The residents of Sumay were forced out of their homes and the village taken over by the engineers. The labor battalions, each made up of 800 Korean laborers and 100 Navy supervisors had little equipment. It was largely a hand effort requiring one year to build the runway and construct an operations building. The U.S. Marine Barracks and facilities in Sumay were used for housing. A second Japanese airfield was constructed near Agana and a third was under construction near Barrigada in July 1944.

Apart from the airfield construction the Japanese did not build up the defenses of Guam during the first year of their occupation. In September 1943 American air strikes in the Gilberts (Kiribati Islands) was evidence to the Imperial Headquarters that the Central Pacific was in immediate danger. At an Imperial Conference on September 30 the decision was made to reinforce the Marianas. However urgent needs at Rabaul would drain off much of the needed aircraft and troops.

The Imperial Army's 13th Division in China was selected for the Marianas with an advance detachment of 300 soldiers dispatched to Guam in October. The main divisional elements never joined the advance force as the division fought in south China. The 29th Division of the Kwantung Army replaced the 13th for Marianas duty. The 29th Division was reorganized into regimental combat teams and was en route during early March. The sea voyage for the 29th and additional troops to reinforce the Marianas was risky as submarines of the Pacific Fleet were attacking many of the Japanese convoys. The 29th Division convoy ran into the *U.S.S. Trout* which sank the *Sakito Maru* and damaged the *Aki Maru* with the loss of 1,400 men and a regiment's equipment. Three destroyers escorting the convoy attacked and probably sank the *Trout*.

As soon as the reinforcements reached the Marianas they went to work constructing island defenses. The main defenses in Guam were placed on the western coast between Facpi Point and the north edge of Tumon Bay, at the best landing

beaches. Some 48 coastal defense guns were emplaced, most of them in open positions as there was not time or materials to casemate them. The guns were sited for a defense at the beach line in accordance with the Japanese strategy of beach line defense. The enemy was to be destroyed before they could get ashore, or if they were able to land to drive them off the beach prior to the establishment of a beachhead. There was neither time nor the inclination for a defense in depth.

The one exception to this was on Orote Peninsula where the 54th Naval Guard Force had time to carefully plan and construct defenses in depth. Here dual purpose guns were emplaced to fire antiaircraft, against Apra Harbor targets and protect the approaches to the peninsula. Hidden in caves and the jungle along Agat Bay on the south shore and above Apra Harbor on the north were machine guns, 37 mm and 75 mm guns. For example Dadi Beach gun positions and 120 mm guns near the airfield laid a devastating barrage on Marines as they tried to advance onto Orote Peninsula from Agat. The guns in caves along Sumay cliff held up the advance of Marines on the north side of the peninsula.

In front of the dual purpose emplacements and beach defenses of Orote Peninsula was a defensive line across its narrow neck. Stretching from the east side of Dadi Beach to Apra Harbor was an integrated defense line of machine gun emplacements, trench works and individual firing positions. The line was sited on a slight incline above the rice fields and swamp lands at the edge of the peninsula.

American Recapture

Success in the Marshall Islands, Kiribati, and the neutralization of Truk (Chuuk), allowed for an early assault on the Marianas. On both Saipan and Guam many guns were found waiting to be installed and positions unfinished. The defenders were not able to draw upon all their resources to defend the Marianas which were considered part of the inner defense line. For the Americans the capture of the Marianas would break this line and more significantly bring the Japanese home islands within range of the very heavy bombers, the B-29s.

Saipan was to be invaded on June 15, followed a few days later by invasions of Tinian and Guam. Strong resistance at Saipan and the employment of the entire Marianas reserve forced a delay in the landings at Tinian and Guam. The U.S. Army's 77th Infantry Division was tapped as a replacement reserve for the southern operations (Guam) and its invasion rescheduled for July 21, 1944.

Marines came ashore at Agat and Asan beaches, just where the Japanese had expected. The 3rd Marine Division assaulted Asan while the 1st Provisional Marine Brigade hit Agat Beach. The 77th Division came ashore later that day at Agat. While the preinvasion bombardment had been heavy and destroyed many guns, hidden and cave positions came to life when the landing forces neared the beach or were ashore. A strong point in a rock outcropping at Gaan Point on Agat Beach destroyed nine LVTs (Landing Vehicle Tracked) as they crossed the reef (this strong point with its 75 mm gun positions and cave shelters is today a feature within the War in the Pacific National Historic Park). To the north at Asan casualties were not heavy until the

Marines were on the beach and hidden guns in Chonito and Bundschu Cliffs opened fire.

The Japanese island defense plan called for powerful counterattacks if the landing forces were not destroyed on the beach. Beginning the first night there were counterattacks at both beaches with heavy losses for the Japanese. Following a series of unsuccessful counterattacks a large scale counterattack was planned for July 25/26. It would strike at the U.S. southern troops advancing out of the Agat beach area, at the Asan beachhead, and Marines at the main Japanese defense line on Orote Peninsula. This all-out counterattack failed with heavy loss among the infantry units. The surviving Japanese then headed to the north end of the island but were too disorganized to make effective use of the excellent defensive terrain of the northern end of Guam. On August 11 the island was declared secured with about 17,000 Japanese killed and U.S. deaths at 2,124. Even though the island was secured patrol and search efforts were needed to locate and capture or kill Japanese stragglers.

Orote Peninsula had been captured on July 29 with the raising of the American flag in the ruins of the Marine Barracks. Marines found the bronze plaque of the Marine Barracks in the rubble and proudly displayed it at the flag raising.

The 2d Marine Engineer Battalion (Aviation) immediately went to work to repair the Japanese airfield on Orote. The runway was ready for limited service on July 31 when a Navy Avenger landed. It was a short stay as snipers opened fire on the plane. Night fighters, F4F Hellcats, began to arrive on August 4, led by Major Ross Mickey, Commanding Officer of VMF(N) 534. Soon afterwards elements of VMF 216, 217, and 225 were launched from the carrier *Santee* for duty at Orote.

The fighter squadrons were assigned to Marine Air Group 21 and would fly numerous combat missions for the remainder of the battle for Guam. Soon after the island was declared secure VMTS 131, a torpedo bomber squadron arrived and assumed anti-submarine duties. By mid-November MAG-21 was comprised of 12 squadrons based at Orote (also called West Field). MAG-21 had a strength of 529 officers, 3,778 enlisted men, and 204 aircraft.

MAG-21 saw little action once Guam had been secured. One mission in early 1945 was to intercept and destroy a Japanese seaplane with a VIP aboard. In mid-1945 MAG-21 was transferred from Orote to Agana Airfield (today Brewer Field). Orote became a repair depot for Navy aircraft, new and damaged planes. During the final months of 1945 1,800 planes were serviced or repaired each month. Air operations were restricted due to dangerous cross winds which had troubled the Marine and Navy pilots. The airfield was closed and abandoned in 1946.

U.S. Military Construction

Construction of what would become today's Naval Station was launched on August 5, 1944 with the emplacing of pontoon piers in Apra Harbor. The first pier on Cabras Island was completed on August 22 and by October there were six operational piers. By July 1945 there 14 quay-wall berths, nine pontoon piers, two wood fuel

piers, ten LST berths, and one submarine pen (U.S. Navy 1946).

The advance naval base Guam was named Lion Six. It included some 30 departments covering the entire range of naval logistics and support. Most of the departments of Lion Six were allocated space on Orote Peninsula. Orote Peninsula was rapidly built into a major forward naval base.

For example the supply department arrived in two LVTs at Agat Beach and grew to 1,804,000 square feet of covered warehouse space in the first year. To create this square footage of storage 453 Quonset huts (40' x 100') were erected at what became known as Camp Bright (named for Lieutenant Graham Bright, USN, who was killed in the defense of Guam in December 1941). There was also open storage space and 530,000 cubic feet of reefer space, and more than 200 fuel storage tanks at various locations. To fill this space as many as 120 Liberty ships and 20 tankers were unloaded each month during the first year.

On November 11, 1944 the supply department was commissioned a Naval Supply Depot. By 1946 the NSD had grown to 13,000 military and civilians, its highest number. That year it was renamed a Naval Supply Center. In 1949 its activities decreased and was returned to the status of a depot and has been the NSD since.

During the 1950s and 1960s the NSD Quonset huts were replaced by modern concrete warehouses. The two deck World War II metal NSD administration building across Shoreline Drive from Dadi Beach was replaced in 1965.

The administration center of Lion Six was established to the east of the ruins of the Marine Barracks. Quonset huts were erected for offices and housing. On October 21, 1944 Lion Six was renamed the Naval Operating Base (NOB), Guam. By June 1945 nearly 3,000 Quonset huts had been erected at the NOB. A 1950s building program, typhoon Karen on November 11, 1962, and the Vietnam buildup saw the replacement of Quonset huts with air conditioned concrete structures.

In 1946 naval personnel assigned to Guam were again allowed to bring their families. Base housing was rushed to completion that year. Initially the housing was converted Quonset huts. For example the former Base Hospital 18 at Apra Heights was made into family housing and renamed Base 18 and today Apra Heights. Construction of permanent concrete family housing units was started in the 1950s. On Orote Peninsula four housing areas were built; Lockwood Terrace, Sumay, North Tipalao, and South Tipalao.

At the end of the Vietnam War the abandoned Orote Airfield came to life briefly as a refugee camp. A tent city was rapidly erected to house 50,000 refugees from that war. The camp contained 3381 tents, 360 latrines, 150 showers, and numerous galleys to feed its residents. The camp opened on April 25, 1975 and was closed on June 25, 1975 as most refugees had already moved on to their new homes across the United States.

The World War II construction on Orote Peninsula involved clearing large areas of jungle. Orote Point was one area which was not developed leaving prewar

and Spanish remains in the jungle. As Quonsets were replaced by concrete two deck barracks a number of housing or camp areas such as Dadi Beach were allowed to be reclaimed by the jungle. This post war vegetation has now hidden the footprints and elements of the original World War II base.

DADI BEACH HISTORIC FEATURES

F: Dadi Beach, Phase I-A Survey

The Dadi Beach parcel was inspected in the first field survey, at the time it was under consideration as a construction project area. This site may not be employed as a construction locale but even if avoided this recreation area will be impacted by an increased population on this portion of the Naval Station. The field survey did encounter historic features which require protection from the expected increased use of Dadi Beach as a place of recreation. The features are discussed below, the feature numbers are those employed in the field survey report.

Site 2-1129 - Japanese Gun Caves: Concurred with recommendation to map, record, and test caves during Phase II fieldwork. Caution should be exercised regarding testing, as unexploded ordnance may be encountered.

TN-11a - Concrete and Masonry Gate Posts: Two gate posts which marked the entrance to Officers Country and the Captain's Quarters of Camp Bright, Naval Supply Depot, are extant. The housing was two deck, metal Butler type buildings. Across Shoreline Drive from the entrance posts was the headquarters building of the NSD. It was a two deck, metal Butler type building, which was removed in 1965. The gate posts may be National Register eligible if they are included in a thematic nomination of American base construction of 1944-1945.

TN-11b - Palm Beach Theater: The open-air seating area, and coral stone retaining walls of this theater survive. The Palm Beach theater had seating for 3,500. It was constructed in August 1945. Basketball and tennis courts were also constructed near the theater. The theater was still in operation in 1949 but its closing date is unknown. It is a feature requiring more research and consideration in the context of a thematic nomination. There is also the more intact and 5,000 seat outdoor Naval Operating Base theater (Nob Hill Bowl) in the brush near the Naval Station administration area. Together they would recall morale building recreational activities of World War II.

TN-11c - Concrete Foundations: Concrete pads of the housing units serve as footprints of the compound. They can be cleared and used to outline the former housing area. Additional research is needed to obtain plot plans and construction details of the housing area.

TN-12 - Japanese Cave Defenses: At the northwest end of Dadi Beach are gun caves in the cliff line. These caves were central to the initial defense of Orote Peninsula. Guns emplaced in the caves laid deadly fire onto Marines trying to advance onto the peninsula. They forced the attacking Marines off the Agat-Sumay Road and onto the rice paddies where they came under intense machine gun fire. These caves are eligible for the National Register and could be nominated in a thematic context of Japanese defenses of Orote Peninsula which would include all surviving defenses.

TN-14 - Japanese Pillbox: This is the only known surviving concrete pillbox on the peninsula. It is also the only extant one of its type to have been found in recent Central Pacific surveys. This rare pillbox is eligible for the National Register, it also could be included in the nomination for defenses of Orote Peninsula.

Underwater Artifacts: Considerable amounts of battle debris and equipment rests offshore of Dadi Beach and Haputo Point. These areas were used as dumps after the war so it is not clear which items are battle flotsam and what was dumped. An underwater investigation is recommended.

Interpretation of Dadi Beach

The Dadi Beach artifacts present a fine opportunity to interpret the Japanese defense and American post battle construction. Their instructive value is enhanced by their location. All of the features are an easy walk if marked trails and clearing of destructive and thick vegetation is accomplished. Signage or an informational kiosk could recall the story of wartime battles and post battle U.S. construction. Additionally a base history brochure might be made available. This document should indicate other historic sites and degree of difficulty of access as visitors will include the now aged World War II veterans.

Additional historical documentation of Dadi Beach, the gun caves, defense lines, and battle for Orote Peninsula should be part of a base-wide history. This could include National Register nominations for Japanese defenses and American construction.

NATIONAL REGISTER NOMINATION AND INTERPRETATION OF THE JAPANESE DEFENSE OF OROTE PENINSULA

Documenting the Defense of Orote Peninsula

The defense of Orote Peninsula was unique in the War in the Pacific up to and through the campaign in the Marianas. It was a defense in depth with well planned defensive lines supported by artillery and mortar fire. This was in direct contrast with the thin beach line defense usually encountered. A shortage of time, material, and inclination led the Japanese to the more aggressive beach line defense backed up by counterattacks. After the Marianas, Japanese defenses were more in depth and more deadly for the invasion forces.

Colonel Tsunetaro Suenaga, Commander of the 38th Infantry, with the responsibility of the Agat Defense Sector which included Orote Peninsula, had planned a tough line of resistance at the neck of the peninsula. Naval units on the peninsula built strong points, additional defensive lines, supported by cave emplaced and well-camouflaged guns.

The 38th Infantry was positioned in Agat, Mount Tenjo, and the southern approaches to the peninsula. On the peninsula were about 2,500 troops comprised of the 54th Keibitai (naval garrison force), remnants of the 38th Infantry, two companies of antiaircraft troops, former air crews (all the aircraft had been destroyed), and Korean laborers pressed into combat. Commander Asaichi Tamai, IJN, of the 263rd Air Group and senior naval officer, became the Orote defense commander following the death of Colonel Suenaga leading a July 21-22 counterattack.

The initial defense line was on the high ground at the neck of the peninsula. A series of concrete pillboxes, coconut log barricades, and firing positions ran from Dadi Beach (BM 30) to Abo Cove. In front of the line were rice paddies and on the north and south shores the two roads, Piti-Sumay and Agat-Sumay, which led onto the peninsula. Artillery on Mount Tenjo was preregistered on both roads while mortars and the Dadi Beach guns covered the Agat-Sumay Road. Additional artillery was sited at Tipalao, the Marine Barracks, and the Rifle Range.

Marines approaching from Agat came under intense fire and were forced off the Agat-Sumay Road into the rice paddies. Here the machine guns and weapons sited on the high ground opened fire. This defensive line was overcome with hand-to-hand combat supported by armor which quickly destroyed the Japanese Type 95 light tanks which drove down the roads to attack the Marines.

Today the road to the Navy Exchange facilities covers the site. All that remains for interpretation and documentation are the extant defenses at Dadi Beach. Additionally the rice paddies in front of the defense line are now wetlands and protected.

The first line was overcome by the 4th Marines (on the left, south), and 22d Marines (on the right) on July 24, 1944. The attack across the peninsula resumed on July 25 and the Marines discovered that numerous defenses and tough defenders remained. There was still heavy fire from Tipalao and the Rifle Range. The Marines on the right moved only a few hundred meters when they were halted at Road Junction (RJ) 15 where the two roads joined.

On the 25th a full-scale Japanese counterattack was ordered. Orote Peninsula troops for the assault formed up in the mangrove swamp to the east of RJ 15. This massive counterattack planned by the island commander, Lieutenant General Takeshi Takashina, called for attacks on the Marine lines and beachheads. On Orote Peninsula the counterattack was launched by Commander Tamai at 2230 that night. The Americans in front of RJ 15 called in the most concentrated artillery fire of the battle for Guam. Even with the heavy artillery fire individual Japanese broke into the American lines but were killed in hand-to-hand fighting. The counterattackers were not able to break through the Marine lines (1st Prov. Mar. Brig., WD, 1 Jul-10 Aug 44, pp. 8-9).

The next day the Marines were ready to resume the assault on Orote. On the left there was a rapid advance but still the guns at Tipalao were active. They had not been silenced as believed. On the right it was slow going as mortar fire slowed the Marines. The terrain on the right was effectively used by the defenders. A strong point had been built at RJ 15 and on the right of the junction was the mangrove swamp and on the left was wetlands. The road was mined and 100 meters west of the junction was a ridge line with machine gun positions which fired on the Marines at RJ 15. By the end of July 26 the Marines had only advanced just beyond RJ 15.

Today RJ 15 has been extensively improved as the junction of Marine Drive and Route 2. In 1944-1945 storage areas were built on both sides of RJ 15. There is a low probability of extant remains of the defenses here.

The advance on July 27 ran into excellent defenses on the ridge line beyond RJ 15 and silence the artillery and guns at the Rifle Range, Marine Barracks, and airfield which were laying deadly fire onto advancing Marines.

The ridge line behind RJ 15 became the site of the administrative area of the Naval Operations Base with hundreds of Quonset huts constructed on the ridge line. Again this is another area with little chance of existing reminders of the Japanese defense or the Marine advance.

There was yet another defense line, at the coconut grove on rising ground 500 meters before the prewar Marine Barracks was a strong point with well-camouflaged coconut log pillboxes holding machine guns. Behind the strong point was a line of 250 pillboxes and emplacements supported by gun caves in the Sumay cliffs. This line was at the Rifle Range, airfield, and across to Sumay. Marines destroyed it on July 28 and this broke the Japanese resistance on Orote Peninsula.

Construction after the capture of Orote included NOB activities, an expanded airfield, and in the 1950s the Lockwood Terrace family housing removed likely footprints of the defenses and the battle.

Pockets of resistance were cleared during the morning of July 29 and that afternoon at 1530 the U.S. flag was raised at the destroyed prewar Marine Barracks. Marines found little left of their former camp but did discover the original bronze plaque, identifying the Marine Barracks, and proudly displayed it at the flag raising. This plaque is just as proudly displayed now at the present day Marine Barracks, Naval Station Guam. The site of the prewar Marine Barracks is within the Lockwood Terrace and Sumay Housing Areas.

One Japanese pocket of resistance at Gabgab Beach was destroyed but few defenders were found west of the airfield. Gun caves and positions west of Sumay on the shore line were abandoned. Fort Santiago and Orote Point were not defended.

A number of the defenses in this western portion survive. The caves in Sumay cliffs are extant. At Gabgab Beach three of the many pillboxes are intact. A Seabee veteran, Rolland M. Seldon, recalled in an interview, destroying gun positions at Gabgab when his Seabee unit constructed a recreation beach here in March 1945.

The gun caves west of San Luis Point to Gabgab Beach have not been investigated or has the Fort Santiago area received a systematic survey. This locale of the Naval Station should be surveyed as part of the National Register determination within the context of Japanese defense of Orote Peninsula. Fort Santiago and Orote Point also need to be considered in terms of Spanish, American seven-inch gun positions, and Japanese occupation.

Most of the 2,500 Japanese defenders of Orote Peninsula died and were buried on this land. A few escaped by barge or swimming to Piti to fight and die elsewhere on Guam. For reasons of sanitation the burial of Japanese was quick and in mass graves.

POTENTIAL FOR ENCOUNTERING JAPANESE MASS GRAVES: GUAM AND THE MARIANAS

Mass Burial in the Pacific

Burial of the dead in the Pacific War had its own very special and difficult nature, it was a war characterized by heavy casualties in short time periods. Unlike Europe it was not a protracted war with relatively straight battle lines and rear areas. Even when there were rear areas there were not civilians or prisoners available to assist in the collection and careful burial of enemy dead. Virtually all transportation was devoted to combat, leaving only meager transportation for the collection and burial of both American and Japanese dead. Massive Japanese counterattacks also created a chaotic situation where thousands of dead would litter battlefields after one attack.

There was also the climate, hot and humid which caused rapid decay, stench, germination of insects and the potential for disease transmission. The dead had to be quickly buried to protect the living from disease and discomfort.

In the Marshall Islands campaigns the burial process was overcome by these factors. The large number of dead, in short time periods, far exceeded the capability of the graves registration teams. The Army plan in the Marshall Islands was for soldiers in the Band to move friendly remains from the front lines to a nearby trail, where labor or reserve troops could transfer the dead to collection points. At the collection points graves registration personnel would complete the paperwork and prepare the fallen for transfer to divisional or island cemeteries at the beaches.

Too few soldiers were available for graves work so found themselves unable to keep up with the rapid battle. Added to their problems were thousands of decomposing Japanese bodies which had to be left where they laid until after the battle. On Kwajalein Island alone there were nearly 4,000. It took days to bury these dead while the stench and health hazards grew. The burial problem was so great that it delayed the start of some island garrison projects.

The problems experienced in the Marshalls were studied by the planners for Operation Forager, the assault of the Marianas. Planning for the Marianas included revisions in the handling of American and Japanese dead. One improvement was the creation of specialized sanitary details trained in the use of sodium arsenite. They would spray Japanese dead in the field, and American dead at the island cemeteries, and when they had time spray living sites to control flies.

Graves Registration, Marianas

Operation Forager at Guam and Saipan included expanded graves registration units. The 27th Infantry Division at Saipan had one platoon to support the assault and two for the garrison force. There was also a small sanitary detail for sodium arsenite spraying, directed by the Medical Inspector.

Saipan and Guam had an adequate force of sodium arsenite spraying squads but a shortage of transportation and burial teams to recover American dead and dispose of Japanese dead. "The method of evacuation of friendly dead was never perfected to complete satisfaction, due to the paucity of transportation. The standing operating procedure for the division calls for evacuation by battalion to RCT collecting points, and by regiment from RCT (Regimental Combat Team) collecting points to the division cemetery. When operations were slow and fatal casualties few, the dead were evacuated as per plan, but when the troops moved forward rapidly, and suffered heavy casualties, dead were left behind without evacuation in some instance longer than should be the case. On D plus 5, G-4 was able to allocate one DUKW (2 1/2 ton amphibious truck) to the Graves Registration Officer, but this served only to pick up isolated cases of bodies which had been overlooked initially, and found in areas no longer under the control of any combat unit" (G-1 Rpt., Op. Forager, 27th Division, pg.4).

At both Saipan and Guam following the large Japanese counterattacks the burial system was overloaded. On Saipan "when the 105th Infantry suffered the terrific Japanese counterattack of July 7, leaving 461 U.S. dead on the field within an area of less than a square mile, it was absolutely impossible for the unit to cope with the situation... The difficulties of locating the bodies among the thousands of Japanese dead, of recovering bodies from shell holes which had filled with water, and the collection of bodies which had been badly shattered by mortar fire made it impossible to complete collection of these dead in less than 4 1/2 days, notwithstanding the amount of personnel and transportation involved. This delay in evacuating our own dead is believed to have had a depressive effect on the morale troops in the area" (G-1 Rpt., Op. Forager, 27th Division, pg.4).

The graves registration effort was somewhat eased on Saipan where there was a large group of Korean laborers available to assist in the burial of Japanese dead. Over 200 laborers were used to field bury Japanese dead.

On Guam plans for extensive post battle construction meant more engineering equipment including bulldozers. They were diverted to the battlefields to rapidly bury the thousands who died in the main counterattacks.

Interring Japanese

The Japanese dead were interred in a number of different ways; understanding the methods can aid in predicting burial sites. Before island invasions the Japanese who fell victim to bombing raids and naval bombardment were, when possible, cremated in accordance with Japanese tradition. As fuel supplies and American air coverage increased this was not possible so tradition had to give way to field burial. The dead were buried near their gun positions with memorial markers indicating their graves. For example a National Archives photograph records a Guam 200mm gun position with marked graves (127 GW 1384 91693). At Yap during the construction of a new airport burials of this type were uncovered near an antiaircraft gun position.

The number buried at their gun positions from preassault bombardment is small in comparison to the post-battle burials by American forces. These are the most likely burials to be encountered and contain in each grave from a few to 500 human remains. Because of time constraints and battle needs there developed regular patterns of mass burial.

These regular patterns provide the archaeologist with predictive tools for the locating of mass burials. There were four American mass burial techniques; to employ existing natural depressions, shell craters, Japanese defensive trenches, and bulldozer dug trenches. For example at Guam, a ravine on the Asan River, above Asan village, was filled with 250 Japanese dead after the counterattack of July 25-26. In the village of Asan Japanese dead were placed in an antitank ditch which was covered by a bulldozer. Often the bulldozers followed the graves registration teams who separated American from Japanese dead, the Japanese were either bulldozed over or placed in trenches dug by the bulldozers.

A review of National Archives photographs (documents on the burials have yet to be found) of Japanese dead on Orote Peninsula suggest three burial techniques. The first burials were in the trenchworks and at the defensive lines. Following the counterattack of July 25 some 400 dead were collected and buried in bulldozed trenches east of RJ 15 (see NA photograph SC 111-210555 for a view of the dead on the battlefield). This site was filled and became a storage facility in late 1944. Bulldozers were also used to bury dead at the Marine Barracks Rifle Range. Wood signs were posted at each burial with the number of dead for statistical purposes (CTF 56, 1 Sep 44, Enc. F).

After Orote Peninsula had been secured and the 2nd Engineer Aviation Battalion went to work repairing the airfield they had to divert engineers to burial duty as health problems were feared from the many dead Japanese still littering the Orote battlefields. The dead were collected and trucked to central points for burial, away from construction sites but adjacent to roads. One such site was at the junction of Orote Point Road and San Luis Road. Today it is within the Lockwood Terrace Housing Area and is a grassy plot.

The Lockwood Terrace mass burial site is a Guam Register of Historic Places (3-1092) feature. Information on this burial site is limited, based upon the recollection of an eye-witness, Jesus C. Lizama. Mr. Lizama, who was 16 years old in 1944,

"was returning to his home in Sumay, after the battle for Orote Peninsula, he was confronted with death everywhere. Decomposing bodies of Japanese soldiers were strewn over the streets. Big flies hovered over the bodies and a nauseating smell filled the air." (Guam Register 1977).

After tarrying to gather souvenirs, he left the village around high noon. While he was walking toward Orote airfield along San Luis road, he noted a flurry of activity by U.S. forces. They were burying Japanese dead in a large shell or bomb crater. The dead were being off-loaded from trucks and put in the pit. Mr. Lizama walked away as the work continued. The pit was covered over and the count of dead added to the figures for Orote Peninsula.

Based upon the review of available documents, National Archives photographs, and the Guam Register, it can be assumed that mass graves are to be expected at the initial defense line, in the vicinity of RJ 15, in the area of the former Rifle Range and Marine Barracks, and to the north of the airfield. Further research might uncover mapping of the burial of about 2,500 Japanese dead on Orote Peninsula, but to date efforts have been unsuccessful.

Excavation and Archaeology

The expansion survey areas do not have a high probability of burial sites but future expansion and development should consider the locating and recovery of human remains. This would have both scientific and cultural worth. The return of remains is extremely important to the Japanese. At the same time excavation using professional archaeological methods can produce valuable research data.

Research questions which can be answered include, how well equipped were the soldiers. This can be measured by ammunition supplies and military gear present (rifles will not be present as they were recovered before burials). Personnel identification tags and canteens with names inscribed can be used in conjunction with unit rosters to identify units involved in the counterattacks or battles. If multiple graves are opened rough battle maps are possible showing locations of units and troops.

Questions may also be site specific. For example there are questions concerning the firing of artillery point-blank into the counterattack on Tanapag Plain, Saipan. The condition of human remains in front of the artillery can resolve this debate. If the attackers were hit by artillery at close range the extensive trauma will be obvious.

A systematic review of the Orote defense and counterattack before excavation would suggest other research questions relevant to Orote Peninsula sites.

HISTORIC FEATURES, PHASE I-B SURVEY

A: Coastal Zone North of Haputo Road

PS-11 - Hand Grenade: A Mark 2, World War II American fragmentation type, "pineapple" grenade was found. Recommend its removal by EOD personnel. Not National Register eligible.

C: Headland at North End of Tipalao Bay

TN-19 - Concrete Foundation: Further archival and photographic research is required to determine the function of this concrete remains.

TN-20 - Water System: A 1921 Marine Corps report (USMC 1921) discussed the absence of water in this area and the need for water to supply the barracks at the Tipalao gun position. Additional investigation is needed to date and evaluate the age of this water system.

TN-21 - Recreation Site: The physical layout and construction details suggest that the stone and concrete materials at this feature are from a recreation facility. The 14th Marine Antiaircraft Battalion was allocated this parcel in 1944 and may have built a club or picnic area at this site. The site does not appear on a 1949 Naval Station recreation map. Photographs of various time periods would be helpful in delineating its function and time period.

TN-22 - Japanese Gun Cave: The size of this cave, seven meters wide and five meters deep, suggests that it was a natural cave modified by the Japanese. A constructed cave would have followed the standardized plans with a gun opening of 2.50 meters width, not five meters as with this cave. Internal chambers were constructed in this cave for shelter and ammunition storage. A likely gun in this size cave would be a 75mm and may have played a significant role in the defense of Orote Peninsula.

A gun in this cave is a possible source for the attack on the U.S.gunboat LCI (Landing Craft Infantry) 366 which was hit while attempting to neutralize the cliffline gun caves. The Executive Officer and six men on LCI 366 were killed.

This gun cave is National Register eligible as an element of the thematic nomination.

TN-23 - Sewer Line: Not National Register eligible.

D: Central Tipalao Bay

TN-24 - Possible Recreation Site Foundations: Additional investigation is also necessary to identify these remains. If identified as a recreation site it probably is less significant than the more intact Palm Beach and NOB Theaters. National Register

eligibility depends upon more precise site identification.

E: Headland Opposite Neye Island (North of Dadi Beach)

PS-13 - Caves: These three rubble filled caves in the cliff line where probably not as critical in the defense of Orote Peninsula as the gun caves to the south.

National Register eligible, studied as part of the thematic nomination.

TN-25 - Sewer Pipes: Not National Register eligible.

TN-26 - Gun Cave: This natural cave was improved with coral filled fuel drum firing wall and constructed ammunition and shelter chambers. National Register eligible.

TN-27 - Defensive Caves: This is a complex of three caves, including TN-27 which is two caves that were gun positions. They were connected to TN-28, a fire control post. National Register eligible.

TN-28 - Fire Control Post: I-type tunnel, the type used by the Japanese as fire control and command posts. National Register eligible.

TN-29 - Japanese Gun Cave: Constructed cave for 75 mm gun. National Register eligible.

TN-30 - Command Post Cave: This type of fissure and sinkhole natural cave was employed as command posts, often for the local commander. A communications center would also have been sited in the cave. National Register eligible.

PS-14 - Possible Site: This site is well suited for the placement of an observation post, but there is no physical evidence of such a feature. Further research is necessary to identify its actual wartime and post battle use.

H: Old Quarry

PS-15 - Abandoned Quarry: Not National Register eligible.

I: Haputo Road - Marine Drive

PS-16 - Equipment Parking Pad: This slab is not National Register eligible.

PS-17 - Possible Head: This possible latrine or head is not National Register eligible.

PS-18 - Concrete Foundation Pads: Further research required to identify its function. May be supports for radio towers or observation towers. National Register eligibility to be evaluated.

SUMMARY OF FINDINGS

The most significant features discovered in the expansion surveys were the Japanese gun and defense caves. There are a sufficient number of these defenses to effectively recall the battle for Orote Peninsula. They could be treated as a historic context and with other peninsula Japanese defenses covered in one National Register nomination.

Additionally there are American construction features which recall the rapid and massive buildup of Orote Peninsula. They recall the great Seabee effort.

National Archives Photographs: The Still Photograph Section of the National Archives holds hundreds of photographs of counterattack dead and burial in mass graves in the Marianas.

Photo 2. This is a typical photograph (National Archives Photo No. 127-GW-1319-87126) of dead of the battle on Tanapag coastal plain, in the Marine sector. The photograph contains much information. For example, note most or all are in uniform suggesting no civilian participation. There are numerous rifles, possibly fitting the estimate of one-half of the troops; canteens, helmets, and other equipment are also present.

National Archives Photographs: The Still Photograph Section of the National Archives holds hundreds of photographs of counterattack dead and burial in mass graves in the Marianas.

Photo 3. On a number of islands bulldozers turned under the Japanese bodies covering them with only a shallow soil cover. An example of this burial method can be seen in the above photograph taken at Tinian Island (National Archives Photo No. 127-N-90931).

VIII: RESULTS OF LABORATORY ANALYSES

Standards of Sample Collection and Analysis

Provenienced assemblages of faunal bone, marine molluscs, charcoal samples for radiocarbon dating, and prehistoric ceramics were recovered from test excavations at three sites. Ceramics, shell, and historic materials were also recovered from hand augers, power augers, and shovel probes. However, these materials were considered unprovenienced and were not included in the laboratory analyses summarized here.

All excavated sediments were screened through 1/4 inch mesh. Many fragile artifacts, bone fragments, chunks of charcoal, and other items were removed from the screens and bagged separately. Also tossed from the screens were all rocks larger than a fifty-cent piece. The materials left in the screens were placed in bulk bags and transported to the IARII Guam office, and eventually shipped to IARII Honolulu for washing, sorting and analysis.

The number of formal prehistoric artifacts recovered was rather small, and are described below. Although two or three probable pieces of historic ceramics were found during the field survey of Tipalao Bay, these were not collected (none had any identifying marks). Very few historic pot sherds were encountered in the controlled excavations as well. No complete bottles were collected during survey, nor were the several bottles uncovered during trenching at Tipalao Bay saved. No other materials such as trade beads, buttons, coins, or other commonly occurring historic items are known to be in the artifact collection. In a separate section below, the assemblage of historic materials and recent trash recovered from the controlled excavations is tabulated and discussed.

The methods and standards of analysis specific to each assemblage analysis are discussed as appropriate below.

Analysis of Midden Remains

The midden components which reflect prehistoric subsistence activities most directly are faunal bone and foodshell remains. For the most part, these materials represent the refuse of purposeful foraging, hunting, butchering, and cooking behavior in the past. Because an understanding of subsistence behavior is considered critical to the comprehension of past social systems, an attempt is made to identify the elements of the faunal bone and shell collections which do not derive from human activity. In the following discussions, an emphasis is placed on distinguishing faunal material which originated from natural, non-human agencies.

Fish and Mammal Bone Identification

The assemblage described in this analysis was recovered from the controlled test excavations at the prehistoric rockshelter (Site 2-1302), the Japanese bunker and cave below Camp Bright (Site 2-1301), and from Tuparao Village (Site 2-1311). A total of 1248 whole and fragmented bone, teeth, and fish scales was recovered; just over ninety percent of this assemblage derived from the four test units at the prehistoric rockshelter. Much smaller collections were recovered from the two other sites: the bunker and cave complex yielded 96 pieces (roughly 7.7 percent of the collection), and the testing at Tuparao Village recovered 21 pieces (about 1.7 percent).

The faunal assemblage was analyzed by Alan C. Ziegler, Ph.D. Commonly accepted laboratory procedures were used to sort, examine, and identify the materials. In general, fishbone fragments were identified to the family level, although the genera could be determined in some situations. In the following tables, unidentified fishbone fragments are summarized by category of bone (e.g., maxillary, quadrate, vertebra). In about 60 cases, it was possible to estimate the probable length of the fish based on the vertebral remains. However, depending on the fish species and position of the vertebrae in the spinal column, these length estimates may be in error by as much as 20 to 30 percent (Ziegler 1992). In addition, the length data do not inform us about the number of fish harvested. That is, two bones reported as originating from a 25 centimeter long fish do not necessarily derive from separate fishes; the vertebrae are raw bone counts, not MNI. For these reasons, the limited amount of data available on probable fish length are not reported (but these data are on file at IARII in Honolulu).

In many cases, bone fragments could not be assigned to a taxon more specific than, for example, "Medium Lizard" or "Small/Medium Vertebrate". In these cases, the size distinctions are intended as generalizations only. Remains listed in these categories could not be conscientiously assigned to any more specific taxa.

In several instances analyzed bone could not be distinguished between bird and bat. These fragments have been reported as "Medium Bird or Medium Pteropodid". It is most likely that the majority of this material belongs in the latter taxon because "birds of any size seem extremely rare" in the collection (Ziegler 1992). One or more fruit bat species of significant size were apparently recovered in the excavations, and may represent a significant source of food for human consumption.

Finally, it must be noted that the summaries presented here tally raw fragment counts. In a very general fashion such counts are broadly similar to NISP (Number of Individual SPecimens) data. While it is unlikely that every vertebral spine, fish scale, and tooth came from separate, distinct animals, such a situation is possible. The data tabulated here must be viewed as an estimate of the *maximum* number of animals originally present in the deposits (Grayson 1984). Although the real numbers of fish, birds, and other animals present were probably lower, the gross fragment counts do suffice as a rough measure of abundance. And because the excavations at the three sites were carried out in exactly the same manner, these data are internally consistent and comparable to one another.

Below, Tables 4 through 7 summarize the faunal materials recovered from the rockshelter. Materials recovered from the Japanese bunker below Camp Bright are listed in Tables 8 and 9; Table 10 details the small assemblage from the Tuparao Village excavations. The materials from the latter two sites derive from provenience levels of twice the volume as those at the rockshelter. Although all sediments were removed in arbitrary 10 centimeter levels, the test units in the Japanese Bunker and at Tuparao Village measured 50 centimeters by 1 meter, while the rockshelter was tested with four smaller units measuring 50 centimeters square. Even allowing for minor measurement errors and differences in test unit size, the rockshelter was much richer in faunal material than the other two sites. Compare, for example, the bone recovered from Test Unit 2 in the Japanese Bunker, with the assemblages from Test Units 3 and 4 in the rockshelter; the volumes of these three units are roughly the same.

The materials recovered from Test Unit 1 at the rockshelter appear to be food refuse. Nearly all the bones derive from small and medium sized fish of typical inshore families; the medium sized bird remains are not *Gallus gallus* (Ziegler 1992). The burned and discolored soil and ash noted between 50 and 66 centimeters below surface in this unit may have been an extramural hearth, and may account for the minor bone concentration at this level. The data also indicate the sterility of the upper 40 or 50 centimeters of clay soil capping the cultural deposits in the Test Unit 1 area.

Test Unit 2 faunal remains are summarized in Table 5. This is the smallest subassemblage of bone from the rockshelter; a high volume of coral and limestone rock was encountered in the unit. Evidence of disturbance was noted throughout the unit as well. It is possible that the rat bone was *in situ* when recovered from 70 to 80 centimeters below surface or it may have been accidentally dislodged during excavation and fallen to that depth from a more shallow level. There is a very slight possibility that one or two of the mammal bone fragments are human.

Test Units 3 and 4 were in close proximity to each other and essentially the same volume of sediment was removed from each. A similar faunal assemblage was recovered from each test unit as well, although 53 percent of the collection derives from Test Unit 3, while 43 percent of the rockshelter faunal assemblage originated in Test Unit 4. The materials recovered from these two units are listed in Tables 6 and 7. The fish remains represented are significantly more varied than the other sites and test units. Not only are there several families of inshore fish, but there are also two or three families of fish requiring offshore fishing technology. Sea turtle, chicken, fruit bat, and "medium lizard" were also eaten here.

In Test Unit 3 (Table 6) *Rattus* and the Giant Neotropical Toad (*Bufo marinus*) are restricted to the upper 20 centimeters of the deposit. These two animals were not present at all in Test Unit 4. The toad was introduced to Guam historically (Ziegler 1992); it is uncertain when *Rattus* made its way to the island.

Although it is possible that some of the fragments of "medium mammal" bone recovered from units 3 and 4 could conceivably be human, the only probable human bone fragments derive from Test Unit 2. In that excavation, the most disturbed test unit in the rockshelter, two probable human metatarsal shafts were recovered from 15 to 25 centimeters below surface.

Table 4. Summary counts of faunal bone from Test Unit 1, Site 2-1302, Dadi Beach Rockshelter (TN-13).

Taxon (common name)	centimeters below surface 40-50	50-60	60-70	70-80	100-110	Total per Taxon
OSTEICHTHYES (bony fish)						
Scarid (parrotfish)		2				2
Acanthurid (surgeonfish)		1			1	2
Balistid (triggerfish)		1				1
unidentified bone						
maxillary				1		1
quadrate		1				1
vertebra		4	5	1	1	11
bone fragment	3	7	2		1	13
scale		1				1
AVES						
medium bird		2				2
MEDIUM VERTEBRATE	1					1
Total per Level	4	19	7	2	3	35

Table 5. Summary counts of faunal bone from Test Unit 2, Site 2-1302, Dadi Beach Rockshelter (TN-13).

Taxon (common name)	centimeters below surface 0-10	15-25	25-35	35-45	45-55	70-80	Total per Taxon
OSTEICHTHYES (bony fish)							
Scarid (parrotfish)					1		1
unidentified bone							
vertebra	1		1				2
bone fragment				1			1
MAMMALIA							
Rattus sp.						1	1
small/med mammal	3						3
medium mammal		2					2
MEDIUM VERTEBRATE	1						1
Total per Level	5	2	1	1	1	1	11

Table 6. Summary counts of faunal bone from Test Unit 3, Site 2-1302, Dadi Beach Rockshelter (TN-13).

Taxon (common name)	centimeters below surface 0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	Total per Taxon
OSTEICHTHYES (bony fish)												
Belonid (needlefish)					1							2
Exocoetid (flyingfish)							1				1	2
Mullid (goatfish)								1				1
Labrid (wrasses)		1	2		1						1	5
Scarid (parrotfish)	2	1	1	1			1	1			1	6
Acanthurid (surgeonfish)		1			3		1	1			1	7
Scombrid (Tuna, Mackerel)							1					1
Balistid (triggerfish)	1				1	2			2			6
unidentified bone												
maxillary	2				1							3
quadrate					1							1
vertebra	11	9	1	17	9	6	8	5	4	2	8	80
bone fragment	14	6	30	33	63	14	12	4	6		3	185
scale			13	31	177	30	21	9	2		6	289
AVES												
Gallus gallus										1		1
MAMMALIA												
Rattus sp.											1	1
small/med mammal		1					1					1
AMPHIBIA												
Bufo marinus	1	1										2
REPTILIA												
Cheloniid						1	1					2
medium lizard					1	2						2
MEDIUM VERTEBRATE						1						4
SMALL/MED VERTEBRATE				1								1
Total per Level	31	21	49	83	258	56	47	21	14	3	21	604

Table 7. Summary counts of faunal bone from Test Unit 4, Site 2-1302, Dadi Beach Rockshelter (TN-13).

Taxon (common name)	centimeters below surface 0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	Total per Taxon
OSTEICHTHYES (bony fish)												
Belonid (needlefish)			3	2								5
Holocentrid (squirrelfish)					1							1
Labrid (wrasses)			2			1	1					4
Scarid (parrotfish)			1									1
Acanthurid (surgeonfish)			1	1		1		1				4
Balistid (triggerfish)			1		2						1	4
Diodontid (spiny puffers)							3					3
unidentified bone												
maxillary				1						1		1
quadrate			1									1
vertebra	2		18	13		16	10	4	3	2	4	72
bone fragment		5	43	29	6	24	9	3	3	2	1	125
scale		4	153	51	1	45	3					257
MAMMALIA												
medium Pteropodid				1								1
MEDIUM VERTEBRATE			2									2
Total per Level	2	9	225	97	10	87	26	8	6	5	6	481

The assemblage of faunal bone from the Japanese bunker below Camp Bright (Site 2-1301) is summarized in Tables 8 and 9. The richer of the two excavations was Test Unit 2 (Table 9) which yielded 58 items from about .25 cubic meters. From Test Unit 1, 39 items were recovered from .4 cubic meters. The material from Test Unit 1 includes no fish remains identifiable to the family level. Test Unit 2 had only one parrotfish fragment among the 29 fishbone fragments.

It is probable that much of the faunal material from both test units in the bunker and cave complex derive from natural processes. Clear evidence of the use of the cave by feral dogs was noted during work in the cave. Shallow holes or wallows were seen, a large mandible with gnaw markings on it was recovered from the rear of the cave, and dogs were seen on several occasions leaving the cave as we approached. Given these observations, it is possible that much of the faunal bone recovered from this site derive from the hunting and scavenging of the local wild dog population.

Some of the animals represented by the bone counts may have lived and died naturally in the cave, or been hunted and killed there by the dogs. This scenario seems especially likely for the cat, rat, lizard, toad, and possibly bat remains. Although no bats were seen living in the cave, they may have done so in the recent past, and they may have been preyed on by the dogs. At any rate, regardless of which of the remains represent canine foraging activity, and which animals were natural inhabitants, there are few indicators of human subsistence activity.

Table 10 summarizes the faunal remains recovered from the Tuparao Village site. The materials from both test units are listed in the same table, and total only 21 items. Test Unit 2 yielded only one squirrelfish bone and a rat incisor. In Test Unit 1, concentrations of bone were recovered from the 60 to 70 and 70 to 80 centimeter levels. Half of the 8 pieces of bone from 70 to 80 centimeters below surface are fish, the other half are mammal and vertebrate remains. Directly above, one of seven bone fragments is *Homo sapiens* and the other six are possibly human. According to the analyst, "the material categorized as mammal could possibly be human; that is... [the Tipalao Bay/Tuparao Village] area might be a significant burial area (Ziegler 1992:4). Of the 19 fragments recovered from Test Unit 1, 10 may be human bone fragments.

Marine Shell Identification

An assemblage of molluscan shells weighing over 44.5 kilos was recovered from the three sites tested with controlled excavations. The majority of this material appears to be cultural foodshell refuse. In the total assemblage, which is 91 percent bivalves, very few naturally killed (i.e., drilled by predatory gastropods) valves were noted. However, up to 10 percent of the gastropod shells in the collection may be natural midden components; they exhibit damage characteristic of predatory crabs, or have been modified by hermit crab inhabitants (Carucci 1992a). This rough estimate of natural shell is derived from the MNI-based analysis of selected provenience levels.

The entire shell assemblage was analyzed by weight; only a few proveniences were also analyzed by MNI counts. It was not possible to analyze the huge amount of shell using both weights and MNI (which is always preferable), or some combination

Table 8. Summary counts of faunal bone from Test Unit 1, Site 2-1301, Japanese bunker/cave below Camp Bright (TN-12).

Taxon (common name)	centimeters below surface 0-10	10-20	20-30	30-40	47-60	60-80	Total per Taxon
OSTEICHTHYES (bony fish)							
unidentified bone							
quadrate		1			1		2
vertebra		1			2	1	4
bone fragment		1	1	2	1		5
AVES							
Gallus gallus						1	1
AVES / MAMMALIA							
medium bird or							
medium Pteropodid			1		1	2	4
MAMMALIA							
Homo sapiens	1						1
Canis familiaris	1						1
Felis catus		1					1
medium Pteropodid				1			1
small/med mammal			3				3
medium mammal	1				1		2
AMPHIBIA							
Bufo marinus		2	1	1	1		5
REPTILIA							
medium lizard		1	1				2
MEDIUM VERTEBRATE		2		1		1	4
SMALL/MED VERTEBRATE					3		3
Total per Level	3	9	7	5	10	5	39

Table 9. Summary counts of faunal bone from Test Unit 2, Site 2-1301, Japanese bunker/cave below Camp Bright (TN-12).

Taxon (common name)	centimeters below surface 0-10	10-20	20-30	30-40	40-50	Total per Taxon
CHONDRICHTHYES						
shark or ray					1	1
OSTEICHTHYES (bony fish)						
Scarid (parrotfish)					1	1
unidentified bone						
vertebra	4	8	1	3		16
bone fragment	3	4	3	1	1	12
AVES / MAMMALIA						
medium bird or						
medium Pteropodid			1	1		2
MAMMALIA						
Rattus sp.	1			2		3
large Bovid	1					1
medium Pteropodid				1		1
small/med mammal	4	2				6
medium mammal				1		1
med/large mammal	1					1
large mammal				1		1
AMPHIBIA						
Bufo marinus		1				1
REPTILIA						
medium lizard					1	1
MEDIUM VERTEBRATE		2	2	2	1	7
SMALL/MED VERTEBRATE	3					3
Total per Level	17	17	7	11	5	57

Table 10. Summary counts of faunal bone from Test Unit 1 and Test Unit 2, Site 2-1311, Tuparao Village (PS-12).

Taxon (common name)	centimeters below surface TU 1 60-70	TU 1 70-80	TU 1 80-90	TU 1 90-100	TU 2 10-20	Total per Taxon
OSTEICHTHYES (bony fish)						
Holocentrid (squirrelfish)		1			1	2
Scarid (parrotfish)		1	1			2
unidentified bone						
vertebra		1				1
bone fragment		1		1		2
scale			1			1
MAMMALIA						
Homo sapiens	1					1
possible *H. sapiens*	6					6
Rattus sp.					1	1
small/med mammal		2				2
medium mammal		1				1
MEDIUM VERTEBRATE		1				1
SMALL/MED VERTEBRATE			1			1
Total per Level	7	8	3	1	2	21

of weight and NISP or fragment counts. Logistical and time constraints, for the most part imposed by the tight reporting schedule required by the scope of work, made it necessary to limit this analysis to shell weights only.

These same time constraints made necessary two additional adjustments to the analysis. First, many shell bags from the rockshelter contained great amounts of tiny shell fragments. It was not possible to physically sort all of this "shell gravel" into specific taxa, but the relative amounts of shells contained in the fragmentary remains could be accurately estimated using a standard method. First, all large unidentifiable pieces of gastropod and bivalve shells were removed. Then the remaining tiny fragments were examined for an additional five minutes, and the relative abundance of the main constituents of the gravel were estimated based on this careful study (the most common fragments were *Gafrarium pectinatum*, generally followed by lesser amounts of *Tellina*). Once the relative abundance of each shell taxa present was estimated, the percentage estimates were converted into weights. These weights were then included in the totals reported for the appropriate shell taxa. There is no doubt that this method has introduced some error into the weight analysis. However, the level of error is considered acceptable, and it was thought to be much more desirable to limit the huge amount of "unidentifiable" shell by including the "gravel" in the shell weight analysis.

The second methodological adjustment concerns the shell recovered from Test Unit 2 at the rockshelter. This relatively small collection of shell was not included in the analysis. Not only were there clear indications of disturbance noted when Test Unit 2 was excavated, but many of the shells were fragmented. For these reasons, and to help decrease the overall size of the total assemblage to be examined, the shell from Test Unit 2 was removed from the analysis.

Considering the weights of gastropods and bivalves combined, the Dadi Beach Rockshelter (Site 2-1302) accounted for 93.2 percent of all shell remains recovered. Slightly more than two kilos of shells (4.6 percent of the entire assemblage) were recovered from the test units at Tuparao Village (Site 2-1311), and the cave and bunker complex below Camp Bright (Site 2-1301) yielded less than a kilo of shell (2.2 percent of the assemblage). From all three sites, unidentifiable shell amounted to 3,130.4 grams and accounts for only 7.02 percent of the entire collection.

Table 11 summarizes the shell materials recovered from Test Units 1, 3, and 4 from the Dadi Beach Rockshelter. Just over 94 percent of the excavated shells are whole or fragmented bivalves; the total weight of gastropod shells recovered is only 2.4 kilos. By percentage, one third of the gastropod remains were not identifiable. *Strombus gibberulus* comprises one fifth of the collection, followed by *S. mutabilis* (16.5 percent) and *Cerithium nodulosum* (7.0 percent).

While the total shell weights recovered from Test Units 1 and 4 are nearly the same, substantially fewer bivalves were recovered from Test Unit 3. However, each test unit contained major concentrations of a single bivalve species between about 70 to 90 centimeters below surface. At these depths, up to 93 percent of the bivalves recovered were *Gafrarium pectinatum*. The weights and relative percentages of shell from Test Unit 1 are reported by level in Table 12. Table 13 reports percentages and weights from Test Unit 3, and Table 14 details the shell assemblage from Test Unit 4.

Table 11. Total shell weights (grams) by taxa recovered from Test Units 1, 3, and 4, Site 2-1302, Dadi Beach Rockshelter (TN-13).

Taxon	TU 1	%	TU 3	%	TU 4	%	TOTAL	%
Patellidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trochus spp.	19.3	3.3	40.2	5.1	10.6	1.0	70.1	2.9
Turbo spp.	1.0	0.2	0.0	0.0	29.1	2.8	30.1	1.3
Nerita spp.	11.0	1.9	4.5	0.6	4.3	0.4	19.8	0.8
Cerithium echinatum	0.9	0.2	2.8	0.4	0.0	0.0	3.7	0.2
Cerithium nodulosum	30.9	5.3	110.8	13.9	26.8	2.6	168.5	7.0
Cerithium spp.	14.1	2.4	9.9	1.2	21.7	2.1	45.7	1.9
Lambis lambis	58.5	10.0	0.0	0.0	0.0	0.0	58.5	2.4
Strombus gibberulus	134.7	23.0	157.9	19.9	257.3	25.1	549.9	22.9
Strombus mutabilis	89.6	15.3	135.3	17.0	172.7	16.8	397.6	16.5
Hipponix spp.	0.5	0.1	0.0	0.0	0.0	0.0	0.5	0.0
Cypraea moneta	0.0	0.0	6.0	0.8	0.0	0.0	6.0	0.2
Cypraea spp.	1.8	0.3	21.6	2.7	11.8	1.2	35.2	1.5
Natica gualteriana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polinices sp.	0.0	0.0	1.5	0.2	0.0	0.0	1.5	0.1
Cymatium nicobaricum	17.4	3.0	8.2	1.0	5.7	0.6	31.3	1.3
Bursa bufonia	0.0	0.0	7.5	0.9	0.0	0.0	7.5	0.3
Chicoreus sp.	0.0	0.0	6.8	0.9	0.0	0.0	6.8	0.3
Drupa spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cantharus fumosus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vasum turbinellus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vasum spp.	12.8	2.2	22.7	2.9	18.4	1.8	53.9	2.2
Conus spp.	0.0	0.0	19.9	2.5	8.1	0.8	28.0	1.2
Terebra areolata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pythia scarabaeus	55.2	9.4	33.7	4.2	22.0	2.1	110.9	4.6
Achatina fulica	18.2	3.1	25.6	3.2	6.6	0.6	50.4	2.1
Undent. fragments	120.1	20.5	179.5	22.6	430.3	42.0	729.9	30.3
Total per Level	586.0	100.0	794.4	100.0	1025.4	100.0	2405.8	100.0
Anadara antiquata	44.0	0.3	598.1	5.8	182.2	1.3	824.3	2.1
Modiolus sp.	8.8	0.1	46.5	0.4	33.1	0.2	88.4	0.2
Isognomon isognomum	0.8	0.0	22.1	0.2	5.8	0.0	28.7	0.1
Codakia punctata	51.4	0.3	81.6	0.8	63.5	0.5	198.5	0.5
Circe hiulca	586.5	4.0	498.7	4.8	565.8	4.0	1651.0	4.2
Chama spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragum fragum	12.8	0.1	5.8	0.1	13.9	0.1	32.5	0.1
Tridacna spp.	6.7	0.0	203.5	2.0	86.1	0.6	296.3	0.8
Atactodea striata	385.4	2.6	697.3	6.7	1051.3	7.5	2134.0	5.4
Tellina palatam	149.5	1.0	450.2	4.3	431.4	3.1	1031.1	2.6
Tellina scobinata	200.0	1.4	215.9	2.1	232.3	1.7	648.2	1.7
Asaphis violascens	20.5	0.1	52.0	0.5	23.4	0.2	95.9	0.2
Gafrarium pectinatum	12449.7	84.2	7193.2	69.4	10567.9	75.4	30210.8	77.1
Gafrarium sp.	87.9	0.6	38.2	0.4	13.3	0.1	139.4	0.4
Periglypta puerpera	156.6	1.1	37.6	0.4	0.0	0.0	194.2	0.5
Periglypta sp.	38.6	0.3	12.8	0.1	12.4	0.1	63.8	0.2
Pitar pellucidus	1.4	0.0	2.4	0.0	0.0	0.0	3.8	0.0
Undent. fragments	578.1	3.9	203.0	2.0	739.3	5.3	1520.4	3.9
Total per Level	14778.7	100.0	10358.9	100.0	14023.7	100.0	39161.3	100.0

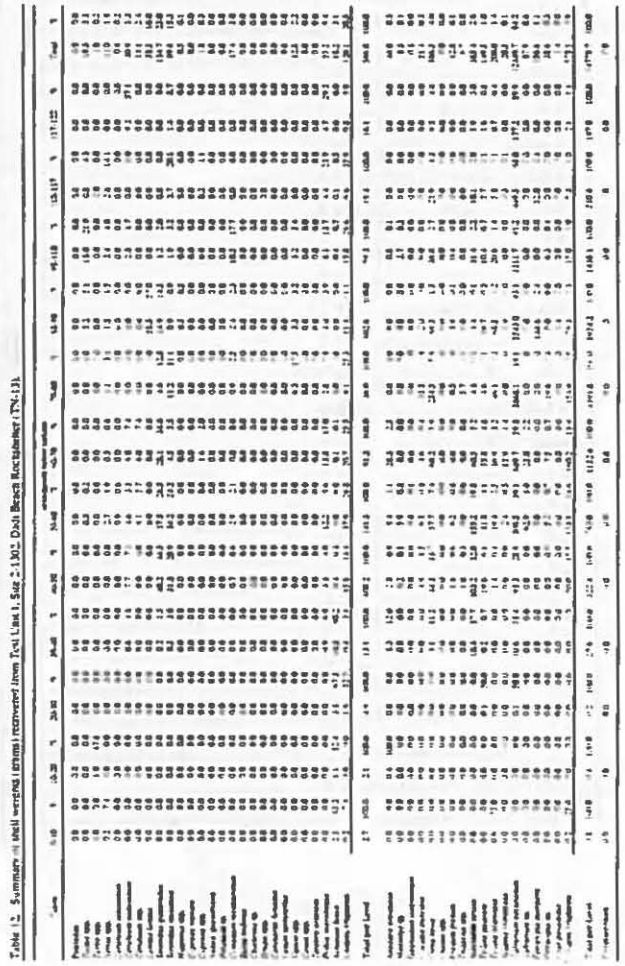


Table 13 Summary of shell weights (grams) recovered from Test Unit 3, Site 2-1302, Dodi Beach Rockshelter (TN-13)

Taxon	0-10	%	10-20	%	20-30	%	30-40	%	40-50	%	50-60	%	60-70	%	70-80	%	80-90	%	90-100	%	100-110	%	110-120	%	Total	%
Pandanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbo spp	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.2	0.0	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	6.3	3.4	1.3	0.7	0.0	0.0	10.4	1.0
Turbo spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	9.7	11.4	6.8	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.4	0.0	0.0	29.1	2.8
Pollet spp	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	1.1	0.8	0.7	0.4	0.6	0.4	0.0	0.0	0.2	0.2	0.1	0.2	1.0	0.6	0.0	0.0	4.3	0.4
Cymbiola rutilostoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbiola innotabilis	0.0	0.0	0.0	0.0	0.0	0.0	9.6	7.6	3.0	2.4	1.2	0.8	4.1	2.4	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1.6	0.0	0.0	20.8	2.0
Cymbiola spp	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.0	14.3	9.9	3.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.8	0.0	0.0	21.7	2.1
Lambis lambis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus gibberulus	0.0	0.0	0.0	0.0	21.0	16.1	33.0	25.6	47.2	33.3	34.2	25.7	16.7	11.2	0.0	0.0	4.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0	157.3	15.1
Strombus mutabilis	0.0	0.0	0.0	0.0	23.0	17.7	6.0	4.6	1.5	1.0	0.4	0.3	0.1	0.1	0.0	0.0	2.0	1.4	0.0	0.0	1.4	0.8	0.0	0.0	33.9	3.2
Hippopus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea moneta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea spp	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.0	1.8	1.3	1.7	1.1	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.5
Nassa gualteriana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pollexia sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium muricinum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.7	4.5	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	0.5
Murex haleyi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chicoreus sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drupa spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conomurex fenestratus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus luhuanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra crenulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraecassis rufa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraecassis sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Semicassis granulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Semicassis sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phos spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbonium vestiarium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbonium thomasi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total per Level	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus gibberulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus mutabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hippopus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea moneta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nassa gualteriana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pollexia sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium muricinum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Murex haleyi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chicoreus sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drupa spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conomurex fenestratus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus luhuanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra crenulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbonium vestiarium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbonium thomasi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total per Level	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-mangroves	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	

Table 14 Summary of shell weights (grams) recovered from Test Unit 4, Site 2-1302, Dodi Beach Rockshelter (TN-13)

Taxon	0-10	%	10-20	%	20-30	%	30-40	%	40-50	%	50-60	%	60-70	%	70-80	%	80-90	%	90-100	%	100-110	%	110-120	%	Total	%
Pandanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbo spp	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.2	0.0	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	6.3	3.4	1.3	0.7	0.0	0.0	10.4	1.0
Turbo spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	9.7	11.4	6.8	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.4	0.0	0.0	29.1	2.8
Pollet spp	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	1.1	0.8	0.7	0.4	0.6	0.4	0.0	0.0	0.2	0.2	0.1	0.2	1.0	0.6	0.0	0.0	4.3	0.4
Cymbiola rutilostoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbiola innotabilis	0.0	0.0	0.0	0.0	0.0	0.0	9.6	7.6	3.0	2.4	1.2	0.8	4.1	2.4	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1.6	0.0	0.0	20.8	2.0
Cymbiola spp	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.0	14.3	9.9	3.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.8	0.0	0.0	21.7	2.1
Lambis lambis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus gibberulus	0.0	0.0	0.0	0.0	21.0	16.1	33.0	25.6	47.2	33.3	34.2	25.7	16.7	11.2	0.0	0.0	4.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0	157.3	15.1
Strombus mutabilis	0.0	0.0	0.0	0.0	23.0	17.7	6.0	4.6	1.5	1.0	0.4	0.3	0.1	0.1	0.0	0.0	2.0	1.4	0.0	0.0	1.4	0.8	0.0	0.0	33.9	3.2
Hippopus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea moneta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea spp	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.0	1.8	1.3	1.7	1.1	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.5
Nassa gualteriana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pollexia sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium muricinum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.7	4.5	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	0.5
Murex haleyi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chicoreus sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drupa spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conomurex fenestratus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus luhuanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra crenulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbonium vestiarium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbonium thomasi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total per Level	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus gibberulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus mutabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hippopus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea moneta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cypraea spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nassa gualteriana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pollexia sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium muricinum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Murex haleyi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chicoreus sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drupa spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conomurex fenestratus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus luhuanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra crenulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The shell materials recovered from Tuparao Village (Site 2-1311) are detailed in Tables 15 and 16. Test Unit 1 (Table 15) yielded a slightly greater total weight of shell from an excavated volume much larger than Test Unit 2 (Table 16). Together, these two units contained the greatest relative amount of unidentifiable shell recovered from the three sites tested; 33 percent of the shell by weight could not be identified.

Test Unit 1 at the Tuparao Village site contained roughly equal amounts of gastropods and bivalves. However, 49 percent of the gastropods were either non-food land snails (*Pythia scarabaeus* and *Achatina fulica*) or unidentified fragments. After accounting for the land snails and unidentified fragments, *Strombus gibberulus* was the next most commonly occurring gastropod (12.8 percent), followed by *Cypraea spp.* (9.9 percent). Although shell from these provenience levels were not all analyzed by MNI counts, 5 crab-crushed and 3 hermited *Strombus gibberulus* shells were noted.

It is possible that the relative abundance of cowrie shells in Test Unit 1 is also related to natural process. This is because the thick basal portions of the shells both preserve well and are easily identified even when broken. Also, since hermit crabs are not known to inhabit cowries, it would be highly unusual for a large crab which normally preys on hermits (and live gastropods) to attack and damage the dead, empty shells, breaking them into smaller and eventually unidentifiable pieces. That is, if a natural predator (or human) attacks a cowrie shell, it is likely to be broken only once; while old, dead gastropod shells may host numerous hermit crabs and be broken again and again by predators. In sum, not only does the cowrie shape favor preservation and identification, but the shells do not succumb to the common destructive processes that other gastropod shells are subjected to. Much or all of the cowrie shell fragments from this test unit may simply represent natural beach debris.

Of the bivalve remains recovered from Test Unit 1, only about 20 percent of the fragments could not be identified. No drilled valves or other obviously natural shells were noted during the analysis, but many shells were quite small and may have been natural debris. After unidentified shells, the two most common taxa recovered were *Tridacna spp.* (20.5 percent) and *Anadara antiquata* (19.7 percent), both fairly heavy varieties of shell. If the categories *Gafrarium pectinatum* and *Gafrarium spp.* are added together, they would comprise the fourth most common taxon present (15.3 percent). The latter category, *Gafrarium spp.* is probably mostly *G. tumidum*, but may in addition contain one or more other species.

The second assemblage of shell from Tuparao Village derives from the darkly colored surface midden which was sampled by Test Unit 2 (Table 16). A significantly greater weight of gastropod shells (58 percent) was recovered. However, a little more than half (50.5 percent; 560.7 grams) of the shells and fragments were either non-food land snails (*Pythia scarabaeus*) or unidentifiable. The most common foodshell taxon by weight was *Strombus gibberulus*, but as much as half of these shells appeared to be natural. Although no MNI counts are available for comparison, the 84.8 grams of *S. gibberulus* from Test Unit 2 contained 6 hermited shells and 32 crab-crushed shells.

Third and final subassemblage of shell derives from the two controlled test units excavated inside the bunker/cave complex below Camp Bright (Site 2-1301). A total of only 990.7 grams of shell was recovered from this site, 58 percent of which

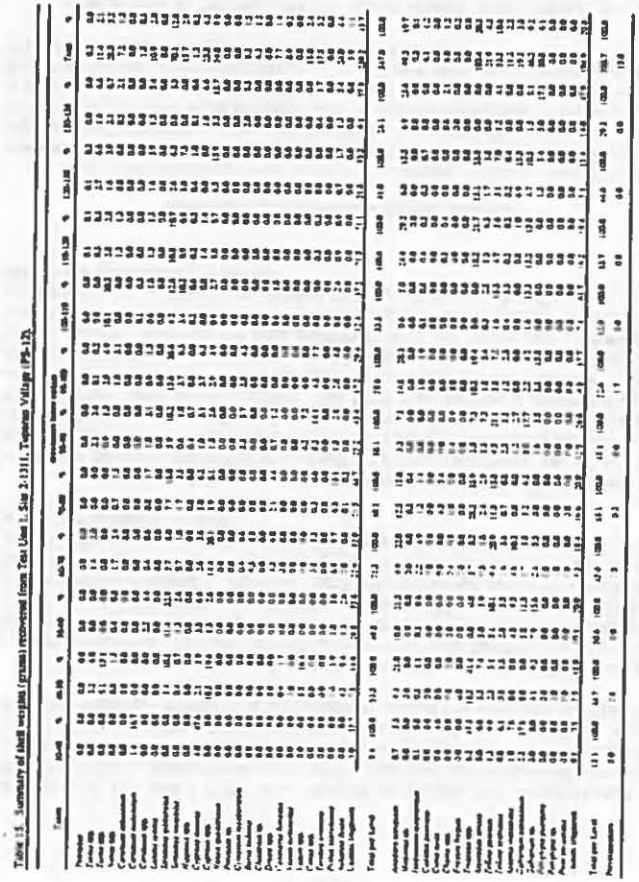


Table 16. Summary of shell weights (grams) recovered from Test Unit 2, Site 2-1311, Tuparao Village (PS-12).

Taxon	centimeters below surface 0-10	%	10-20	%	20-30	%	30-40	%	Total	%
Patellidae	0.0	0.0	0.5	0.3	1.0	0.9	0.1	0.5	1.6	0.3
Tectus spp.	0.3	0.1	0.2	0.1	1.5	1.4	0.0	0.0	2.0	0.4
Turbo spp.	9.8	4.1	0.0	0.0	0.2	0.2	0.0	0.0	10.0	1.8
Nerita spp.	1.6	0.7	0.3	0.2	0.9	0.8	0.0	0.0	2.8	0.5
Cerithium echinatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cerithium nodulosum	22.1	9.2	5.8	3.1	0.0	0.0	0.0	0.0	27.9	5.0
Cerithium spp.	2.1	0.9	3.9	2.1	3.9	3.5	1.6	8.3	11.5	2.1
Lambis lambis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus gibberulus	37.5	15.6	29.3	15.4	17.6	15.9	0.4	2.1	84.8	15.1
Strombus mutabilis	6.0	2.5	5.3	2.8	3.6	3.2	1.1	5.7	16.0	2.9
Hippopus spp.	0.2	0.1	0.3	0.2	0.2	0.2	0.2	1.0	0.9	0.2
Cypraea moneta	6.6	2.7	5.0	2.6	4.3	3.9	0.0	0.0	15.9	2.8
Cypraea spp.	9.1	3.8	12.8	6.7	8.4	7.6	3.8	19.7	34.1	6.1
Natica gualteriana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polinices sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium nicobaricum	0.0	0.0	3.3	1.7	1.3	1.2	0.0	0.0	4.6	0.8
Bursa bufonia	0.0	0.0	10.7	5.6	0.0	0.0	4.7	24.4	15.4	2.7
Chicoreus sp.	0.0	0.0	3.9	2.1	0.0	0.0	0.0	0.0	3.9	0.7
Drupa spp.	0.0	0.0	5.2	2.7	0.0	0.0	3.3	17.1	8.5	1.5
Conchorus fumosus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vasum turbinellus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vasum spp.	4.7	2.0	2.8	1.5	3.3	3.0	0.0	0.0	10.8	1.9
Conus spp.	13.7	5.7	8.3	4.4	0.0	0.0	0.0	0.0	22.0	3.9
Terebra areolata	0.0	0.0	0.0	0.0	4.7	4.2	0.0	0.0	4.7	0.8
Pythia scarabaeus	6.1	2.5	7.5	3.9	12.4	11.2	0.9	4.7	26.9	4.8
Achatina fulica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unident. fragments	120.6	50.2	84.9	44.7	47.7	43.0	3.2	16.6	256.4	45.7
Total per Level	240.4	100.0	190.0	100.0	111.0	100.0	19.3	100.0	560.7	100.0
Anadara antiquata	28.9	17.1	33.2	21.0	22.5	30.0	0.0	0.0	84.6	20.6
Modiolus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isognomon isognomum	0.0	0.0	1.0	0.6	0.0	0.0	0.0	0.0	1.0	0.2
Codakia punctata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ctena bella	0.1	0.1	1.0	0.6	0.2	0.3	0.0	0.0	1.3	0.3
Chama spp.	2.0	1.2	2.0	1.3	0.0	0.0	0.0	0.0	4.0	1.0
Fragum fragum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tridacna spp.	30.8	18.2	23.1	14.6	0.9	1.2	0.0	0.0	54.8	13.4
Atactodea striata	1.1	0.7	2.9	1.8	2.1	2.8	0.0	0.0	6.1	1.5
Tellina palatam	24.9	14.7	24.2	15.3	11.7	15.6	1.3	16.7	62.1	15.1
Tellina scobinata	3.3	2.0	1.9	0.6	11.7	15.6	0.0	0.0	16.0	3.9
Asaphis violascens	0.0	0.0	4.4	2.8	1.2	1.6	0.0	0.0	5.6	1.4
Gafrarium pectinatum	36.9	21.8	14.8	9.4	12.5	16.6	3.8	48.7	68.0	16.6
Gafrarium sp.	12.0	7.1	25.3	16.0	1.4	1.9	0.0	0.0	38.7	9.4
Periglypta puerpera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Periglypta sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pitar pellucidus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unident. fragments	29.1	17.2	25.2	15.9	10.9	14.5	2.7	34.6	67.9	16.6
Total per Level	169.1	100.0	158.1	100.0	75.1	100.0	7.8	100.0	410.1	100.0
Polyplacophora	0.7		0.0		0.0		0.0		1.4	

derived from Test Unit 1 (Table 17). Although the greatest total weight of shell was from Test Unit 1, almost three-fourths of the gastropod shells recovered were either land snails (43.4 percent) or unidentified fragments (28.1 percent). And although Test Unit 2 yielded a greater amount of bivalve remains, half of the gastropod remains were land snails (32.9 percent) or unidentified fragments (18.1 percent; see Table 18).

After accounting for non-food land snails and unidentified shells, the most common component of the shell assemblage recovered from Test Unit 1 at Site 2-1301 is *Cerithium spp.* (4.9 percent). Among the bivalves, after the unidentified fragments, the two most common taxa are *Anadara antiquata* (23.3 percent) and *Gafrarium pectinatum* (14.9 percent). However, these percentages are based on unimpressive total shell weights (23.3 grams and 14.9 grams) and the relative ranks within the shell assemblage are not necessarily indicative of human process even though both species are known foodshell varieties.

Test Unit 2 yielded an assemblage of gastropod shell that is 32.9 percent land snail (17.7 percent *Achatina fulica*; 15.2 percent *Pythia scarabaeus*), and 18.1 percent unidentified fragments. By weight, these are the top three categories of shell in this assemblage; the next most common gastropod taxa is *Cerithium spp.* (14.2 percent of the collection, based on 14.5 grams). The bivalve assemblage is dominated by the dense, heavy *Tridacna spp.* (56.0 percent); the next most common taxon is *Anadara antiquata* (10.0 percent, 30.8 grams) which barely outweighs the unidentified shells in the assemblage. Although the total assemblage from this unit is only slightly more than 400 grams and conclusions must be considered tentative, the shell weight data are not indicative of a rich cultural midden, but instead suggest that the dense, heavy shells were differentially preserved.

Summary and Discussion of Midden Analysis

The shell assemblage was analyzed by weight, although several selected provenience levels were also examined using MNI methodologies (which included the separation of bivalves into right and left valves). By weight, the most common taxon in the entire collection is the pectinate Venus *Gafrarium pectinatum*. This small clam is normally found in shallow water buried in sand, although it may also adapt to silty areas near the mangrove fringe; average size is 3 to 4 centimeters (Abbott and Dance 1986; Amesbury et al. 1986; Stojkovich and Smith 1978).

Also present in the collection are *Tellina palatam* (palate tellin), *Atactodea striata* (the striate beach clam), *Ctena bella* (the bella lucina), and *Anadara antiquata* (antique ark). The small striate beach clam (no larger than 2.5 cm) lives in sandy intertidal beaches. It is a favored, known food source in other Micronesian island groups (Carucci 1992a), and it certainly appears to have been intentionally collected on prehistoric Guam. The small lucina clam and palate tellin are also common foodshells in archaeological deposits in the Mariana Islands. These two species tend to favor clean sand on reef flats and lagoon floors. Both are still harvested and eaten by the inhabitants of Guam (Amesbury et al. 1986).

Table 17. Summary of shell weights (grams) recovered from Test Unit 1, Site 2-1301, Japanese bunker/cave below Camp Bright (TN-12).

Taxon	0-10	%	10-20	%	20-30	%	30-40	%	40-47	%	47-60	%	60-80	%	Total	%
Patellidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.1	0.0
Terebra spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	6.4	0.0	0.0	2.2	0.7
Turbo spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nerita spp.	0.0	0.0	1.0	2.2	0.1	1.0	0.0	0.0	0.0	0.0	1.7	5.0	0.1	0.6	10.9	3.4
Cymatium echinatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium nodolosum	0.0	0.0	0.0	0.0	1.0	4.0	3.7	8.4	0.0	0.0	0.0	0.0	0.0	0.0	11.7	3.6
Cymatium spp.	1.1	6.2	0.5	1.3	3.2	1.9	3.0	10.1	0.1	17.6	0.9	2.6	1.2	7.2	15.0	4.6
Lambis lambis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus gibberulus	1.2	10.0	1.0	4.1	1.2	0.7	1.7	3.8	0.0	0.0	1.5	4.4	1.0	6.0	14.3	3.2
Strombus mutabilis	0.4	2.2	1.2	4.6	3.7	2.3	2.1	6.8	0.0	0.0	2.3	6.7	1.1	15.6	13.4	4.1
Hippopus spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1
Cypraea annulus	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	1.3	3.8	0.0	0.0	2.1	0.6
Cypraea spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nerita guaherensis	1.0	5.6	1.4	3.2	3.3	2.0	4.4	14.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	3.7
Pyknaret sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium nicobaricum	0.0	0.0	0.0	0.0	1.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.5
Bursa bubonia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charonia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drupa spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.3
Conchorhinus lamarcki	0.0	0.0	0.0	0.0	0.7	0.4	0.0	0.0	0.0	0.0	1.6	4.7	0.0	0.0	2.3	0.7
Vexum semisulcatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Latirus spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conus spp.	0.0	0.0	0.0	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2
Terebra areolata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrene semiverbana	1.2	6.8	1.1	3.0	1.9	0.7	1.0	3.4	0.1	13.0	1.1	10.2	1.0	10.0	19.0	5.0
Sulcanna fulva	2.2	14.1	20.7	79.2	76.2	42.2	4.0	19.9	0.0	0.0	1.6	4.7	0.0	0.0	133.0	37.3
Unident. fragments	1.0	7.2	2.4	8.1	44.2	20.4	10.2	32.0	1.1	67.4	14.0	40.4	6.4	76.2	91.2	28.1
Total per Level	17.7	100.0	29.2	100.0	107.6	100.0	44.2	100.0	4.6	100.0	34.3	100.0	16.7	100.0	354.6	100.0
Anadara antiquata	3.6	17.6	1.1	5.3	36.1	48.1	15.1	37.1	0.0	0.0	16.0	22.0	2.1	4.6	99.3	22.3
Modiolus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isognomon isognomum	0.3	1.2	0.0	0.0	0.0	0.0	0.3	0.8	0.0	0.0	0.0	1.1	1.5	2.9	3.8	1.2
Codakia punctata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circe hetu	2.0	13.7	1.2	3.6	2.3	6.8	1.9	5.1	0.2	1.2	1.0	3.4	1.2	2.3	13.7	3.4
Chama spp.	0.3	2.4	0.0	0.0	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.4
Fragum fragum	0.0	0.0	2.2	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.3	3.0	1.2
Tridacna spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	7.7	0.0	0.0	0.3	16.0	18.2	4.0
Austrodon striata	1.4	9.5	1.1	7.2	1.2	3.1	1.2	3.9	0.1	46.9	0.4	6.3	2.2	9.4	22.0	9.6
Tellina palatam	0.3	1.2	0.7	3.6	0.2	0.5	1.0	0.1	0.0	0.0	0.3	11.9	0.0	16.0	31.3	8.4
Tellina scabrosa	0.2	1.0	0.0	0.0	1.1	2.9	0.2	1.4	0.4	4.6	1.7	5.3	0.7	1.3	6.6	2.7
Asaphis violascens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	3.0	2.1	3.5	4.2	1.6
Gafrarium pectinatum	2.7	17.2	2.3	16.9	4.2	11.0	4.4	11.9	2.3	30.0	12.3	19.0	7.1	12.9	37.0	14.9
Gafrarium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Periglypta puerpera	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Periglypta sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinctada margaritifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unident. fragments	4.7	32.4	10.2	30.7	3.7	7.0	14.0	30.2	2.1	15.2	17.0	27.1	13.0	30.2	73.1	28.2
Total per Level	28.2	100.0	25.7	100.0	38.2	100.0	37.0	100.0	13.0	100.0	70.0	100.0	33.1	100.0	254.6	100.0
Percentages	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	

Table 18. Summary of shell weights (grams) recovered from Test Unit 2, Site 2-1301, Japanese bunker/cave below Camp Bright (TN-12).

Taxon	0-10	%	10-20	%	20-30	%	30-40	%	40-50	%	50-60	%	Total	%
Patellidae	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Terebra spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbo spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nerita spp.	1.6	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.0	1.8	1.8
Cymatium echinatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium nodolosum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	15.7	0.0	0.0	2.1	2.1
Cymatium spp.	4.4	13.0	4.5	13.5	0.3	6.3	2.0	23.9	0.2	1.6	2.0	25.2	14.1	14.2
Lambis lambis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strombus gibberulus	5.4	15.4	2.1	6.1	0.2	16.7	0.0	0.0	2.0	13.6	0.0	0.0	10.1	10.1
Strombus mutabilis	2.1	7.1	4.7	13.0	0.2	10.4	0.9	8.1	1.6	12.3	1.7	17.2	11.1	11.0
Hippopus spp.	0.1	1.7	0.0	0.0	0.0	0.0	0.1	0.9	0.1	0.8	0.1	1.0	0.0	0.0
Cypraea annulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	4.3	0.0	0.0	0.6	0.6
Cypraea spp.	0.0	0.0	1.7	4.9	0.0	0.0	0.0	0.0	0.0	0.0	3.0	30.3	4.7	4.6
Nerita guaherensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyknaret sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatium nicobaricum	0.0	0.0	1.3	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.3
Bursa bubonia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charonia sp.	0.0	0.0	1.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Drupa spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Conchorhinus lamarcki	0.4	1.4	0.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8
Vexum semisulcatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Latirus spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conus spp.	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terebra areolata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrene semiverbana	1.9	9.9	1.3	17.0	1.3	11.1	1.1	10.6	0.3	2.3	1.7	17.2	13.6	13.2
Sulcanna fulva	8.1	27.6	0.3	2.2	2.0	29.8	0.2	4.6	0.0	0.0	0.0	0.0	18.1	17.7
Unident. fragments	3.0	13.3	4.4	12.7	0.7	14.6	1.3	13.9	7.2	56.3	0.6	6.1	18.3	18.1
Total per Level	29.4	100.0	34.7	100.0	4.8	100.0	10.8	100.0	12.8	100.0	9.9	100.0	102.6	100.0
Anadara antiquata	13.4	44.2	10.3	33.9	3.8	22.4	0.9	8.8	1.3	4.8	0.8	8.0	30.8	30.0
Modiolus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isognomon isognomum	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
Codakia punctata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circe hetu	1.4	3.8	3.3	11.5	0.3	3.1	1.2	0.6	1.2	4.4	0.3	3.3	6.3	3.9
Chama spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragum fragum	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.6	0.0	0.0	0.0	0.0	1.3	0.3
Tridacna spp.	0.0	0.0	0.0	0.0	0.0	0.0	17.3	91.9	0.0	0.0	0.0	0.0	17.3	3.6
Austrodon striata	0.8	3.3	1.3	4.9	1.8	11.2	2.7	1.4	1.8	6.6	0.6	2.6	9.2	3.0
Tellina palatam	0.1	0.4	7.7	23.3	0.4	2.3	1.1	0.6	0.5	3.0	4.6	20.3	14.7	4.8
Tellina scabrosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	8.9	0.2	0.9	2.6	0.8
Asaphis violascens	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.4	0.1
Gafrarium pectinatum	3.8	13.6	3.2	10.5	1.1	6.8	4.4	2.4	3.4	19.9	0.6	3.3	20.1	6.6
Gafrarium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Periglypta puerpera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Periglypta sp.	0.0	0.0	0.0	0.0	4.1	27.9	0.0	0.0	1.7	13.7	0.7	3.1	10.5	3.4
Pinctada margaritifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.4	0.0	0.0	1.2	0.4
Unident. fragments	2.4	9.9	4.2	13.8	2.6	16.1	1.3	1.9	0.2	1.3	0.8	3.4	7.8	2.6
Total per Level	24.3	100.0	30.4	100.0	14.1	100.0	188.3	100.0	27.1	100.0	22.7	100.0	309.1	100.0
Percentages	0.0		0.0		0.0		0.0		0.0		0.0		0.0	

The presence of *Anadara antiquata* and *Gafrarium pectinatum* in the refuse midden contained in the rockshelter strongly suggest that the prehistoric inhabitants of the area foraged in the mangroves of Apra Harbor. Both of these species, as well as *G. tumidum* (which may be present in the rockshelter midden), are known mangrove associates (Morton 1983). Marine biological surveys of the mangrove communities of Apra Harbor conducted in the 1970s have encountered both *Gafrarium* species in the muddy bottom along the mangrove fringe (Stojkovich and Smith 1978).

The same study which provided information about molluscan species extant in Apra Harbor also included a survey of a portion of Agat Bay (Stojkovich and Smith 1978). The survey was conducted in central Agat Bay, in an environment similar to Dadi Beach: a shallow, sand-covered reef flat with scattered, small coral patch reefs. It can be assumed that the molluscs in these two areas would be the same. Six shell taxa accounting for 9.3 percent of the rockshelter shell assemblage were identified in the sandy habitats of Agat Bay, but were not found in the survey of the Apra Harbor mangroves. The six taxa include: *Modiolus*, *Codakia punctata*, *Ctena bella*, *Fragum fragum*, *Tellina palatam*, and *T. scobinata*. Also present in Agat Bay was *Gafrarium pectinatum*, suggesting that this animal might have been collected from both Agat Bay and Apra Harbor. The habitat preferences of the molluscs indicate that 2 or 3 percent of the assemblage was probably collected in the mangroves, while at least 9 percent came from the reef flats of Agat Bay. Although the 30 kilos of *Gafrarium pectinatum* cannot be assigned entirely to one habitat, it appears that substantially more molluscs were foraged from the reef flats than the mangroves during prehistoric times.

Several important points must also be made concerning the faunal bone data discussed above. First, it is important to note that differential preservation has played a large role in which species of fish and how many pieces of bone were recovered from the rockshelter. Some provenience levels contained few fragments of fishbone while other levels contained scores of fragments, vertebrae, and hundreds of fish scales. In the latter situation, preservation is close to perfect; in the former, it is clear that the few bones recovered tended to be the more dense, compact mouth bones. Thus, species having easily recognizable, durable bones and mouth parts are probably found in higher numbers in the collection due to preservation, not because of specific hunting, butchering, and cooking practices. It is unclear if the faunal assemblage is large enough to examine this pattern further.

Second, it is important to note that 548 of the 1248 faunal items tabulated are single fish scales. It is unlikely that they came from 548 separate fish. On the other hand, each of the osseous elements attributed to named fish families may represent separate fishes. When two or more elements are listed in the same taxon in the same test unit, these may still represent more than one animal. This is especially true if the fragments are separated by a vertical distance of two or three levels.

An important third point concerning the rockshelter is that very little evidence of mixture was found in the faunal assemblage. Few rat and toad remains were recovered from the four test units, and those that were originated at relatively shallow levels. In general, the shell assemblage also has few indications of postdepositional mixture. In sum, the rockshelter sediments evaluated by Test Units 3 and 4 are well preserved, virtually undisturbed cultural deposits.

By contrast, the faunal materials recovered from the sandy sediments of the bunker and cave below Camp Bright are not exclusively cultural in origin. Some of the bone and much of the shell appears to be natural. In addition, no intact prehistoric deposits or living surfaces were encountered in the cave.

The faunal collection from the Tuparao Village site has characteristics of both the other sites. This smallest of the three faunal bone assemblages has several pieces of identifiable fishbone, but the materials derived from a tumbled, disturbed matrix of clay soil, fill, and darkly stained natural beach sands. The upper stratigraphic layers of the site appear to be disturbed and mixed, possibly by heavy machinery or other vehicular traffic. The lower levels exhibit some evidence of storm events and natural churning. Shell materials from this site are clearly not all cultural in origin. Metal fragments and shards of glass are mixed together with prehistoric sherds and pieces of shell throughout the excavated column of Test Unit 1. Between 60 and 80 centimeters below surface, a significant number of probable human bone fragments was found. Although these were not recognized as human in the field, it is now clear that either historic World War II interments or prehistoric burials may be present.

Analysis of Formal Artifacts

A total of 11 formal artifacts was recovered from the controlled excavations and surface context. The rockshelter yielded six formal artifacts, the sinkhole caverns (Site 3-1304) three, and the Tuparao Village area two. The most interesting and perhaps previously unreported behavior indicated by this small assemblage involves the probable use of the two large mauls. These basalt artifacts were apparently used as hammers to harvest stalactites from the sinkhole caverns. Broken stalactites were noted in the vicinity of both mauls. A fine, white calcareous powder was also found in the battered pock marks of the mauls. It is likely that the basalt mauls were left in the caves by people who had been harvesting calcium carbonate.

The following short discussions describe each of the formal artifacts. Descriptions and provenience are summarized in Table 19.

Ground Basalt Tool

This item was a surface find, located 4 meters west and 1.5 meters south of the datum at the rockshelter, Site 2-1302. The tool is adze-like in shape, and may be a ground stone adze. Its maximum dimensions are length: 82.7 mm; width: 64.3 mm; thickness 24.0 mm. The tool weighs 223.6 grams and is made out of a moderately fine grained basalt. One end (the butt or poll) is rounded, and the other end has been broken off. The central areas of the flat front and back surfaces are ground.

Sea Urchin Spine Abrader

This brownish red slate pencil urchin spine (probably *Heterocentrotus mammillatus*) was found between 40 and 50 centimeters below surface in Test Unit 3 at the rockshelter. The artifact has one bevelled abraded surface at the distal end which is about 14 mm in length. The abrader surface intersects the single ridge that runs down the length of the otherwise circular spine. Maximum dimensions are length: 46.9 mm; width/diameter: 7.2 mm; thickness 8.0 mm. The abrader weighs 1.9 grams.

Table 19. Summary of formal artifacts recovered from controlled excavations and surface context.

Site Number Site Name	Artifact	Provenience
2-1302 Prehistoric Rockshelter	Ground basalt tool	Surface, 4 m west, 1.5 m south of datum
	Sea urchin spine abrader	TU 3, 40-50 cmbs
	Coral hammerstone	TU 3, 50-60 cmbs
	Pearl shell fishhook fragment	TU 4, 20-30 cmbs
	Abrader, branch coral	TU 4, 30-40 cmbs
	Tridacna adze fragment	TU 4, at 41 cmbs
3-1304 Sinkhole Caverns	Basalt maul	On floor of alcove in upper limestone cave
	Large, fragmented basalt maul	On floor of deep, inner chamber of lower cave
	Circular fragment or spall of basalt (maul ?)	Found next to large maul in lower cave
2-1311 Tuparao Village	Slingstone; ground silt stone or mud stone	Surface, at south end of Tipalao Bay, inland of beach rock
	Small fragment of worked pearl shell	TU 1, 80-90 cmbs

Coral Hammerstone

This dense, fist sized coral cobble was recovered from Test Unit 3 at the rockshelter, from between 50 and 60 centimeters below surface. The hammerstone is shaped like a cowrie shell, with a humped top opposite a flat surface, and two pointed ends. The pointed ends and central portion of the humped top show evidence of use, abrasion, and pecking or chipping. Maximum dimensions are length: 116.4 mm; width: 75.0 mm; thickness 53.2 mm. The artifact weighs 577.0 grams.

Pearl Shell Fishhook Fragment

This small shell fragment appears to be part of a fishhook, probably made out of *Isognomon*. The worked shell was found in Test Unit 4 at the rockshelter, between 20 and 30 centimeters below surface. Its maximum dimensions are length: 31.2 mm; width: 6.0 mm; thickness: 2.6 mm. The fragment weighs 0.5 grams.

Abrader, Branch Coral

This artifact is an abrader, made of a fragment of elkhorn or staghorn coral; about 20 mm of the slightly narrower distal end exhibits utilization. The tool was found between 30 and 40 cmbs in Test Unit 4 at the rockshelter. It is 80.5 mm long, has a maximum diameter of 12.5 mm, and weighs 15.9 grams.

Tridacna Adze Fragment

The sixth formal artifact recovered from the rockshelter is an adze fragment from 41 cmbs in Test Unit 4. The poll end of the partly ground *Tridacna* fragment is complete, but the cutting edge is broken (Photo 5). Maximum dimensions are length: 82.7 mm; width: 47.0 mm; thickness: 14.2 mm. The adze weighs 73.7 grams.

Basalt Maul

This artifact is a massive, slightly conical dark gray basalt hand hammer or maul (Photo 6). It was found on the floor of a small alcove in the upper cave in the subsidence shaft (the western locus) of Site 3-1304. The maul is 124.1 mm tall and has a maximum width of 86.0 mm. The small, nearly flat upper facet is about 65 mm by 52 mm; the broad bottom facet is 85 mm by 83 mm. Around the lower edge where the angled sides meet the bottom, small chips of rock are missing. Portions of the broad bottom surface appear ground as if from use (food or fiber pounder ?). The small upper facet has evidence of battering; a fine, white calcareous powder remains in several places on the battered ends of the maul. The artifact weighs 1,505.5 grams.

Large, Fragmented Basalt Maul

This larger, broken maul was found on the floor of the small inner chamber below the entrance of the lower cave in the subsidence shaft, Site 3-1304. It is made of a dark gray-green basalt and has a rough surface which appears pecked in places (Photo 7). The maul is 207.0 mm tall and has a maximum diameter of 92.0 mm. The oval, nearly intact top measures 70 mm by 48 mm. Several large pieces are missing from the lower portion of the maul, leaving a broken, faceted surface. A light brown calcareous residue adheres to the end of the maul. The artifact weighs 2,195.6 grams.

Circular Fragment or Spall of Basalt

This small piece of basalt was found in the inner chamber of the lower cave, 45 centimeters away from the large, fragmented basalt maul (Site 3-1304). It is

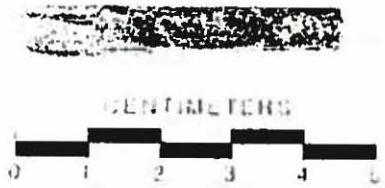


Photo 4. Pencil urchin abrader recovered from 40 to 50 centimeters below surface in TU 3 at the rockshelter, Site 2-1302 (TN-13).

Photo 5. A *Tridacna* adze fragment recovered from 41 centimeters below surface in TU 4 at the rockshelter, Site 2-1302 (TN-13). The bit end is missing, the poll end is complete.

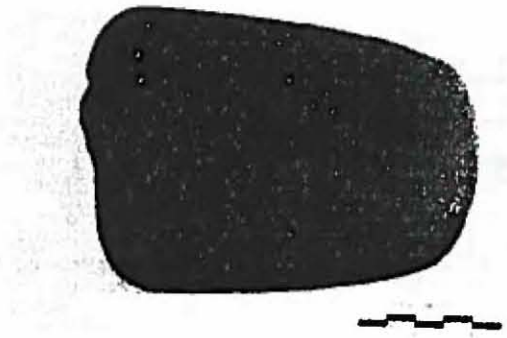


Photo 6. Basalt maul or hammer recovered from the upper cave in the subsidence shaft, western locus, Site 2-1304 (PS-1).

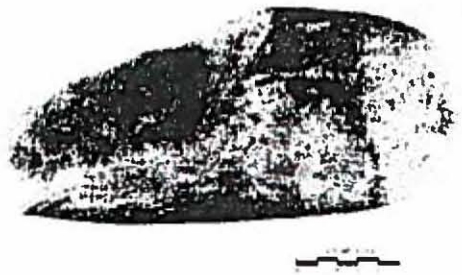


Photo 7. Large, fragmented basalt maul recovered from the inner chamber of the lower cave of the subsidence shaft, western locus of Site 3-1304 (PS-1).

assumed that this spall was flaked off of a larger artifact (another maul); however, it is not demonstrably part of the large maul found nearby. The spall is a circular, wafer-like piece of gray-green basalt. It has a very rough surface and measures 81 mm in diameter and is 34 mm thick. The fragment weighs 232.2 grams.

Slingstone

This artifact was found at the south end of Tipalao Bay, on an intertidal part of the sandy beach inland from the beachrock and coral rubble. Provenience of the artifact has been assigned to Tuparao Village, Site 2-1311. The slingstone is apparently made out of silt stone or mud stone and has been ground into shape. The artifact may have two or three very faint concentric lines incised on its surface. The slingstone is 56.7 mm long, and has a diameter of 34.2 mm. It weighs 63.5 grams.

Fragment of Worked Pearl Shell

This artifact is a small fragment of worked pearl shell recovered from the 80 to 90 cmbs level of Test Unit 1 at Tuparao Village. The piece is roughly circular and appears to be shaped; it may be a portion of a fishhook. The artifact measures 19.1 mm long and is 3.1 mm in diameter. It weighs 0.4 grams.

Analysis of Historic Materials

The historic materials recovered from the controlled test excavations consist mainly of metal fragments and glass. These materials are essentially modern trash; no historic diagnostics of any kind were found during the project. The greatest amounts of intrusive modern trash were recovered from the Tuparao Village area (Site 2-1311) and the bunker/cave complex below Camp Bright (Site 2-1301). Some historic trash was also recovered from the rockshelter (Site 2-1302), but in relatively small amounts.

Table 20 summarizes the historic materials recovered from Test Unit 1 at the Tuparao Village site area. More than half of the material originated in the deepest two levels, which also yielded 7.9 grams of small metal (brass ?) grommets. These items may have come from shoes or military boots.

The sediments excavated from Test Unit 2 contained such a small amount of historic trash that a table is not necessary to list the weights. In the first excavation level, 24.3 grams of shrapnel and 1.9 grams of glass were recovered. The second level yielded a nail weighing 0.8 grams. That is all.

Table 21 summarizes the historic materials recovered from Test Units 1 and 2 at the bunker/cave complex below Camp Bright. Metal items, especially nails and can fragments, are common. Also present in relative abundance are fragments of clay pigeons (shooting targets) and brass rifle shell casings. Other interesting artifacts and materials include linoleum (which was often mistaken for thin prehistoric ceramics during excavation), pieces of what appeared to be metal ammo belt clips, leads for a mechanical or drafting pencil, and fragments of coal, tar, or tarpaper. In Test Unit 1 especially, the historic trash appears to be evenly distributed throughout the excavation levels. In general, the prehistoric sherds and shell materials were also rather evenly strewn throughout the unit, indicating that the deposits had been mixed.

Table 20. Summary of historic trash weights (grams) recovered from Test Unit 1, Site 2-1311, Tuparao Village (PS-12).

	centimeters below surface												
	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-134	TOTAL
Misc Metal		3.8	17.3	18.1	4.3	10.6	8.4	7.6	12.4	390.8	83.2	458.5
Strap Metal	31.9									18.3		70.2
Nails		4.7			3.4		8.8			14.4	3.7	39.0
Foil			0.1									0.1
Grommets										3.2	4.7	7.9
Glass	11.5	10.7	24.2	3.9	2.1	3.2	5.1		0.1	3.3	42.4	106.5
Mica										0.3		0.3
Ceramic		10.6										10.6
Clinx					0.3							0.3
Plastic	0.4						0.1					0.5
Rubber		1.1										1.1
Total per Level	43.8	30.9	41.6	22.0	12.3	13.8	22.4	7.6	12.5	332.3	136.0	695.2

Table 21. Summary of historic trash weights (grams) recovered from Test Units 1 and 2, Site 2-1301, Japanese bunker/cave below Camp Bright (TN-12).

	TU1 — centimeters below surface								
	0-10	10-20	20-30	30-40	34-37	40-47	47-60	60-80	TOTAL
Misc Metal	1.3		1.6	4.8		6.6	18.7	4.9	37.9
Rusty Can	23.1	8.0							31.1
Wire							20.2		20.2
Shrapnel		10.8							10.8
Nails				33.4		20.1	22.6	8.1	84.2
Rifle Shell			13.8	26.8		26.5	15.7		82.8
Ammo Belt						13.6			13.6
Foil		0.2					0.1		0.3
Glass	3.0	0.1	19.0	8.4		4.9	7.4		42.8
Lightbulb					10.0				10.0
China		2.7							2.7
Clay Pigeon	1.3		1.9	36.4	4.2	3.7	0.1		47.6
Pencil Lead	0.4								0.4
Plastic		0.1				0.2			0.3
Button	0.5			0.1					0.6
Rubber	0.2	5.8							6.0
Linoleum		2.7							2.7
Coal/Tar	0.6	8.1		0.9					9.6
Total per Level	30.4	38.5	36.3	110.8	14.2	75.6	84.8	13.0	403.6

	TU2 — centimeters below surface					
	0-10	10-20	20-30	30-40	40-50	TOTAL
Misc Metal					0.1	0.1
Wire			3.3			3.3
Foil		0.1				0.1
Glass	0.2	4.1				4.3
Clay Pigeon	0.8	18.1	30.8			49.7
Pencil Lead	0.4				0.5	0.9
Plastic	0.1					0.1
Rubber		1.5				1.5
Linoleum		0.2	0.9			1.1
Unident Glass and Metal Artifact				3.3		3.3
Total per Level	1.5	24.0	37.0	3.3	0.6	66.4

Finally, very little historic trash was encountered in the four test excavations at the rockshelter. Test Unit 1 had a large piece of shrapnel near the surface, and smaller pieces of metal down to a depth of 40 centimeters. Glass fragments (10 grams or less) were encountered down to 50 centimeters. The unit thought to be disturbed, Test Unit 2, contained small fragments of metal (which altogether totalled 34.2 grams) down to 90 centimeters below surface. Test Unit 3 contained the remains of one or two small glass bottles with plastic caps and dried yellow paint or polish. These were recovered from levels 2 and 3 (between 10 and 30 centimeters below surface). Unit 4 had 2 small metal fragments weighing a total of 4.4 grams. One each was recovered from level 1 and level 2. Together these data suggest that the cultural deposits in the rockshelter suffered relatively little postdepositional disturbance, with the exception of Test Unit 2.

Radiocarbon Dating Results

Fifteen samples from controlled excavations and 5 samples from the Tipalao Marsh core (Site 3-1327) were submitted to Beta Analytic for radiocarbon dating. All pertinent data are summarized in Table 22, including sample numbers, provenience, adjusted ages, and calibrated ages. All dated samples were corrected for isotopic fractionation (C13/C12). Of the excavated samples, 13 were charcoal, one was unburned or partly burned coconut shell, and one was comprised of shell fragments. One of the excavated charcoal samples (Beta # 58437) was not dated because too little carbon remained after pre-processing. Also, the coconut sample (Beta # 58436) from the lower limestone cave (Site 3-1304) dated as modern; and the charcoal sample from Test Unit 1 in the Japanese bunker was contaminated (probably by tar or some other petrochemical), yielding a date of 9000 B.C. This leaves 12 radiocarbon dates from excavated contexts to be discussed (11 charcoal samples and one marine shell sample).

The calibrated dates listed in Table 22 are presented graphically in Figure 18; both table and figure present the data in the same order. From the top, first are the two dates from the Japanese Bunker below Camp Bright (the 9000 B.C. date from the contaminated sample is not included in Fig. 18). Next, the dates from the rockshelter Test Units 1 through 4 follow in order, with multiple dates within the test units arranged by increasing depth. Finally, the single shell date from the Tuparao Village site area is given.

The calibrated age ranges listed in Table 22 and presented in Figure 18 are derived from the Stuiver and Reimer (1993) computer program. The program calculates probability distributions which represent the likelihood that the date in question will occur in the age range indicated. A three part scheme is used to graphically distinguish between date ranges of 0 to 10 percent probability, 11 to 50 percent, and 51 to 100 percent probabilities. Figure 18 does not discount any age ranges based on the probability distribution; all of the calibrated ranges for each date are reported in the figure. Note that only four dates (Beta numbers 57030, 57031, 57032, 57033) have outlying date ranges with small probabilities. Compare these dates to Figure 19 which reports the radiocarbon age ranges in a standard 1 and 2 sigma format. The slightly skewed ranges of the four dates is more apparent.

Table 22. Radiocarbon dates from Guam Navy EIS Project.

Catalog #	Beta #	Provenience	Weight / Material	Age B.P.	DC/12C	Adjusted Age B.P.	Calibrated Age Ranges[1]	Probability	Intercepts
110	58439	2-1301 (TN-12), TU-1, 30-40 cm b.s.	6.2 g charcoal	9700 ± 100	-26.0	9690 ± 100	9050-8520 B.C.	100%	9000 B.C.
108	58440[2]	2-1301 (TN-12), TU 2, 30-40 cm b.s.	3.9 g charcoal	1220 ± 90	-26.4	1200 ± 90	A.D. 670-1000	100%	A.D. 870
18a	57030	2-1302 (TN-13), TU 1, 70-80 cm b.s.	20 g charcoal	1220 ± 50	-24.6	1230 ± 50	A.D. 678-894 920-948	96% 4	A.D. 786
21a&b	58441[2]	2-1302 (TN-13), TU 1, 98-110 cm b.s.	9 g charcoal	1380 ± 80	-25.0	1380 ± 80	A.D. 540-870	100%	A.D. 660
29a	57031	2-1302 (TN-13), TU 2, 45-55 cm b.s.	5 g charcoal	410 ± 90	-25.1	410 ± 90	A.D. 1320-1340 1390-1670	1% 99	A.D. 1460
39a	58442	2-1302 (TN-13), TU 3, 30-40 cm b.s.	18 g charcoal	1000 ± 70	-27.0	970 ± 70	A.D. 960-1230	100%	A.D. 1030
44a&b	57032	2-1302 (TN-13), TU 3, 80-90 cm b.s.	17 g charcoal	850 ± 60	-25.7	840 ± 60	A.D. 1040-1100 1110-1290	15% 85	A.D. 1220
46a&b	57033	2-1302 (TN-13), TU 3, 100-110 cm b.s.	12 g charcoal	320 ± 60	-25.5	310 ± 60	A.D. 1450-1670 1780-1800 1940-1955	95% 3 2	A.D. 1640
3c	57034	2-1302 (TN-13), TU 4, 20-30 cm b.s.	16 g charcoal	800 ± 50	-25.3	790 ± 50	A.D. 1161-1301	100%	A.D. 1263
4b	58443	2-1302 (TN-13), TU 4, 30-40 cm b.s.	24 g charcoal	980 ± 60	-25.2	980 ± 60	A.D. 970-1210	100%	A.D. 1030
9a&b	57035[2]	2-1302 (TN-13), TU 4, 80-90 cm b.s.	8 g charcoal	1200 ± 60	-25.1	1200 ± 60	A.D. 690-970	100%	A.D. 870
11a	58444[2]	2-1302 (TN-13), TU 4, 100-110 cm b.s.	4 g charcoal	1230 ± 90	-26.0	1220 ± 90	A.D. 660-990	100%	A.D. 790
50	58436	3-1304 (PS-1), surface, underground cave	20 g coconut shell	121.7 ± 0.7% modern	-27.4	122.3 ± 0.7% modern			
S1	58438[3]	2-1311 (PS-12), TU 2, 22-30 cm b.s.	45.3 g mollusc shell	770 ± 60	+1.1	1200 ± 60	A.D. 1180-1440	100%	A.D. 1310
105	58437	2-1311 (PS-12), TU 1, 130-136 cm b.s.	6.7 g charcoal	N/A[4]					

Table 22 continued. Radiocarbon dates from Guam Navy EIS Project.

Catalog #	Beta #	Provenience	Weight / Material	Age B.P.	DC/12C	Adjusted Age B.P.	Calibrated Age Ranges[1]	Probability	Intercepts
TIP 2, 88-97	62497	Tipalao Marsh, Core 2, 88-97 cm b.s.	112.0 sediment	2060 ± 60	-27.4	2030 ± 60	A.D. 90-170 B.C. A.D. 100-130	96% 3%	40 B.C. 30 20 10 1
TIP 2, 185-190	60077	Tipalao Marsh, Core 2, 185-190 cm b.s.	80.2 g sediment	3130 ± 70	-28.6	3080 ± 70	1500-1480 B.C. 1460-1130	2% 98%	1380 B.C. 1340 1320
TIP 2, 275-280	60078[2]	Tipalao Marsh, Core 2, 275-280 cm b.s.	74.7 g sediment	3670 ± 80	-23.1	3700 ± 80	2330-1800 B.C.	100%	2120 B.C. 2080 2040
TIP 2, 390-395	60079	Tipalao Marsh, Core 2, 390-395 cm b.s.	74.3 g sediment	5000 ± 80	-28.3	4950 ± 80	3950-3630 B.C. 3560-3540	98% 2	3710 B.C.
TIP 2, 464-472	60080	Tipalao Marsh, Core 2, 464-472 cm b.s.	136.4 g sediment	6210 ± 70	-24.8	6210 ± 70	5270-4960 B.C.	100%	5210 B.C. 5170 5140

[1] Calibration from CALIB Rev. 3.0.3, Radiocarbon Calibration Program, Stuiver and Reimer (1993) and Stuiver and Pearson (1993); all sample ranges encompass 95% confidence interval.

[2] Sample received extended counting time to reduce statistical error.

[3] Calibration from data set for marine radiocarbon (Stuiver and Braziunas, 1993); Delta R value of 115 ± 50 years calculated according to Stuiver, Pearson and Braziunas (1986) using historic *Strombus gibberulus gibbosus* shell collected in Guam in 1930 (Athens 1986:113).

[4] Insufficient carbon for dating analysis, sample (0.5g charcoal) returned.

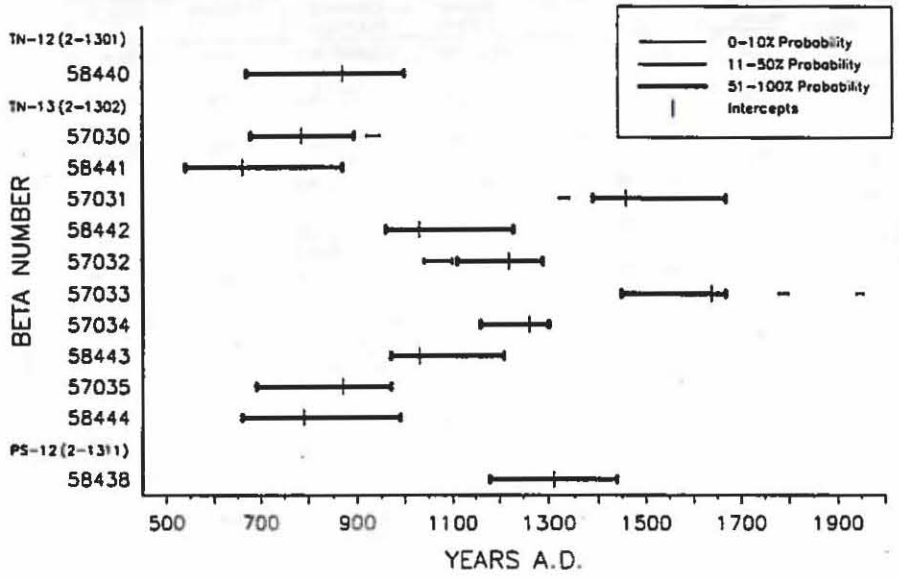


Figure 18. Graphic representation of calibrated radiocarbon dates from Guam Navy EIS Project

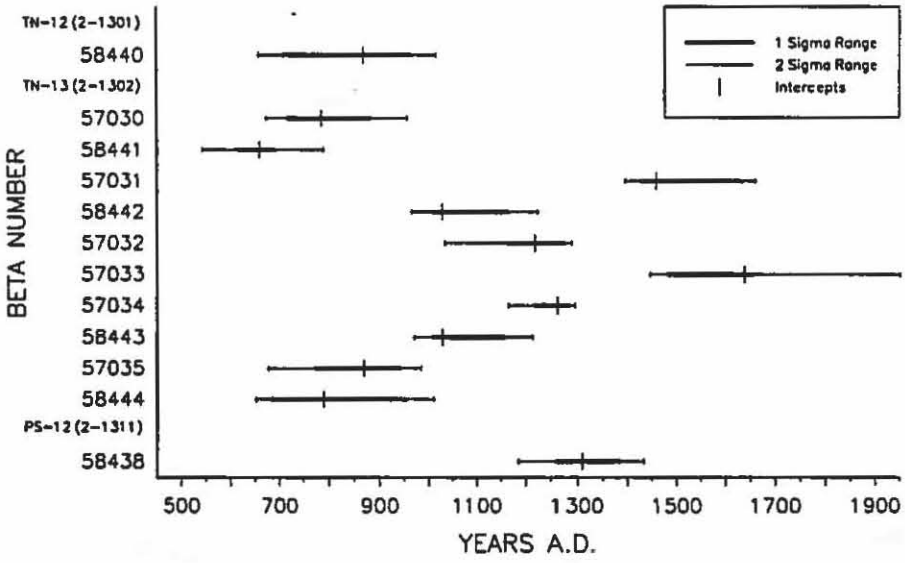


Figure 19. Guam Navy EIS radiocarbon dates, 1 and 2 sigma ranges.

Examination of the table and figures suggests that the one charcoal date from the Japanese bunker (Site 2-1301) falls into a similar calibrated range as the deepest date from Test Unit 4 of the rockshelter (Beta # 58444). While it would be unwise to place too much importance on this comparison, a possible explanation is cultural material of the same age as the lower levels of the rockshelter was washed into the Japanese bunker and subsequently dated. If this assumption is accurate, the material washed into the cave could have been transported a great distance during a storm, or could have originated quite close to the mouth of the cave.

Two dates were derived from materials in Test Unit 1 of the rockshelter. The deepest date, from charcoal recovered from between 98 and 110 centimeters below surface, has a calibrated age range of 640 to 870, and an intercept of A.D. 660. The other date from Test Unit 1 (Beta # 57030) appears to be about 100 years later, but there is some overlap with the deeper date.

Test Unit 2 at the rockshelter was considered the most disturbed of the four controlled test units, and little quality charcoal was encountered. One sample was submitted for dating from the unit, and resulted in an overall date range of A.D. 1320 to A.D. 1670. The provenience level dated was between 45 and 55 cmbs.

Three samples were dated from Test Unit 3. The oldest date of the trio is apparently the shallowest sample (Beta # 58442; 30-40 cmbs). Excavation records note that some sort of congealed yellow paint or polish, bottle glass and plastic caps were encountered between 20 and 30 cmbs, but it is not clear if this dated sample should be considered "contaminated" or not. Together, the date from the 30 to 40 cmbs level and the next lower date from 80 to 90 cmbs form a fairly tight cluster. It is likely that the rockshelter sediments at this location, down to about a meter below the surface, date to A.D. 1000 to A.D. 1200. Perhaps the deepest sample from Test Unit 3, which has a calibrated range (95 percent probability) of A.D. 1450 to A.D. 1670 can be explained by excavation error. Field notes indicate a general difficulty in removing the deepest levels, and there was some concern about the vertical mixture of materials. However, no specific observations were made about the charcoal.

The greatest number of suitable charcoal samples derived from Test Unit 4. Samples from 20 to 30, 30 to 40, 80 to 90, and 100 to 110 centimeters below surface were submitted for analysis. The dates from these samples form a convincing series; looking just at the intercept dates (Table 22), it appears that 116 years may have passed for every 10 centimeters of sediment which accumulated between 20 and 40 centimeters below surface. However, if just the lowest three dates are considered, the 80 centimeters of sediments from 30 to 110 centimeters below surface spans about 240 years, for an average of 30 years per 10 centimeters of accumulation. Of course, this is a simplistic view of two very dynamic processes (i.e., the radioactive carbon cycle, and the gradual accumulation of natural and cultural sediments in a semi-enclosed space), but it does call attention to the four dates and their relationship to one another.

The final successfully dated sample was the only shell to be submitted for a date. This sample consisted of numerous pieces of short-lived molluscs (both gastropod and bivalve) collected from 22 to 30 centimeters below surface in Test Unit 2 at Tuparao Village, Site 2-1211. The sample yielded a calibrated age range of A.D. 1180 to A.D. 1440. This shell material dates the shallow, dark surface soil that was evaluated with the controlled excavation of Test Unit 2.

The dark sediments of Test Unit 2 do not represent an intact cultural midden, as indicated by the materials recovered in the excavation. Recovered from the unit were just 2 pieces of bone, a relatively small sample of prehistoric sherds (dominated by fragments less than 2 centimeters in diameter, found mostly in the upper 2 levels), and a shell assemblage which includes many natural shells (18 hermited gastropod shells, 23 crab-severed shell apices, and 11 crab-crushed shells). If these materials and sediments are *in situ*, it would appear that the soil was darkly stained by an overlying midden which was removed at some time in the past. Alternatively, the dark soil may have been trucked in and used for fill, perhaps when the baseball field was constructed. It should be noted, however, that there appears to be no sedimentological break between the dark soil and the lighter sediments below it.

IX: ANALYSIS OF PREHISTORIC POTTERY

by

Stephen K. Wickler

Introduction

Analysis of prehistoric pottery recovered during Phase II test excavation at three sites, 2-1311, 2-1301, and 2-1302, is discussed in this section. The primary objective of ceramic analysis was to identify the period of occupation represented and investigate the range of temporal and spatial variability in pottery attributes for each of the sites. Due to the limited amount of controlled excavation from which ceramics were recovered, consisting of two 1 x .5 m units each from 2-1311 and 2-1301 and four .5 x .5 m units from 2-1302, the scope of pottery analysis was of necessity limited to general characterization of small site samples which are not necessarily representative of the overall site assemblages.

All but a very small percentage of the ceramics displayed attributes characteristic of the latter part of the Latte Period (i.e., after ca. AD 1200) although radiocarbon dates from 2-1302 indicate occupation earlier in the Latte Period as well (ca. AD 1000). Site 2-1302 has a low amount of late Pre-Latte Period pottery in the lower component of at least one test unit (TU-1) which is consistent with radiocarbon dates ranging roughly from AD 600 to AD 800. Occupation prior to AD 1000 is also indicated by the presence of a few late Pre-Latte to early Latte Period sherds from Test Unit 1 at Site 2-1311.

The initial portion of this report outlines the methodology employed in selection of attributes for analysis, sampling procedures, and recording techniques. This is followed by discussion and interpretation of attribute frequencies for the combined ceramic sample and analytical results for individual sites.

Analytical Methodology

A total of 2,643 sherds weighing 15.65 kilograms was recovered during controlled excavation. The majority are from 2-1302 (n=2,210; 83.6%) with much lower quantities at 2-1311 (n=310; 11.7%) and 2-1301 (n=123; 4.7%). Sherd frequencies are presented by excavation level for each test unit in Table 23.

The first stage of analysis involved separating all sherds with a maximum diameter less than 2 cm from the remainder of the sample. These sherds were counted but eliminated from further analysis due to their small size and often eroded condition. The elimination of small sherds, which account for 50.2% (n=1,326) of the total excavated sample, significantly reduced the number of sherds available for analysis. All but nine of the sherds less than 2 cm in size are non-diagnostic and the diagnostic sherds are rim lip fragments of insufficient size to provide useful data.

Sherds greater than 2 cm in diameter were first sorted into diagnostic rims (including incomplete fragments with a portion of the lip or lower rim absent) and non-diagnostic body sherd categories. Sherds from each category were further separated on the basis of surface treatment into plain and textured (wiped or combed) groups. The frequencies for these categories are found in Table 23. No definite decorated sherds were identified although several body sherds had cross-hatched lines which appeared to be part of an incised pattern (Fig. 20: a,b). These incisions were not considered to be decoration as they resemble sherds which had been purposefully wiped during the finishing stages of vessel manufacture for a non-decorative purpose. Evidence for secondary use of sherds following vessel breakage occurs in the form of eight body sherds with ground beveled margins from sites 2-1311 and 2-1302 (Fig. 20: c-f).

Following initial sorting, a variety of attributes were recorded for sherds over 2 cm in diameter using the computer database program Dbase IV. Data recorded from a total of 1,280 sherds, 1,194 (93.3%) of which were non-diagnostic body sherds, was input into a Dbase file which was then converted to a file within the statistical program SPSS/PC+ for further analysis. Attributes recorded for non-diagnostic body sherds were restricted to body thickness and temper type. Additional attributes recorded on diagnostic rim sherds include rim thickness, the ratio of rim to body thickness, rim orientation and form, and lip form.

Continuous attributes which were recorded include rim and body sherd thickness. These measurements were made with a vernier caliper to the nearest tenth of a millimeter. Rim thickness was recorded only on sherds with complete lips and measured at the point of maximum lip expansion or reduction relative to the vessel body. Body thickness was recorded below the point of initial reduction or expansion on rim sherds and in a representative location for average thickness on body sherds. Only sherds with intact, uneroded surfaces were measured. An attribute was created which provided a rim to body thickness ratio for complete rim sherds expressed as rim thickness (r) divided by body thickness (b) or (r/b). This ratio enabled examination of the degree of rim expansion or reduction quantitatively with reduced rims having a ratio of less than 1 and expanded rims more than 1. Rim diameter was reconstructed for rim sherds of adequate size using a template with concentric arcs representing rim diameters ranging from 2-50 cm in 2 cm increments.

Table 23. Ceramic frequency data, Navy EIS Project, Guam.

ID #	Cat. #	Site	Unit (TU)	Layer/ Level	Depth cm BS	Non-diagnostic sherd totals				Diagnostic sherd totals				Sherd Total	Total Sherd wt. (g)
						(<2cm)	(>2cm) plain	(>2cm) wiped/ crushed surface	Total (>2cm)	(<2cm)	(>2cm) plain	(>2cm) wiped/ crushed	Total		
1	1-4	2-1301	1	I/1	0-10	8	5	–	5	–	–	–	–	13	27.2
2	17,18	2-1301	1	I/2	10-20	4	1	–	1	–	–	–	–	5	6.3
3	5,6	2-1301	1	I/3	20-30	10	6	2/0	8	–	1	–	1	19	113.6
4	7	2-1301	1	II/1	30-40	2	–	1/0	1	–	1	–	1	4	62.6
5	9,11	2-1301	1	III/1	40-47	1	1	0/1	2	–	–	–	–	3	9.8
6	12,13	2-1301	1	IV/1	47-60	9	2	–	2	–	–	–	–	11	48.4
7	15	2-1301	1	V/1	47-60	3	–	–	–	–	–	–	–	3	10.6
8	16	2-1301	1	V/2	60-80	5	5	–	5	–	–	–	–	10	65.0
					Unit Total	42	20	3/1	23	–	2	–	2	68	336.5
9	1	2-1301	2	Level 1	0-10	6	8	1/1	10	–	–	–	–	16	89.7
10	2	2-1301	2	I/2	10-20	8	8	2/0	10	–	1	–	1	19	57.2
11	3	2-1301	2	Level 3	20-30	4	3	0/1	4	–	–	–	–	8	21.8
12	4	2-1301	2	Level 4	30-40	2	1	–	1	–	–	–	–	3	11.4
13	5	2-1301	2	Level 5	40-50	1	3	0/1	4	–	–	–	–	5	20.4
14	6	2-1301	2	Level 6	50-60	2	2	–	2	–	–	–	–	4	10.5
					Unit Total	23	25	3/3	31	–	1	–	1	55	211.0
15	2	2-1302	1	I/2	10-20	–	1	–	1		–	–	–	1	1.2
16	4	2-1302	1	I/4	30-40	15	5	–	5	–	–	–	–	20	35.0
17	5	2-1302	1	II/1	40-50	35	26	1/0	29	1	2	–	3	67	235.1
18	6	2-1302	1	III/1	50-60	30	25	3/0	28	–	3	–	3	61	235.3
19	7	2-1302	1	III/2	60-70	3	–	–	–	–	1	–	1	4	10.3
20	8	2-1302	1	IV/1	60-70	7	15	–	15	–	–	–	–	22	125.6
21	11	2-1302	1	V/1 & V/2	70-80	1	2	–	2		–	–	–	3	12.6
22	13	2-1302	1	VII/1	88-98	0	4	–	4	–	1	–	1	11	42.1
23	15	2-1302	1	VIII/1	98-110	1	2	–	2	–	2	–	2	5	69.4
					Unit Total	98	82	4/0	86	1	9	–	10	194	746.7
24	1	2-1302	2	I/1	0-10	35	6	0/3	9	–	2	–	2	46	152.1
25	2	2-1302	2	I/2	10-15	52	15	1/0	25	1	3	–	4	81	288.3
26	3	2-1302	2	II/1	15-25	63	36	0/2	38	1	6	0/1	8	111	304.0
27	4	2-1302	2	II/2	25-35	60	42	3/2	47	–	7	0/1	8	115	346.3
28	5	2-1302	2	II/3	35-45	9	6	–	6	–		–	–	15	47.9
29	6	2-1302	2	IIA/1	45-55	27	14	4/1	19	1	–	–	1	47	171.6
30	7	2-1302	2	IIA/2	55-60	8	5	–	5	–	1	–	1	14	52.8
31	8	2-1302	2	IIA/3	60-70	12	–	–	–	–	–	–	–	12	16.2
32	9	2-1302	2	III/1	70-80	13	3	2/0	5	–	–	–	–	18	48.0
33	10	2-1302	2	III/2	80-90	3	2	–	2	–	–	–	–	5	16.2
34	11	2-1302	2	III/3	90-100	1	–	–	–	–	–	–	–	1	1.2
					Unit Total	285	129	10/17	156	3	19	0/2	24	465	1844.6
35	1	2-1302	3	I/1	0-10	32	32	4/1	47	–	–	1/0	1	70	416.3
36	2	2-1302	3	I/2	10-20	26	20	3/2	25	–	–	–	–	51	203.2
37	3,4	2-1302	3	I/3	20-30	36	46	7/2	55	–	1	1/0	2	93	758.3
38	5,6	2-1302	3	I/4	30-40	33	35	23/0	58	–	3	1/0	4	95	910.3
39	7,8	2-1302	3	I/5	40-50	58	54	38/0	92	–	4	1/0	5	155	1481.9
40	9	2-1302	3	I/6	50-60	40	26	37/0	63	–	1	–	1	104	1125.7
41	10	2-1302	3	I/7	60-70	35	38	30/0	68	–	3	–	3	106	1034.5
42	11,12	2-1302	3	I/8	70-80	31	33	19/0	52	–	1	–	1	84	932.8
43	13,14	2-1302	3	I/9	80-90	9	7	3/0	10	–	1	–	1	20	159.8
44	15	2-1302	3	I/10	90-100	4	5	0/1	6	–	1	–	1	11	130.2
45	16	2-1302	3	I/11	100-110	14	12	7/2	21	–	3	–	3	36	176.5
46	17	2-1302	3	I/11	110-120	4	–	–	–	–	–	–	–	4	5.0
					Unit Total	312	309	171/18	497	–	16	4/0	20	829	7317.5
47	1	2-1302	4	I/1	0-10	8	5	0/3	8	–	2	–	2	18	165.6
48	2	2-1302	4	I/2	10-20	34	18	6/2	26	–	–	–	–	60	214.1
49	3	2-1302	4	I/3	20-30	180	35	57/0	92	–	3	–	3	275	1074.2
50	4	2-1302	4	I/4	30-40	52	23	9/0	32	–	3	–	3	87	335.4
51	5,6	2-1302	4	I/5	40-50	87	129	17/0	146	1	13	–	14	247	2000.7
52	7	2-1302	4	I/6	50-60	5	4	–	4	–	1	–	1	10	51.4
53	8	2-1302	4	I/7	60-70	2	3	–	3	–	–	–	–	5	14.8
54	9	2-1302	4	I/8	70-80	–	1	–	1	–	–	–	–	1	6.2
55	10	2-1302	4	I/9	80-90	1	2	–	2	–	–	–	–	3	9.3
56	12	2-1302	4	–	100-110	9	6	–	6	1	–	–	1	16	72.8
					Unit Total	378	226	89/5	320	2	22	–	24	722	4024.5
57	2	2-1311	1	II/1	30-40	1	1	–	1	–	–	–	–	2	7.6
58	3	2-1311	1	II/2	40-50	4	6	–	6	–	–	–	–	10	32.3
59	1,4	2-1311	1	III/1	50-60	6	4	1/1	6		1	–	1	13	49.8
60	5,6	2-1311	1	III/2	60-70	19	3	0/2	5	–	2	–	2	26	94.6
61	7,8	2-1311	1	III/3	70-80	21	6	2/10	18	1	2	–	3	42	251.6
62	9,10	2-1311	1	III/4	80-90	17	6	0/1	7	–	1	–	1	25	97.2
63	11,12	2-1311	1	III/5	90-100	8	6	–	6	–	1	–	1	15	61.5
64	13	2-1311	1	III/6	100-110	2	1	–	1	–	–	–	–	3	8.9
65	15,16	2-1311	1	III/7	110-120	15	8	–	8	–	1	–	1	22	47.6
66	17,18	2-1311	1	III/8	120-130	4	5	–	5	–	–	–	–	9	20.2
67	20	2-1311	1	III/9	130-136	1	–	–	–		–	–	–	1	7
					Unit Total	98	44	3/14	61	1	8	–	9	168	672.0
68	1,2	2-1311	2	I/1	0-10	44	12	5/1	18	–	1	–	1	63	233.0
69	3	2-1311	2	I/2	10-20	30	20	2/1	23	1	1	–	2	55	308.7
70	4	2-1311	2	I/3	22-30	9	7	–	7	1	–	–	1	17	50.2
71	5	2-1311	2	II/1	12-20	3	–	–	–	–	–		–	3	4.6
72	6	2-1311	2	II/2	20-30	3	–	–	–	–	–	–	–	3	3.5
73	8	2-1311	2	II/3	30-40	1	–	–	–	–	–	–	–	1	1.8
					Unit Total	90	39	7/2	48	2	2	–	4	142	501.8
					Grand Total	1326	873	290/60	1223	9	79	4/2	94	2643	15.655
					%	50.2	33.0	11/2.3	46.3	.3	3.0	.2/.1	3.6	–	–

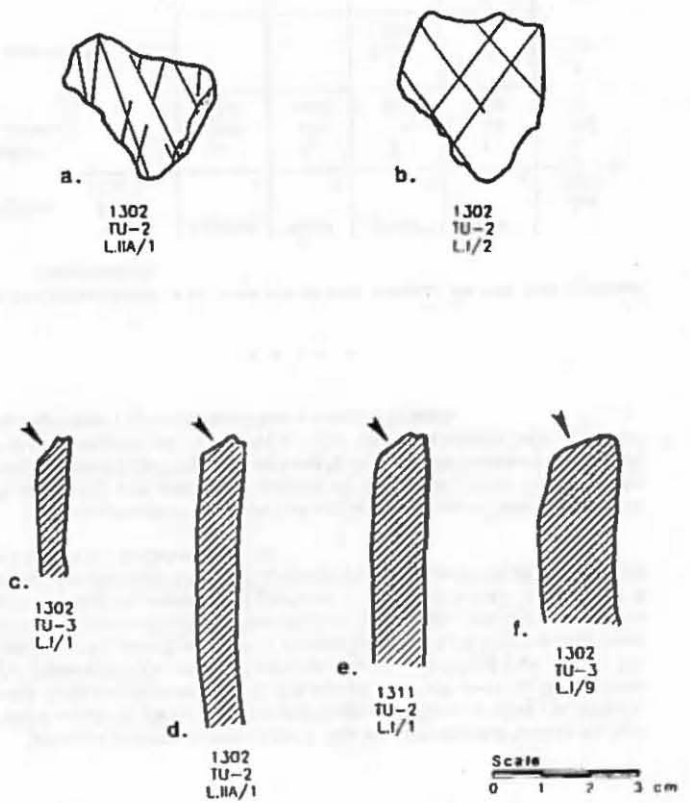


Figure 20. Sherds with ground margins and possible incised sherds.

Attributes related to rim morphology were recorded in order to provide information concerning aspects of general vessel form with potential temporal and spatial significance in the prehistoric ceramic sequence for Guam. Rim orientation was recorded relative to the central vertical axis of the vessel as everted or direct. Rim form was recorded as expanded, reduced, or parallel with an additional distinction between robust and gradually expanded lips. A total of five lip forms were also recorded (rounded, flat with sharp or rounded margins, flat with internal expansion, and pointed).

Temper type was recorded on the basis of dominant non-plastic inclusions observed within the clay body which included variable percentages of volcanic and calcareous sand grains either mixed or as single entities. Surface treatment was recorded during initial sorting as a count of sherds with modifications of the exterior vessel surface during the finishing stages of manufacture. Surfaces were either wiped to create regular parallel striations with multiple orientations or combed with a serrated object such as a shell edge producing a pattern of adjacent parallel grooves of regular width and depth.

Attribute Frequencies - Combined Sample

Of the 2,643 sherds recovered during excavation, less than half (n=1,280; 48.4%) were of suitable size and sufficiently uneroded for inclusion in the computer-based analysis. A total of 86 rim sherds was analyzed out of the 94 excavated including 43 complete rim sherds, 28 rim lip fragments, and 15 lower rim sherds with incomplete lips. No diagnostic sherds other than rims were present. The distribution of sherds is discussed on a site by site basis below. A majority of the sherds analyzed are from Site 2-1302 (n=1,103; 86.2%) with much lower amounts at 2-1311 (n=119; 9.3%) and 2-1301 (n=58; 4.5%). The frequency of attribute states for each of the attributes is discussed below beginning with those related to vessel morphology and followed by temper type and surface treatment.

Rim Morphology

Discrete or non-continuous attributes recorded which relate to vessel morphology include rim diameter, rim form, rim orientation, and lip form. Rim form has been demonstrated to have temporal and geographical significance in the Marianas, particularly the distinction between parallel and reduced rims known as Type A and expanded Type B rims. Type A rims are characteristic of the Pre-Latte Period with a transition to Type B rims of increasing relative and absolute thickness during the Latte Period. Sant and Lebetski (1988) and others (e.g., Wickler 1993) have noted the existence of an early Type B rim which is gradually expanded. This early form is eventually replaced by the more robust classic Type B rim during the latter part of the Latte Period.

Braced or robustly thickened Type B rims are predominant at each of the three sites and comprise 64.2% (n=43) of the total sample of 67 rims for which rim form was recorded. Gradually expanded Type B rims account for 23.9% (n=16) of the rim forms and the remaining 6% are evenly divided between parallel and reduced Type A rims. The high percentage of robust Type B rims is characteristic of late Latte Period sites on Guam and indicates that all three of the Latte Period site assemblages most likely date to after AD 1000 although the sample size is quite small at 2-1301 and 2-1311. Robust Type B rim profiles are illustrated in Figure 21, gradually thickened Type B rim profiles in Figure 22, and Type A rim profiles in Figure 23.

The crosstabulation between rim form and lip form found in Table 24 shows that 90.3% of the rims have rounded lips including all robust Type B rims and all but one gradually expanded Type B rim. The other four lip forms are associated with Type A rims and one early expanded rim. Thus there is a clear correlation between Type B rims and rounded lips unlike Type A rims which have a variety of lip forms.

* * * * *

Table 24. Crosstabulation of rim form and lip form attributes for rims from combined ceramic sample.

RIMFORM→	Count / Row Pct / Col Pct	expanded 1	braced 2	parallel 3	reduced 4	Row Total
LIPFORM ↓ rounded	1	15 26.8 93.8	38 67.9 100.0	2 3.6 50.0	1 1.8 25.0	56 90.3
flat-rounded	2			1 100.0 25.0		1 1.6
pointed	3				3 100.0 75.0	3 4.8
internally expanded	4	1 100.0 6.3				1 1.6
flat-sharp	5			1 100.0 25.0		1 1.6
Column Total		16 25.8	38 61.3	4 6.5	4 6.5	62 100.0

Number of Missing Observations = 1218

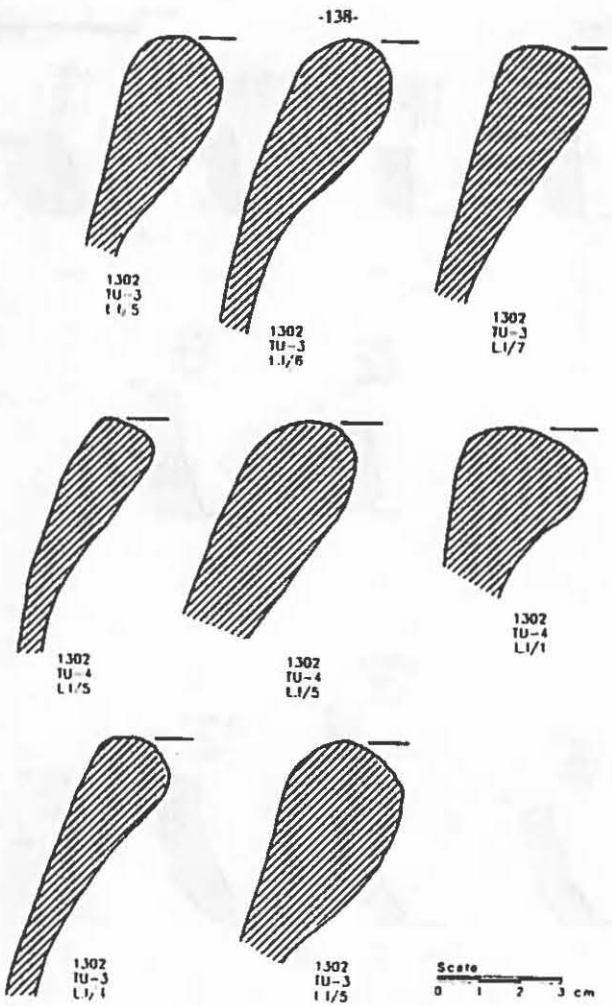


Figure 21. Robustly thickened Type B rim profiles.

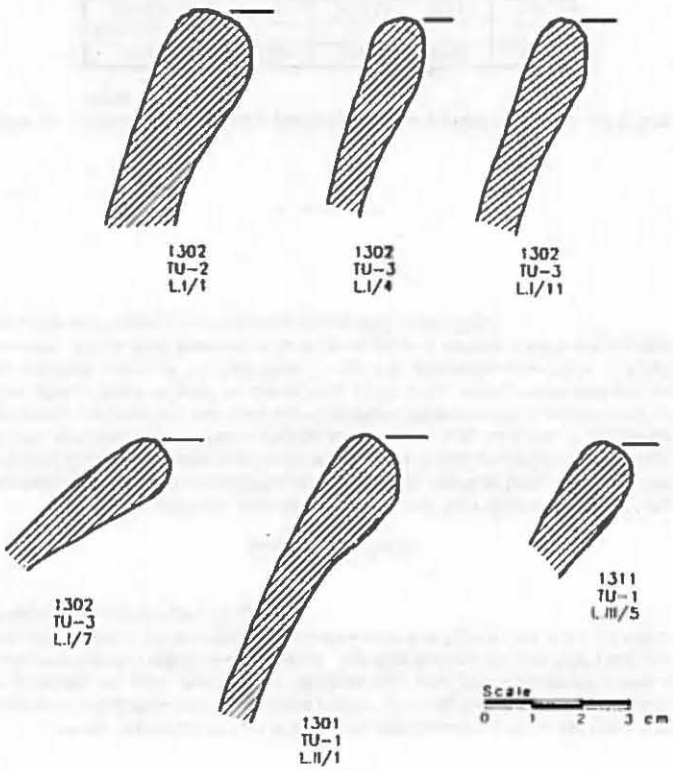


Figure 22. Gradually thickened Type B rim profiles.

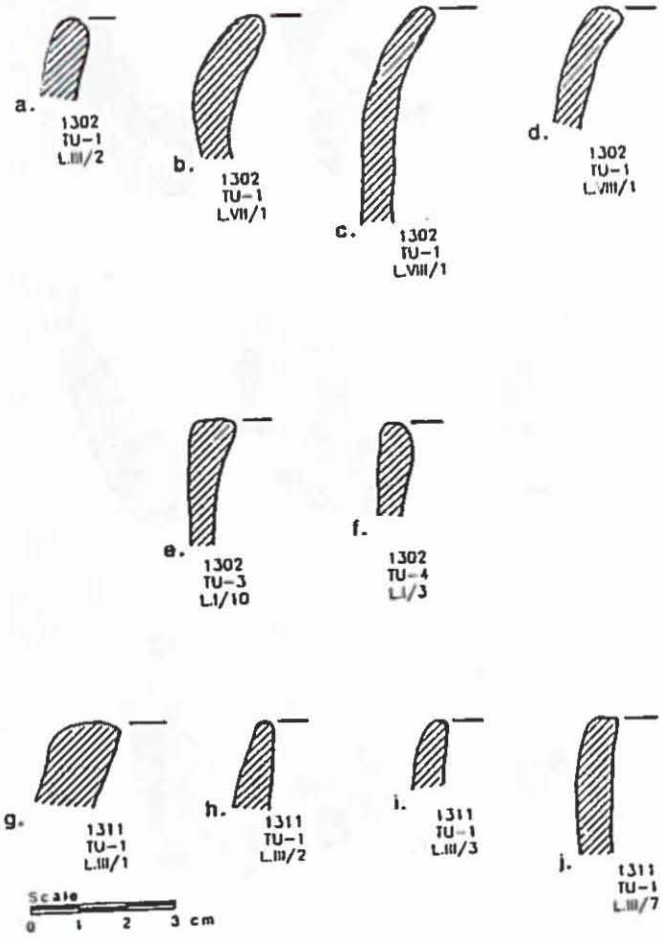


Figure 23. Unthickened Type A rim profiles.

All but three of the 69 rims with a known orientation are inverted and come from large restricted globular pots with a simple profile. This is by far the most common vessel form during the Latte Period in the Marianas and these pots undoubtedly served a utilitarian function such as food preparation. The three non-inverted rims have a direct or vertical orientation and come from unrestricted vessels with Type A rims at 2-1311 and 2-1302 as illustrated in Figure 23 (f, h, j).

Continuous Attributes

Non-discrete attributes recorded include rim and body thickness and the ratio between these as well as reconstructed rim diameter. As shown in Table 25, average rim and body thickness increases significantly between Type A rims, gradually expanded Type B rims, and robust Type B rims as does the ratio of rim to body thickness. The presence of vessels with relatively thin walls and dramatically thickened rims is characteristic of Latte sites on Guam as noted by Graves *et al.* (1988: 218). Average body thickness for the combined sample of 1,225 sherds is 7.5 mm with thicknesses from 3.8 to 17.5 mm recorded. This is at the lower end of the thickness range of between 7 and 9 mm recorded for a number of Guam Latte Period sites Graves *et al.* (1988: 217).

* * * * *

Table 25. Rim and body thickness (mm) and rim to body ratios for Type A and B Rim Forms.

Rim Form	Total	Range	Mean	S.D.
Form A				
Rim Thickness	8	5.0-13.5	6.91	2.81
Body Thickness	6	6.2-8.1	6.97	.70
Rim/Body Ratio	6	.71-1.1	.87	.17
Gradual Form B				
Rim Thickness	15	6.3-16.5	13.18	2.55
Body Thickness	9	4.0-8.8	7.37	1.66
Rim/Body Ratio	9	1.48-2.02	1.68	.17
Robust Form B				
Rim Thickness	34	13.8-32.4	21.25	4.68
Body Thickness	31	5.4-15.6	9.02	2.70
Rim/Body Ratio	27	1.3-4.56	2.52	.80

Only six rim diameters could be reconstructed from the entire sample of rim sherds and these were found in excavation units TU 3 and 4 in Site 2-1302. They range from a small-mouthed unrestricted bowl with a 10 cm diameter mouth found in TU 3, Level 3 (Fig. 23: f) and restricted jar with a 16 cm diameter from TU 3, Level 7 to restricted vessels with robust Type B rims and larger orifices of 34 cm, 38 cm, and 40 cm from excavation levels 5 through 7 in TU 3.

Temper Type

The dominant temper type at each site is a mixture of fine calcareous sand grains and relatively fine volcanic sand classified as mixed sand temper (MST). Neither type of inclusion usually exceeds a density of about 10% although sherds from Site 2-1311 appear to have a somewhat higher density (up to 30%) of calcareous sand than the other two sites. The low density of calcareous grains in many sherds suggests inadvertent rather than purposeful addition to the clay body. MST is found in 91.8% (n=1,174) of the combined sherd sample. Two minor temper types consisting of volcanic sand (VST) and calcareous sand (CST) account for 4.5% (n=58) and 3.7% (n=47) of the sample respectively. VST inclusions are predominantly subangular to rounded lithic fragments and mineral sand grains found in low quantities and are similar to MST sherds except for the absence of calcareous sand. CST sherds have relatively high densities of calcareous sand (30% or higher) compared to MST pottery and are clearly associated with the Pre-Latte to early Latte ceramics. This is supported by the predominance of CST in Type A rims in contrast to braced Type B rims which are all MST as shown in Table 26.

Surface Treatment

Roughening of the exterior vessel surface by wiping or scraping during the finishing stage of pottery manufacture was evident on a number of sherds at each site. Although not included as a formal attribute in the computer-based analysis, frequencies of sherds with diameters greater than 2 cm with surface modification were recorded for each excavation level as shown in Table 23. Two forms of surface treatment, wiping and combing, were distinguished as previously discussed. Wiping is the most common technique and is found on 23.7% (n=290) of the body sherds over 2 cm in diameter while only 4.9% (n=60) are combed. A lower percentage of rim sherds are wiped (4.7%; n=4) and combed (2.4%; n=2) than body sherds although the sample is too small to assess the significance of this difference.

Scraping and wiping of the exterior vessel surface is a distinguishing characteristic of Latte Period ceramics with wiping most common and combing less frequent. Butler (1990: 41) has suggested that the appearance of textured surfaces in the Latte Period is functionally related to the production of taller and less stable vessels for which surface roughening enabled a better grip on pots containing hot liquids for boiling food. The

Table 26. Crosstabulation of rim form and temper type attributes from combined ceramic sample.

TEMPER →	Count / Row Pct / Col Pct	CST 1	MST 2	VST 3	Row Total
RIMFORM↓					
expanded	1	2 12.5 33.3	14 87.5 23.3		16 23.9
braced	2		43 100.0 71.7		43 64.2
parallel	3	2 50.0 33.3	1 25.0 1.7	1 25.0 100.0	4 6.0
reduced	4	2 50.0 33.3	2 50.0 33.3		4 6.0
Column Total		6 9.0	60 89.6	1 1.5	67 100.0

Number of Missing Observations = 1213

* * * * *

presence of carbon residues noted on the interior surfaces of some body sherds supports the interpretation that vessels were used in food preparation.

Evidence for modification of sherds following vessel breakage was found on a total of eight body sherds which had one margin ground smooth forming a beveled surface along the edge. Six sherds were found in the upper and lower deposit at Site 2-1302 in TU 1 (Layer II/3 and IIA/1) and TU 3 (Levels 1, 3, and 9) as well as TU 1 (Layer II/3) and TU 2 (Layer I/1) at Site 2-1311. Four of these sherds are illustrated in Figure 20 (c-f). The grinding did not extend completely through the vessel wall indicating that a groove had been ground in the exterior surface of larger sherds which were subsequently broken at the groove either purposefully or as a result of pressure from grinding. Similar grinding has been found by the author on Latte Period ceramics from sites on Tumon Bay and Agana

Bay on the west coast of Guam (Wickler 1993, in prep.). The initial stage of grinding represented by grooves of variable depth was noted on both rim and body sherds from these sites. No other evidence of such grinding from prehistoric sites in the Marianas has been reported in the literature to my knowledge and the purpose remains unknown.

Site 2-1302 Ceramics

Site 2-1302 includes a rockshelter at the base of a limestone cliff along the inland margin of a beach cove and a sandy bench ca. 8 m in width in front of the rockshelter. Pottery was analyzed from four .5 x .5 m test units placed at the rear of the rockshelter (TU 3 and TU 4), near the edge of the sandy bench (TU 2), and in a raised berm formed by silt and rocks which had washed over the cliff edge (TU 1). TU 1 and 2 encountered more disturbed strata than TU 3 and 4 in which the deposits were relatively undisturbed (although anomalous radiocarbon dates indicate mixture of material in TU 3).

Of the 2,210 sherds recovered during excavation, 1,103 were included in the computer-based analysis. As shown in Table 27, 93.5% of the sherds from 2-1302 are non-diagnostic body fragments and the remainder of the sample is divided between complete and fragmentary rim sherds. A majority of the pottery analyzed came from TU 3 (45.9%) and TU 4 (29.6%) with minor quantities from TU 2 (16%) and TU 1 (8.5%). TU 3 and 4 are similar stratigraphically with only one layer identified and were excavated in 10 cm arbitrary levels to a depth of 110 cm below surface. Both units have dense concentrations of pottery in the upper portion of the deposit which peak in Level 5. The number of sherds decreases sharply below this level in TU 4 but remain high in the lower TU 3 deposit. Radiocarbon dates from the upper half of the deposit in both units indicate occupation during the first half of the Latte Period between AD 950 and AD 1200 while basal dates between AD 650 and AD 1000 from TU 4 document a late Pre-Latte component. Similar early dates were also obtained from the base of TU 1. TU 1 has a relatively high density of pottery in the middle of the deposit between 40 and 60 cm below surface as in TU 3 and 4, but not much in the lower deposit. The highest density of pottery occurs in the upper 35 cm of TU 2 with uneven distribution below this depth.

The collective ceramic evidence from 2-1302 is highly characteristic of the Latte Period and several attributes indicate that most pottery is typical of the latter part of this period. No evidence of ceramics from the Pre-Latte Period or earliest part of the Latte Period was found in any units except for TU 1 which agrees well with the dates from this unit. The early dates from TU 4 were from levels with minimal pottery and only one diagnostic sherd (a small Type B lip fragment) so the lack of contemporary ceramics is not surprising. Examination of attributes from each of the test units revealed no pattern of temporal change except in TU 1 where an earlier ceramic component is present. Variation between the combined ceramic samples in units aside from TU 1 is also minimal.

Table 27. Crosstabulation of sherd type by excavation unit for Site 2-1302.

UNIT →	Count / Row Pct / Col Pct	TU-1 1	TU-2 2	TU-3 3	TU-4 4	Row Total
SHTYPE ↓						
rim	1	4 10.5 4.3	7 18.4 4.0	17 44.7 3.4	10 26.3 3.1	38 3.4
rim-lip fragment	2	3 15.0 3.2	6 30.0 3.4	3 15.0 0.6	8 40.0 2.4	20 1.8
rim-lip missing	3	2 14.3 2.1	8 57.1 4.5		4 28.6 1.2	14 1.3
body	4	85 8.2 90.4	155 15.0 88.1	486 47.1 96.0	305 29.6 93.3	1031 93.5
Column Total		94 8.5	176 16.0	506 45.9	327 29.6	1103 100.0

Number of Missing Observations = 0

* * * * *

Rim form within 2-1302 is dominated by Type B rims, most of which are braced or robustly thickened as shown in Table 28. Although the sample size is small, TU 1 exhibits an interesting contrast from the other test units in that it has a majority of Type A parallel and reduced rims while none are found in the other units. Rim thickness data supports the rim form evidence with the lowest average thickness in TU 1 (6.3 mm) and much higher averages for TU 2 (15.3 mm), TU 4 (18.5 mm), and TU 3 (19.8 mm) although the TU 1 sample consists of only four sherds. Mean body thickness is much more consistent between units and ranges from 7.3 mm in TU 4 to 7.5 mm in TU 3, 7.7 mm in TU 1, and 7.8 mm in TU 2. The percentage of MST sherds at 2-1302 is similar to that of Type B rims (91.9%) and the remaining sherds are nearly evenly divided between CST and VST as indicated in Table 29. As with rim form, temper frequencies from TU 1 contrast sharply with the other units as CST and VST are co-dominant and MST sherds are slighily less common. All rims from 2-1302 have an inverted orientation except for a single direct rim from TU 4 (Fig. 23: f) and all but two rim lips (a pointed lip from TU 1 and internally expanded lip from TU 3) are rounded.

Table 28. Crosstabulation of rim form by excavation Unit for Site 2-1302.

UNIT → / RIMFORM ↓	Count / Row Pct / Col Pct	TU-1 1	TU-2 2	TU-3 3	TU-4 4	Row Total
expanded	1	1 6.7 16.7	5 33.3 31.3	4 26.7 22.2	5 33.3 33.3	15 27.3
braced	2	1 2.8 16.7	11 30.6 68.8	14 38.9 77.8	10 27.8 66.7	36 65.5
parallel	3	2 100.0 33.3				2 3.6
reduced	4	2 100.0 33.3				2 3.6
	Column Total	6 10.9	16 29.1	18 32.7	15 27.3	55 100.0

Number of Missing Observations = 1048

Table 29. Crosstabulation of temper type by excavation unit for Site 2-1302.

UNIT → / TEMPER ↓	Count / Row Pct / Col Pct	TU-1 1	TU-2 2	TU-3 3	TU-4 4	Row Total
CST	1	32 78.0 34.4	5 12.2 2.8	3 7.3 0.6	1 2.4 0.3	41 3.7
MST	2	29 2.9 31.2	167 16.5 94.9	492 48.6 97.2	325 32.1 99.4	1013 91.9
VST	3	32 66.7 34.4	4 8.3 2.3	11 22.9 2.2	1 2.1 0.3	48 4.4
	Column Total	93 8.4	176 16.0	506 45.9	327 29.7	1102 100.0

Number of Missing Observations = 1

Changes in pottery attributes between excavation levels within individual test units is minimal in all units except TU 1 where a shift from traits characteristic of late Pre-Latte Period to Latte Period ceramics is evident despite the small sample size represented. Type B expanded rims are found only in the upper portion of TU 1 in Layer II and III as indicated in Table 30. The lower deposit contains four non-expanded Type A rims evenly divided between parallel (Fig. 23: a,b) and reduced (Fig. 23: c,d) forms. As shown in Table 31, a parallel shift in temper type occurs from exclusively CST sherds in Layers IV through VIII in the lower deposit to a predominance of VST in Layer III and MST in Layers II and I.

* * * * *

Table 30. Crosstabulation of rim form by excavation level for Site 2-1302, Test Unit 1.

RIMFORM → / LAYER/LEVEL ↓	Count / Row Pct / Col Pct	expanded 1	braced 2	parallel 3	reduced 4	Row Total
II/1			1 100.0 100.0			1 16.7
III/1		1 100.0 100.0				1 16.7
III/2				1 100.0 50.0		1 16.7
VII/1				1 100.0 50.0		1 16.7
VIII/1					2 100.0 100.0	2 33.3
	Column Total	1 16.7	1 16.7	2 33.3	2 33.3	6 100.0

Number of Missing Observations = 88

Table 31. Crosstabulation of temper type by excavation level for Site 2-1302, Test Unit 1.

TEMPER →	Count / Row Pct / Col Pct	CST 1	MST 2	VST 3	Row Total
LAYER/LEVEL					
	I/2		1 100.0 3.4		1 1.1
	I/4		3 100.0 10.3		3 3.2
	II/1		24 77.4 82.8	7 22.6 21.9	31 33.3
	III/1	6 19.4 18.8	1 3.2 3.4	24 77.4 75.0	31 33.3
	III/2			1 100.0 3.1	1 1.1
	IV/1	15 100.0 46.9			15 16.1
	V & VI/1	2 100.0 6.3			2 2.2
	VII/1	5 100.0 15.6			5 5.4
	VIII/1	4 100.0 12.5			4 4.3
	Column Total	32 34.4	29 31.2	32 34.4	93 100.0

Number of Missing Observations = 1

In summary, two sets of ceramic attributes characteristic of 1) late Pre-Latte and 2) Latte Period occupation are evident at Site 2-1302. The early pottery is characterized by calcareous sand temper (CST) and Type A non-expanded rim forms which are both inverted and direct in orientation and have a variety of lip forms. Pre-Latte pottery from intact deposits is restricted to the lower portion of TU 1. The later Latte Period ceramics are predominantly tempered with a mixture of volcanic and calcareous sand (MST) and have Type B gradually and robustly thickened rim forms with an inverted orientation and rounded lip. Textured exterior surfaces due to wiping and combing are present on a significant percentage of the Latte Period sherds.

Site 2-1301 Ceramics

No evidence of Pre-Latte pottery is present at the rockshelter Site 2-1301 and most of the Latte Period ceramics appear to be quite late based on rim form and other attributes. With only 58 sherds nearly evenly divided between two test units, this site has the smallest sample of the three analyzed. As shown in Table 32, the low number of diagnostic sherds from this site, consisting of two complete rim sherds from Test Unit 1 and a single lip fragment from Test Unit 2, severely limit the scope of analysis. The rims are incurved, robustly expanded Type B forms with rounded lips which are typical of the late Latte Period. Except for three volcanic sand temper (VST) sherds from TU 1, the 2-1301 pottery assemblage has a mixture of calcareous and volcanic sand temper (MST). Body thickness for the 56 sherds measured ranges from 4.3 to 13.1 mm with a mean of 7.1 mm.

Site 2-1311 Ceramics

This site is a beach backshore area of Tipalao Bay potentially including the area formerly covered by the Spanish/Chamorro village of Tuparao. Pottery was analyzed from two controlled test units excavated off of backhoe trenches which encountered potential prehistoric cultural deposits, although it is uncertain if these are *in situ* due to evidence of storm disturbance and the mixture of historic and prehistoric material.

As with Site 2-1301, the number of diagnostic sherds within the sample of 119 sherds analyzed was minimal with only three complete rim sherds and six lip fragments from TU 1 and two rim fragments from TU 2 (see Table 33). The ceramic assemblage is generally characteristic of the late Latte Period which is consistent with a calibrated radiocarbon date on shell of AD 1180-1440 (Beta-58438) from TU 2. There is some evidence of late Pre-Latte to early Latte Period sherds in TU 1 but they are mixed with Latte Period pottery and have likely been displaced. TU 1 has the most sherds with the greatest density in the middle portion of the deposit while TU 2 is much shallower with most sherds found in the upper 10 cm.

Table 32. Crosstabulation of sherd type by excavation unit for Site 2-1301.

UNIT →	Count / Row Pct / Col Pct	TU-1 (1)	TU-2 (2)	Row Total
SHTYPE ↓ rim	1	2 100.0 7.7		2 3.4
rim-lip fragment	2		1 100.0 3.1	1 1.7
body	3	24 43.6 92.3	31 56.4 96.9	55 94.8
	Column Total	26 44.8	32 55.2	58 100.0

Number of Missing Observations = 0

Table 33. Crosstabulation of sherd type by excavation unit for Site 2-1311.

UNIT →	Count / Row Pct / Col Pct	TU-1 (1)	TU-2 (2)	Row Total
SHTYPE ↓ rim	1	3 100.0 4.3		3 2.5
rim-lip fragment	2	6 85.7 8.6	1 14.3 2.0	7 5.9
rim-lip missing	3		1 100.0 2.0	1 0.8
body	4	61 56.5 87.1	47 43.5 95.9	108 90.8
	Column Total	70 58.8	49 41.2	119 100.0

Number of Missing Observations = 0

A majority of the rims in TU 1 and all rims in TU 2 are incurved and robustly thickened with rounded lips. TU 1 has two reduced rims with pointed lips and MST which appear to be from the late Latte Period (Fig. 23: h, i). Two parallel rims were also found in this unit with flat lips, one of which has MST and is from the Latte Period (Fig. 23: g). The other parallel rim has a direct orientation and CST typical of Pre-Latte to early Latte Period pottery (Fig. 23: j). Although MST is dominant in both test units and represents 89.1% (n=106) of the total sample, a few CST and VST sherds are present in each unit. Rim thickness ranges from 5.0 to 29.3 mm with a mean of 15.4 mm (n=8). Body thickness ranges from 3.8 to 17.5 mm with a mean of 7.8 mm (n=113). No temporal change in ceramic attributes was apparent in either test unit although the small sample size and disturbance of the deposits limit the potential for such fine-grained analysis.

X: PALEOENVIRONMENT OF THE OROTE PENINSULA

by

J. Stephen Athens and Jerome V. Ward

The purpose of the paleoenvironmental study is to provide an environmental context for prehistoric settlement and land use of the Orote Peninsula on the west side of Guam. Ideally, this would involve data on the period prior to the human settlement of Guam as well as a continuous record during the time of prehistoric occupation. The primary data would be sedimentological and vegetational (pollen and charcoal particles) with tight control over chronology. The strategy will be to recover and analyze a wetland sediment core. Such cores have been shown to be very productive in many parts of the world, including tropical and sub-tropical Pacific islands, for the Holocene period (e.g., Athens *et al.* 1992, Athens and Ward 1993). Of particular concern for the present project will be the distinction between natural environmental changes, including those which are a part of long term environmental processes, and those which are related to the advent and intensification of human settlement and activities, particularly agriculture. This distinction has been one of some contention in the literature concerned with past Pacific island environments and the degree to which humans have been responsible for altering the landscape (e.g., Nunn 1991). In addition, the record of plant introductions and data relating to land use will be of particular interest. Coring and paleoenvironmental studies have been previously conducted on Guam only with limited success (e.g., Cordy and Allen 1985, Hunter-Anderson 1989). However, several recent projects (pers. comm., J. Ward and R. Hunter-Anderson) besides the present one hold considerable promise for greatly expanding knowledge concerning Guam's prehistoric and prehuman environmental past.

As the project area contained a relatively large and centrally located wetland, an ideal opportunity was at hand for conducting a paleoenvironmental study as part of the archaeological inventory survey. The unnamed wetland, hereafter referred to as Tipalao Marsh,* was assigned the temporary site number of PS-6 during the archaeological inventory survey as a result of its potential to contain significant information about the prehistoric past. This was later changed to a permanent Historic Preservation Office site number, which is 3-1327.

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* The name 'Chongchong' is printed across the wetland--shown as an area with standing water--on the U.S. Army Corps of Engineers map of 1913-1914 (see Fig. 8). However, it is unclear exactly to what this name refers (i.e., it may be the general area and not just the wetland). The marsh is presently not referred to by any name and 'Tipalao Marsh,' a name taken from the neighboring Tipalao area to the southwest (which appears on the 1913-1914 map) and Tipalao Bay next to it, seems clear and unambiguous.

The general location of the marsh on Orote Peninsula may be seen in Figure 24. It is situated near the eastern part of the peninsula next to the North Tipalao Naval housing area. Much of the area around the marsh has been modified as a result of military development, and some filling of the marsh on its east side has obviously occurred. The marsh is located within a definite basin with land rising substantially on all sides except to the east in the direction of the Inner Apra Harbor. Other relatively large wetlands presently exist in the Camp Bright and Camp Roxas areas to the southeast where Orote Peninsula joins the main island of Guam (see Figure 24). Topographical considerations suggest that these wetlands almost certainly never connected with Tipalao Marsh.

Figure 25 presents a detailed map of Tipalao Marsh, surrounding features, and the locations of the two cores that were taken. Although no effort was made to specifically define the boundaries of the marsh, it appears to measure approximately 800 m long (NW to SE) and roughly 200 m wide as shown in Figure 25. The total area of the marsh is approximately 14 ha (35 acres). Before infilling around the eastern perimeter by the military, of course, the marsh would have been somewhat larger and possibly much larger (i.e., it may have extended all the way to Inner Apra Harbor--see below). An overview of the east end of the marsh is shown in Photo 8. The surface of the marsh is 1.5 to 1.8 m above mean sea level in the southeastern half and 2.1 m above mean sea level in the northwestern half, according to a recent topographic survey map of the peninsula.

Environment

Orote Peninsula consists almost entirely of a Pliocene and Pleistocene white limestone plateau of reef origin with a small area of alluvium just east of the marsh, and an extensive area of artificial fill surrounding the Inner Apra Harbor (Fig. 26; see Tracey *et al* 1992, Tracey *et al* 1964). The limestone belongs to the Mariana formation, which also makes up the plateau of the northern half of Guam. According to Easton *et al.* (1978:9-10), there has been a ca. 3 m uplift of Guam during the past 3000 to 4000 years. The specific effects of this uplift on Orote Peninsula, which gently slopes upward to the west, have not been described. Tectonic movement, of course, could have had a substantial impact on the sedimentary record and vegetational sequence of Tipalao Marsh.

The particular geological circumstances underlying the formation of the basin occupied by Tipalao Marsh are unclear. No faults have been mapped in this area, though there is an inferred thrust fault at the western tip of Orote Peninsula (Tracey *et al.* 1992). However, this fault presumably would not have directly affected the marsh.

Presumably and at a very general level, marsh formation can be attributed differential tilting of the peninsula through tectonic processes. This would explain why the eastern part of the peninsula and surrounding areas are at or near sea level whereas the western part is elevated (the western tip of Orote Peninsula reaches an elevation of nearly 60 m). Such a process presumably also characterized the late

Figure 24. Portion of USGS topographic map showing Orote Peninsula and location of Tipalao Marsh.

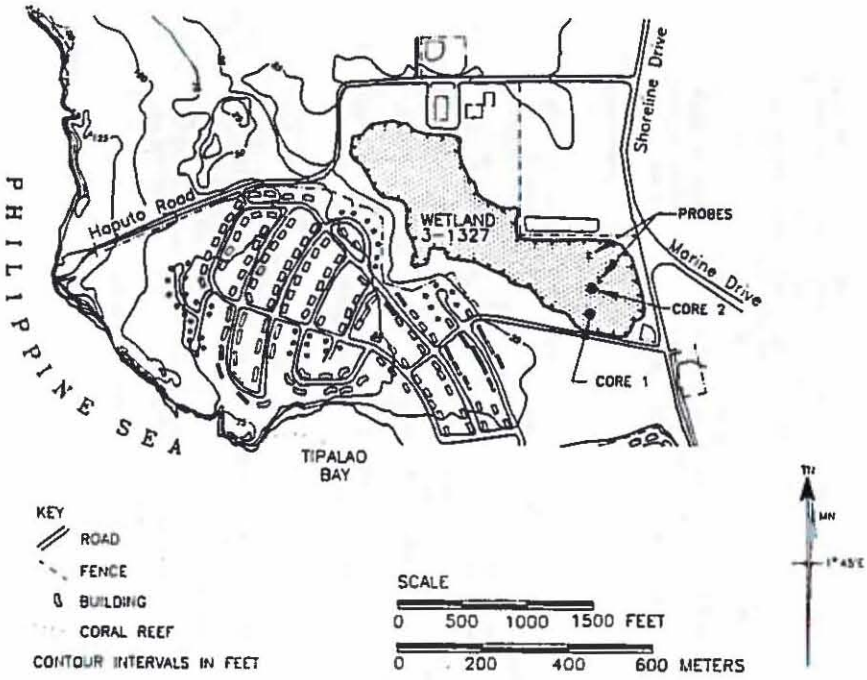

Figure 25. Map of Tipalao Marsh showing coring locations.

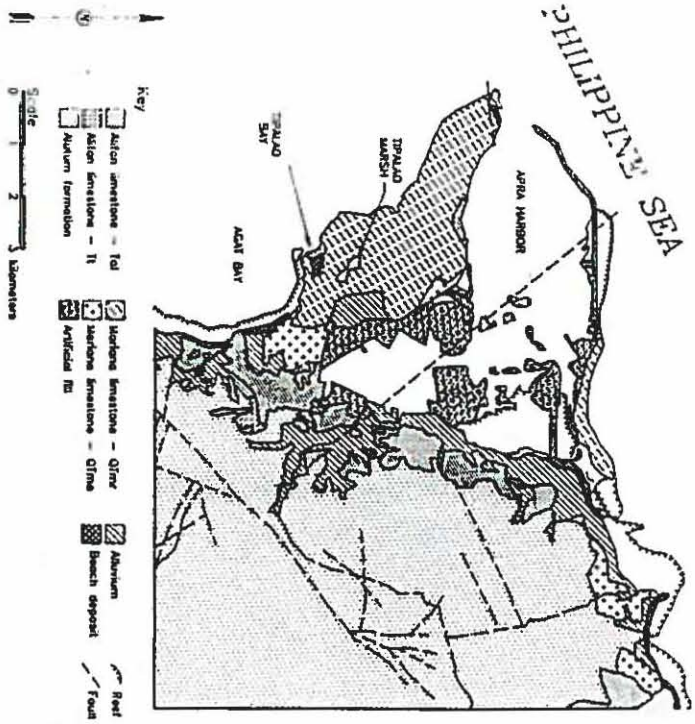

Figure 26 Geological map of Orote Peninsula, Guam (after Tracey *et al.* 1992). See Tracey *et al.* (1992) for complete description of map key.

Photo 8. Overview of east end of Tipalao Marsh. Photograph taken from U.S. Navel Public Works Center, view to south.

* * * * *

Holocene of this area, though Easton *et al.* (1978) do not specifically mention Orote Peninsula.

The broad area of alluvium mapped to the east of Tipalao Marsh by Tracey *et al.* (1964:Fig. 31) is perhaps indicative of this tilting process (see also Fig. 26). In this same vein, it is also of interest to note that the 1913-1914 U.S. Army Corps of Engineers map (shown in Fig. 8) depicts a large area of mangrove forest immediately east of the marsh, indicating that this area was at or near sea level (before military infilling). Thus, the eastern part of the peninsula clearly does not appear to be emerging despite general tectonic processes operative on Guam during the late Holocene.

The present day location of Tipalao Marsh is depicted as standing water on the 1913-1914 map, suggesting that the actual marsh area of today is probably within a depression. The map, in fact, suggests that the area of standing water may not have quite connected with the marsh, though the map scale and the presence of a re- makes this unclear. Thus, it does not appear that the marsh can be entirely explained as a result of the tilting of Orote Peninsula. It seems likely, rather, that the depression could be the result of a fault running just northeast of the Tipalao Housing area (the Tipalao Housing area is considerably elevated above the marsh) in the same direction

as the long axis of the marsh. Whether or not such a postulated fault does exist will have to await a geological study of this area.

Although much of the original Orote limestone surface has been extensively modified by military development, the archaeological survey located several pristine areas with extensive "pit and pinnacle" formations (north and south of the western part of Haputo Road). Besides karst-like terrain, these areas contained large areas of native limestone forest (see below), possibly indicative of the type of vegetation that was once much more widespread on the peninsula. The pit and pinnacle areas have an elevation of approximately 30 to 40 m, which compares to just 1.5 to 2.1 m for the marsh. Whistler (1992:18-19) describes the vegetation as,

> ...dominated by native tree species, the most common of which are *Ficus prolixa* (banyan), *Pisonia grandis*, and *Neisosperma oppositifolium*. Less common native trees include *Cynometra ramiflora*, *Intsia bijuga* (ifil), *Pipturus argenteus*, *Aglaia mariannensis*, *Premna serratifolia*, *Polyscias grandifolia*, *Pouteria obovata*, *Psychotria mariana*, *Guettarda speciosa*, *Melanolepis multiglandulosa*, *Pandanus tectorius* (screwpine), and *Pandanus dubius*. Two other trees were noted to be less common: *Tristeriopsis acutangula* and *Heritiera longipedunculata* ....Another rare...tree species, *Drypetes dolichocarpa*, is reported to occur in the limestone forest to the west on Orote Peninsula, and could conceivably also be found on this parcel. Also common in [the] Seabee Quarry forest [within the general area] is the native cycad *Cycas circinalis*, which is more of an understory species. Native epiphytic ferns, such as *Phymatosorus scolopendria*, *Microsorium punctatum*, and *Pyrrosia lanceolata*, are also present.

With respect to Tipalao Marsh, Whistler (1992:21), reports that it is dominated by,

> *Brachiaria mutica* (California grass), *Cyclosorus [Thelypteris] interruptus* (marsh fern), *Acrostichum aureum* (swamp fern), *Lygodium microphyllum* (a vinelike fern), *Paspalum vaginatum* (a littoral and coastal marsh grass), *Scirpus littoralis* (a sedge), *Eleocharis dulcis* (water chestnut), and *Polygonum minus* (an herb). A thicket of *Hibiscus tiliaceus* (beach hibiscus) covers the southeast side of the wetland.

To this list may be added *Saccharum spontaneum* (on the marsh edge; pers. comm., Michael Subbert, PBEC). A stand of *Casuarina equisetifolia* (ironwood) was also noted on the southwest marsh edge. Finally, the north edge contained several coconut palms. *Phragmites karka*, a tall marsh grass, though common on Guam, was *not* present at Tipalao Marsh.

The only other significant vegetation community possibly related to Tipalao Marsh concerns the large area of mangrove forest documented to the east on the 1913-1914 U.S. Army Corps of Engineers map (shown in Fig. 8). Unfortunately this forest community no longer exists and it is unlikely that it was ever described. However, the map does demonstrate the former presence of a mangrove community in close proximity to Tipalao Marsh.

For further information on the modern vegetation of Orote Peninsula, much of it introduced or found in disturbed environments, Whistler (1992) provides an excellent discussion.

Methodology

Two sediment cores were recovered from Tipalao marsh within the project area on December 8 and 9, 1992 under the direction of J. S. Athens and with the assistance of IARII archaeologists Richard Olmo and Wendy Goodman. The locations are shown in Figure 25 and Photos 9 and 10. The field days were sunny to mostly sunny, providing excellent working conditions. While the marsh was wet, it was entirely covered by vegetation and there were no areas of open water (though areas with solid stands of *Scirpus* were very wet and could not be easily traversed on foot due to the unconsolidated nature of the underlying sediment).

* * * * *

Photo 9. Location of Core 1. Photograph shows extrusion of basal sample.

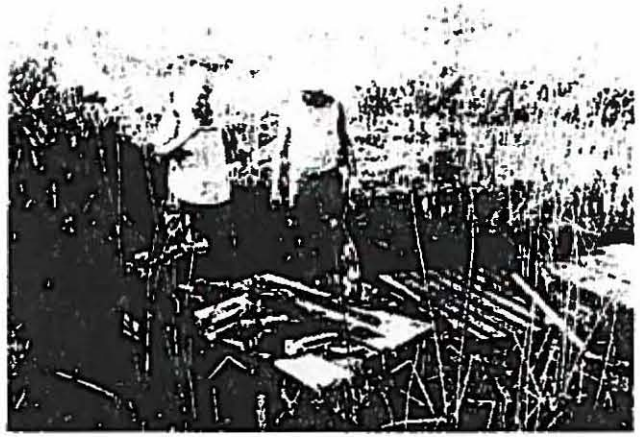

Photo 10. Location of Core 2. Note just extruded core sample on board.

* * * * *

The coring work had originally been scheduled to coincide with the final stage of the IARII Phase II-A archaeological survey in early September. However, the passage of typhoon Omar in late August left the marsh with 1.5 m (5 ft) of standing water, which did not completely drain until the onset of the dry season. Rather than have to deal with the complication of standing water for the coring, it was decided to delay work until the water had subsided. Such storm flooding may be a regular occurrence for Tipalao Marsh. However, the 1913-14 U.S. Army Corps of Engineers map (Fig. 8), which depicts standing water for the area, suggests that it may have been a more permanent feature of the basin in earlier years.

The sediment cores were obtained with a modified Livingstone piston sampler. This hand-driven device is designed to recover sediment samples in their proper stratigraphic context with minimum or no disturbance to the sediments and minimum or no contamination to the sample from extraneous sediments (see Photo 11 for an illustration of a core sample from the base of Core 2). The sampler is driven by hand one meter at a time, pulled up, extruded of its sediment load, and the cycle is repeated until the bottom is reached. The design of the device prevents contamination during successive drives, avoids problems of rodding, and eliminates loss of samples as a result of hydrostatic suction (see Wright *et al.* 1965, 1984). The Livingstone corer is only appropriate for sampling shallow lakes (less than 20 m deep) and wetland sediments, and generally has a

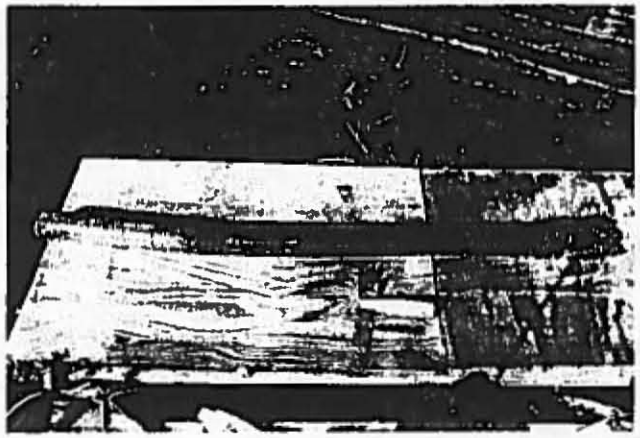

Photo 11. Core sample from base of Core 2. Deep end of core is to left where gleyed clay layer may be seen.

* * * * *

maximum penetration depth of about 15 to 20 meters unless obstructed by rocky sediments or very compact sediments.

Selection of the actual coring location at Tipalao Marsh was primarily a matter of finding the place with the deepest sediments, which would generally be expected toward the center of the wetland. Once at the coring location, several wooden pallets were placed next to the bore hole to provide a solid surface on which to stand. The pallets also helped keep the area around the bore hole clean and free of slumpage during the coring operation.

After recovery of the first core, several probes were made with the corer drive rod to locate possible deeper sediments. As a result of this search, the area around the Core 2 location was found to have significantly deeper sediments than the Core 1 location. Another core, therefore, was taken at this location. A thorough examination of sediment thickness throughout the marsh, however, was not attempted.

Following each drive for each core, the samples were extruded onto a pallet board covered with clean plastic wrap (to avoid contamination; see Photos 9, 10, and 11). Following the recording of its depth and length, and after making preliminary

observations on the sediment, all of which normally requires about 1 or 2 minutes of exposure for the sediment, segments of 50 cm (or less) of the entire sample were completely wrapped in plastic and then in heavy duty aluminum foil for rigidity. Each sample container was labeled with an indelible black marking pen, and the top and bottom depths were carefully noted at the ends of each segment. The samples were subsequently boxed together for air transport to Honolulu (IARII has state and federal soil importation permits).

The sediment was examined and described in detail in the IARII laboratory in Honolulu. At this time Core 2 was also subsampled for pollen and radiocarbon dates. These subsamples were then packaged and mailed to the palynologist (Dr. Ward) and the radiocarbon laboratory (Beta Analytic Inc.) for analysis. The sediment descriptions and subsampling were undertaken by Athens.

Sediment Description

Tables 34 and 35 present detailed sediment descriptions for each core. The profiles of each core are shown in Figure 27, which also indicates the locations of the pollen samples and radiocarbon dates for Core 2. The surface elevation of both cores was approximately the same. Core 1 reached a depth of 3.85 m, while Core 2 reached 4.98 m. Both cores terminated on what is believed to be limestone, fragments of which were brought up in the core. The base seemed to be solid rock and not lagoonal detritus or a coral head. However, the exact nature of the basal rock could not be determined with certainty. Just above the rock, both cores had the same gleyed clay layer 32 and 26 cm thick, respectively. As may be noted on the profile, the depth of this layer was quite different in the two cores, a matter that will be addressed below. The clay layer, which has a slight amount of fine calcareous sand, evidently formed a largely impermeable layer that allowed the retention of water on the limestone substrate.

Above the gleyed clay layer Core 1 had a black to very dark brown series of humic silt to peat layers and sublayers all the way to the top. Core 2, however, was strikingly different. Although there was a black humic silt layer above the gleyed clay, it extended up to only 390 cm (from 472 cm). Thereupon a series of sublayers--IIIa to IIIe--were present. The upper sublayers were a bright reddish brown (moist) color, often with distinct banding. These sublayers also had a pronounced gelatinous texture, which diminished somewhat with depth. This gelatinous texture is caused by organic debris from the green alga, *Botryococcus*, which occurs abundantly in Layer III (as determined by spore analysis--see below). The bright reddish brown color turned to black upon drying, as indicated in the soil description for Core 2 (see Table 35). In contrast, the lower sublayers of Layer III were tan in color and consisted of fine sand.

Layers I and II in Core 2 are very similar to Layer I of Core 1, consisting of humic silt and peat.

Overall, the sediment types contained in both cores--mostly peat or peaty silt --suggest a wetland-type of environment for Tipalao Marsh throughout much of the

Table 34. Soil description, Core 1, Tipalao Marsh, Guam.

Layer	Depth cm	Munsell Color (dry)	Sediment Description
Ia	0-120	10YR 2/2	Very dark brown; humic silt with numerous fine rootlets; lens of brown loam 1 to 1.5 cm below surface; other macro-organics not present; water-saturated but firm; non-sticky, non-plastic; massive; lower boundary clear.
Ib	120-159	10YR 2/2	Very dark brown; humic silt/peat; few rootlets but other macro-organics very abundant; water-saturated but firm; non-sticky, non-plastic; massive; lower boundary clear.
Ic	159-182	7.5YR N2/	Black; humic silt/peat; few macro-organics; firm sediment; lower boundary clear.
Id	182-220	10YR 2/2	Very dark brown; peat with little silt; abundant macro-organics; non-sticky, non-plastic; massive; firm sediment; lower boundary clear.
Ie	220-343	10YR 2/2	Very dark brown; humic silt/peat; abundant macro-organics; non-sticky, non-plastic; massive; firm sediment; lower boundary abrupt.
If	343-353	10YR 2/2	Humic loam, some organics, slightly sticky, plastic; small amount of fine sand.
II	353-385	2.5Y 4/3	Olive brown; gleyed clay with small amount of fine calcareous sand; firm sediment; lower boundary abrupt.
III	385+		Limestone.

Table 35. Soil description, Core 2, Tipalao Marsh, Guam.

Layer	Depth cm	Munsell Color (dry)	Sediment Description
I	0-14	7.5YR N2/	Black; loam, very organic; sediment somewhat firm though water-saturated; massive; sticky, plastic; numerous fine rootlets; lower boundary diffuse.
IIa	14-130	10YR 2/1	Black; peaty silt with numerous fine and some thicker rootlets to ca. 100 cm; below this depth rootlets are absent; sediment relatively firm though water-saturated; massive; non-sticky, non-plastic; lower boundary diffuse.
IIb	130-200	10YR 2/1	Black; peaty silt with macro-organic remains; sediment relatively firm, but becomes much softer at 200 cm; massive; non-sticky, non-plastic; lower boundary somewhat diffuse.
IIc	200-250	10YR 2/1	Black; humic silt but less peaty but still macro-organic remains; much softer sediment than Layer IIb; weak, crumb; non-sticky, non-plastic; lower boundary diffuse.
IId	250-275	7.5YR N2/	Black; humic silt, no macro-organic remains; sediment becomes much firmer; non-sticky, non-plastic; lower boundary clear.
IIIa	275-292	7.5YR N2/	Black; gelatinous silt; transition zone, finely banded black and reddish brown sediments; sediment very cohesive (can be cut into slivers); no macro-organics; non-sticky, non-plastic; lower boundary abrupt.
IIIb	292-312	7.5YR N2/	Black; gelatinous silt but with slightly more of a crumb texture (reddish brown color when wet); non-sticky, non-plastic; lower boundary abrupt.

Table 35 (cont).

Layer	Depth cm	Munsell Color (dry)	Sediment Description
IIIc	312-327	10YR 8/3 and 10YR 2/1	Very pale brown and black; banded silt with whitish specks; the specks appear as clusters of grains but do not have the texture of sand--they are interpreted as decomposed calcareous sand grains; non-sticky, non-plastic; lower boundary abrupt.
IIId	327-351	10YR 7/3	Very pale brown; very fine calcareous sand with numerous lenses, some irregular; slightly gelatinous texture; scattered pieces of black organic remains; non-sticky, non-plastic; lower boundary abrupt.
IIIe	351-390	10YR 6/2	Light brownish gray; very fine sand with little black pieces of organic material; no lenses but otherwise very similar to Layer IIId; becomes slightly lighter in color at 369 cm; slightly gelatinous texture; non-sticky, non-plastic; lower boundary abrupt.
IV	390-472	7.5YR N2/	Black; humic silt with some macro-organics; slightly gelatinous; non-sticky, non-plastic; gleyed clay band between 465-466 cm; lower boundary abrupt.
V	472-498	2.5Y 4/2	Dark grayish brown; gleyed clay with a few sand mottles; sticky, plastic; lower boundary abrupt.
VI	498+		Limestone.

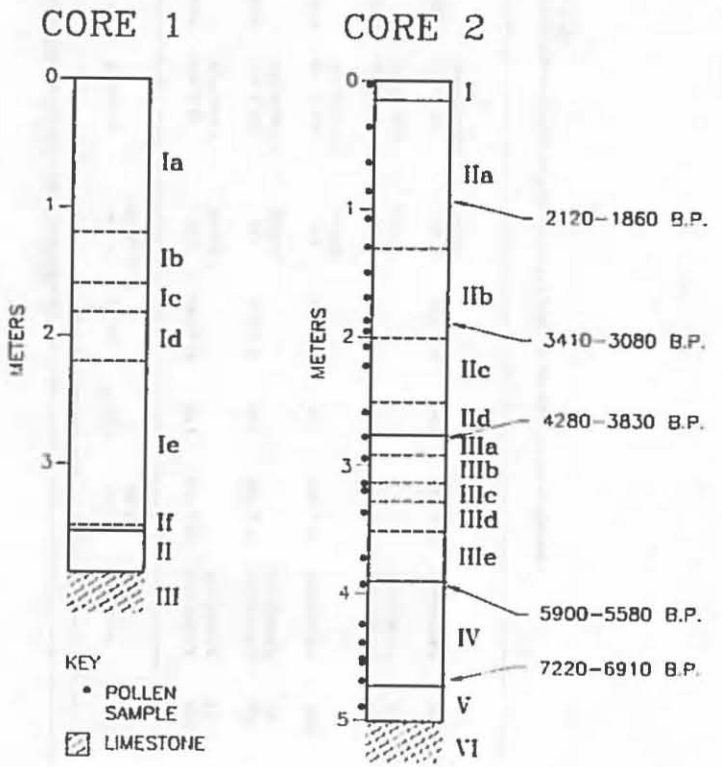

Figure 27. Profiles of Cores 1 and 2, Tipalao Marsh. Note locations of pollen and radiocarbon samples in Core 2. The radiocarbon dates represent the most probable calibrated date range at a 95% confidence interval.

period that sediment has accumulated in the basin. However, there are a number of details that point to a rather complex depositional history.

An obvious and interesting question concerning the cores is how to interpret the pronounced sedimentological difference between Cores 1 and 2, which are separated by only about 60 meters. A major aspect of this difference concerns the fact that there that there is no corollary to Layer III of Core 2 in Core 1. A possible clue to the reason behind this may have to do with the very different elevations of the limestone bedrock and the gleyed clay layer between the two cores. Although an uneven substrate is not unusual in itself, the formation of the same gleyed clay layer of the same approximate thickness at very different elevations does seem unusual. In consideration of how clay layers usually form--alternating wet and dry conditions--and the fact that the rise in sea level probably created a broad and very shallow protected estuary, it is difficult to account for the same clay layer forming at very different elevations. If the water had been deep, presumably this would have precluded the alternating wet and dry conditions needed to form the clay layer. Because of this it is postulated that following the formation of the clay layer, there was vertical movement along an underlying fault in which one side was displaced with respect to the other. This displacement created a basin in the Core 2 area which allowed the retention of standing water. With rain and runoff, this portion of the basin became largely a freshwater pond. This accounts for the presence of *Botryococcus* and the gelatinous sediment of Layer III in Core 2. The Core 1 side of the Marsh evidently was more of a wetland covered with vegetation, presumably mangrove trees, given the pollen findings for Layer III of Core 2 (see below).

If the above explanation is correct, the sediment sequence of Core 1 should include the entire temporal span as represented in Core 2 notwithstanding the absence of a definite Layer III counterpart in Core 1. While the fault model can be hardly considered proven with the available evidence, there is as yet no equally satisfactory alternative explanation. Because of funding constraints, pollen analysis and radiocarbon dating was restricted to just one core--that of Core 2. However, it is hoped that Core 1 can be eventually fully analyzed, and perhaps this will provide further insight into the problem.

Chronology of Core 2 and Interpretation of Sediments

In order to obtain an absolute age for the Tipalao Marsh sediments, five radiocarbon samples of sediment were submitted from Core 2 to Beta Analytic Inc. for dating. The resulting dates and other relevant information concerning the samples are presented in Table 36. The samples have all been adjusted for isotopic fractionation and calibrated using the CALIB 3.0 computer program of Stuiver and Reimer (1993). The sediment profile of Core 2 also shows the dates along with their stratigraphic locations. As may be seen, all samples are in proper stratigraphic order, and the dates illustrate a reasonable progression of age with depth. These factors suggest that all of the dates provide an accurate approximation of the age of the samples. As may be seen, Core 2 clearly encompasses all but the earliest part of the Holocene.

Table 36. Radiocarbon dating results, Core 2, Tipalao Marsh, Guam

Area	Cat. #	Beta #	Provenience	Weight/ Material g	Age B.P.	C13/C12	Adjusted Age B.P.	Calibrated Age*	Probability
Tipalao Marsh	Tip 88-97	63487	Core 2, IIa, 88-97 cm b.s.	122.0 sediment	2060 ± 60	-27.4	2030 ± 60	2120-1860 B.P. 1850-1820 B.P.	96 % 3 %
Tipalao Marsh	Tip 185-190	60077	Core 2, IIb, 185-190 cm b.s.	80.2 sediment	3130 ± 70	-28.6	3080 ± 70	3410-3080 B.P. 3450-3430 B.P.	98 % 2 %
Tipalao Marsh	Tip 275-280	60078	Core 2, IIIa, 275-280 cm b.s.	74.7 sediment	3670 ± 80	-23.1	3700 ± 80	4280-3830 B.P.	100%
Tipalao Marsh	Tip 390-395	60079	Core 2, IV, 390-395 cm b.s.	74.3 sediment	4950 ± 80	-28.3	4950 ± 80	5900-5580 B.P. 5510-5490 B.P.	93 % 2 %
Tipalao Marsh	Tip 464-472	60080	Core 2, IV, 464-472 cm b.s.	136.4 sediment	6210 ± 70	-24.8	6210 ± 70	7220-6910 B.P.	100%

* Calibration from Calib 3.0 computer program of Stuiver and Reimer (1993); 95% probability age range. For data set references see volume 35 of *Radiocarbon* (1993).

The radiocarbon dates can be used to determine sediment accumulation rates, which are an important source of information on infilling processes and the environment. Sediment accumulation rates also make it possible to obtain specific dates along any point of the core. Although this can be accomplished by hand, a computer program prepared by Louis J. Maher, Jr., the DEP-AGE program, is much faster and provides more information (see Maher 1992:13-17). The program has the advantage of providing a series of alternative mathematical models for determining sediment accumulation rates.

Although there is no way of knowing with certainty which model is the correct one without running a large number of radiocarbon dates, most can be easily eliminated from consideration because they incorporate features that obviously do not fit the particular coring situation. For the present study, only two models, illustrated as graphs in Figures 28 and 29, seem worth consideration. These consist of a graph derived from a 3-degree polynomial function (Fig. 28) and a simple linear interpolation graph based on connecting the mid-points of all the radiocarbon dates (Fig. 29). A comparison of ages and sediment accumulation rates at 1-meter intervals is presented in Table 37. Although there is relatively little difference between the two graphs, for purposes of the present discussion the polynomial model is preferred. This is because of its smooth transitions between the radiocarbon dates rather than sharp disjunctions (it is unrealistic to assume that all the sediment accumulation rates just happen to change exactly where the radiocarbon samples were taken). In any case, the difference between the two models is negligible. While interpolated sediment accumulation dates appear to represent precise age determinations, they are based on radiocarbon dates and therefore must be regarded as only approximations of the true age.

Using the polynomial model, the ages of all of the sedimentary units in Core 2 are presented in Table 38. As may be seen, the base of the core has an age of 7924 years (the linear model indicates 7627 years). The significance of this date is that it indicates the time that the limestone shelf of the east end of Orote Peninsula became submerged following the end of the Pleistocene. Although local tectonic factors cannot be ruled out, it is almost certain that sea level rise following the retreat of continental glaciers was the primary cause of this submergence.

As the present surface of the marsh has an elevation of approximately 1.5 to 2.1 m above mean sea level, the limestone surface at the base of Core 2 (5 m below the surface) is 3.2 m below present mean sea level. Since there is no data anywhere to suggest a sea level rise of this magnitude (independent of tectonic processes) following its initial post-glacial rise, it is clear that other processes--i.e., tectonic factors--have been operative in the Tipalao basin. Evidence for downward displacement of the Core 2 side of the basin following deposition of the gleyed clay layer has already been presented. Such downward displacement has apparently occurred throughout the entire period represented by the Tipalao sequence. Since the gleyed clay layer formed between 7206 and 7869 years B.P., initial tectonic activity is recorded just after this time with the formation of Layer III.

The time represented by the formation of glayed clay layer, perhaps 800 or so years, may also be indicative of a brief pause in sea level rise. With the alternating

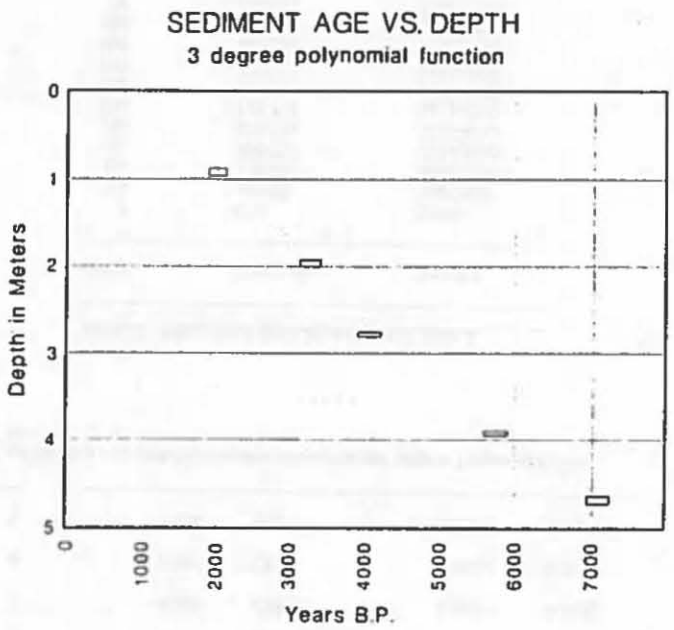

Figure 28. Sediment accumulation graph for Core 2 using a 3-degree polynomial function. Radiocarbon dates are calibrated at 1 sigma confidence interval.

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wetting and drying of a tidal estuary, there was time for the clay particles to settle out of sediment eroded from the Tipalao catchment area, which thereby facilitated the formation of an impermeable layer on top of the limestone. It is probably not a coincidence that this date is just the time that Shackleton's (1987, as presented in Dawson 1992:224) oxygen isotope curve (planktonic and benthonic ^{18}O data) of global sea level history indicates a pause during the post-glacial rise of sea level. It is also just the time when marsh formation is first known to occur in Hawaii following Pleistocene sea level rise (Athens *et al.* in prep.).

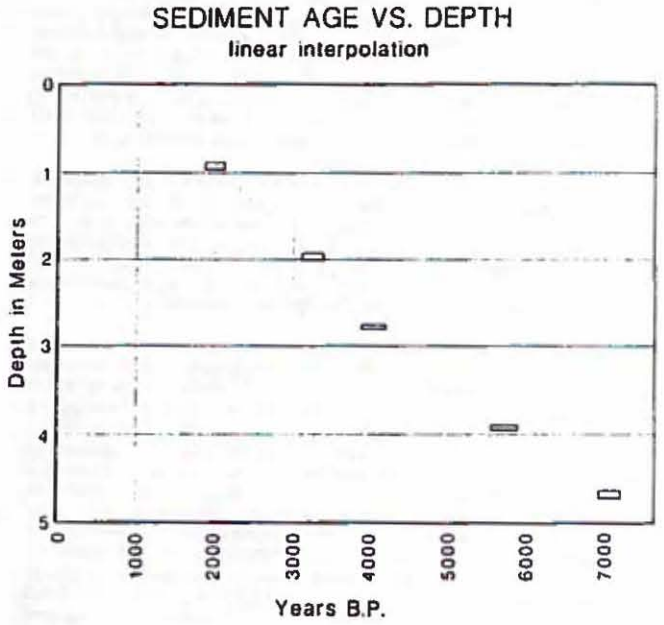

Figure 29. Sediment accumulation graph for Core 2 using linear interpolation. Radiocarbon dates are calibrated at 1 sigma confidence interval.

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With the presumed continued rise of sea level after the pause, the Tipalan basin would be expected to became even more under the influence of marine conditions. Initially, this does in fact seem to be the case. Layer IIIe and IIId to some extent, which are just above the clay layer, consist largely of very fine calcareous sand. This clearly suggests a direct marine influence, albeit one in a very low energy environment. The dates for this time period, from the base of IIIe to the top of IIId, are 5589 to 4705 years B.P.

Table 37. Age and sediment accumulation rate at 1-meter intervals for Core 2.

Depth m	Age B.P.*		Sediment Accumulation Rate cm/yr	
	Polynomial	Linear	Polynomial	Linear
surface	0	0	-	-
1	2,030	2,081	0.0641	0.0829
2	3,314	3,280	0.0914	0.1000
3	4,387	4,385	0.0881	0.0682
4	5,754	5,872	0.0594	0.0570
5	7,924	7,627	0.0365	0.0570

* age based on most probable calibrated radiocarbon date range at 1 sigma confidence interval.

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Table 38. Interpolated dates for soil layers, Core 2.

Layer	Depth cm	Age B.P.
I	0-14	0-368
IIa	14-130	368-2468
IIb	130-200	2468-3314
IIc	200-250	3314-3845
IId	250-275	3845-4111
IIIa	275-292	4111-4297
IIIb	292-312	4297-4525
IIIc	312-327	4525-4705
IIId	327-351	4705-5015
IIIe	351-390	5015-5589
IV	390-472	5589-7206
V	472-498	7206-7924
VI	498+	7924

Interpolated ages based on 3 degree polynomial function regression model from DEP-AGE program of Maher (1992). Total of 5 calibrated radiocarbon dates used in program.

The rest of Layer III, up to its top at 2.75 m, however is of quite a different character. Here the sediment becomes silt that is quite gelatinous and the sand disappears. As already noted, the gelatinous texture is produced by *Botryococcus*, a freshwater alga. Pollen analysis, furthermore, indicates an abundance of the tidal mangrove species, *Rhizophora*. It is clear, therefore, that the basin has become much more isolated from marine influence, which essentially occurs at the base of Layer IIIc, which dates to 4705 years B.P.

The only problem with the above scenario is that tectonic processes, as previously discussed, come into play at this time and supposedly cause the downward displacement of the Core 2 side of the basin. The net effect, therefore, should be a much more pronounced marine influence--the sea water could now rush into the basin--rather than just the opposite as the data so clearly indicate. The only explanation that can be offered at this time is that downward displacement was accompanied by the upward building of a berm along the east coastline of Inner Apra Harbor, and that this thereby prevented an active marine transgression. The sand at the base of Layer III, which is very fine and homogenous, may have derived from such a berm, which could have been created by a storm event or perhaps more gradual processes. Following this, sedimentary deposition, aided by the development of a mangrove forest, kept pace with downward displacement. Water was too deep within the the Core 2 area, however, for mangrove colonization, though it may have grown in the vicinity of Core 1. Since *Botryococcus* is a freshwater alga, rainwater runoff must have collected and remained as standing water in the basin around Core 2.

Layers I and II are very closely related, consisting largely of black humic silt and peaty sediments (though Layer I is actually a loam). The profile presumably represents a continuous sequence of sediment accumulation from the top of Layer III, beginning about 4111 years B.P. and lasting until the present day. Radiocarbon dates of 3410-3080 years B.P. at 185-190 cm and 2120-1860 years B.P. at 88-97 cm suggest that this is indeed the case. The black organic-rich sediments of Layers I and II also indicate a productive wetland community within the marsh basin. Apparently standing water no longer accumulated in the basin, or at least it was sufficiently intermittent to prevent or minimize the growth of *Botryococcus*. Interaction with the sea cannot be detected on the basis of sedimentological or pollen evidence. Presumably there was continued gradual downward displacement of the Core 2 area.

Palynomorphs and Other Microfossils

Twenty six sediment samples from Core 2 were processed for pollen analysis in the usual manner for Pacific lowland sediments using HCl to dissolve carbonates, KOH to solubilize organics, HF to dissolve silica, acetolysis solution to break down the cellulose, and dilute HNO3 to oxidize the remaining microscopic plant debris, including lignin. This procedure largely follows Herngreen (n.d) except that the resulting residue was mixed in a Calgon solution to float off the finest clay-sized fraction. Some samples from Layer III contained so much oil produced by the *Botryococcus* colonies that a preliminary acetone rinse had to be used before continuing with the aqueous extraction process. The pollen residue was then mounted in glycerine jelly (Erdtman 1960), which has a favorable index of refraction for viewing and photographing palynomorphs (pollen, spores, and other organic-walled microfossils). Photomicrographs were taken of selected palynomorphs and these are shown in Plates 1 and 2.

Palynomorph Types Recovered

Palynomorph preservation in the core was not consistent from interval to interval, which probably resulted from oxidation of the organics due to sediment mixing or exposure to a well-aerated aqueous environment. Counts of palynomorphs in intervals that were too low to use for comparative purposes in the pollen diagram are given in Table 39; these are samples from 167-169 cm, 195-196 cm, 258-260 cm, 294-296 cm, 311-317 cm, 319-321 cm, 450-452 cm, and 488-490 cm with total sums all around 100 or less (see pollen and spore totals in Table 39 and Fig. 30--see also Table 40). In addition, five intervals contained pollen sums around 60 or less but were included since the combined sum with spores was over 200; these are 84-86 cm with 57, 128-130 cm with 43, 336-338 cm with 63, 423-425 cm with 7, and 436-441 with 50 pollen grains. A pollen sum of 200 is considered sufficient to provide statistical reliability for most situations. However, for Pacific samples with high spore counts it may be preferable to attain a count of 200 pollen grains of extra-local and regional types, excluding the local and aquatic forms. If the locally derived pollen is included in the pollen sum it will produce a corresponding decrease in the other sum components (Moore *et al.* 1991).

Palynomorphs were identified using published pollen floras that include Pacific types, chiefly Selling (1946, 1947) for Hawai'i, Cranwell (1953) for New Zealand, Huang (1972) for Taiwan, along with a personal (i.e., Ward) reference collection of pollen and spores from Guam. In addition, Roubik and Moreno (1991), even though a Neotropical reference, was useful in keying out unknowns into broad taxonomic groups. Two slides were counted per sample, each with a 22 X 40 mm cover glass area to arrive at a pollen sum based on total pollen and spores.

Table 39 lists the pollen, spores, and other types by sediment depth in cm., and Table 40 provides age determinations for each sample interval as derived from the DEP-AGE program in addition to information on palynomorph abundance and charcoal particle abundance. The pollen types are placed in broad ecological categories: Dryland or Coastal types, which may include some species more at home in upland or wet-mesic forest environments such as *Elaeocarpus*, *Freycinetia*, *Wikstroemia* and certain Urticaceae with 31 taxa, Mangrove forest with three taxa, Herbs, comprised mainly of grasses and sedges, with 8 taxa, and 10 unknown types which largely belong to the first-named group. The pteridophyte spores are listed by aperture type, whether monolete or trilete, and secondly by sculpture type if the species was not readily identified or was of a generalized morphology. Monolete spores number 7 while there were 9 in the trilete group, including three species of *Lycopodium* and *Selaginella*, actually more primitive than ferns and called 'fern allies.' Other types of palynomorphs include stellate hairs or trichomes from leaf surfaces and microforaminifera indicative of marine conditions. Other types seen freely in the microscope slides but excluded from the palynomorph sum include fungal spores, plant cuticle, conducting tissue, and amorphous plant debris. The only algal type present was that

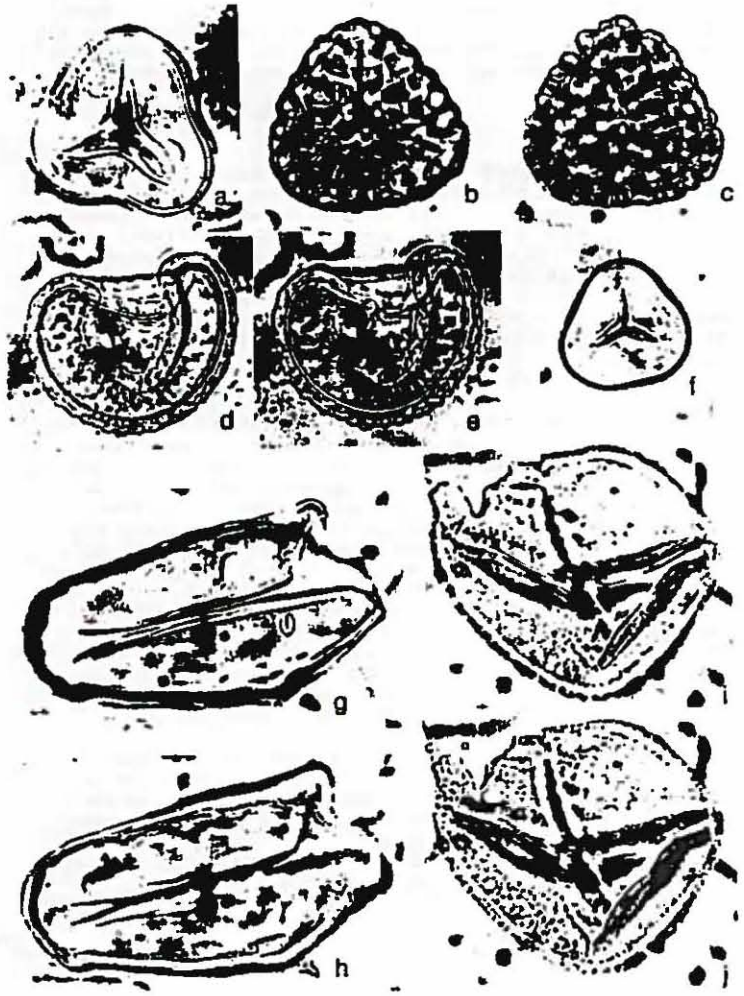

Plate 1. **Photomicrographs of pollen and spores:** Figs. 'a' through 'f' 400 X. Figs. 'g' through 'j' 1,000 X. A) *Acrostichum aureum*, 59-61 cm; b & c) *Lygodium*, 222-224 cm; d & e) Monolete, verrucate type, 59-61 cm; f) Trilete, psilate type, possibly *Adiantum*, 59-61 cm; g & h) Cyathea-morphic, 222-224 cm; i & j) Araceae, spiny type, 336-338 cm.

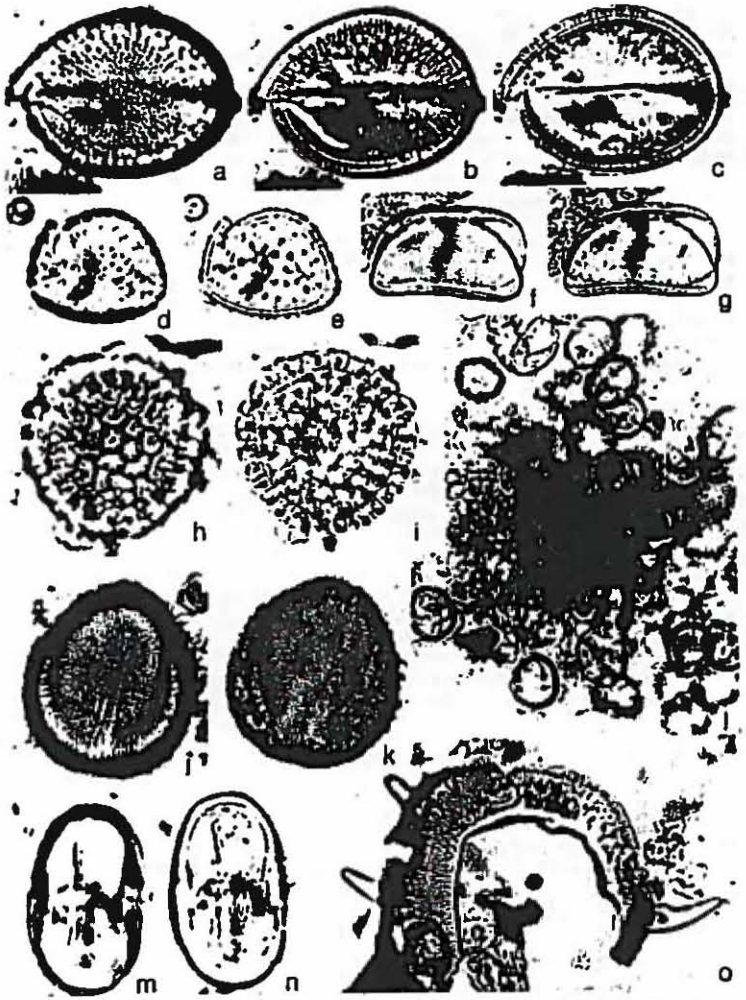

Plate 2. **Photomicrographs of pollen and spores:** Figs. 'a' through 'c', 'h', 'i', 'm', and 'o' 1,000 X. Figs. 'd', 'e', 'f', 'g', 'j', 'k', 'l', and 'n' 400 X. A, b, & c) Monosulcate, foveolate/reticulate, 140-142 cm; d & e) *Pandanus*, 270-278 cm; f & g) *Meyenxylon emarginata*, 336-338; h & i) Rubiaceae type, 336-338; j & k) *Pinonia*, 319-321 cm; l) Clump of *Rhizophora* pollen, 319-321 cm; m & n) *Proserpinaca*, 467-469 cm; o) Fragment of *Hibiscus tiliaceus* pollen, 222-224 cm.

Table 39. Pollen and spores from Core 2, Tipalao Marsh, Guam. The sample numbers are given as depths in cm.

	0-3	36-38	62-64	84-86	105-110	128-130	146-152	167-169	184-190	195-196	205-211	222-224	258-260
Species or type													
Marker	57	160	130	52	115	3	5	6	63	14	101	74	70
Pollen:													
Dryland or coastal types:													
Aeschynomene indica	2	1											
Areca catechu							17	3	1				
Arthacese		1	3				1					1	
Artocarpus	4												
Asteraceae (high spine)	3		4										
Barringtonia	2	1	1		1		17		1		1	1	
Casuarina equisetifolia	86		2		2								
Cocos nucifera	5	60	62	5	27	3	2	1			1	14	
Cyrtandra curvisepala	1												
Elaeocarpus ?							6					1	
Erythrina	1	1	4	1	1		1				1		
Euphorbia	2												
Gerrera					1								
Hibiscus tiliaceus	1				2							1	
H. sp	4		2		1							1	
Macaranga thompsonii	3	1										3	
Myrsinaceae					2		3					3	
Pandanus	4		2	5	181	25	63		85	7	41	125	1
Phyllanthus saffordii		1	1				1						
Pouteria			1				1	1					
Rubiaceae	1				1	1	1		1				
Sida	1												

Table 39 (cont.).

	0-3	36-38	62-64	84-86	105-110	128-130	146-152	167-169	184-190	195-196	205-211	222-224	258-260
Terminalia		2	2		1		5	1	1			2	
Trumfetta pentandra ?							3		1	1			
Wikstroemia elliptica			2										
Mangrove forest types:													
Bruguiera gymnorhiza	4												
Lumnitzera littorea		2			1								
Rhizophora	13		2	2	10				5		1	2	3
Herbs:													
Araceae, spiky						10	2						
Chenopam	3											1	
Chenopam (reticulate)			1										
Cyperaceae	30	84	45	41	19	2	5		103		23	10	15
Ipomoea												1	
Liliaceae		1					1					1	
Poaceae	13	5	109	2	1							6	1
Poaceae giant	1												
Unknown types													
Tricolpate, coarse reticulate	11				3		73				1	3	
Tricolporoidate, granulate	2												
Tricolporate, reticulate		1	3		3	2	3		1	1	1	1	
Tricolporate, retic., very coarse, lg	1						1						
Tricolporate, retic., loose sexine		1	2										
Tricolporate, granulate		2	1	1		1	12			3		1	

Table 39 (cont.)

	0-3	36-38	62-64	84-86	105-110	128-130	146-152	167-169	184-190	193-196	205-211	222-224	258-260
Trapaceae, verrucate		13											
Monocolpate, low spines			9									1	
Monocolpate, fovea/rugu.					1	1			8	5	3	6	
Total pollen	197	177	258	57	258	43	218	6	207	19	73	187	20
Fern spores													
Monolete													
Thelypteris interrupta*	123	190	331									143	
Polypodium psilostelum type	7			1	74	46	42	8	8	5	7	46	
granulate	81	30	34	7	39	14	47		8	2		25	3
lg. granulate	18	36	12	1	42	18	4			7		43	
psilate	230	19	27	2	27	5	29	5	1	3	14	117	2
verrucate	2		143	13		29	60	1	41		165	65	8
fine verrucate				16	207	24	77	23	180	14	2		
Trilete													
Acrostichum aureum	179	141	316	224	308	54	119	14	195	5	100	228	4
Gleichenia lineata			1	1								5	
Lygodium	150	3			3	5		1			3	27	
Lycopodium cernuum	3	1	1										
Pteris			3		2								
psilate	2	4	16	1	1	27							
fine reticulate		62											
Total spores	775	486	1084	268	701	222	358	52	413	36	291	709	17
Total	972	663	1342	325	959	265	576	58	620	55	364	896	37

Table 39 (cont.).

	276-278	294-296	311-317	319-321	336-338	371-373	392-394	423-425	436-441	450-452	452-457	467-469	488-490
Species or type													
Marker	31	31	201	58	305	333	3	57	178	0	119	433	31
Pollen													
Dryland or coastal types													
Aeschynomene indica									2			11	
Avena sativa							1						
Amaranthus (high-spine)						1							
Bertagnona	1												
Casuarina equisetifolia			1										
Cocos nucifera	1			1									
cf. Dunalia rufescens												1	1
Ehretiaceae ?								1				1	
Erythrina							1						
Fagraeaceae									1		1		
Grevea			1										
Mascarenga thompsonii	3							1					
Maurocyclus ammarum					2							1	
Myrtaceae						1	2	2				10	
Pandanus	72			10	12	8	8	1	33	2	6	420	
Poaceae			1	1	1	1						2	
Poaceae						1						1	
Rubiaceae	1			2	5								
Solanaceae									1				
Terminalia	1			1	1			1	5			534	
Tremolata procumbens ?									1		1	43	
Urticaceae												1	

Table 39 (cont.).

	276-278	294-296	311-317	319-321	336-338	371-373	392-394	423-425	436-441	450-452	452-457	467-469	488-490
Mangrove form types:													
Bruguiera gymnorrhiza	16					38							
Rhizophora	98		6		35	162							
Herbs:													
Acrostichum aureum	2				2								
Chenopodium	2											1	
Chenopodium (reticulate)												5	3
Cyperaceae	1					14	392					1	
Poaceae	1					1						10	
Unknown types:													
Tricolpate, coarse reticulate	1						1						
Tricolporoidate, granulate				1									
Tricolporate, psilate												17	
Tricolporate, reticulate	2		2	11	3		1	1	2				
Tricolporate, granulate	7					3			1		3	54	2
Monocolpate, low spines					1				3			1	
Monocolpate, foveolate	9					5			1				
Total pollen	223	0	11	28	63	227	406	7	50	2	11	1112	6
Fern spores:													
Monolete:													
Polypodium pallidum type	36	1	2	35	65	10	10	3					
granulate	1		1	2	5	2	2						2
lg. granulate	3			2									
psilate	38		6	2	12	15	12	1	7		8	91	3

Table 39 (cont.).

	276-278	294-296	311-317	319-321	336-338	371-373	392-394	423-425	436-441	450-452	452-457	467-469	488-490
verrucate	5		26	1			1		29		6		
fine verrucate	22			7	10	10		1					
Trilete:													
Acrostichum aureum	329		21	12	163	29	100	214	343	37	405	422	
Gleichenia linearis												1	
Lygodium				1		2							
Lycopodium cernuum												1	
L. phlegmaria					1							2	
Pteris	1				2		4	2				5	13
Selaginella												1	
psilate				11					2				
Total spores:	435	1	56	73	258	68	129	221	381	37	417	523	18
Other types:													
Setiate hairs	20		2			1							
Microforaminifera								49	3			7	
Total	678	1	67	101	321	306	535	277	431	39	428	1642	24

Table 40. Interpolated dates for pollen samples, samples with low palynomorph counts, and charcoal particle abundance, Core 2.

Sample Number		Age[1] Years B.P.	Low[2] Palynomorph Counts	Charcoal[3] Particles
Tip 2	0-3	53	-	C
Tip 2	36-38	883	-	C
Tip 2	62-64	1399	-	S
Tip 2	84-86	1787	-	-
Tip 2	105-110	2,145	-	R
Tip 2	128-130	2454	-	R
Tip 2	146-152	2718	-	R
Tip 2	167-169	2951	X	-
Tip 2	184-190	3170	-	-
Tip 2	195-196	3265	X	-
Tip 2	205-211	3401	-	R
Tip 2	222-224	3561	-	R
Tip 2	258-260	3940	X	-
Tip 2	276-278	4132	-	-
Tip 2	294-296	4330	X	-
Tip 2	311-317	4549	X	-
Tip 2	319-321	4620	X	-
Tip 2	336-338	4831	-	-
Tip 2	371-373	5312	-	-
Tip 2	392-394	5638	-	-
Tip 2	423-425	6182	-	-
Tip 2	436-441	6466	-	-
Tip 2	450-452	6728	X	-
Tip 2	452-457	6805	-	-
Tip 2	467-469	7111	-	-
Tip 2	488-490	7630	X	-

[1] Interpolated ages based on 3 degree polynomial function regression model from DEP-AGE program of Maher (1992). Total of 5 calibrated radiocarbon dates used in program.

[2] X = low palynomorph count; less than 100 in total.

[3] Scale utilized is Abundant, Common, Sparse, and Rare.

* * * * *

of *Botryococcus*, a colonial green alga which produces large amounts of oil inits cells that are embedded in an orange-colored mucilagious sheath (Prescott 1962, Smith 1950). *Botryococcus* is a widely distributed type occurring in freshwater pools or lakes. According to Round (1981), *Botryococcus* occurs freely in eutrophic (nutrient rich) aquatic ecosystems. In the Tipalao core it occured abundantly in the six Layer III samples from 276 to 373 cm, which had a largely reddish-brown color before drying (except near the base, which was sandy).

In Table 41 the unknowns or tentatively identified pollen types are listed by aperture and sculpture type. In general these types comprise a low relative percentage of the pollen flora. The exceptions include the 140-142 cm interval with 15% contributed by the coarsely reticulate tricolpate, and the 319-321 cm interval where the tricolporate reticulate type assumes 12% of the total. Additional modern pollen reference material is currently being prepared to assist in the identification of these unknowns.

Pollen Zones and Assemblages

A pollen and spore diagram for the Tipalao Marsh assemblage is shown in Figure 30 and is based on a sum of total pollen and spores. These data are summarized in Table 42, which lists pollen Zones 1 through 4, the lower and upper of which are subdivided into zones 'a' and 'b.' The sediment layer designations are shown here for comparison.

The diagram (Fig. 30) shows an overall abundance of *Acrostichum* spores, which peak in Zone 1b but remain conspicuous throughout. By way of comparison, the abundance of *Acrostichum* spores were recorded throughout a 1 km mangrove transect on Tonga. The results indicated close to 100 percent of the spores at the lagoon fringe, between 20-50 percent in the mid-mangrove community, and 10 percent or less in the more landward sampling locations along with over 50 percent non-mangrove species (Ellison 1989).

The Tipalao diagram also shows *Pandanus* in almost every sample, though it dominates the pollen portion of the diagram only in Zone 3.

The basal zone, divided into Zones 1a and 1b due to the dominance of taxa, represents a marine deposit in part based on the presence of microforaminifera (Table 39). In Zone 1a, represented essentially by the 467-469 cm interval since the basal sample was not plotted, *Terminalia** and *Pandanus* attain the highest levels in the core with 33 and 26 percent, respectively. At this interval ferns hold to low levels, *Acros*

* Two species of *Terminalia* are reported for Guam: *T. catappa* and *T. latoralis*. The former is a medium to large tree, often cultivated, that grows in the uplands, but is also found on the edge of beaches. Stone (1970:440) reports that "[*T. catappa*] is not particularly common in Guam but is being planted now more extensively." The latter species is a shrub or small tree, always found in littoral areas, on the beach, or among coral boulders (Stone 1970:439-440). Until reference pollen can be checked for *T. latoralis*, it is not know if these species can be distinguished palynologically.

Table 41. List of unknown or tentatively identified pollen types.

Aperture Morphology	Sculpture Type	Remarks
tricolpate	coarse reticulate, ca. 75 μm	very conspicuous grain
tricolporoidate	granulate, ca 30 μm	aperture margins jagged
tricolporate	reticulate, 18-30 μm	generalized type representing several species
tricolporate	granulate, ca. 28 μm	thin-walled, rhomboidal, small pores, legume?
tricolporate	psilate, ca. 25 μm	
tricolporate	reticulate, ca. 50 μm	very coarse reticulum, thin-walled, large grain
tricolporate	reticulate, ca. 30 μm	sexine disattached from nexine layer, Rosaceae?
triporate	verrucate, ca. 30-35 μm	similar to Ulmaceae
triporate	psilate to granulate, ca. 35 μm	listed as Triumfetta?
Monosulcate	granulate with spines 1 μm long, overall ca. 60 μm	spherical grain, palm?
Monosulcate	foveolate to reticulate, ca. 30 μm	elliptical shape, thick-walled

* * * * *

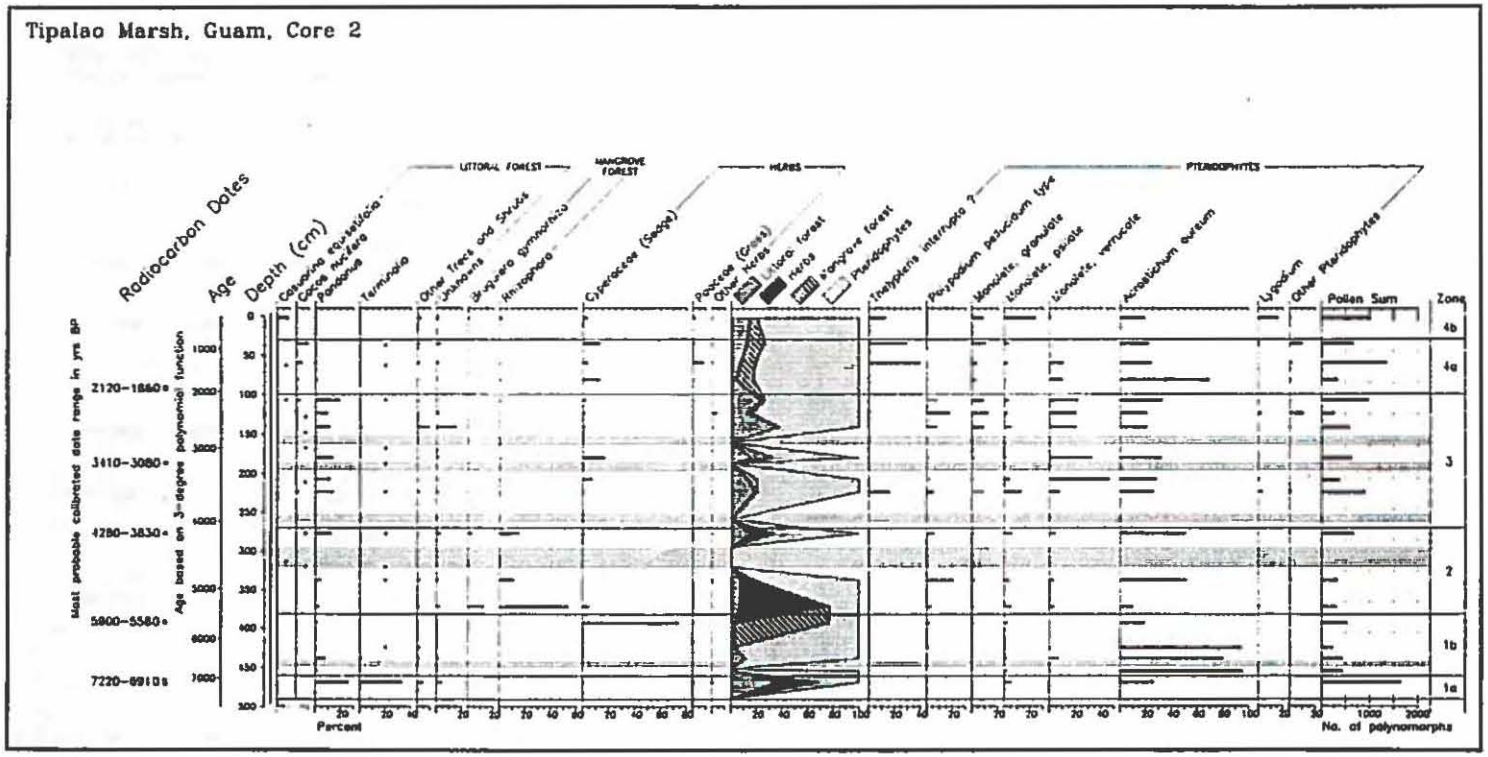

Figure 30. Pollen and spore percentage diagram from Core 2, Tipalao Marsh, Guam. Low count intervals are indicated with a screen pattern. Dots indicate presence (count too low to show graphically).

Table 42. Pollen zones compared to the sediment layers, showing the dominant types present in a given zone. The suggested environments of deposition are given at the right. Note that the zone intervals are discontinuous due to sampling gaps.

Pollen Zone	Depth cm	Sediment Layer	Dominant Types	Environment of Deposition
4b	0-3	I	*Casuarina*, monolete psilate, *Lygodium*, *Acrostichum*	freshwater marsh
4a	36-84	IIa	*Cocos*, Cyperaceae, Poaceae, *Thelypteris*, *Acrostichum*	freshwater marsh
3	105-260	IIb,c,d	*Pandanus*, various fern taxa	freshwater marsh
2	276-373	III	*Botryococcus* bloom, *Rhizophora*, *Bruguiera*, *Acrostichum*, *Polypodium pellucidum* type	mangrove swamp
1b	392-452	IV	Cyperaceae, *Acrostichum*	brackish marsh
1a	467-490	IV, V?	*Terminalia*, *Pandanus*	brackish swamp

* * * * *

tichum being chief among them at 26 percent. Because of the presence of abundant opaque sulfide (pyrite) spherules, Zone 1a, dating to ca. 7097 years B.P. at the 467-469 cm interval, is interpreted as representing a marine swamp with *Terminalia* and *Pandanus* growing on the margins. It is possible, however, that *Terminalia* was not restricted to the wetland margins but was much more abundant on the limestone plateau, perhaps due to more constant wet conditions (i.e., less pronounced seasonality) on Guam during this early time period. In this respect, its virtual disappearance from the pollen diagram in all later sampling intervals suggests that it may have once been more widespread than simply a wetland strand plant; otherwise the strand conditions must have been of a very different character than was the case for later periods.

The Zone 1b spectra from 392 to 457 cm display a loss of arboreal taxa with *Acrostichum* surging close to 95 percent in the 423-425 cm and 452-457 cm intervals, while Cyperaceae (sedge) achieves dominance in the next sample at 73 percent where *Acrostichum* is only 18 percent. This pollen zone, dating between 6805 and 5638 years B.P., is interpreted as having been deposited under brackish conditions with the indication that the salt-tolerent *Acrostichum* was present. The diminished levels of *Terminalia* and *Pandanus* in this zone, which were dominant types in Zone 1a, is difficult to understand. Although *Pandanus* is relatively common later in the profile, the *Terminalia* counts remain very low, suggesting a real difference in vegetation structure and not simply a sampling problem.

Pollen Zone 2, encompassing the interval from 276-373 cm, is dominated by the mangrove taxa *Rhizophora* and *Bruguiera*, which together reach over 65 percent in the basal sample, indicating mangrove conditions (Grindrod [1985] has shown that pollen samples containing over 50 percent mangrove taxa represent mangrove swamps). In the latter part of this zone, mangrove pollen falls to 15 percent or less, indicating an upper mangrove community or one marginal to the lagoon fringe. Other components in this zone include *Pandanus*, among the arboreal taxa, which ranges from 2 to 12 percent. *Acrostichum* is still dominant in this zone, making up 50 percent of the count at the 336 and 276 cm levels, while the *Polypodium pellucidum* type rises to about 20 percent in the former level. This zone, which dates between 5312 and 4132 years B.P., clearly indicates a marine incursion with the dominance of mangrove taxa. Abundant *Botryococcus* spores and organic debris are quite conspicuous in every sample of this zone, which accounts for the gelatinous silt as noted in the soil description (Table 35). The abundance of *Botryococcus* suggests the saline effect of the marine incursion was somehow mitigated and that brackish water conditions prevailed.

In pollen Zone 3, from 128 to 260 cm, the sampling location is once again dominanted by *Pandanus* among the pollen contributors. Several monolete fern groups begin to rise in importance in this zone, sharing dominance with *Acrostichum*, especially the verrucate type, and to a lesser extent the psilate, granulate, and *Polypodium pellucidum* types. Zone 3, which dates between 3975 and 2360 years B.P., is interpreted as representing a freshwater marsh.

Pollen Zone 4a from 36-86 cm is dominated by sedge and grass, *Cocos*, and among the pteridophytes, *Acrostichum* and *Thelypteris*, illustrated in Figure 29. *Acrostichum* continues to be abundant but its dominance is shared by *Thelypteris* in the upper levels of Zone 4a beginning with the 62-64 interval dating to about 1399 years B.P. Among the fern taxa, *Acrostichum* is always dominant, soaring to 69 percent in the 84-86 cm interval (1787 years B.P.). Somewhat unusually, *Thelypteris* suddenly appears in very high numbers at the 62-64 cm interval (1399 years B.P.) after a hiatus since the 222-224 cm interval.

Pollen Zone 4b, represented by a surface sample from 0-3 cm, contains a distinct microflora dominated by *Casuarina*, and four fern types as seen in Figure 30. The ferns, listed in order of dominance, are monolete psilate, *Acrostichum*, *Lygodium*, and *Thelypteris*. These palynomorph types are indicative of a freshwater marsh. The monolete psilate and *Lygodium* types suggest a disturbed habitat.

Charcoal Particles

Charcoal particles were observed during counting of the palynomorphs and data on its occurrence are presented in Table 40 (see Patterson *et al.* 1987 and Tolonen 1986 for discussions of the goals and methods of charcoal particle analysis). A qualitative estimate was used to determine the relative abundance using four increasing levels: rare, sparse, common, and abundant. All of the charcoal particles noted belonged to the woody, rather than grass or monocot category.

The charcoal particle data show an interesting pattern. Below the 222-224 cm interval dating to 3561 years B.P., there are no particles, suggesting that fire probably did not naturally occur on Guam. From this interval up through the 105-110 cm interval charcoal particles only rarely occur in most intervals, indicating that fire use was relatively constant in the environment but not widespread or intense for a long period of time. The advent of charcoal particles is presumably the result of human settlement on Guam beginning about 3561 years B.P. At the 62-64 cm interval the record of charcoal particles increases through to modern times, suggesting a greater prevalence of fire in the environment. The absence of charcoal particles in the 167-169 cm and 195-196 cm intervals may in part be explained by the poor palynomorph recovery in these intervals.

It is possible that much of the charcoal observed in the Tipalao core, consisting of very small particles, was wind-blown from a distant point of origin rather than having derived from burning within the Tipalao Marsh catchment area. Since none of the samples contained abundant charcoal, it would appear that fire was never heavily used in this part of Guam.

Record of Plant Introductions

Several pollen types were recovered from the Tipalao profile that are relevant the history of plant introductions on Guam. This discussion relies on the compilations of Micronesian dicotyledons by Fosberg *et al.* (1979) and monocotyledons by Fosberg *et al.* (1987) to determine whether a given taxon is endemic, indigenous, or naturalized. The latter category refers to plants introduced by man either directly or indirectly. For purposes of this study, it is not important to distinguish between endemic (found only on Guam) and indigenous (naturally occurring on Guam as well as other areas).

Artocarpus pollen was found in the surface sample only but this could be one of three species present on Guam today, *A. altilis*, *A. heterophyllus*, or *A. mariannensis*, the latter of which is considered indigenous. Based on the reference material available, *Artocarpus* pollen is uniform at the generic level so that species cannot be easily discerned.

Cocos nucifera pollen was seen most abundantly in the near surface samples to 105 cm (2145 years B.P.), but was also fairly abundant in the 222-224 cm interval (3561 years B.P.), followed by single grain occurrences at the 276-278 (4132 years B.P.) and 319-321 cm (4620 years B.P.) intervals. The sample from 222-224 dates to

the time of the earliest human settlers in the Mariana Islands. The occurrences below this date are well before the advent of the accepted time for initial human arrival. This information, therefore, suggests that coconut is probably indigenous, but that it arrived relatively late on Guam by natural means. Such an interpretation is in contrast to the Stone (1970:28) and Fosberg *et al.* (1987) listing of the species as naturalized (i.e., aboriginally introduced). Evidence for the late but natural arrival of coconut on Guam is suggested by the 467-469 cm sample, which contained an extremely abundant and well-preserved palynomorph assemblage. The absence of coconut from this interval suggests that it was not present along this coast of Guam some 7000 years ago.

Hibiscus tiliaceus pollen occurred in the surface sample and at 105-110 cm and 222-224 cm intervals, the latter dating to 3561 years B.P. Since Fosberg *et al.* (1979) list this species as indigenous, its presence should be expected throughout the profile. However, as its pollen has rarely been found in other tropical Pacific wetland deposits, even when these are in proximity to groves of *Hibiscus tiliaceus* (e.g., Kawainui Marsh, Oahu, Hawaii (Athens and Ward 1991), it is possible that the pollen does not preserve and/or disperse well. The other records of *Hibiscus* species from the surface, and the 59-61 cm and 105-110 cm intervals represent naturalized and perhaps indigenous species. *Hibiscus tiliaceus* is the only species known to be indigenous, while seven additional species are considered naturalized (Fosberg *et al.* 1979). Until additional pollen reference material is analyzed, it will be difficult to resolve this question.

Only six grains of the cheno-am type were recovered from throughout this profile. These represent pollen of the Chenopodiaceae and/or Amaranthaceae families, which are not distinguishable. Since all of the chenopods are naturalized while there are six species of indigenous amaranths, the record in prehistoric layers should represent that of the latter family. Closer to the surface a mixture of types would be expected.

A single grain of *Ipomoea* pollen was seen in the 222-224 cm (3561 years B.P.) sample, which keys to *I. batatas* based on overall dimensions, and also the size of the spines and pores. It would be premature to claim a record for this species at such an early date at Tipalao, however. There are twelve other species of *Ipomoea* found on Guam today, and five of these are indigenous. Morphological comparisons must be made of these species before the identification of *I. batatas* can be firmly established.

The record of *Casuarina equisetifolia* dominates the surface sample and appears in the 61 cm (1339 years B.P.), 105-110 cm (2145 years B.P.), and 311-317 cm (4549 years B.P.) intervals before disappearing entirely from the profile. Its appearance in the sample below the surface implies that it was definitely present during the prehistoric period and that the deepest occurrence suggests that it likely has a natural origin on Guam. This data appears to confirm the interpretations of Stone (1970:27) and Fosberg *et al.* (1979) that *Casuarina* is indigenous. The prehistoric occurrence of *Casuarina* in Guam has been also documented in deposits dating to about 1500 to 1000 years B.P. in the Agat area (Ward 1989).

Data Summary and Implications for Prehistory

Core 2 at Tipalao Marsh appears to encompass a continuous depositional sequence beginning about 7900 years ago following the post-Pleistocene rise in sea level. Although the pollen record is not as complete as would have been preferred, it is nevertheless sufficiently detailed and abundant to provide a solid interpretive base. Among the more important findings relating to the prehistory of Guam and land use on the Orote Peninsula are:

1. The record demonstrates that the basin in which Tipalao Marsh formed has undergone a series of environmental transformations since sediment first began to accumulate some 7900 years ago following the post-Pleistocene rise in sea level. These changes include both the depositional context within the marsh basin (primarily a result of tectonic processes and sea level change) and the vegetation within and surrounding the basin. Some of the late vegetational changes possibly may be attributed to human impacts and land use. However, the earlier transformations, predating 3500 years B.P., obviously do not involve human influence.

   The most significant late vegetational change, which presumably refers to the area surrounding the Tipalao wetland, concerns the rapid decline of *Pandanus* and "other" forest trees beginning after 105-110 cm interval, which dates to 2145 years B.P. in upper Zone 3. By the 128-130 cm interval, dating to 2454 years B.P., the "other" forest trees had declined to a very low percentage of the total pollen. Also, by the 84-86 cm interval, dating to 1787 years B.P., *Pandanus* has become only a very minor component of the overall vegetation record. Almost coincidentally, at 1399 years B.P. (the 62-64 cm interval), grass suddenly become a notable component of the vegetation record. This in particular suggests habitat disturbance within the watershed. The fact that the grass record then drops to a very low percentage at the 36-38 cm interval (883 years B.P.) and remains low until modern times may indicate agricultural abandonment of the peninsula during the historic period. However, such an interpretation is seemingly contradicted by a date of 883 years B.P. for this interval, which is about 300 to 400 years too old to be included in the period. It is quite possible, nevertheless, that the sediment accumulation curve from the the date was derived is not quite right, and that the date could actually be younger than presently indicated (note that 300 years encompasses only about 19 cm of sediment accumulation).

   Another interpretation for the fall in grass pollen late in the sequence concerns the possible establishment of intensive agriculture late in prehistory in Guam. As will noted, coconut pollen is quite high for both the 36-38 cm and 62-64 cm intervals, suggesting more intensive agricultural use of the land, which is also suggested by the higher charcoal particle counts for this time period (see below). If intensification involved the establishment of an agroforest, perhaps the amount of pioneering grasses would have been reduced following initial clearing. With this interpretation, there need not be any concern about the accuracy of the date for the 36-38 cm interval.

The extent to which the above vegetation changes reflect large-scale or major anthropogenic impacts such as recorded for the island of O'ahu in Hawaii (Athens *et al.* 1992) is unclear. Additional stratigraphic studies of pollen records elsewhere on Guam are needed to properly evaluate such an interpretation, as well as to confirm the Tipalao Marsh findings.

2. The preponderance of *Terminalia* in the early Zone 1a and its virtual disappearance from the other sampling intervals throughout the core suggests a very different kind of plant community for this time period than any presently known on Guam. *Pandanus* also reaches its peak during this period although it is again very abundant throughout Zone 3. If *Terminalia* had simply been growing as a wetland strand tree, a reasonable interpretation given its presently known habitat preferences, its presence should be more visible throughout the core. As this is *not* the case, the possibility must be considered that it was a prominent component of the limestone forest along with *Pandanus*. For this to have been the case, however, climatic conditions presumably would had to have been less seasonal and wetter. Whether or not this this was the case can only be securely determined with further coring studies covering a similar time period.

3. The record for the initial appearance of charcoal particles at 3561 years B.P. appears to coincide with the present understanding for the date of the first arrival of humans in the Mariana Islands, which is thought to have been roughly 3500 years ago based on archaeological data from Saipan (see Hunter-Anderson and Butler 1991:20-21). Prior to that time there is no indication for the occurrence of natural fires on Guam, at least in the Tipalao Marsh are area. This fact suggests that the charcoal is unlikely to be of natural origin, and is perhaps the result of burning for opening up small agricultural plots (to allow sunlight into the gardening area as well as to produce ash for fertilizer) by the earliest human settlers. The Tipalao charcoal, therefore, appears to confirm earlier evidence for the date of the initial arrival of humans in the Mariana Islands, as well as to document their presence in Guam by about 3,500 years B.P. Clear documentation of the earliest sites on Guam has remained elusive and problematical compared to the other Mariana Islands (see discussion in Athens 1986).

4. A long-standing research topic has concerned the question of whether the savanna vegetation of the interior of Guam is of natural or human origin (see Zan and Hunter-Anderson 1987). Believing that the hypothetical interior forests were removed by fire for indigenous agricultural expansion, an anthropogenic origin for the savannas, the result of a cycle of forest burning, farming, and eventual land degradation, has been assumed by many investigators. Countering this view, Zan and Hunter-Anderson (1987) argue persuasively for their natural origin, compiling an impressive body of botanical and geological evidence, archaeological and ethnographic data, and theory and logic to demonstrate their case. While the Tipalao charcoal data cannot address this broad question because of its location, it is of some interest to note that fire was evidently *not* part of the natural landscape in at least the Orote area until the arrival of humans. If there was a naturally occurring

savanna, and it seems likely that there was given the evidence of Zan and Hunter-Anderson (1987), fire evidently was not necessary to maintain it. However, this does not negate the possibility that fire could have been used during prehistoric time to expand an already existing savanna landscape.

5. Another interesting factor concerning the charcoal particles is that they do not become common until the 36 to 38 cm interval, which dates to about 883 years B.P. This date is particularly notable because it suggests that use of fire did not become common until almost precisely the time of the initial construction of the megalithic *latte* monuments. Because Tipalao Marsh is not connected to one of Guam's interior watersheds, the charcoal is almost certainly not derived from the interior uplands but rather derives from the vicinity of Tipalao Marsh (though at least some of the charcoal could have been wind-blown from distant sources). Thus, at approximately the time *latte* began to be built, there was a considerable intensification in the use of fire. Although this could have been for agricultural purposes, the establishment of an agroforest may actually have reduced the amount of open field burining in Guam at this time. The increased production of charcoal may actually be the result of general population growth and the increased number of cooking fires, trash burining in habitation areas, and fires needed for pottery making.

6. The record for the initial introduction of coconut to Guam appears to be the result of a natural rather than human mode of transport approximately 4620 years ago. Guam, however, appears not to be alone in the Pacific in being a recipient of this tree, apparently unaided by humans during the mid-Holocene. A long pollen record from Kosrae suggests that coconut only arrived late in the middle Holocene though well prior to initial human settlement (see Ward 1993, Athens 1993).

Although the possibility should be considered that coconuts could have been brought into Micronesia during the middle Holocene by one or more very early population radiations from the south or southwest. Settlements, however, were short lived and failed to become established, though coconut remained as a legacy of this earliest human endeavor in Micronesia. Unfortunately, however, there is as yet not the slightest independent evidence for an earlier period of human settlement on these islands.

Spriggs (1984, Hope and Spriggs 1982) reports the presence of coconut on Aneityum in Melanesia at about 5000 years B.P., which is substantially earlier than the earliest known human contact, suggesting its ability to naturally colonize Pacific islands. However, it is not known whether coconut actually arrived on Aneityum during the Holocene as seems to be the case in Micronesia. It was also present on Mangaia in the Southern Cook Islands during the entire 7000 year record of a core sequence (Kirch *et al.* 1992:175). This places it well before the arrival of humans. The natural colonization of coconut, therefore, would presumably have been widespread among islands in the southern tropical Pacific, which is perhaps not surprising since these areas are much closer to the possible source areas of natural-

ly dispersing coconuts (perhap the Solomon Islands, Vanuatu, and Fiji--see Spriggs 1984:74, citing Harries 1978) than Micronesia.

Additionally, in a preliminary report of an interesting and lengthy pollen record from Atiu in the Cook Islands, Flenley (n.d.) demonstrates the pre-human presence of coconut by about 5700 years B.P. when the pollen record first begins. Until about 4000 years B.P. it remains an important albeit minor component of the forest assemblage. Interestingly, however, coconut begins to increase dramatically after this time at the expense of other forest trees and another Palmae type. It then declines dramatically late in the prehistoric period. The Atiu record not only documents the pre-human presence of coconut, but it appears to show how dynamic the vegetation communities of some islands can be during the mid-Holocene prior to human influence (also see dramatic example natural change in Mangaia core sequence--Kirch *et al.* 1992:177).

Conclusion

The Tipalao Marsh core has provided a nearly 7900 year old continuous sedimentary sequence for Orote Peninsula, Guam. During this span of time a series of environmental changes have occured that are reflected in the sedimentary and palynological records. The earlier changes--before about 3500 years B.P.--are definitely of a natural origin, most likely related to tectonic processes, changing sea levels, possible climate change, and possible successional development within the wetland. After this date, these processes would have continued, though human settlement on Guam would have introduced another element of change.

One of the earliest changes has to do with the dominance of *Terminalia* and *Pandanus* some 7000 years ago. Although the importance of *Pandanus* in the limestone forest is not surprising, the apparent prevalence of *Terminalia* is quite unusual. Conceivably, this large tree was a component of the limestone forest and was not simply growing along the marsh edge. If so, this suggests a wetter or perhaps less seasonal climate for Guam during the early Holocene.

The presence of human occupation is first evident in the core sequence about 3500 years B. when charcoal particles first appear in the sequence. At 1399 years B.P. the quantity of charcoal particles begins to increase, and by 883 years B.P. they are common in the record. Also, there is an abundance of grass pollen for the first time at 1399 years B.P. The former suggests increased human activities, while the latter suggests a sudden increase in the amount of landscape disturbance possibly related to agricultural practices and population increase.

A substantial transformation of the regional (as opposed to wetland) vegetation types is suggested by the steep decline in *Pandanus* and "other" tree species, which began just after 2145 years B.P. The mechanism behind this transformation is unclear. Dates from various paleoenvironmental records in the tropical Pacific that are suggestive of climatic change as opposed to human impacts (see especially the Mangaia record--Kirch *et al.* 1992) do not seem to coincide with the Tipalao record. It is perhaps more likely that changes in Tipalao core are related to prehistoric Chamorro

population growth and expansion of agricultural production. The decline overlaps with increases in both grass pollen and charcoal particles.

The documentation of coconut at 4620 years B.P. suggests that it arrived in Guam without the aid of human transport. At 3561 years B.P. the frequency of coconut pollen increases substantially for just the one sampling interval at 222-224 cm. It does not again become pronounced in the record until about 2145 years B.P. at 105-110 cm, and it remains significant until the modern sample. The late increase in coconut appears to coincide with the decline in *Pandanus*.

XI: CONCLUSION AND RECOMMENDATIONS

Project Assessment: Completion of Scope of Work

In general, the entire set of fieldwork activities mandated by the scope of work was completed. Despite less than ideal field conditions, all archaeological fieldwork was completed on schedule (although the environmental coring was postponed due to inclement weather) and all areas were surveyed carefully and with the same level of diligence. However, it is still possible that a prehistoric site, historic feature, or more likely, an isolated artifact or two went undiscovered by the field crew. All surveys were thorough, but the rugged topography coupled with the dense vegetation found in much of the project area made one hundred percent coverage very difficult. While it is probable that a few isolated artifacts were missed in the pit and pinnacle landscape of Areas A and B, or the tall grass of Area K, this could not be helped. On the other hand, larger, more substantial sites such as foxholes may have gone undiscovered, but this should only be considered a possibility not a probability.

Two general factors greatly affected the fieldwork and the overall execution of the project. One of these factors is virtually beyond the control of planners, engineers, and archaeologists; but the other is a managerial consideration which was extremely valuable and highly recommended. First, the project had to deal with some severe weather and field conditions related to the passage of Typhoon Omar. This major typhoon crossed the central part of Guam on 28 August, 1992. Damage caused by Omar was extensive: for several days there was no tap water; for several weeks untreated water was not safe to drink; and for a month or more, large portions of the island were without electricity. Communications and transportation networks suffered both on and off the island, which limited mail delivery and contact between the field crew and the IARII home office. Although Typhoon Omar greatly disrupted the final four weeks on Guam (three weeks fieldwork, one week archival research), there was no direct impact on the quality of the work done or the completion of activities listed in the scope of work. While it is impossible to predict the occurrence or destructive power of typhoons, it is clearly necessary to allow for the negative impacts caused by storms when existing scopes of work are amended, or subsequent multi-phase project continuations are approved.

The second general factor affecting the project concerns the management and oversight provisions included in the scope of work. Early in the project it was very clear that regular contact between the Guam HPO, the Navy, and the contractors (both Belt, Collins & Associates and IARII) created a positive collaborative atmosphere. While these contacts were largely mandated by the scope of work, they were nonetheless an extremely valuable asset. For example, the required briefing of HPO office staff and Naval Station Civil Engineering staff resulted in the discovery of several important, but previously unknown, documents and maps relevant to the project. Future archaeological work on the military installations of Guam should also include the cooperation of the HPO, the military, and the contracting firms.

Summary of Major Project Findings

The prehistoric deposits in the rockshelter (Site 2-1302) are an important find. There were one or two bone fragments recovered which may possibly be human, but the existence of burials in the rockshelter deposits has not yet been established. The present value of the site is as a huge, rich faunal and artifact collection dating back to about A.D. 600. Although some late Pre-Latte Period pottery was recovered, the majority of the ceramic material is Latte Period. The deep, well stratified midden deposits also hold quantities of well preserved marine foodshell, fishbone, mammal, reptile, and fruit bat remains. These faunal materials are the remains of everyday meals eaten thirteen hundred years ago, and may inform us about many aspects of prehistoric Chamorro life.

The two large basalt mauls and smaller maul fragment are apparently unique; similar finds have not been reported in the literature. The presence of the mauls and the patterned damage found near them indicate that prehistoric Chamorros ventured into the caverns of Site 3-1304 (PS-1) to "harvest" calcium carbonate in the form of stalactites. Perhaps they hammered off portions of rock curtains and other dripstone forms as well, to carry back to their villages. While two stalactites and two ground stingstones have been found at Latte Period sites (Darlene Moore, personal communication to Richard Olmo), the exact reasons for harvesting fragments of calcium carbonate are unclear. It is possible that the material was desired for the production of slaked lime, to be chewed with *betel* nut. However, any form of calcium carbonate can be burned to make lime, from marine shell and coral to limestone. It is unknown why calcium carbonate deposits available in the cave would be favored over the more convenient forms of the material.

The suite of seven sea level defensive caves built by the Japanese constitute a valuable series of World War II-era sites. From Site 3-1305 (TN-22) in the sea cliff of northern Tipalao Bay, south around the headland to Site 2-1310 (TN-30) just north of Site 2-1129, the modification and use of natural caves suggests that the Japanese military was desperate to build defendable positions prior to the American invasion in mid-1944. Some of these caves may have been left unfinished, but it is difficult to prove this since all of them are empty; none of the positions contain a gun or other permanent emplacement. The floor of the caves are nearly featureless, scoured limestone bedrock. No prehistoric or historic cultural materials remain *in situ*; today only mounds of water rounded coral cobbles and flotsam from recent storms fill the caves.

Another important finding concerns the possibility of human remains in the area of Tipalao Bay (Tuparao Village, Site 2-1311). At most, no more than a dozen bone fragments were recovered from Test Unit 1 which may be human. During excavation, this possibility was not recognized. However, analysis has indicated that at least one or two bone fragments are definitely human, while there is a good chance that five or six other fragments are human as well. All further work in this area must consider the possibility of encountering human remains.

Finally, it is important to note that the explanatory models we developed to interpret, analyze, and describe the cultural materials and sites in the Tipalao Bay and Dadi Beach areas are essentially correct. Before the backhoe trenches were dug and

the power auger tests drilled at Tipalao Bay, a tentative explanatory model was formulated which outlined the natural history of Tipalao Bay. This preliminary model was based on analysis of aerial photos, various maps, and observations of the physical characteristics of the ground surface itself. All of these sources indicated that prior to the military buildup in the 1940s, the Tipalao Bay backshore was a low area of sand dunes and palm trees. Periodic severe storms would have caused some disturbance to the ground surface and possibly to buried deposits as well.

Subsequent to World War II, the low Tipalao Bay backshore was extensively filled, increasing the elevation in some areas by 1 or 2 meters, and defining more clearly the hill slope at the back of the bay. The backhoe trenches, auger tests, and controlled excavations all confirmed that this explanatory model is correct; the original backshore ground surface was lower than today, and now lies under a meter or more of artificial fill. This layer of fill has not necessarily preserved buried deposits, because materials located at the elevation of the original ground surface may have been disturbed by storms.

On Dadi Beach, at the Japanese bunker and cave complex below Camp Bright (Site 2-1301), it was expected that test excavations would encounter intact stratified historic and prehistoric deposits. This was not to be the case; the scatters of molluscan shell and prehistoric ceramics on the surface of the sandy deposits inside the cave were misleading. Historic and prehistoric materials were found thoroughly mixed throughout the 60 to 80 centimeters of sandy sediments removed from the two test units in the cave. The results of the excavations were somewhat unexpected, but have been supported by other observations made in the area following Typhoon Omar. Just 40 meters north of the bunker, an area roughly 40 meters by 30 meters received a storm deposit consisting of a layer of clean carbonate sand 15 centimeters thick over a layer of sorted, rounded coral pebbles 7 centimeters thick. The storm surge and wind-driven waves of Typhoon Omar reached to within a few meters of the central part of the bunker, while evidence indicated that the seaward portion of the site was heavily impacted. Similar observations were made at Site 2-1129, about 300 meters north up the beach.

Final Site Significance Assessments

A total of 15 sites was considered eligible for the National Register. Of these, 13 were assigned official site numbers and names by the Guam Historic Preservation Office. Two sites (PS-1 and PS-2) were combined into a multiple locus site and given one site number (3-1304). One site considered eligible by the historian and the archaeologists (TN-21, stone wall and steps) was not assigned an official site number.

There has been no disagreement on the original findings of not eligible (NE), or "not a property". That is, no features or areas first reported as not eligible have subsequently been found eligible (after review by the Guam HPO, or archaeologists at PACNAVFACENGCOM), or to require additional work.

The sandy marsh at the south end of Dadi Beach (PS-10) was evaluated for coring potential and found inappropriate. This area is now considered NE.

The core samples removed from the "Tipalao Marsh" have contained valuable paleoenvironmental data. This area is now considered eligible for the National Register based on criterion D.

Finally, the series of seven Japanese defensive caves (Sites 3-1305, 2-1306, 2-1307, 2-1308, 2-1309, 2-1310, and 2-1312) are clearly eligible, as a thematic group, for both the Guam Register and the National Register. Their nomination to both should be pursued by the appropriate Guam HPO personnel.

Interpretive Planning Potential Within Project Area
by H. David Tuggle

The Dadi Breach area offers an excellent opportunity for the development of an outdoor historical interpretive center for the Naval Station. Three main periods of Orote Peninsula and Apra Harbor could be easily presented at an introductory point and by reference to existing natural and cultural features.

Information on the pre-Spanish Chamorro history of the area could be discussed (without reference to specific sites).

The history of the Spanish forts could be presented by reference to the rampart that crossed the isthmus and Dadi Beach.

The focus interpretation, would of course be the Japanese defenses and the 1944 US assault. Although this is not an assault beach, it is significant for the nature and extent of the Japanese defense and for its role in the battle of Orote. As Denfeld notes in his study of the area (this report), the defenses of Dadi and Mt. Tenjo artillery that provided a major setback in the assault.

The three main Japanese military components at Dadi (Sites 1129, 1301, and 1303), the defensive features and remains of the battle offshore, and the extensive archival information on associated features (such as photographs of landmines, reef defenses, and gun positions) provide all of the elements for the development of an outstanding passive interpretive program.

An interpretive program should be developed as a part of a larger historic sites management plan. Such planning involves means to protect sites as well as interpret them. This could be accomplished in conjunction with the ongoing efforts of the National Park Service War in the Pacific National Historical Park, which involves interpretive development of the Agat Bay defense complex immediately south of Dadi Beach.

The preparation of an interpretive management plan and the interpretive development of Dadi Beach is recommended.

Discussion of Archaeological Research Importance

The archaeological testing already completed at the rockshelter and Tuparao Village has found significant cultural materials. Proper study of the large collection of faunal material from the rockshelter is required, and additional research at both the rockshelter and Tuparao Village is of considerable importance.

The faunal bone and marine shell assemblages from the prehistoric rockshelter represent valuable data sets. Time and logistical constraints made it necessary to use expedient analytical methods (e.g., shell weights were tabulated instead of the more time consuming right and left valve differentiation and MNI counts) in an attempt to complete the analysis on schedule. However the richness of the midden argues for a much more in depth study. Assuming time, personnel, and money are available, both the bone and shell should be examined and analyzed using alternate methodologies.

If the prehistoric rockshelter cannot be adequately protected from indirect impacts (see discussion below), then a fully funded data recovery plan should be implemented. If a full scale excavation is attempted at the rockshelter, it is imperative that adequate funds be budgeted for the analysis of midden materials. If this project were used as a guide, it would suggest that certain budgetary parameters be doubled to allow an in depth analysis of the faunal bone and foodshell. For example, twice as much time and/or money must be set aside for the analysis. The quality, importance, and value of the rockshelter deposits demand such treatment.

Further archaeological study is also necessary at the Tuparao Village site. It is possible that human burials may be found, and further testing is necessary to determine if the remains of the village can be located. The sandy backshore of Tipalao Bay would have offered a very inviting site for a village. The sandy plain would have supported the growth of important plants and vegetation as well as being a comfortable area to live in. Certainly, the sand dunes and flats behind the bay would have been more hospitable than the expanse of pit and pinnacle karst to the north and south, and the vast mangrove swamp of Apra Harbor over the low ridge to the northeast. More detailed information concerning this site is required by those interested in the study of Chamorro prehistory.

RECOMMENDATIONS

Mitigation of Proposed Construction Project Impacts

The management of negative impacts to an archaeological site is referred to as mitigation. The mitigation of a site may involve complete avoidance and preservation by redirecting the impending construction or other hazard, or a site may be mitigated through controlled, scientific excavation. In between the two extremes of complete preservation and complete destruction is an entire range of options. The mitigation process usually provides time for planners to react, and preliminary data upon which decisions are based. This report, for example, has provided data and recommenda-

tions concerning the archaeological sites identified during the project. Once the new housing areas are selected, these data should be used in the planning process to mitigate possible negative impacts on sites located in those areas.

To discuss the mitigation of direct negative impacts related to construction of the new housing areas meaningfully, it is first necessary to consider which sections of the project area are likely to be selected for use. It is obvious that archaeological sites will not receive direct negative impacts if they are avoided entirely. For example, the beaches and cliffs identified as Area C, Area E, and Area F in this report, are unlikely to be directly impacted by the planned new housing construction. The central part of Tipalao Bay (Area D) will probably be avoided by major construction, too, because of its low elevation and poorly compacted fill soils. However, if development is planned for Tipalao Bay, the area to be impacted should be tested prior to construction. Also, all non-scientific excavations in the area should be monitored by archaeologists.

Areas H and K contain sites and potential sites, and might be selected for construction. Although this is unlikely because both areas have less than ideal soil conditions, the mitigation of adverse impacts to the sites and potential sites in these areas must be considered. The use of Area H would require the abandoned quarry (PS-15) to either be filled, or possibly excavated and the surrounding area levelled and compacted. If excavated, the work would have to be monitored for live ordnance and possible hazardous waste. This monitoring might identify significant historical items from the war era. If the quarry were filled prior to construction in the area, then any deposits in the pit would essentially be preserved. Either mitigation option would probably be acceptable if the quarry in Area H were adversely impacted. To build in Area K, the only mitigation necessary would probably be to record any and all *in situ* post-World War II concrete foundations, fence posts, bridges, etc. Essentially, the mitigation efforts required in both Area H and Area K are somewhat minimal.

The remaining areas to be discussed are Areas A, B, G, I, and J. The inland survey sections designated Areas G, I, and J are relatively flat and could be utilized for the housing expansion. Area I contains the wetland, Site 3-1327 (PS-6), which has now been cored and has been judged to contain significant paleoenvironmental data, and which apparently qualifies as a wetland under existing federal guidelines. Two potential sites in Area I (PS-16 and PS-18) have been researched, but archival and documentary searches have been inconclusive. These two possible sites are interesting, but not National Register eligible, nor are the remaining sites (TN-3, TN-4, TN-5, and PS-7) eligible. The use of Area I for new housing would probably have to avoid the wetland for engineering and environmental reasons. The remaining sites, however, have been adequately tested and recorded. Similarly, the single identified site in Area J has been recorded, and is not eligible for the National Register. Area J can also be considered for use without mitigation.

Area G contains Sites TN-2 and TN-8, both of which warrant mitigation in the form of further study. Minimally, mapping and photographic recordation of the sites is necessary before they could be destroyed in part or in whole. TN-2 is a dry-laid coral facing along an embankment of the roadside drainage ditch, and TN-8 is a large area covered by numerous concrete foundation pads. The Quonset huts of the Naval Supply Depot were once located in this area.

The remaining two parcels, Areas A and B, are both rugged sections of pit and pinnacle karst limestone topography. These are potential building sites as well. Much of Area B south of Haputo Road appears to be pristine, with large sections of undisturbed limestone forest. However, no sites were identified in Area B, and mitigation is not required based on archaeological grounds. The limestone caverns are located in Area A to the north of Haputo Road. It is recommended that negative impact to these caves (in the subsidence shaft and sinkhole features) be avoided if possible. If the caverns are to be directly impacted by planned construction, they should be photographically recorded using professional personnel and equipment. Somehow, the potential indirect impact caused by the likely increased recreational use of this area must be mitigated as well. This is considered below.

Mitigation of Possible Indirect Impacts

Good planning and management is necessary to mitigate the indirect negative impacts caused by increased access and use of site areas. Both the greater population of the Naval Station and the increasing use of base areas by civilians will indirectly threaten the preservation and integrity of several archaeological sites. The especially vulnerable sites are located along Dadi Beach. Several possibilities for the mitigation and management of the Dadi Beach sites are possible. In general, it is recommended that the area be protected and managed as a World War II thematic site. Proper management may involve placing some areas off limits. For example, the Japanese command bunker (Site 2-1303) may soon become covered in grafitti or otherwise vandalized. It is in a secluded but easily accessible location that invites abuse. Wanton destruction or "pot-hunting" for artifacts in the bunker/cave complexes is also probable. But the addition of permanent interpretive signs which identify the sites as valued properties listed on the National Register should limit senseless damage and vandalism.

If the rockshelter site is not directly threatened by development, if a full scale excavation in not necessary for the site, then a long term program of monitoring must be established. Periodically, qualified personnel should visit the site to check for vandalism and to evaluate the effects of erosion. This type of monitoring program has the advantage of low cost, and it helps to preserve valuable data for future research. However, if use of Dadi Beach increases to such an extent that the integrity of the site is threatened, complete excavation of the site should again be considered. Dadi is a very popular beach for military personnel. With several thousand additional persons on base (regardless of their actual housing location), plus increased public use of the beach, there will no doubt be some negative effects. Use of Dadi Beach by larger groups of people will augment the threat to the site from artifact looters and vandals. In sum, sustained indirect impact argues just as strongly for complete data recovery as does the direct impact of a construction project.

The limestone caverns north of Haputo Road will also need protection from indirect negative impacts. If housing is constructed near the caves, the new residents will probably venture into the caves. Here there is a safety concern, as well as a desire to protect an impressive natural and archaeological site. Fences around the subsidence shaft and cave entrances are not recommended. Instead, perimeter fences

should be built around any new housing units constructed in the Haputo Point area. Also, existing fencelines in the vicinity of the Seabee quarry should be posted against trespassing and emergency phone numbers (police, PWC, Naval Station security, fire station) should be listed on the sign. Such a sign might discourage the merely curious, while also making available critical public safety information.

Long-Term Recommendations

The following recommendations should be considered for implementation as soon as possible. However, a longer time frame may be necessary before all of the suggestions can be implemented.

First, in conjunction with the preservation and management of the suite of features and properties on Dadi Beach, it is strongly recommended that the reef and lagoon offshore be examined. This area requires a detailed underwater survey for the recording of features associated with the recapture of Guam. The metal items observable from the shore are in an advanced state of deterioration and should be recorded as soon as possible. It is not known if any remnants of the Japanese defense of Dadi exist offshore, but if so, they are threatened with each new typhoon.

During the survey of the waters off of Dadi, a thorough study of the shallow areas just beyond the reef of Tipalao Bay should also be completed. For this survey and the underwater survey recommended for Dadi Beach, local divers and dive shop owners should be interviewed concerning known wrecks and features in the two areas. Members of Naval Station diving clubs might be allowed to participate in the survey, which would save resources and make available valuable information. Much time and effort could probably be saved if the local diving public were involved in the surveys.

Second, it is recommended that a detailed survey be conducted by boat of the coastline and cliffs in the northern part of the project area. This survey should cover at least a kilometer, starting at the northern headland of Tipalao Bay and running north to well beyond Haputo Point. Although these cliffs were technically within the assigned project survey area, it is only possible to examine them from the water. The upper edges of the cliffs have been surveyed, but the cliff faces themselves have not as the field crew had no access to water transportation. There is some possibility that significant World War II wreckage or Japanese defensive sites might be found. If so, such sites would have to be added to the multiple property listing of Japanese defensive sites on file with the Guam Historic Preservation Office.

Third, it is recommended that two areas of the pit and pinnacle landscape be set aside as natural preserves. The first location is the north central part of Area A. This preserve should include the west and east loci of Site 3-1304. In order to conserve the entire range of pit and pinnacle forms, the preserve should encompass all the land from the high cliff overlooking the coast, to the edge of the old quarry (Area H). Even if there is resistance to designating this area as a preserve, it is strongly recommended that the Seabees not expand their quarry into Area A from the east. The second location for establishment of a preserve is Neye Island (Area F). This small, rugged island off of the southern headland of Tipalao Bay conserves the only remnant

of natural karst landscape in the immediate area. There are no installations on the island, and it should be a simple matter to place it in reserve for complete protection. Once officially established, signs could be posted on the headland shore opposite the island warning people of its status as a preserve. The limestone caverns and the karst landscape of Haputo Point and Neye Island are valuable environmental areas which deserve both intelligent management and preservation.

NOTE:

Part II is not included in this Appendix. As explained in section 4.10.1, Part II provides the detailed site locations inventory, which is summarized in Part I. Copies of the complete report (Parts I and II) have been distributed to the Guam Historic Preservation Office, the Micronesian Area Research Center, and the Nieves Flores Memorial Library.

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Appendix I

Socioeconomic Impact Assessment

SOCIO-ECONOMIC IMPACT ASSESSMENT OF NEW U.S. NAVY ACTIVITIES IN GUAM

August 1992

Prepared for:
Belt Collins & Associates

Prepared by:
Community Resources, Inc.

EXECUTIVE SUMMARY

This report deals with social, economic, and fiscal impacts of new Navy activities and personnel on Guam in the aftermath of the closing of U.S. Navy bases in the Philippines. The actual relocation of troops and materiel to Guam due to base closures is not under study, since it is not subject to environmental review.

THE PROJECT. The proposed action consists of several new Navy activities (listed in Belt Collins, 1992) located mainly at the Naval Station, Apra Harbor (NAVSTA) and Andersen Air Force Base (AFB), the deployment or hiring of personnel needed for those activities, and associated new construction.

New Navy operations will create jobs for an additional 1,377 military personnel on permanent duty on Guam, 319 full-time civilians, and some 424 transient personnel. Military Sealift Command operations will bring civilian mariners from four ships to the island regularly. Other additional ship visits will further increase the number of transients on Guam.

An estimated 1,455 dependents will accompany the additional military personnel based on Guam. Of these, about 530 are expected to find jobs on the island.

Construction in support of new operations will provide structures needed to perform the new activities, housing for military families, and infrastructural improvements. The total cost of proposed construction is about $320 million.

EXISTING AND LIKELY FUTURE CONDITIONS. Guam today has a prosperous economy supported by tourism and military spending. The current situation contrasts with the domination of the local economy and society by the military during most of the island's history as a U.S. Territory. In 1990, Guam had over 133,000 residents and, on average, over 7,000 visitors at a time. Unemployment is low. However, many short-term foreign workers on-island have recently left Guam, as new construction has slowed.

Guam's infrastructure has not kept pace with the economy. Power outages are everyday occurrences. Housing is in very short supply, since new housing construction has largely been aimed at the visitor and upscale part-time resident markets.

Projections now being developed for government planning purposes suggest that by 2010 the resident population could increase by nearly 80% (to 237,000) and the visitor count could triple (to 23,000). These projections assume that tourism will fuel growth. Military expenditures have been treated as constant, and hence as accounting for a diminishing share of the economy.

Guam residents' responses to anticipated growth mix support for continuing prosperity, much concern over infrastructure and public facilities, and an interest in greater community control over new developments.

ECONOMIC IMPACTS. The project will create (a) direct jobs due to construction and Navy operations, and (b) indirect and induced jobs due to the purchase of goods and services in the local economy by contractors, the Navy, and their employees. For this report, Community Resources, Inc. (CRI) estimates the size of indirect and induced impacts depending in part on information on the Guam labor force and earlier calculations of the impact of new spending on Guam.

Between 1993 and 1998, many new jobs on Guam will be associated with the project, largely due to construction. After this period, the number of project-related civilian direct, indirect, and induced jobs will be smaller than the number of project-related military dependents added to the labor force. Hence the long-term impacts on the employment market include both new jobs and a small reduction in the number of non-military in-migrants needed to fill available jobs on Guam.

Over a five-year period, the construction work included in the project would generate, on average, about 360 direct full-time construction jobs annually on Guam. In addition, about 860 indirect and induced jobs, on average, would be supported by project construction during that period. Based on current plans, construction would peak in 1994 (with over 800 direct jobs created), diminish to a low level by 1997, and then end.

With the project, military spending on major construction projects continues, when it was otherwise expected to end. In the context of the recent construction slowdown, the project could help to insulate Guam's construction industry from the impacts of quickly changing demand during the 1990s.

Navy policy calls for workers on major construction projects to be U.S. citizens. Guam residents will likely be preferred as construction workers, since Guam construction wages are lower than Hawaii and Mainland wage scales.

The Navy's new activities would support nearly 1,700 full-time military and civilian employees. Indirect and induced employment is estimated as about 150 jobs, continuing indefinitely.

The Navy intends to hire Guam residents for direct civilian operational jobs. If necessary, its apprenticeship program could be expanded to train applicants for project-related jobs. The project hence provides opportunities for career advancement for some of Guam's workers and young people. However, it must be assumed, given Guam's high employment, that jobs previously held by direct employees, along with indirect and induced jobs, would largely be filled by in-migrants.

Military spouses would account for about 530 additional members of the labor ırce, compared to the 460 or so operational direct, indirect, and induced jobs associated ith the project. As a result, the net impact on the civilian labor force is a slight decrease in e demand for other in-migrants to fill jobs.

All project-related civilian jobs would amount to about 3% of Guam's total projected bcount in 1995. By 2010, after project construction has ended, project civilian jobs ould account for less than half a percent of the total jobcount. The project's permanent ilitary postings would amount to about 11% of the total number of military billets ojected for Guam in both years.

Construction would generate an average of $28.6 million in personal income nnually, of which $12.9 million would be in direct construction workers' salaries. Over $40 illion would be paid to operations-related workers annually, nearly all of which would go direct Navy employees (both civilians and military posted on Guam).

RESIDENT POPULATION AND HOUSING. The military families associated with the oject are projected as occupying 645 households. Housing is available on-base for ilitary without families on Guam. (Quarters may be cramped, especially for transients.) amily housing is available at Andersen Air Force Base for about 250 families. Project ans include the construction of 308 units of family housing at a site to be determined at AVSTA. For planning purposes, CRI estimates that those units would be available in 996.

If price is not considered, demand for off-base housing associated with the project ould amount to 395 units until the new family housing is built, when it would decline to 87 nits. In response to this extra demand, the Navy has arranged a long-term lease for 115 nits in Chalon Pago. The remaining demand is then subject to market conditions. Due to gh rental prices, about 50 project-related Navy families in 1994, and 150 in 1995, might ot come to Guam at all because affordable housing is not available.

The change in Guam's population and off-base housing demand due to the project onsists of (a) the new military and military dependent population and (b) a small ecrease in future in-migration, since project-related military dependents will fill more ivilian jobs than the project will create. (Construction workers are not included in ssessing long-term population and housing impacts. Since the industry depends on a ow of projects, a particular project does not bring new in-migration so much as support ne industry's continued well-being. Also, the possibility of short-term impacts is limited by ne fact that major construction companies have dormitories to house their workers.)

DE FACTO POPULATION. The total population on Guam at any time associated with ne project can be estimated by taking into account new resident population and ansients. The project would bring about 680 transients to Guam, on average, at any one

time. The de facto population impact would then be about 3,500 persons. Project transients form less than 20% of the total military transient population projected for 1995 and less than 10% of the total visitor count.

The project-related population will spend most of the time living and working on military bases. However, concern has been expressed about the impact of the new Navy activities on off-base entertainment districts. Assuming that visits to those areas only occur on weekends, an average of over 800 Navy personnel and civilian mariners associated with the project (including resident military) could be added to the existing military population visiting entertainment districts. The project-related increment would form about 20% of the military total, and hence amount to a noticeable increase in customers in those areas where military customers predominate. In relation to the total population visiting Guam's entertainment districts (including tourists and civilian residents), the increase is modest.

FISCAL IMPACTS. Revenues accruing to the government of Guam (GovGuam) from the project can be estimated by identifying various taxes and other revenues associated with the economic impacts of the project. Costs could not be estimated with such precision, so an "average cost" method -- based on the average cost of government services per person, not the marginal cost of extending services to a new population -- is used to reach a maximal estimate of costs associated with the project.

GovGuam revenues associated with the project are estimated as peaking at over $31 million (1992 dollars) in 1994, and as stabilizing at over $8 million as of 1998. Government costs would be about $5 million annually. The cumulative balance of revenues over costs is estimated as about $70 million in the year 2000, and nearly $100 million in 2010.

PUBLIC FACILITIES AND SERVICES. The report examines project impacts on education, public safety (police and fire protection), health services and recreation. Because the population impacts of the project are an addition to the number of military and military dependents, and a small decrease in the in-migrant civilian population drawn to Guam, much of the demand for public services will be met by military institutions. Small increases in personnel may be needed in some Guam programs to serve the increased population. (Since the long-term impact of the project is a small decrease in non-military in-migrants, the project could result in slightly lower demand for civilian public services in areas such as health, where both civilian and military facilities serve the public.)

Education is of special concern, since the Guam Department of Education (DOE) is the sole provider of public education. DOE administrators have indicated that schools throughout Guam are at or near capacity, but the additional students associated with the project could be served, if they do not all arrive at the same time.

About 410 students (grades K through 12) are estimated by CRI as associated with the project, of which over 340 are projected as enrolled in public schools. More than a third of the students would likely be housed at Andersen AFB and hence would attend nearby schools. About a third might be located at NAVSTA and in central Guam in the next few years. When the proposed military housing at NAVSTA is built, about half the new students would be located in Piti and Santa Rita. (One of the proposed housing sites is in Piti; the other two are in Santa Rita.)

A recreation impact of importance to Navy personnel will be the closing of Gab Gab Beach, on the Orote Peninsula, for approximately 32 days a year due to the presence of explosives at Kilo Wharf. This beach is a preferred recreation site for NAVSTA personnel.

GENERAL SOCIAL IMPACTS. Potentially, the project could lead to impacts above all on Navy personnel and dependents. It will increase demand for housing and child care among a population with limited ability to pay Guam's high costs. Family stress could well increase.

The project's impact on the civilian housing market is small compared to the total level of demand. However, current tenants at Apusento Gardens on month-to-month leases will be affected, as they will have to seek alternative housing soon.

Small impacts are expected for Guam businesses (due to additional business and, for a few, the loss of employees who take Navy jobs). Entertainment districts will see an increase in activity.

The project's impact on Guam's island society and politics is expected to be slight. The increased military presence does not stand in the way of citizens' efforts to (a) transfer NAS Agana to civilian hands, (b) negotiate Commonwealth status for Guam, or (c) open up access to private holdings through Federal land in the North.

MITIGATIONS. Mitigation measures include steps already planned by the Navy (such as construction of family housing and child care facilities), expansion of counseling programs, and improvements at an alternative beach site at NAVSTA.

FOREWORD

Community Resources, Inc. (CRI) staff contributing to this report, from April to August, 1992, included John M. Knox (Principal), John Kirkpatrick, (Project Director), Paul Kiikoro, Banks Lowman, and Paula Arcena. CRI also benefitted from the work of its associates Eric Abdullateef, Carol Ibanez, and Raymond Cruz.

Most data-gathering on Guam was done by CRI staff. CRI staff followed up on some issues by phone and fax. Ibanez and Cruz also did research on Guam between May and July, 1992.

The report was written before Typhoon Omar hit Guam. The devastation wrought by the storm has changed both the existing conditions described in this report and, it seems likely, the timing of anticipated future events. Guam's people, military and civilian, have worked hard to rebuild after past typhoons, and we hope that Guam will emerge strengthened from its ordeal. As we warn in the text of the report, calculations of future conditions in any particular year must be treated as approximations, not as precise forecasts.

The description and analysis of a complex island society was only possible with the help and good will of many people on Guam. Both civilian and military officials provided CRI with detailed information and the benefit of their own understanding of Guam's problems and opportunities. Many busy people made time to help us, despite full schedules and the need to prepare for and implement the Subic relocation. The contact list included in Appendix A of this report indicates the extent of our debt.

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF THIS REPORT

This report provides a socio-economic impact assessment of the Navy's action in locating personnel and operations in the Territory of Guam in addition to those already in place. The new activities are summarized in Section 1.2. The new activities have been assigned to Guam as a consequence of the closure of U.S. Navy facilities in the Philippines.

The closure of the Subic Bay Naval Base and relocation of activities to Guam and other sites are due to a decision of the government of the Philippines, and are not subject to environmental review. The Navy will publish an Environmental Impact Statement (EIS), conforming to National Environmental Policy Act (NEPA) requirements, for the long term implementation of the new activities on Guam. Belt Collins and Associates is preparing the EIS for the Navy. This document is written as a technical study to be attached to that EIS.

The action subject to the EIS includes Navy operations on Guam, the posting of Navy personnel, bringing their dependents to Guam, hiring civilians to fill operational jobs, and construction projects associated with those operations. The scope of this definition of the action is unusually comprehensive, notably because the Navy includes construction of infrastructure and support facilities as part of the action. In this report, the terms "the project" and "new Navy activities" refer to the action as defined here and described further in the next section.

The present report provides a detailed assessment of economic and social impacts of the project on the Territory of Guam and its people. It hence serves as a source of findings for the Navy's Environmental Impact Statement.

It must be stressed that this report deals with the socio-economic impacts of new Navy activities on Guam over the long term. It is not intended as an assessment of the military's role in Guam, or of the immediate impacts of closing Subic Bay. Currently, operations, personnel, and equipment are being moved to Guam from the Philippines. The move means some discomfort or dislocation for many in the Armed Forces, and perhaps for others on Guam. It also brings windfalls, such as recreation equipment and temporary employment. These short-term impacts are noted briefly in this Introduction, but are otherwise outside the scope of this report.

As a socio-economic impact assessment, this report is intended to identify and disclose information of use to members of the general public and to decision-makers as

they evaluate the implications of proposed developments. It provides discussion of possible impacts and of steps that might mitigate unwanted impacts.

This chapter includes sections on:

- The purpose and scope of this report;
- The various activities that, taken together, are the "action" under review in this report and the EIS; and
- The linkages between the action and various potential impacts described in later sections.

Subsequent chapters deal with:

- Existing and likely future conditions on Guam, which form the context for assessing the impacts of the proposed action;
- Impacts of the project on employment, income, and the Guam labor force;
- Impacts on population and housing on Guam;
- Fiscal impacts, i.e., changes in the revenues and expenditures of the Government of Guam, attributable to the proposed action;
- Impacts on public facilities and services (education, recreation, health services, public welfare and family services, police and fire protection); and
- Impacts on social life on Guam attributable to the project.

1.2 DESCRIPTION OF THE PROPOSED ACTION

The new military operations are listed in Belt Collins (1992). They will be located in four regions:

Andersen Air Force Base (AFB). A Fleet Logistics Support Squadron (VRC-50) will provide an air link to carrier battle groups in the Western Pacific. Flight operations associated with this activity are covered in a separate environmental assessment.

This activity will involve some 505 permanent jobs for Navy personnel. About four times a year, when battle groups are near Guam, an estimated 90 persons will be on island for a few days while coming to or going from the carriers.

- **Mid-Guam.** Four units with positions for a total of 145 military personnel will be located at Naval Air Station (NAS) Agana. At Naval Hospital, 77 new health care positions will be added.

  In addition to these permanent Navy positions in this region, about 10 new NAS positions will be filled by personnel on temporary assignment.

- **Apra Harbor Area.** Guam's increased importance in support of Western Pacific operations will mean increases in personnel, ship visits, and activities. An estimated additional 150 containers of cargo per month will come to Guam by way of the commercial port, in addition to current freight.

  Permanent Navy postings in various activities will number about 500, while new civilian positions will create 317 jobs.

  Civilian crews of Military Sealift Command (MSC) ships will be based in Oakland and "foredeployed" on Guam. In effect, the ships will operate from Guam, but the sailors will have no rights to housing. They will be regular visitors to the island, but few or none would have dependents on Guam.

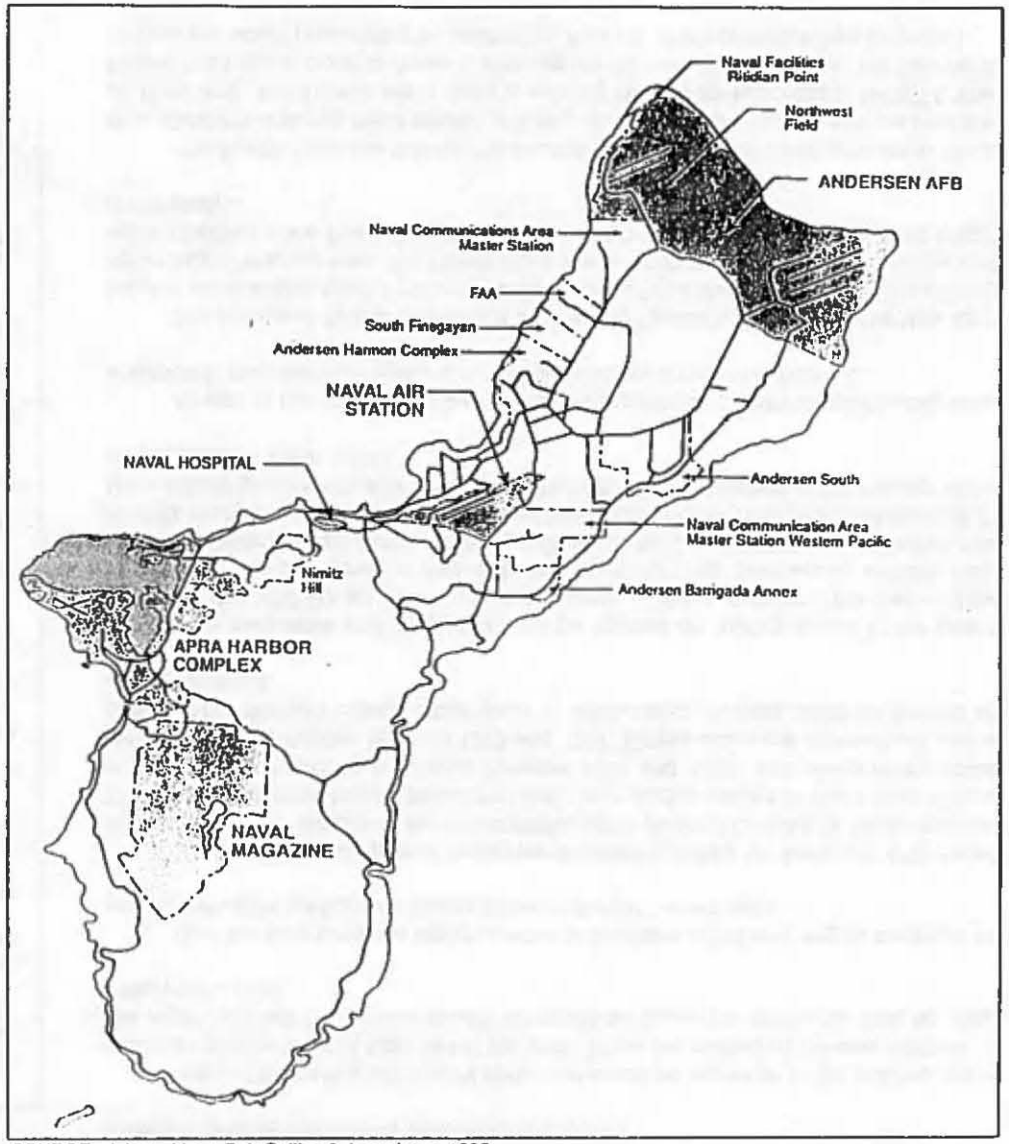
  With some 76 additional port calls (over the annual average for 1989-1990), Guam will see an increase in sailors on brief visits. The number of sailors on liberty will double, from an estimated 16,000 to 32,500 annually.

  With additional ammunition stored and transshipped on Guam, Kilo wharf on Orote peninsula will see increased use. Surrounding areas, including a beach popular with Naval Station personnel, will be inside an Explosive Safety Quantity Distance arc, and hence unavailable, for an estimated 32 days per year.

- **Naval Magazine.** Ammunition stored at the Naval Magazine will increase about 50% in tonnage. Some 150 new Navy positions and 22 civilian jobs (of which 20 would be filled by transient hires) are expected to be added to the Naval Magazine personnel strength.

Exhibit 1-A shows the location of major Navy activities on Guam. Exhibit 1-B tabulates the additions to personnel on Guam associated with the new activities. The permanent personnel figures were developed by Belt Collins and Associates after meetings with Navy officials. These are relatively reliable estimates, since they reflect

EXHIBIT 1-A: AREAS OF PROPOSED ACTIONS



SOURCE: Adapted from Belt Collins & Associates, 1992.

EXHIBIT 1-B: DIRECT EMPLOYMENT AND VISITORS TO GUAM, NEW NAVY ACTIVITIES ASSOCIATED WITH SUBIC ROLLBACK, BY LOCATION ON GUAM

	Anderson AFB	Agana NAS/ Naval Hospital	Naval Station	Naval Magazine	TOTAL GUAM
PERMANENT PERSONNEL (1)					
Military	505	222	500	150	1,377
Civilian	0	0	317	2	319
TOTAL	505	222	817	152	1,696
TRANSIENT PERSONNEL (2)					
TEMPORARY DUTY PERSONNEL					
Annual Total Persons	90	10	304	20	424
Average Days on Guam per Year	56	360	259	360	
Average Person-Days on Guam	5,040	3,600	78,700	7,200	94,540
Average Days Off-Base per Year	56	50	43	50	
Average Person-Days Off-Base	5,040	500	13,100	1,000	19,640
CIVILIAN MARINERS					
Annual Total Persons			315		315
Average Days on Guam per Year			37		
Average Person-Days on Guam			11,784		11,784
Average Days Off-Base per Year			17		
Average Person-Days Off-Base			5,392		5,392
SAILORS ON LIBERTY					
Annual Total Persons			16,500		16,500
Average Days on Guam per Year			8.6		
Average Person-Days on Guam			142,500		142,500
Average Days Off-Base per Year			1.5		
Average Person-Days Off-Base			24,750		24,750
TOTAL PERSON-DAYS					
Transients on Guam	5,040	3,600	232,984	7,200	248,824
Transients Off-Base	5,040	500	43,242	1,000	49,782
TOTAL PERSON-YEARS (3)					
Transients on Guam					682
Transients Off-Base					136

NOTES: (1) Permanent personnel counts from Belt Collins (1992).
(2) Transient personnel counts from Belt Collins interviews with Navy authorities. Length of visits estimated by CRI.
(3) Person-Days are converted into Person-Years to estimate visitor population in Exhibit 5-C.

manpower strength of known units or the personnel needed to accomplish known tasks assigned to Guam. The figures for transients derive in part from Belt Collins' work, in part from estimates by Community Resources, Inc. (CRI).

Many of the permanent military personnel would be based on Guam but involved in offshore operations for at least part of the year. These are treated as full-time residents in this report, but will likely make smaller demands on Guam for resources than do other military personnel.

Over the long term, the actual number of positions could vary slightly from year to year. Small variations from the figures shown in Exhibit 1-B are likely.

Construction in support of these new activities is slated for Andersen AFB, Naval Station, and Naval Magazine. No new construction is planned for NAS or Naval Hospital. The total construction budget associated with the project is valued at about $320 million, in projects that could be authorized between 1992 and 1996, and which hence could therefore actually happen between 1993 and 1997. (These dates are approximate. Some construction, deemed urgent, could occur in 1992. Other projects could be delayed or denied funding.)

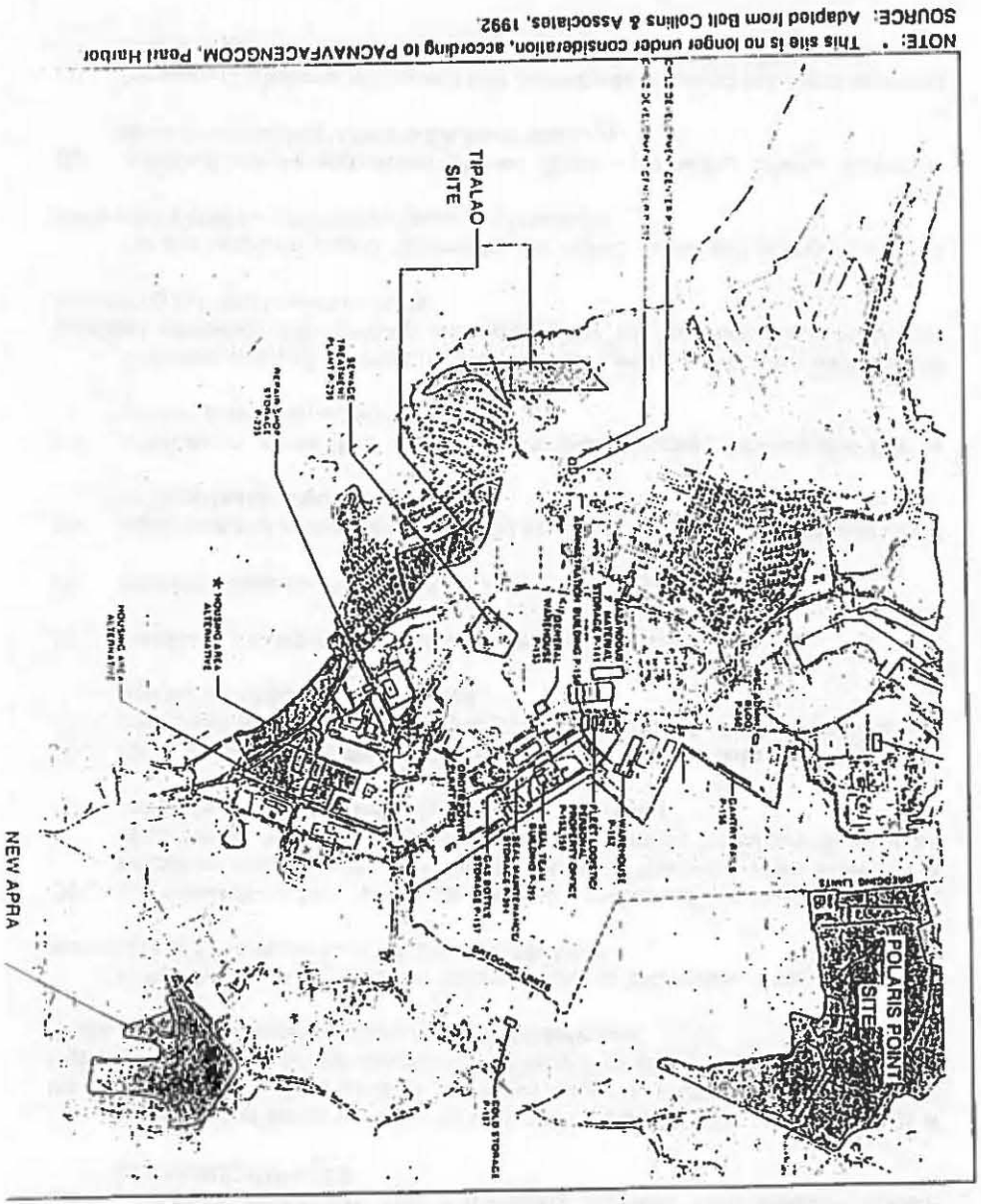
Navy personnel and dependents will be housed on military bases to the extent possible. The VRC-50 squadron and dependents -- about one-third the total military population -- will be housed at Andersen AFB. Andersen has more space available than Navy installations. When it stopped being a Strategic Air Command installation with B-52s in 1989, many of its personnel were moved to the Continental U.S. (The total increase in Navy military positions due to the Subic rollback is about equivalent to the number of Air Force positions lost in 1989.)

As part of the action, the Navy seeks authorization to construct 308 housing units at NAVSTA. Possible sites now under consideration are shown in Exhibit 1-C.

The proposed Tipalao Site adjoins the existing Tipalao housing area. The New Apra Heights site is inland, toward the community of Santa Rosa and next to part of the existing Apra Heights housing area. The Polaris Point site is inland from the submarine tender and related facilities at the Point. A fourth site, known as the Old Orote Village site, is no longer under study.

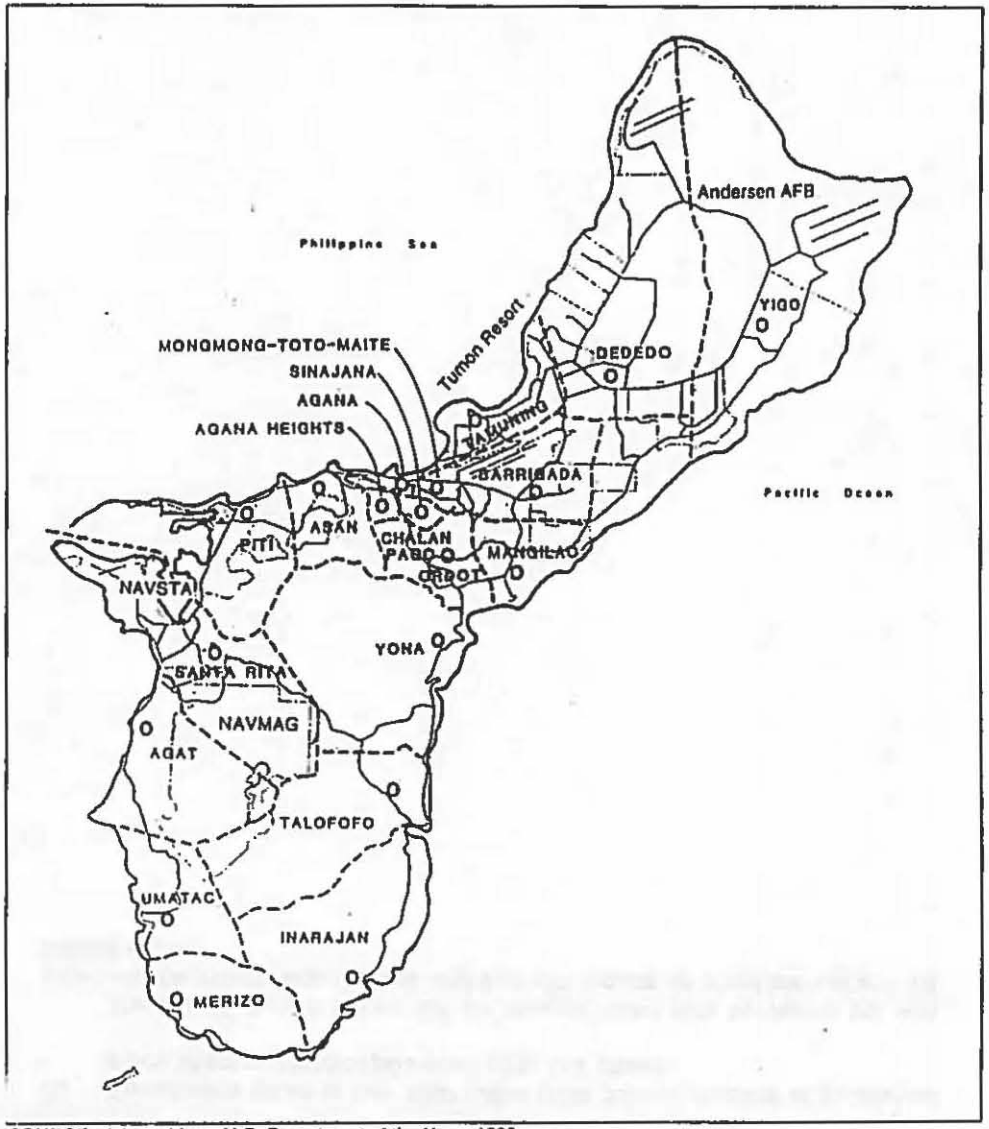
The Polaris Point site is in the Piti election district, while the other sites are in Santa Rita. (Exhibit 1-D shows these election districts, also known as villages.) All three sites are on Navy land. The Tipalao site is close to existing facilities for residents of NAVSTA. The Polaris Point site is close to Route 1, and outside the main NAVSTA gate. The New Apra Heights site would presumably be reached by Route 2, which connects Agat to Route 1.

EXHIBIT 1-C: APRA HARBOR COMPLEX PROJECTS



NOTE: This site is no longer under consideration, according to PACNAVFACENGCOM, Pearl Harbor
SOURCE: Adapted from Bell Collins & Associates, 1992.

EXHIBIT 1-D: ELECTION DISTRICTS



SOURCE: Adapted from U.S. Department of the Navy, 1985.

1.3 LINKAGES BETWEEN THE PROPOSED ACTION AND MAJOR SOCIO-ECONOMIC IMPACTS

The proposed action will occur on land now held by the U.S. military. Impacts of the proposed action will arise both on military bases and off-base. Socio-economic impacts include both localized effects and ones likely to be dispersed across the island of Guam. Localized impacts will largely occur on military bases.

In the short term – before the actions subject to EIS review -- the major socio-economic effects on Guam from the rollback will include:

(1) For hundreds of Navy personnel and their families, moving to Guam from the Philippines and adapting to a new duty station. This will involve a mixture of opportunities, such as better employment opportunities for military dependents, and problems, notably due to Guam's high cost of living.

(2) For other Navy personnel and families, dislocation due to a policy that dependents cannot join personnel transferring to Guam (from sites other than the Philippines) until available housing is guaranteed.

(3) Potentially, a sharp increase in military demand for housing;

(4) Potential imbalances between demand and local supply of public services;

(5) Equipment and resources either moved from Subic Bay or originally requisitioned for Subic but diverted to Guam; and

(6) A temporary demand for workers to improve temporary facilities and help to relocate personnel and activities.

Over time, many of the initial shocks associated with the relocation will fade. The relocated population will eventually be replaced by military personnel and families transferring to Guam from other posts.

For the long-term project covered by this report, social and economic impacts follow mainly from the following components of the action:

(1) Additional military and civilian jobs on Guam -- providing salaries subject to taxation, and adding dollars to the island economy.

(2) Presence of additional military and their dependents on island, leading to increased labor available for civilian jobs, and demand for housing and public services.

(4) Increase in the numbers of transient civilian mariners and Navy personnel, leading to increased spending on island.

(5) Construction valued at over $300 million (1992 dollars). Because of government policy, direct construction jobs would go to U.S. citizens.

The impact analysis follows out the linkages noted here by dealing first with economic and demographic impacts, and then with impacts on social services and the broader society.

2.0 EXISTING AND PROJECTED CONDITIONS

2.1 HISTORICAL BACKGROUND

2.1.1 Spanish Colonization

Near the western edge of the Pacific, Guam has been settled for some 4,000 years. Chamorro, the language indigenous to Guam and the other islands of the Marianas, is more closely related to languages in the Philippines, Indonesia, and Palau than to those found in island groups east of Guam (Bellwood, 1979). Subsistence agriculture was well developed, and could support a large population and complex social system. When the explorer Ferdinand Magellan arrived en route to Asia in 1521, Chamorro farmers grew rice along with such widespread Oceanic plants as breadfruit and taro (Barrau, 1963).

By 1565, the Spaniards had claimed Guam as an extension of their Philippine-based Far East empire. It took another 103 years, however, before Jesuit missionaries arrived to spearhead colonization of the island. Spanish military rule and European diseases quickly ravaged the indigenous population base. As resistance against the conquistadores diminished over the last decades of the seventeenth century, Spanish culture began to pervade Guam's society.

Guam served as a supply port for galleons on the Manila-Acapulco route. This trade ended in 1821 with Mexican independence. During the remainder of the nineteenth century, American whalers found Guam a convenient location for reprovisioning their ships.

The U.S. Navy seized control of Guam during the 1898 Spanish-American War. Martial law was instituted while the Navy used Guam as a naval outpost supporting the American occupation of the Philippines. During this period, Guam's culture, which had been a blend of Chamorro and Spanish influences, was heavily affected by the American presence.

2.1.2 World War Two

The Versailles Treaty of 1919 ceded the German Marianas to Japanese rule. This increased Guam's strategic importance in the Western Pacific, but, in deference to Japan's recognized sphere of influence, little was done to strengthen existing American forces. As a consequence, lightly defended Guam easily fell to the Japanese the day after the Pearl Harbor invasion.

As part of their island-hopping campaign in the Pacific, the Americans returned in force in 1944 and heavily bombarded the Japanese fortifications. Most of the island's structures and vegetation were levelled in the pre-invasion shelling -- especially in Agana, the principal town. The fierce battle to retake Guam ended with the U.S. Navy regaining dominion over the island.

Under Admiral Nimitz, Guam became the headquarters of the American effort to finally defeat the Japanese. Its proximity to Japan made it an ideal location for B-29 bomber bases and the transshipment of troops.

2.1.3 Post-War Events

Post-war Guam has undergone several major upheavals: rapid militarization, natural disasters, responses to economic and political strife in Asia, and political uncertainty. Exhibit 2-A shows the value of naval construction projects from 1945 to 1990. Surges in construction point to some of the disruptions that have greatly affected the island:

- Extensive war reconstruction and the buildup of the island's new bases (1945 to 1950);
- The Korean War and cold war hostilities (mid-1950s);
- Typhoon Karen (1963);
- The Vietnam War build-up, when Guam served as waystation for troops in-transit (mid-1960s); and
- Typhoon Pamela (1976).

The Territory's political history, in which the federal government has played a strong role, has also been turbulent. The Organic Act of 1950 handed federal administration of Guam over from the Navy to the U.S. Department of the Interior; it also granted Guam residents U.S. citizenship. Despite these steps towards demilitarization, a security clearance was required to enter the Territory until 1962, and governors were appointed by Washington until the early 1970s.

Easier access to the island during the 1960s helped Guam's economic base to slowly diversify, making it less reliant on federal spending. With increased economic self-sufficiency came the desire for increased political autonomy. In 1982, a plebiscite was held, offering a number of political status choices (Commission on Self-

EXHIBIT 2-A: NAVY CONSTRUCTION, 1946-1990

NOTES: Includes work outside Guam under OICC Marianas. All values in constant millions of 1986 dollars.

SOURCE: Adapted from table produced by Officer in Charge of Construction Marianas.

Determination, 1988). Close to half the participating voters opted for Commonwealth status, and another quarter preferred Statehood.

The 1986 formation of the neighboring Commonwealth of the Northern Marianas rekindled interest in the nature of Guam's relationship to the United States. Guam's Commonwealth Act, which calls for a political "partnership" between the Government of Guam and the federal government, won approval in a 1987 plebiscite (Commission on Self-Determination, 1988). The Act is a focal point for negotiations between Guam's Commission on Self-Determination and the United States, but to date Guam legally remains under federal control.

2.2 SITES POTENTIALLY AFFECTED BY PROPOSED ACTION

2.2.1 Islandwide

With a land area of some 212 square miles, Guam is the largest and most populous island in Micronesia. The island is comprised of two major geographical areas:

- Northern Guam is a result of a series of volcanic eruptions along the ocean bed. Millennia of erosion have created a relatively flat limestone-capped plateau that abruptly terminates in sheer seacliffs. The north is sparsely inhabited and predominantly covered in *tangan tangan* -- a dense-growing hardy shrub.

- Southern Guam is composed of the remnants of more recent lava flows and is characterized by basaltic, mountainous terrain that tapers off into a narrow coastal strip. The mountains are mainly denuded of vegetation beyond tussocks and dry grasses. The southern coastal highway is dotted with picturesque beachside villages.

The girth of the island stretches only four miles across. Agana and Tamuning, the center of Guam's urban area, lie on the western coast. Suburbs extend northwards to Dededo and Yigo villages and southwards to the villages of Asan and Piti. Downtown Agana bustles with commerce and government. Fast-food restaurants, shopping malls, and rush-hour traffic congestion throughout the Agana area reflect Guam's rapid urbanization. Outlying villages -- particularly in the south -- are more reminiscent of the island's traditional, moderately-paced lifestyle.

Of the various peoples that form Guam's population, there are four main components: long-term civilian residents, short-term military residents, short-term immigrants (Micronesians from the former Trust Territory and H-2 foreign workers), and tourists (mainly Japanese). Since visitor spending boosts the economy, Japanese tourists are generally welcomed as a valuable resource. Furthermore, the average tourist stays on

island for only three days and basically confines himself to the general Tumon area, thus limiting the possibility for conflict with residents.

The situation between long-term civilian residents and military personnel is more complex. Guam's major military bases are fairly self-sufficient communities that require little day-to-day interaction with the civilian communities (for example, on-base commissaries stock goods at prices considerably cheaper than off-base establishments). However, military personnel do avail themselves of off-base liberty opportunities, occasionally resulting in barroom brawls. Some long-term residents view the military as a distinct but benevolent body that offers protection from potential foreign antagonists while providing stable employment; others harbor an underlying sense of resentment, feeling intruded upon and alienated in their own homeland.

As the newest groups on island, many short-term immigrants from Micronesia and the H-2 foreign workers have not yet been assimilated. Micronesian immigrants often experience western culture shock upon arrival in Guam. Social ills associated with this culture shock (e.g., a higher incidence of crime, poor educational attainment) have, unfortunately, led to Micronesians achieving notoriety as a cause of many Guam problems. Although not considered a particular threat, the H-2 foreign workers are by no means socially accepted. Both regulatory and cultural restrictions placed on H-2 workers usually leave them on the periphery of mainstream society.

2.2.2 Proposed Activity Sites

The Department of Defense (DoD) still plays a major role in Guam's affairs. Military installations occupy some 30% of the land area, and the federal government employs 12% of the civilian workforce directly.

The proposed action involves new activities at four bases: Andersen Air Force Base, Naval Air Station Agana, Naval Station Guam, and Naval Magazine Guam.

ANDERSEN AIR FORCE BASE. Andersen Air Force Base covers most of the island's northern region, and is the single largest military base on Guam. At its peak usage during the Vietnam era, Andersen housed a B-52 bomber contingent that conducted round-the-clock sorties. Current operations are low-key and as a consequence much of its extensive landholdings lie vacant.

NAVAL AIR STATION AGANA (NAS). NAS is situated near the center of the island on a plateau overlooking Agana. NAS services naval aircraft and personnel in transit in the western Pacific. Guam's civilian air terminal lies within NAS.

NAVAL STATION GUAM (NAVSTA). Stretching southwards from Polaris Point to Agat (principally occupying the Orote peninsula), NAVSTA is the island's major naval installation. A number of tenant commands and facilities are sited at the base, along with the bulk of the Navy's housing.

NAVAL MAGAZINE GUAM (NAVMAG). Situated upland from NAVSTA, behind the village of Santa Rita, NAVMAG is Guam's second largest base. NAVMAG provides ordnance support for the Seventh Fleet. Most of the base's 8,840 acres are mountainous and covered in dense vegetation.

2.2.3 Nearby Communities

While the proposed action will be felt islandwide, the communities surrounding the activity sites -- Dededo, Yigo, Asan, Piti, Agat, and Santa Rita -- may be more strongly affected, especially in terms of pressure on educational facilities and rental housing.

DEDEDO. Although this is the largest district on Guam, with almost a quarter of the island's population, the northern portion of Dededo that borders Andersen is only lightly settled. The village center -- at the southern portion of the district -- is near the light industrial region of Harmon, as well as close to the Tumon resort. Other Dededo subdivisions are much more isolated.

Topographically, the district is characterized by thick scrub covering an extremely level plateau, ending in sea cliffs at the western coast. With large tracts of developable flat acreage, Dededo is the major site slated for Government of Guam urbanization projects.

YIGO. Yigo district is located in the island's northeast. It physically resembles its neighbor Dededo, except that Yigo is far less inhabited. Several blocks of land in the area have been identified by the federal government as excess and thus may revert to the Territorial government.

ASAN. Although the entire district of Asan includes most of Nimitz Hill, the village itself occupies a cove south of Agana, bounded by mountain ridges and the sea. Asan was devastated by typhoons in the 1970s and much of the village has been substantially rebuilt under the auspices of the Guam Housing and Urban Renewal Authority (GHURA).

PITI. Piti village is located in the larger cove immediately south of Asan. Since NAVSTA marks Piti's southern limits, and Guam's principal highway -- Marine Drive -- terminates in Piti, the village basically marks the southern end of Guam's urban region.

The southern portion of Piti district includes the Port of Guam, the island's only commercial port. In this general area, a number of small retail establishments are strung out along the portion of Marine Drive that fronts NAVSTA.

AGAT. Agat is situated on a sandy stretch of the island's southern shore. Although imbued with the same quiet residential atmosphere of the other southern villages, Agat is the area's largest village. As the southwest's major center, Agat houses the police's Southwest Precinct and offers the region's only high school. Agat also has the south's only hotel -- the Inn on the Bay -- with accompanying small boutiques.

SANTA RITA. The village itself is nestled in the foothills amidst Agat, NAVMAG, and NAVSTA. Santa Rita's pre-War population resided in the town of Sumay, which is now part of NAVSTA. The townspeople were relocated upland during the post-war build-up of the base. Presently, the village has two major subdivisions: the village center, which includes most of the community facilities, and Santa Rosa, a residential area close to NAVSTA.

2.3 DEMOGRAPHIC CHARACTERISTICS

2.3.1 Population Trends

Guam boasts a population of over 133,000 persons. However, as shown in Exhibit 2-B, Guam's population has traditionally been small, having multiplied tenfold in the past 70 years. The largest proportional increase in population was between 1940 and 1950, when military construction was at its highest. The construction surge required large numbers of military personnel and in-migrant workers, respectively explaining the extremely high rates of increase for Caucasians (40%) and Filipinos (29%) during this period.

Since 1950, Chamorros have comprised only around half of the island's ethnic stock (see Exhibit 2-C). The overall proportion of Caucasians has decreased and the overall proportion of Filipinos has increased steadily. As shown in Exhibit 2-D, Filipinos are the second largest ethnic group after Chamorros. However, over 80% of the Filipinos residing in Guam were born in the Philippines.

Between 1980 and 1990, the share of Pacific Islanders (other than Chamorros) in the population increased slightly. However, in-migration to Guam from the former Trust Territory of the Pacific Islands has increased steadily since treaties assuring free entry to the United States were signed in late 1986 (Rubinstein and Levin, forthcoming). The number of in-migrants to Guam from the Federated States of Micronesia alone has probably doubled between 1990 and mid-1992, to about 6,000 persons (personal communication, Donald H. Rubinstein, Micronesian Area Research Center, University of Guam, June 1992).

EXHIBIT 2-B: POPULATION TRENDS, 1920-1990

	1920	1930	1940	1950	1960	1970	1980	1990
TOTAL POPULATION	13,275	18,509	22,290	59,498	67,044	84,996	105,979	133,152
ETHNICITY								
Chamorro/Part-Chamorro	12,216	16,402	20,177	27,124	34,762	N/A	47,845	57,648
Caucasian	280	1,205	785	22,920	20,724	N/A	8,442	19,160
Filipino	396	365	569	7,258	8,580	N/A	22,447	30,043
Other	383	537	759	2,196	2,978	N/A	27,245	26,301

	1920-30	1930-40	1940-50	1950-60	1960-70	1970-80	1980-90
AVERAGE ANNUAL GROWTH RATE	3.4%	1.9%	10.3%	1.2%	2.4%	2.2%	2.3%
ETHNICITY							
Chamorro/Part-Chamorro	3.0%	2.1%	3.0%	2.5%	N/A	N/A	1.9%
Caucasian	15.7%	-4.2%	40.1%	-1.0%	N/A	N/A	8.5%
Filipino	-0.8%	4.5%	29.0%	1.7%	N/A	N/A	3.0%
Other	3.4%	3.5%	11.2%	3.1%	N/A	N/A	-0.4%

NOTE: N/A Data not available.

SOURCES: U.S. Bureau of the Census, 1992, 1983, 1973, 1963.

As the island economy has diversified, the population has become more stable. Exhibit 2-D's comparison of the major demographic characteristics between 1980 and 1990 shows very few proportional changes over the last decade.

2.3.2 Age and Educational Attainment

Guam's population is young. Almost 70% of the people were under the age of 35 in 1990. The population is also fairly stable, since around 65% of persons aged five and over lived on island in 1985, and about two-thirds of those lived in the same house.

In terms of educational attainment, Guam's people vary widely -- nearly a quarter of those aged 25 and over have a college degree, but another 45% have not graduated from high school.

2.4 HOUSING AND INCOME CHARACTERISTICS

2.4.1 Islandwide

Land available for housing is an important island concern. Beside the 30% of the island that is held by the military, another 30% is land reserved as Conservation (principally owned by the Territorial government). As Exhibit 2-E shows, nearly 40% of Guam's 1990 housing stock of 35,223 units was located in Dededo and neighboring Tamuning -- districts which include large tracts of developable private and Territorial government lands. Limited land in a boom economy has made housing scarce and has driven housing costs to exorbitant levels.

In addition to the land issue and the devastation caused by typhoons, Guam's boom economy has contributed to the housing shortage. Until recently, the construction industry devoted most of its energies to large-scale resort projects, leaving scant resources for less profitable residential construction. Anecdotal evidence from major construction companies on Guam indicates that housing construction is on the rise now that resort-related development is abating.

While crowding decreased from 1980 to 1990 (see Exhibit 2-F), it is still fairly high. More than a fifth of the occupied units are crowded (that is, one or more persons per room).

Despite the housing crunch, over a tenth of all housing units stand vacant. The vacant units (half of which are for rent) are largely in new luxury condominiums with prohibitive rents. Tamuning, which includes the Tumon resort and upscale condo units, has the highest vacancy rate on island (21%) and accounts for a third of all vacant units.

EXHIBIT 2-E: SELECTED HOUSING CHARACTERISTICS BY DISTRICT, 1990

AREA	TOTAL HOUSING UNITS	VACANT UNITS TOTAL	VACANT UNITS For Rent	OCCUPIED UNITS TOTAL	OCCUPIED UNITS Renter-Occupied	LACKING COMPLETE PLUMBING Owner-Occupied	LACKING COMPLETE PLUMBING Renter-Occupied	LACKING COMPLETE PLUMBING Vacant	1989 MEDIAN RENT Gross	1989 MEDIAN RENT Contract
TOTAL GUAM	35,223	11%	4%	31,373	54%	55%	28%	36%	$547	$493
Agana	416	12%	10%	367	74%	64%	60%	12%	$448	$393
Agana Heights	1,008	7%	2%	939	49%	24%	16%	16%	$543	$483
Agat	1,300	13%	2%	1,135	49%	86%	63%	84%	$394	$308
Asan	620	9%	2%	565	54%	5%	3%	35%	$418	$336
Barrigada	2,140	8%	2%	1,975	49%	75%	33%	41%	$540	$494
Chalan Pago–Ordot	1,047	9%	3%	953	33%	74%	61%	77%	$506	$418
Dededo	7,541	8%	2%	6,963	41%	48%	37%	36%	$507	$438
Inarajan	553	12%	2%	488	35%	41%	32%	43%	$322	$248
Mangilao	2,699	10%	5%	2,427	47%	73%	31%	41%	$528	$477
Merizo	469	17%	7%	390	43%	52%	50%	65%	$320	$250
Mongmong–Maite	1,742	10%	4%	1,573	68%	33%	15%	43%	$476	$421
Piti	554	13%	2%	480	52%	48%	26%	53%	$801	$739
Santa Rita	2,343	2%	1%	2,287	75%	57%	16%	73%	$446	$420
Sinajana	712	10%	4%	641	35%	67%	41%	49%	$509	$432
Talofofo	548	5%	1%	521	41%	70%	63%	56%	$486	$419
Tamuning	6,296	21%	10%	4,982	76%	23%	14%	11%	$617	$567
Umatac	188	14%	2%	162	44%	96%	97%	88%	$246	$185
Yigo	3,686	9%	2%	3,370	64%	68%	26%	47%	$591	$534
Yona	1,361	15%	6%	1,155	32%	71%	44%	68%	$424	$353

SOURCE: U.S. Bureau of the Census, 1992.

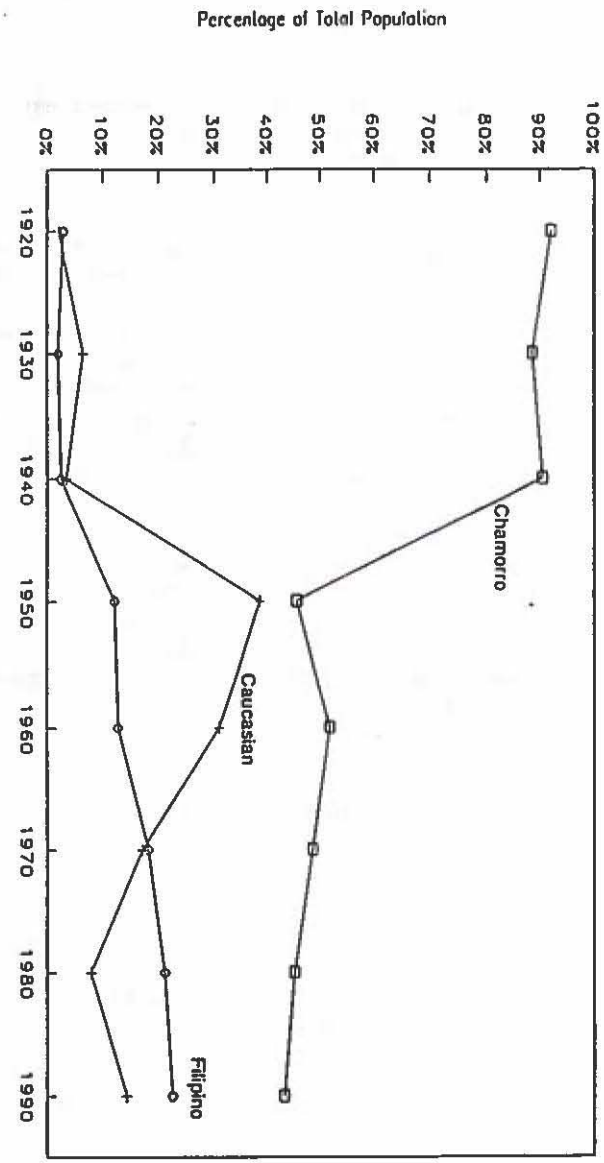
EXHIBIT 2-D: DEMOGRAPHIC CHARACTERISTICS, 1980 AND 1990

	TOTAL GUAM	
	1980	1990
POPULATION	105,979	133,152
ETHNICITY		
Chamorro/Part-Chamorro	46%	43%
Filipino	21%	23%
Caucasian	8%	14%
Other Pacific Islander	2%	5%
Other	23%	15%
AGE		
Less than 5 years	12%	11%
5 to 17 years	29%	24%
18 to 34 years	33%	34%
35 to 64 years	23%	27%
65 or more years	3%	4%
Median age (years)	22.2	25.0
PLACE OF BIRTH (1)		
Guam	49%	48%
Other U.S.-born (2)	24%	23%
Other Pacific Islands	1%	2%
Philippines	16%	16%
Elsewhere	10%	9%
RESIDENCE 5 YEARS PREVIOUS FOR PERSONS AGED 5 & OVER (1)		
Same house	39%	46%
Same district, different house	14%	9%
Different district	13%	12%
United States (3)	20%	20%
Other Pacific Islands	1%	2%
Philippines	5%	5%
Elsewhere outside Guam	14%	13%
EDUCATION OF PERSONS AGED 25 & OVER (1)		
High School Diploma	N/C	33%
College Degree (4)	N/C	23%

NOTES: N/C 1980 and 1990 categories are not comparable.
(1) Based on 15% sample; hence, figures represent estimates only.
(2) Includes persons born in U.S. territories and commonwealths, and persons born abroad or at sea to American parents.
(3) Includes U.S. territories and commonwealths.
(4) Includes Associate, Bachelor's, and graduate degrees.

SOURCES: U.S. Bureau of the Census, 1992, 1984, 1983a.

EXHIBIT 2-C: ETHNICITY, 1920-1990



NOTES: Ethnic data were collected by the Census Bureau for each decennial year except 1970. 1970 figures are estimated by calculating the mid-point between the 1960 and 1980 counts. Readers should note that intercensal fluctuations (due mainly to war and short-term labor migrations) are not reflected in this graph.

SOURCES: U.S. Bureau of the Census, 1992, 1983, 1973, 1963.

EXHIBIT 2-F: HOUSING CHARACTERISTICS, 1980 AND 1990

	TOTAL GUAM	
	1980	1990
TOTAL HOUSING UNITS	28,249	35,223
TOTAL VACANT UNITS	12%	11%
Seasonal/recreational	1%	0%
For sale only	1%	1%
For rent	5%	4%
Other vacant	6%	5%
AGE OF STRUCTURE (1)		
1 year	N/A	9%
2 to 10 years	N/A	21%
11 to 20 years	N/A	41%
More than 20 years	N/A	29%
LACKING COMPLETE PLUMBING (2)	N/C	40%
TOTAL OCCUPIED UNITS	24,834	31,373
TENURE		
Owner-occupied	46%	46%
Renter-occupied	54%	54%
PERSONS IN OCCUPIED UNITS	101,000	124,596
As % of total population	95%	94%
PERSONS PER UNIT	4.07	3.97
PERSONS PER ROOM		
1.00 to 1.50 (3)	15%	13%
1.51 or more (4)	9%	7%
1989 MEDIAN VALUE (5) (owner-occupied)	$57,600	$130,500
1989 MEDIAN GROSS RENT (renter-occupied)	$193	$547

NOTES: N/A Data not available.
N/C 1980 and 1990 categories are not comparable.
(1) Based on 15% sample; hence, figures represent estimates only.
(2) 1990 figures based on 15% sample; 1980 figures based on full sample.
(3) Indicates "mildly crowded" conditions.
(4) Indicates "very crowded" conditions.
(5) Median values are for non-condominium housing units.

SOURCES: U.S. Bureau of the Census, 1992, 1983b.

Almost three-quarters of Guam's housing stock is less than 20 years old. This relatively new housing is the result of both typhoon reconstruction and the island's population pressures. Around 40% of island units lack complete plumbing (partly due to many units in multi-family structures sharing facilities).

Over half of the households rent. This is understandable given the large number of military personnel (most of whom are short-term residents) and the high prices of homes (the median value of an owner-occupied home in 1989 was close to $130,000). Home ownership is highest in the districts of Chalan Pago-Ordot, Inarajan, Sinajana, and Yona.

Median rents in southern Guam are low. However, the housing stock is modest and few units are vacant. Two-thirds of the occupied rental units are in the northern districts of Dededo, Tamuning, Yigo, Barrigada, and Mangilao.

Housing costs for renters are a particular source of concern. The 1989 islandwide median gross rent was around $550, with extremes ranging from as low as $250 in Umatac to as high as $800 in Piti. Close to a quarter of rental households devote 30% or more of their income towards housing costs (as shown in Exhibit 2-G).

Median household and family incomes on Guam in 1989 were roughly $31,000 More than a tenth of island families garnered incomes below the poverty line. Approximately 15% of households received Social Security or some other type of public assistance income.

2.4.2 Military Households

Households comprised entirely of military personnel or dependents take up more than 15% of Guam's occupied units (see Exhibit 2-H). The bulk of the military units (63%) are over 20 years. Most military householders rent (96%). This can place subsidized military renters in competition with low-income civilian renters for units off-base.

Most military households paid no cash rent at all in 1989 (83%). The median gross rent paid by other military households was $100 higher than the islandwide median.

As can be seen in Exhibit 2-I, over half of the military households had 1989 incomes below $25,000 compared to only around 35% for civilian and mixed households. Furthermore, civilian household incomes were distributed much more evenly than military household incomes.

EXHIBIT 2-G: INCOME CHARACTERISTICS, 1989 (1)

	TOTAL GUAM
HOUSEHOLDS	31,373
INCOME	
Median income	$30,755
With Social Security income	8%
With public assistance income	7%
HOUSING COSTS AS PERCENTAGE OF HOUSEHOLD INCOME (2)	
Owner costs at 30% or more (3)	12%
Renter costs at 30% or more (3)	24%
OWNER-OCCUPIED HOUSEHOLDS (2)	
Without a mortgage	38%
With a mortgage	62%
Median monthly costs (3)	$598
FAMILIES	27,313
INCOME	
Below poverty level	13%
Median income	$31,178

NOTES: (1) Based on 15% sample; hence, figures represent estimates only. Comparable income data for 1979 not available.
(2) For specified households.
(3) Costs include mortgage, real property tax, and utilities.

SOURCES: U.S. Bureau of the Census, 1992.

EXHIBIT 2-H: MILITARY HOUSEHOLDS, 1990

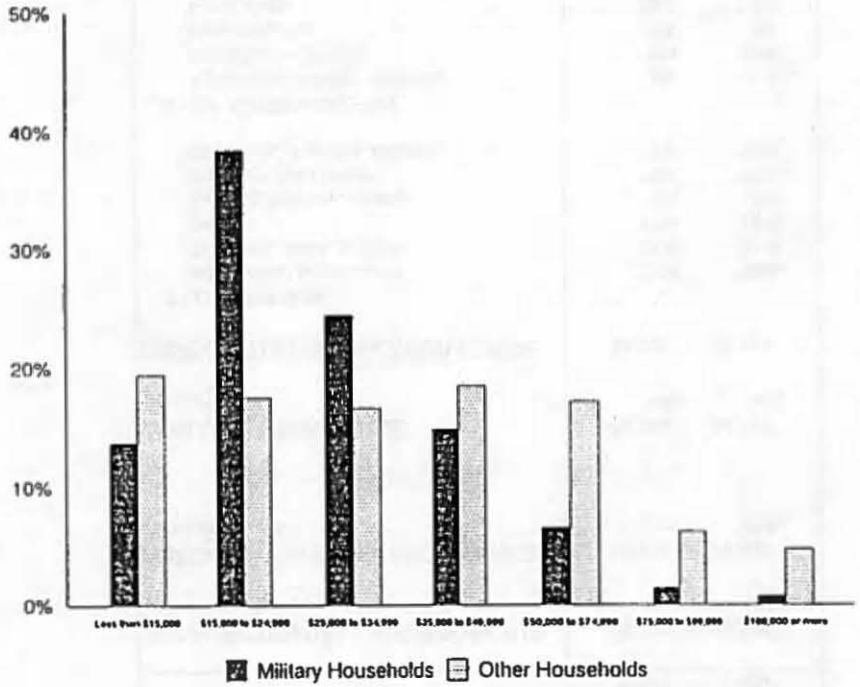
	TOTAL	Military Households (1)	Part-Military Households (2)	Non-Military Households (3)
TOTAL HOUSEHOLDS	31,373	4,844	2,936	23,593
TENURE				
Owner-occuped	46%	4%	49%	54%
Renter-occupied	54%	96%	51%	46%
RENTER-OCCUPIED HOUSEHOLDS	17,065	4,651	1,506	10,908
AGE OF STRUCTURE				
1 to 10 years	26%	7%	23%	34%
11 to 20 years	39%	30%	39%	44%
More than 20 years	35%	63%	38%	22%
YEAR HOUSEHOLDER MOVED IN				
1989	54%	62%	59%	49%
1985-1988	34%	37%	33%	32%
Earlier	13%	1%	8%	18%
1989 GROSS RENT (4)				
No cash rent	37%	83%	42%	17%
$1-$499	27%	3%	15%	38%
$500-$599	10%	2%	10%	14%
$600-$699	9%	4%	10%	10%
$700-$799	5%	2%	8%	6%
$800-$899	4%	2%	6%	5%
$900-$999	3%	1%	3%	3%
$1000-$1999	5%	1%	5%	6%
$2000 or more	1%	1%	1%	1%
1989 MEDIAN RENT (5)				
Gross (4)	$547	$679	$646	$525
Contract	$493	$638	$579	$467

NOTE: (1) Households with all persons in military (mainly active-duty personnel) and military dependents.
(2) Households with some but not all persons in military (including Reserves and National Guard) and military dependents.
(3) Households with no military personnel and no military dependents.
(4) Gross rent includes average monthly cost of utilities (if paid for by renter).
(5) Excludes those who pay no cash rent.

SOURCE: U.S. Bureau of the Census, 1992.

EXHIBIT 2-I: MILITARY HOUSEHOLD INCOME DISTRIBUTIONS, 1989

	All Persons in Military or Military Dependents	Other Households
Less than $15,000	14%	19%
$15,000 to $24,999	38%	17%
$25,000 to $34,999	24%	17%
$35,000 to $49,999	15%	18%
$50,000 to $74,999	7%	17%
$75,000 to $99,999	1%	6%
$100,000 or more	1%	5%



SOURCE: U.S. Bureau of the Census, 1992.

2.5 EMPLOYMENT AND LABOR FORCE CHARACTERISTICS

The Territorial government remains the largest single employer on island, accounting for over a fifth of the civilian labor force. The military (including Reserves and National Guard) is a major employer also, accounting for 13% of the island's total civilian and military potential labor force (as shown in Exhibit 2-J). Furthermore, 86% of dependents of active-duty military personnel aged 16 and over are employed.

Unemployment for the civilian labor force is low, estimated as 3.2% for March of 1991 (Exhibit 2-K). One of the crucial difficulties facing employers is the island's severe labor shortage. For construction work in particular, Guam firms have taken to importing foreign labor on short-term H-2 work visas. In March 1991, a peak year for construction, Guam had close to 7,000 H-2 workers, a substantial increase from 1,200 in the same month only three years earlier (Exhibit 2-L). While such worker importation has been relatively successful for the construction industry, hotels -- which often require workers with strong language skills and vocational training -- are struggling to find suitable employees.

Guam's reliance on civil service and the military for employment is decreasing as the private sector continues to expand. Evidence of the island's construction boom brought about by visitor industry growth can be seen throughout the Tumon resort area: most hotels are new and many structures are still being erected. Exhibit 2-M shows that the number of total available hotel rooms on Guam more than doubled to 5,000 units between 1981 and 1990. In the past year, however, the pace of large-scale resort development -- basically financed by Japanese investors -- has slowed, due to Japan's bearish economic climate.

The majority of jobs (both government and private) are located near the Tamuning-to-Piti strip r ong Marine Drive, forcing many to commute to this general area. Almost a fifth of Guan s workers commute more than half an hour, although the mean commute is only about a quarter of an hour.

2.6 FORCES SHAPING GUAM'S FUTURE

There is a broad consensus among planners on Guam that economic and demographic growth will continue for many years, fueled by continuing expansion of tourism. Their projections assume that military activity will remain at current levels.

Guam's Legislature has mandated creation of a Comprehensive Development Plan. Plans now under development are major parts of the comprehensive plan. Working documents for the Guam 2010 Highway Master Plan and I Tano'-ta: The Guam Land Use Plan provide projections of future conditions. These projections are not official.

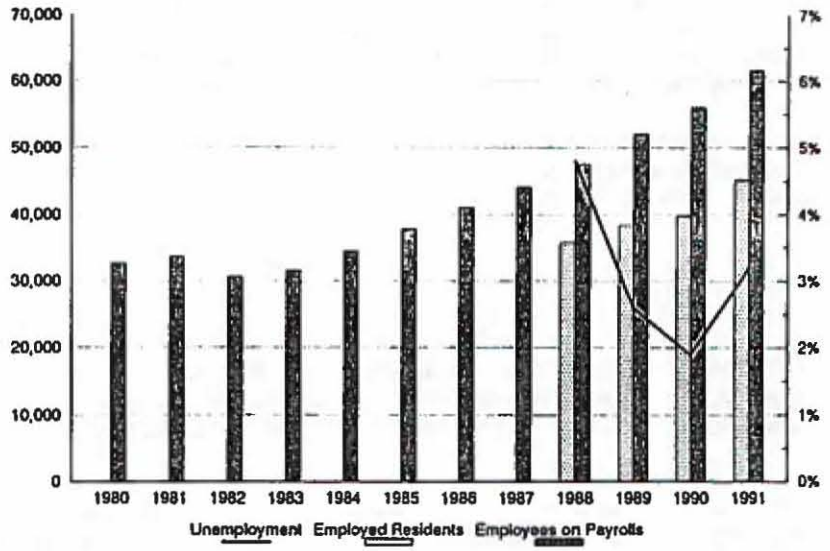
EXHIBIT 2-J: LABOR FORCE CHARACTERISTICS, 1980 AND 1990 (1)

	TOTAL GUAM	
	1980	1990
TOTAL POTENTIAL LABOR FORCE (2)	66,773	90,990
In Armed Forces	15%	13%
POTENTIAL CIVILIAN LABOR FORCE	56,648	79,038
In Labor Force	61%	69%
CIVILIAN LABOR FORCE	34,359	54,186
Unemployed	5%	4%
EMPLOYED CIVILIAN LABOR FORCE	32,692	52,144
BY OCCUPATION		
Managerial, professional	25%	23%
Technical, sales, support	31%	31%
Service	17%	16%
Farming, forestry, fishing	1%	1%
Precision, craft, repair	15%	17%
Operators, cleaners, laborers	11%	12%
BY SELECTED INDUSTRY		
Agriculture, forestry, fisheries	1%	1%
Construction, mining	9%	15%
Manufacturing	5%	4%
Retail trade	20%	19%
Finance, insurance, real estate	5%	5%
Personal, entertainment, recreation	6%	9%
Health, education, professional	20%	17%
Public administration	18%	11%
COMMUTE TO WORK		
More than 30 minutes	N/A	18%
Mean travel time (minutes)	N/A	17

NOTES: N/A Data not available.
(1) Based on 15% sample; hence, figures represent estimates only.
(2) All persons 16 years and over.

SOURCES: U.S. Bureau of the Census, 1992, 1984.

EXHIBIT 2-K: CIVILIAN LABOR FORCE TRENDS



YEAR (1)	EMPLOYED RESIDENTS (2)	UNEMPLOYMENT, RESIDENTS (2)		EMPLOYEES ON PAYROLLS (3)
1980				32,700
1981				33,600
1982				30,600
1983				31,600
1984				34,470
1985				37,910
1986				41,140
1987				44,150
1988	35,740	1,700	4.8%	47,510
1989	38,410	1,010	2.6%	52,110
1990	39,800	760	1.9%	56,080
1991	45,230	1,450	3.2%	61,690

NOTES: (1) As of March.
(2) From Current Labor Force Survey, Bureau of Labor Statistics. Includes civilians 16 years of age and older, but excludes (a) aliens who are not permanent residents, (b) members of the Armed Forces, and (c) military dependents living on military reservations.
(3) From Bureau of Labor Statistics Census of Establishments.

SOURCES: Guam Department of Labor, 1992; Guam Department of Commerce, 1991, 1992.

EXHIBIT 2-L: H-2 WORKERS ON GUAM, 1988-1991 (1)

YEAR (2)	H-2 WORKERS
1988	1,205
1989	2,393
1990	4,572
1991	6,987

NOTES: (1) H-2 visas are issued by U.S. Immigration and Naturalization Service to general laborers for temporary services.
(2) Monthly totals within a given year can vary considerably. The month of March was used here since other Department of Commerce labor force statistics were as of March.

SOURCES: Guam Department of Commerce, 1991, 1992.

EXHIBIT 2-M: AVAILABLE HOTEL ROOMS, 1981-1991 (1)

YEAR	AVAILABLE ROOMS	AS PERCENTAGE OF 1981
1981	2,345	100%
1982	2,416	103%
1983	2,819	120%
1984	2,964	126%
1985	2,991	128%
1986	3,248	139%
1987	3,864	165%
1988	3,939	168%
1989	4,133	176%
1990	4,955	211%

NOTE: (1) Available rooms are total current visitor hotel rooms available for use, including rooms in business and non-tourist hotels. This does not take into account occupancy rates or units under construction.

SOURCE: Guam Department of Commerce, 1991.

2.6.1 Anticipated Economic and Population Growth

Guam's tourist industry has been highly concentrated around Tumon Bay in Tamuning. Additional hotels and condominiums are planned for Tumon and for new resort sites around the island. Reasons for projections of continuing expansion include current high occupancy levels, the development of golf courses and other recreational resources around the island, and the possibility that Guam will attract tourists from several Asian markets, in addition to Japan.

In 1990, Guam had almost 5,000 hotel rooms (see Exhibit 2-M), about 2,000 condominiums ("with possible tourist orientation"), and five golf courses (including two military courses). After subtracting some 800 hotel rooms primarily used for business and other non-tourist purposes, Guam had 4,200 tourist hotel rooms (as shown below). Units under construction and/or proposed were estimated by Guam Visitors Bureau in 1991:

	EXISTING (1990)	UNDER CONSTRUCTION	PROPOSED	TOTAL
HOTEL ROOMS (1)	4,200	4,300	13,150	21,650
Tumon	3,500	2,350	6,150	12,000
Rest of Island	700	1,950	7,000	9,650
CONDOMINIUMS (2)	2,000	N/A	5,000 (3)	7,000
GOLF COURSES	5	7	11	23

NOTES: (1) Does not include business or non-tourist hotel rooms.
(2) Condos for tourist use only.
(3) Includes condos under construction or proposed.

Exhibit 2-N shows expected increases in visitor arrivals and employment. It combines forecasts for the year 2010 from the Highway Master Plan and year 2015 projections from the Land Use Plan. It shows:

- The visitor count increasing almost fivefold by 2015;
- Jobs on Guam nearly doubling in number by 2010; and
- Population nearly doubling by 2015.

Hotel employment and other private sector jobs are projected as increasing both in number and in the share of the total economy, as shown in Exhibit 2-O. In the private sector, only the construction jobcount is expected to fall from current levels.

EXHIBIT 2-N: ECONOMIC AND DEMOGRAPHIC GROWTH PROJECTIONS (1)

	1990	HIGHWAY MASTER PLAN 1995	2000	2005	2010	LAND USE PLAN 2015
Average Daily Visitor Census (2)	7,382	10,042	13,475	18,111	23,174	33,300
Visitor Units Required (3)	5,127	6,974	9,358	12,577	16,093	N/A
Civilian Jobcount	58,670	66,481	N/A	N/A	112,413	N/A
Resident Population	133,152	158,676	N/A	N/A	237,288	263,318

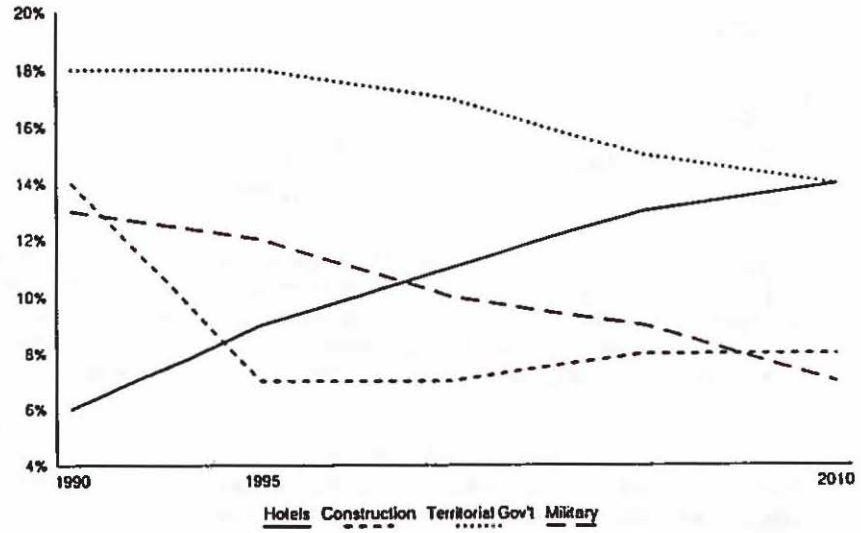
NOTES: (1) These projections have been developed for planning purposes on Guam, independent of the project. They assume that the military population on Guam will remain constant.
(2) Estimate for 2015 is rounded average of three different "visions."
(3) Assuming 80% occupancy.

SOURCES: Wilbur Smith and Associates, in association with Duenas & Swavely, Inc., 1991; Territorial Planning Council, 1992.

EXHIBIT 2-O: PROJECTED JOBCOUNTS

	1990	1995	2010
JOBCOUNT BY INDUSTRY			
Hotel	3,920	7,107	17,147
Retail	9,910	13,387	27,241
Construction	9,400	5,500	9,400
Other Private	16,140	19,898	34,604
Federal (Civilian)	6,880	6,880	6,880
Territorial	12,420	13,709	17,140
Military	8,795	8,795	8,795
Total Civilian Jobcount	58,670	66,481	112,413
Total Jobcount	67,465	75,276	121,208

SHARE OF TOTAL JOBCOUNT



SOURCE: Wilbur Smith and Associates, in association with Duenas & Swavely, Inc., 1991.

Territorial jobs are expected to increase in number, but to amount to a smaller fraction of total employment over time. Federal jobs, both civilian and military, are expected to stay constant. While these public sector job categories would occupy a smaller share of the total jobcount, they would still account for some 27% of the total.

Population increases would be due to both natural increase and in-migration. The Highway Master Plan estimates that as much as 82% of the 2010 population -- 60% of the increase over 1990 figures -- could be accounted for by natural increase, with no further in-migration. In-migrants could include persons from Guam who now live elsewhere in the United States, as well as people from the United States and Asia. (The 1990 Census counted over 49,000 "Guamanians" in the United States, not including overseas territories.)

2.6.2 Military Activity

Apart from the new activities that have followed the closing of Subic Bay, military operations on Guam have been stable or declining:

- Since the Strategic Air Command's B-52 bombers left Andersen AFB in 1989, that base has seen little new activity.
- No MILCON spending -- contract construction for major Navy projects -- was slated for 1993 authorization apart from the rollback. "Urgent" and 1993 authorizations would bring MILCON spending back up to recent levels.
- A March 1992 Navy estimate of the total military and military-related population on Guam anticipated growth in addition to the Subic-related increases. Most of this growth was expected at Andersen AFB:

	Current (March 1992)	Subic -- by Nov. 1992	Additional Increase as of 1995	Total, 1995
Active Duty, in				
Family Housing	5,168	450	309	5,927
Bachelor Quarters	4,487	937	1,306	6,730
Dependents	12,920	1,125	773	14,818
Total	22,575	2,512	2,388	27,475

Most of the additional military population expected by 1995 would be personnel on temporary duty.

By the end of 1992, Guam's military population will be much the same as in 1987.

The non-project "additional increase as of 1995" shown above is treated as part of the cumulative context of the project in the rest of this report. (However, estimates of project manpower shown in Exhibit 1-B are consistently used in this report, instead of the "Subic" numbers shown above.)

2.6.3 Housing

Less hotel construction recently has meant more housing construction. The number of permits issued for apartments and dormitories increased fourfold between 1986 and 1990 (Guam Department of Commerce, 1991). However, most of the 5,000 condominium units under construction or proposed for the coming years are for visitors and part-time residents. While new housing construction strictly for the resident market is lagging, it has still grown considerably: the number of new residential construction permits doubled between 1986 and 1990 (Guam Department of Commerce, 1991).

The population projections in Exhibit 2-N imply a increase in demand for housing. Calculations by Merrill and Associates, Inc. suggest that 5,200 to 6,000 units would be needed by 1995, and 9,900 to 12,500 additional units would be needed by 2000. If the population increases by 1995 as projected in the Highway Master Plan, over 6,400 new units would be needed to house the population at the 1990 household size (3.97 persons/household). The doubling of population anticipated over the next 25 years would generate demand for at least as much new resident housing as is now standing.

New initiatives addressing current and anticipated housing demand are few:

- The Guam Housing Corporation plans to develop 400 homes on a 46-acre site in Dededo. Half will be built with government funding, and half by MDI Corp. as a condition for developing the LeoPalace Resort in Yona and the LeoPalace Hotel in Tumon (Petrovsky, 1992a).
- The Department of Land Management's Land for the Landless program sells government land at $2,500 per 10,000 square-foot lot. Land slated for sale by this program in the next year includes (personal communication, Kin Acfalle, Deputy Director, Department of Land Management, June 1992):
  - 446 acres in Dededo;

- 160 acres in Yigo; and
- 121 acres in Agat.

- GHURA has almost completed subdividing 500 lots in Dededo. Its other major development -- a 270-lot subdivision in Asan -- is only half complete (personal communication, Paul Santos, Engineer, GHURA, June 1992).

- The government's Community Affordable Housing Action Trust Program (CAHAT) is still being developed. Once implemented, CAHAT is expected to help first-time homebuyers qualify for housing with 5% down payments and below-market mortgage interest rates.

- Long-term land leases for Chamorros under the 1975 Chamorro Land Trust Act could bring affordable housing within the grasp of many on Guam.

  Implementation of the Land Trust Act would probably not result in extensive construction of housing in the next decade. Still, individual families could find homes and farm sites under the Land Trust provisions, and the Land Trust could be an important component of the long-term solution of Guam's housing crisis.

- The Navy proposes construction of 308 family units under a 1993 authorization as part of the action under review in this report.

In recent years, much of Guam's housing has consisted of dormitory units and homes with outdoor plumbing. So long as Guam depends on contract workers and other young in-migrants to meet its labor needs, such housing may well suffice. However, increasing demand for separate housing units with standard amenities is likely as Guam's economic boom continues. Hence a housing crisis, allowing owners to raise rents to high levels, is part of Guam's current and emerging situation, independent of the Navy actions under study.

2.6.4 Planning for Guam's Future

The Government of Guam has taken several steps to anticipate future needs and trends. Increased government and community control over economic growth is favored by many on Guam. In meetings held in all districts of Guam (Territorial Planning Council, 1992), concerns were repeatedly expressed about:

- Community input into project approval process;

- Regulations to control development;
- Systematic planning;
- Traffic congestion and safety; and
- Guam's limited infrastructure and public facilities, specifically:
  - Power generation and transmission (principally to eliminate load shedding);
  - Potable water;
  - Sewage treatment;
  - Schools; and
  - Parks and recreation facilities.

At six regional meetings in June 1992, various speakers expressed concern about the specific land use designations being proposed, and about the planning process, according to summaries prepared by the planning consultants. Several citizens expressed dissatisfaction with Guam's infrastructure. In most meetings, some speakers expressed dismay at the expecting doubling of Guam's population.

CRI's interviews with Guam residents were too focused and few in number to support any claims about public opinion in general. Nonetheless, we note that interviewees generally supported economic growth, and were particularly bearish concerning the tourist industry.

The draft land use plan is being revised after further public review. The final plan will be submitted to the Governor in November 1992. It is one of several elements of a Comprehensive Development Plan for Guam. That Plan was mandated by Public Law 20-147 of 1990, which underlined both concern about "unbridled and unmanageable growth" and the need for an integrated planning process. Other planning efforts recently completed or under way include studies of future infrastructure needs, including a Highway Master Plan and a study of port operations and costs (reported in Petrovsky, 1992b).

2.6.5 Citizen Concerns Affecting Views of the Future

For many on Guam, broad political issues affect assessments of a wide range of policies and plans. These are, strictly speaking, outside the scope of the EIS for the

proposed action, since it will not change them. Nonetheless, these remain fundamental to public reception of plans and policies, and deserve note here:

- **The Territory's Political Status.** Guam is an unincorporated territory of the United States, with less control over its land and laws than have States or territories incorporated as Commonwealths. While the Territorial government has much more power than in recent decades, more is wanted. Support for Commonwealth status seems widespread.

  Federal actions with delimited aims, such as wildlife preservation, may be seen as attempts to take sovereignty, land, and power from Guam. Again, Guam's successes are sometimes seen as occurring <u>despite</u> federal policy. Thus Governor Ada has spoken of Guam's tourism boom as arising because "it is an industry that is difficult for the federal government to interfere with" (Ada, 1989).

- **Federal Lands.** Guam's leaders have sought to regain lands little used or unused by the federal government. About 3,000 acres of federal land is now designated as excess and due to be handed over to the Government of Guam (GovGuam). In addition, GovGuam has sought to acquire NAS Agana, so Guam will own and be assured of continuing civilian use of one of its airfields. (In its land use planning process, however, GovGuam has teated nearly all military land as outside its area of interest.)

  Others on Guam seek (a) to have larger areas ceded, and (b) to have them ceded to "the people," not a government entity. For some, "the people" would be members of the Chamorro ethnic group. For others, the appropriate recipients of the land would be descendants of earlier landholders.

- **The Future of Chamorro People/Chamoru Culture.** Activists have begun to develop a vision of native rights for Guam's indigenous people. Elements of that vision are autonomy in relation to the federal government; more control over Guam's land; provision of land for homes and farms for Chamorro people; and pride in a distinctive "Chamoru" identity and language. (The standard spelling clearly has more to do with Spanish and English orthographic patterns than with island speech; the alternate spelling underlines the idea of an independent identity.)

  People identifying as Chamorro form less than half the population. People speaking Chamorro at home accounted for only 29% of the total population, and only 60% of the Guam-born population in 1990 (U.S. Department of Commerce, 1992). Many on Guam are concerned that Chamorros will lose power and identity unless steps are taken to find and establish cultural roots.

3.0 ECONOMIC IMPACTS

3.1 OVERVIEW AND APPROACH

This chapter deals with project effects on employment and income on Guam. It calculates the immediate impacts of Navy activities -- creation of jobs and income, and importation of Navy dependents who will join the labor force -- in a step-by-step process, and then assesses their overall impact, taken together, as part of Guam's island economy.

Impacts -- Findings. The Navy is creating new jobs and bringing people to Guam who will fill jobs. In the next few years, the major change will be the creation of new jobs, both in construction and operations. When the construction needed for the new activities is finished, the number of new workers brought to Guam in connection with the new Navy actions will be greater than the number of new civilian jobs created by those actions. **The short term will see many new jobs created, adding to the immediate need for in-migrant workers. However, the long-term impacts on the employment market will include <u>both</u> new jobs <u>and</u> a small reduction in the number of non-military in-migrants needed to fill available jobs on Guam.** This is because there will be more new civilian workers among the project's military dependents than new civilian jobs created by the project.

Guam's robust tourism-based economy is expected to create thousands of new jobs in the coming years. In comparison, the jobs associated with the project are few.

Impacts -- General Approach. A project's impacts must be assessed in relation to possible conditions at the time those impacts occur. Hence impacts are differences between two futures, the likely future without the project and the future with project. Some impacts, such as direct project employment, can be identified in a fairly straightforward way without consideration of the larger future context -- project jobs would simply not exist without the project. The implications of this fact become clearer when the various employment and labor force effects of the project are viewed together and seen in relation to the future without project.

The overall future context can be modelled using projections. CRI prefers to use projections developed for public policy because these have been subjected to critical review, and may represent a consensus concerning the future. On Guam, there is general agreement that economic growth can and will continue. CRI uses projections which follow from that agreement.

Modeling. The Navy has identified the direct jobs -- military billets and civilian jobs -- needed to perform the activities under study. The employment associated with the activities also includes indirect and induced jobs. Indirect jobs are created as the Navy purchases supplies and services from the local economy to support its activities. Induced jobs are created as wage-earners spend their income in the local economy.

To estimate indirect and induced job-creation associated with ongoing Navy operations, CRI identified sources and amounts of cash from the proposed action that would flow into the Guam economy. Care was taken both to count the various sources of new income associated with the project, and to allow for the fact that Navy families largely shop on-base. Fewer jobs are created when dollars are spent on-base in commissaries and the Exchange rather than off-base. Next, CRI drew on government statistics and studies of the Guam economy to construct a jobcount-based model of the island economy, correlating economic inputs and jobs.

After reviewing several alternative ways to estimate indirect and induced jobs, CRI adapted Hawaii multipliers to use in conjunction with the model of the Guam economy. This approach combined information based on Guam labor force data with multipliers derived from extensive studies of a Pacific island economy with strong tourism, construction, and defense industries. (Multipliers based on Hawaii's 1982 economy are available from the Hawaii Department of Business and Economic Development's Research and Economic Analysis Division. Works used in developing the CRI approach to the effects of new Navy activities on Guam's economy include Anderson et al., 1975; Bank of Hawaii, 1991; Blanchard and Iverson, 1990; Gilliam, 1988, 1989; Guam Department of Revenue and Taxation, 1990; 1992; Hawaii Department of Planning and Economic Development, 1983; Pacific Basin Development Council and School of Travel Industry Management, University of Hawaii, Manoa, 1988; Rioux and Schofield, 1990; SRI International, 1986; U.S. Department of Commerce, Bureau of Economic Analysis, 1980, 1983.)

Indirect and induced jobs associated with MILCON construction were estimated using a multiplier developed by SRI International (1986) for new inputs to the Guam economy. This approach recognizes the large amount of goods and services (including materials and port activity) needed for major construction projects. (The SRI multiplier was developed to estimate the impacts of tourism, but it does not apply only to that sector. It could not be used to estimate indirect and induced jobs associated with operations because Navy activities and personnel cannot be assumed to participate in the local economy to the extent that civilian firms and workers do.)

Estimates. In the exhibits that follow, we show unrounded results of calculations. These may convey an air of certainty and precision that cannot be justified in any projection. We stress that phrases emphasizing orders of magnitude, such as "about 150 jobs" and "a decrease of about 10%," are often appropriate forecasts. The unrounded numbers are shown in part because further calculations will follow from the findings of this Chapter. If the results were rounded, the linkages between economic, demographic, and fiscal estimates would be less clear.

3.2 EMPLOYMENT

3.2.1 Construction

Exhibit 3-A shows the military construction (MILCON) spending appropriations requested for the new Navy activities. The direct construction workforce for these appropriations was estimated on the basis of appropriations, allowing for profit and spending on off-island operations.

The construction workforce could include many new arrivals on Guam -- the exhibit shows jobs by location, not residency status. However, the Navy has a clear policy for its contractors on MILCON projects to hire U.S. citizens, not foreign workers on visas. Hence construction workers will likely be Guam resident citizens or short-term in-migrants from the rest of the United States.

At the end of 1991, the construction jobcount on Guam totalled over 12,000 (Guam Department of Commerce, 1992). About 6,400 workers on short-term (H-2) visas were in construction-related trades (Guam Contractors Association, 1992). The remaining workers were presumably citizens and permanent residents. The average annual direct construction jobcount for the new activities -- about 450 jobs/year for five years -- amounts to less than 4% of the total Guam construction payroll and thus about 8% of Guam's citizen/permanent resident construction workforce.

In recent years, construction payrolls grew in response to a boom in hotel and resort construction. Construction spending has dropped to the level found in the late 1980s (Petrovsky, 1992c). Because the industry relies heavily on workers with H-2 visas, impacts of the slowdown on Guam residents have been muted. Still, local builders and workers have expressed interest in Navy construction as a new source of work.

The effect of the new MILCON construction on the Guam construction industry will depend greatly on timing of other projects. The new Navy construction, along with new housing construction needed to meet Guam's needs, could make up in part for the recent decline in construction spending. If, on the other hand, proposed visitor industry projects are actually built, Guam could see large numbers of H-2 construction workers again. In any event, the Navy preference for U.S. citizen workers would keep wages on MILCON projects above the industry average. (Still, Guam construction wages are well below those paid elsewhere in the United States. Local hiring of subcontractors and workers will make

EXHIBIT 3-A: EMPLOYMENT ON GUAM ASSOCIATED WITH PROJECT CONSTRUCTION (1)

	CONSTRUCTION COULD BEGIN IN THE YEARS: 1993	1994	1995	1996	1997
A. DIRECT EMPLOYMENT (2)					
MILCON Spending (Millions of 1992 $s)	$35.6	$150.7	$89.0	$38.6	$4.8
Jobs	200	848	500	217	27
B. INDIRECT AND INDUCED (3) EMPLOYMENT					
Jobs	480	2,034	1,201	521	65
C. TOTAL JOBS	680	2,882	1,701	738	92

NOTES: (1) Construction allocated to year after proposed authorization, except for housing, which was spread over two years.

(2) Direct construction employment on Guam estimated on the assumptions that 90% of MILCON funds cover construction costs, total labor cost amounts to 25% of construction costs, and 90% of construction labor occurs on Guam. (The remaining 10% would be located in home offices off-island.) An average rate of pay of $15/hr. was assumed, based on talks with construction experts.

(3) Estimated on the basis of a model of the Guam economy, using data from the Guam Depts. of Commerce and Labor, and adapting multipliers developed for Hawaii. Construction Type II Multiplier used: 2.4.

SOURCE: SRI International, 1986.

economic sense even to outside construction firms, should these be awarded MILCON contracts.)

Indirect and induced jobs are created throughout the economy, not just in the construction industry. The number of indirect and induced jobs is estimated by using a multiplier, as described in Exhibit 3-A.

3.2.2 Operations

The new Navy activities are projected to begin when personnel are moved from Subic Bay and to continue indefinitely. The Navy has estimated the permanent direct jobs involved -- 1,377 military billets and 319 civilian jobs (Belt Collins & Associates, 1992). These figures do not include either short-term hires moving personnel and equipment from Subic or transients working on Guam after 1992.

Civilians will work mainly for Naval Supply Depot (where materials handlers and stevedores are needed) and the Ship Repair Facility (where riggers are in demand). These jobs are classified in Wage Grades 5 through 11, earning from about $10 to $15 per hour.

Additionally, about 150 indirect and induced jobs would be created on Guam (as shown in Exhibit 3-B). The number of jobs would expectably decrease (by less than 10%) once new Navy housing is built, and Navy personnel spend less on off-base rents.

To estimate indirect and induced jobs associated with operations, CRI identified major capital flows into the Guam economy. These are the "inputs" shown in Exhibit 3-B. The distribution and number of indirect and induced jobs created by Navy spending is assumed to approximate the distribution of jobs in the overall economy.

CRI used Guam data on jobcounts, wages, sales and receipts in different industries for 1986-1990. (This period was highlighted in part due to the availability of data. Also, the expansion of the private sector since 1990 reflects increased tourism, which is not likely to be affected by the sort of spending modelled in this report -- military operations create few hotel jobs.) New job creation was estimated from the ratio of jobs to sales and receipts in each industrial sector.

EXHIBIT 3-B: DIRECT, INDIRECT, AND INDUCED JOBS SUPPORTED BY NEW NAVY ACTIVITIES AND PERSONNEL ON GUAM

	JOBS	TOTAL WAGES & ALLOWANCES (1) 1993	1994	1995	1996 and Long Term
A. DIRECT JOBS (2)	1,696	$42.5	$41.9	$40.5	$39.2
B. INDIRECT & INDUCED JOBS SUPPORTED BY CONTINUING NEW CASH INPUTS					
INPUT (Millions of 1992 $s)					
Spending by military stationed on Guam and civilian hires (3)		$24.9	$24.3	$22.9	$21.6
Spending by transients (4)		$4.3	$4.3	$4.3	$4.3
Navy activities, support for personnel (5)		$7.1	$7.1	$7.1	$7.1
OUTPUT (6)					
Jobs		153	150	144	138
C. DIRECT, INDIRECT, & INDUCED JOBS		1,849	1,846	1,840	1,834

NOTES: (1) Direct jobs (shown in Exhibit 1-B) do not change over time. Housing allowances and TLAs change depending on availability of housing on Guam. In millions of 1992 dollars.
(2) Permanent new Navy jobs, both military and civilian.
(3) Spending in Guam economy estimated as 50% of military and military dependent post-tax wages, plus housing allowances and estimated child care costs, and 75% of Navy civilian hires' post-tax wages.
(4) Based on population shown in Exhibit 1-B, with daily spending estimated as averaging $50 to $100 per transient.
(5) Estimated as 20% of total payroll for activity, from historic relations between military payrolls and non-construction purchases on Guam. Allows for local purchases by commissaries and Exchange, as well as new activities.
(6) Derived from CRI model of job distribution in the Guam economy.

The distribution of indirect and induced jobs is accordingly expected to be:

Industrial Sector	Percent of Total Guam Jobcount
Agriculture	0.4%
Construction	12.6%
Manufacturing	3.5%
Services	18.9%
Trade	20.9%
Transportation/Utilities	5.9%
Federal Government	15.6%
Territorial Government	22.2%

(CRI excluded Finance, Real Estate and Insurance from the model as affected only marginally, if at all, by military spending.)

3.2.3 Additions to the Civilian Labor Force

Over 450 direct, indirect, and induced permanent civilian jobs would be created by ongoing Navy spending. Dependents of the new Navy personnel would take about 530 jobs, based on civilian labor force participation of military dependents in 1990.

The total increase in military dependents is limited by housing conditions on Guam. As discussed in Chapter 4, the number of Navy families present on Guam would be temporarily reduced in 1994 (by about 50 families) and 1995 (by about 150) due to the combined effects of increased demand and extremely high rental costs.

Navy dependents would hence add the following members to the civilian labor force:

Year	Workers
1993	530
1994	491
1995	404
1996 and later	530

The number of indirect and induced jobs to be filled would also be reduced slightly in 1994 and 1995 with fewer Navy families. The reduction would amount to fewer than five jobs in 1994, and about ten jobs in 1995.

(A few project-related military dependents could take civilian jobs associated with the project. That is not important for the analysis in this chapter, which compares the total job-creation impact of the project with the total project-related increase in the labor force.)

3.2.4 Cumulative Employment and Labor Force Impacts

Project Labor Supply. The Navy has had little difficulty in finding job applicants on Guam, even in the current condition of full employment. Navy pay scales and job security make Navy civilian jobs attractive for many young people or workers in the private sector. (Territorial jobs offer higher wages, so some turnover is possible in Navy civilian jobs.)

The major limit to local hiring is the availability of skilled personnel. The Navy has addressed this constraint by developing an apprenticeship program that has enrolled over 1,000 students since it began in 1956 (personal communication, Jerry W. Stewart, Director, Consolidated Civilian Personnel Office, June 1992). The Navy has made it clear that permanent civilian staff for the proposed action will be locally hired (Belt Collins & Associates, 1992). If qualified applicants are not already available, the Navy's apprenticeship program can produce qualified workers in a few years.

Non-Project Labor Supply. As Guam residents take jobs with the Navy, other positions must be filled by in-migrants or new recruits to the labor force. The Navy's commitment to local hiring hence does not change the fact that new jobs serve to draw outsiders to Guam's labor market. The influx of Navy dependents associated with the new activities does, however, mean that the need for non-military workers will be slightly smaller than it would be otherwise.

The new jobs generating additional need for labor consist in large part of construction jobs (between 1993 and 1997) and trades and service jobs (throughout the period).

Labor Force Impacts in the Context of Guam's Economy. The implications of the proposed action will depend on the state of the island economy. If Guam had high unemployment, a project which brought in more potential members of the civilian labor force would add to existing problems. If the economy continues to expand and unemployment remains low, such a project would help to address the problem of labor supply.

To quantify the relation between the proposed action and Guam's future economy, CRI adapted the projections for 1995 and 2010 developed for the Highway Master Plan study. By using these projections, the difference between the future without the project vs. with the project can be seen. (Other projections, or later revisions of these projections, would no doubt yield slightly different results. However, it is the magnitude of the

difference that is important, and that would be little affected by substituting one projection for another.)

Exhibit 3-C estimates the jobs and labor supply in 1995 and 2010 apart from the proposed action by combining the Highway Master Plan estimates with an adjustment for the impacts on the civilian economy of a non-project military larger than that study assumed. Then the specific new jobs and workers associated with the project are listed. Finally, unemployment is treated as a factor limiting the supply of available labor.

Exhibit 3-C suggests that in 1995 Guam will need to import about 9,250 workers without the project. The project would increase the need for in-migrant civilian workers by about 1,800 -- 20% of the without-project labor deficit. In 2010, a very different picture emerges. Guam's need for in-migrant labor is estimated as even greater than in 1995. **In 2010, the project's impact is to reduce the demand for in-migrant workers slightly.**

The major project-related difference between these two years is that construction spending is high in 1995 and absent in 2010. Construction is projected as reaching a peak in 1994, and ending after 1997. The net impact of the project on civilian labor supply would be to lower slightly the need for in-migrants as of 1998.

(NOTE: To project the number of in-migrants needed, the Highway Master Plan study used a "zero migration model," assuming that no net migration would occur after 1990. Since it is extremely likely that many Guam residents will go off-island for at least part of their lives, the actual level of in-migration needed to support the economy would likely be greater than shown in Exhibit 3-C. The share of civilian in-migration attributable to the project would then be even smaller.)

Project-Related Share of Total Jobcount. Another way to estimate the scope of the project in relation to the overall economy is simply in terms of projected jobs on island. Exhibit 3-D shows the difference in jobcounts between the without-project and with-project futures, combining civilian and military jobs.

The project's military jobs amount to about 11% of the island military strength, while the civilian jobs associated with the project add up to about 3% of the with-project civilian jobcount in 1995, and less than 1% in 2010. The difference between the two futures amounts to some 3,500 jobs in 1995, but drops to 1,800 -- of which only 450 are civilian jobs -- in 2010.

EXHIBIT 3-C: PROJECTED CIVILIAN EMPLOYMENT AND LABOR FORCE ON GUAM, WITH VS. WITHOUT PROJECT*

	WITHOUT PROJECT			WITH PROJECT			DIFFERENCE
	Projected Jobs: Demand	Labor Supply	Differ-ence	Projected Jobs: Demand	Labor Supply	Differ-ence	(Impact)
A. YEAR: 1995							
Duenas Projection (1) Demand	66,481			66,481			
Natural Increase		58,368			58,368		
Adjustment due to Non-Project New Military (2)	270	1,129		270	1,129		
New Military Construction (3)				500			
New Permanent Navy Civilian Jobs (4)				319			
Indirect & Induced Jobs Construction (3)				1,201			
Operations (4)				144			
Military Dependents (5)					530		
Reduction in % of Navy Families on Guam (6)				(13)	(126)		
Unemployment (7)		(2,003)			(2,067)		(more in-migrants needed)
TOTALS	66,751	57,495	(9,256)	68,902	57,834	(11,068)	1,812
B. YEAR 2010							
Duenas Projection (1) Demand	112,413			112,413			
Natural Increase		80,279			80,279		
Adjustment due to Non-Project New Military (2)	270	1,129		270	1,129		
New Permanent Navy Civilian Jobs (4)				319			
Indirect & Induced Jobs Operations (4)				138			
Military Dependents (5)					530		
Unemployment (7)		(3,380)			(3,394)		(fewer in-migrants needed)
TOTALS	112,683	78,028	(34,655)	113,140	78,544	(34,596)	(59)

NOTES: * Values in parentheses are negative.
(1) From Highway Master Plan projections, less military billets and personnel. Labor supply projections follow model of population growth given no migration to or from Guam after 1990.
(2) Adjustment for difference of 2,485 military billets between Navy estimates and Highway study. Jobs listed are indirect and induced jobs (using a ratio derived from CRI model of impacts of the new Navy activities). Additions to labor force are employed military dependents over 16, based on ratio of military personnel to employed dependents in 1990 Census.
(3) From Exhibit 3-A.
(4) From Exhibit 3-B.
(5) From Exhibit 1-B and U.S. Census data on working military dependents in households.
(6) An estimated 148 Navy families who would otherwise transfer to Guam will likely not come, due to Navy policy that dependents can only come when housing is available. Estimate for induced jobs associated with those families from CRI model. Estimate for military dependents' labor force participation from 1990 Census.
(7) Even in Guam's strong economy, some unemployment is likely. A base rate of unemployment is estimated here from forecast jobcounts: the average number unemployed would be about 3% of the jobcount.

SOURCES: U.S. Bureau of the Census, 1992; Wilbur Smith & Associates, in association with Duenas & Swavely, Inc., 1992.

EXHIBIT 3-D: PROJECTED EMPLOYMENT ON GUAM, WITH VS. WITHOUT PROJECT

	WITHOUT PROJECT		WITH PROJECT		DIFFERENCE (Impact)	
	1995	2010	1995	2010	1995	2010
CIVILIAN JOBS	66,751	112,683	68,902	113,140	2,151	457
Share Associated with New Navy Activities						
Operations			0.7%	0.4%		
Construction			2.5%	0.0%		
MILITARY JOBS	11,489	11,489	12,866	12,866	1,377	1,377
Share Associated with New Navy Activities			10.7%	10.7%		
TOTAL JOBS	78,240	124,172	81,768	126,006	3,528	1,834
Share Associated with New Navy Activities			4.3%	1.5%		

NOTES: Military jobcounts have been increased over Highway Master Plan figures to reflect recent Navy estimates of current and likely future staffing. Civilian jobs have been changed from the Master Plan estimates by including (a) new jobs associated with the Navy activities and (b) about 250 indirect and induced jobs estimated as associated with the larger military population. Exhibit 3-C shows adjustments in more detail.

SOURCE: Wilbur Smith & Associates, in association with Duenas & Swavely, Inc., 1992.

3.3 INCOME

3.3.1 Construction

Exhibit 3-E shows personal income -- wages and salaries -- paid on Guam for construction, along with income for indirect and induced jobs associated with construction.

The average annual direct income is $12.9 million (for a five-year period), while $15.7 million in income is earned in indirect and induced jobs associated with construction.

3.3.2 Operations

Exhibit 3-F shows total personal income associated with the ongoing Navy activities under study. The two periods shown are different because of off-base housing costs, as noted in Section 3.2.3.

Total gross personal income associated with operations amounts to over $40 million. The bulk of that income is in direct military and civilian wages and allowances.

3.3.3 Impacts on Guam Incomes

The incomes projected here form a modest addition to the Guam economy. Military spending is second to tourism spending as a source of income on Guam. (Visitors were estimated as spending over $750 million on Guam in 1990, while military spending fell to about $327 million [Guam Department of Commerce, 1991].) Continuing visitor industry growth is expected to fuel nearly all the expansion projected for Guam in the next decades.

While the incremental spending associated with the Navy activities is a small part of the island economy, it contributes to the stability of the economy by lowering its dependence on tourism, which has seen cycles of high growth followed by relatively slack periods.

EXHIBIT 3-E: INCOME ASSOCIATED WITH PROJECT CONSTRUCTION (1)

	FOR PROJECTS BEGINNING IN:					ANNUAL
	1993	1994	1995	1996	1997	AVERAGE
DIRECT EMPLOYMENT (2)	$7.2	$30.5	$18.0	$7.8	$1.0	$12.9
INDIRECT & INDUCED EMPLOYMENT (3)	$8.8	$37.1	$21.9	$9.5	$1.2	$15.7
TOTAL	$16.0	$67.6	$39.9	$17.3	$2.2	$28.6

NOTES: (1) In millions of 1992 dollars.
(2) Based on estimated construction FTE annual wage of $36,000.
(3) Based on estimated average 1992 wage on Guam ($18,250).

SOURCES: Exhibit 3-A; Guam Department of Labor, 1992b.

EXHIBIT 3-F: INCOME ASSOCIATED WITH PROJECT OPERATIONS (1)

	ANNUAL PERSONAL INCOME, FOR THE YEARS:			
	1993	1994	1995	1996 and Long Term
DIRECT EMPLOYMENT (2)	$42.5	$41.9	$40.5	$39.2
INDIRECT & INDUCED EMPLOYMENT (3)	$2.8	$2.7	$2.6	$2.5
TOTAL	$45.3	$44.6	$43.2	$41.7

NOTES: (1) In millions of 1992 dollars.
(2) Includes Navy payrolls for military and civilians, and allowances (COLA, subsistance, housing). Military personnel treated as in normal Navy distribution by rank.
(3) Based on estimated average 1992 wage on Guam ($18,250).

SOURCES: Interviews with Navy personnel and Consolidated Civilian Personnel Office; Navy payroll and allowance tables; Guam Department of Labor, 1992b.

4.0 POPULATION AND HOUSING

4.1 OVERVIEW

The population impacts of a project consist of the additional number of people demanding services or competing for goods such as housing. Often, it is appropriate to focus attention on a project site -- such as a resort -- where new residents, overnight visitors, and daytime visitors are found. However, the new Navy activities are located throughout Guam, on land held by the U.S. Government. There is little concern about congestion at the Naval Station or Andersen AFB. Instead, concern has been expressed about the numbers of (a) new Guam residents; (b) military families competing with civilians for off-base housing; (c) new pupils in the public schools; and (d) military visiting nightspots in Guam's urban center.

This chapter deals first with changes in resident population and housing due to additional military personnel and dependents. Next, the numbers of civilian in-migrants and their demand for housing are projected. (The analysis provides the school population estimates used in Chapter 6.) Finally, the increase in visitors associated with the new Navy activities to entertainment sites is estimated.

Both the military population and in-migrants taking newly created jobs have few non-working dependents. Also, many military spouses will take civilian jobs, offsetting the new jobs created by the Navy activities, as discussed in the last chapter. Hence the total island resident population impact and the housing demand associated with the new Navy activities are relatively small in relation to the jobs created.

Guam's rental housing costs are high and increasing rapidly. Many people have expressed concern that the military will absorb available rental units, pricing civilians out of the market. Some landlords have raised rents recently, apparently because they expect Subic transferees to be able to afford rents of about $1,200 monthly for two-bedroom units (Loerzel, 1992).

After considering current and emerging forces affecting the housing market, CRI finds that the off-base housing impact of the new Navy activities will be small. **Existing and new civilian demand independent of the proposed action will make rental housing extremely hard to find. Most military and many civilians will be able to afford only small or substandard units.** However, the demand contributing to this imbalance comes mainly from the civilian market, primarily associated with the growing tourism economy.

Estimates of the number of military personnel who go off-base for entertainment are far from precise. Still, annual figures can be calculated for additional population (attributable to the new Navy activities) going off-base -- nearly 50,000 person-days for transients, and over 30,000 for resident military. If all of these came to town only on weekends, the average would be about 825 additional consumers per weekend day.

4.2 RESIDENT POPULATION AND HOUSING DEMAND SUPPORTED BY NEW NAVY ACTIVITIES

4.2.1 Resident Military Population

The expected new military and military dependent population from the proposed action is estimated in Exhibit 4-A.

Exhibit 4-A represents the situation expected in most years. In 1994 and 1995, some military families are expected not to come to Guam because of the housing shortage. With the added demand brought by the new Navy activities, about 50 families would be likely not to live on Guam in 1994, and about 150 in 1995. (These estimates derive from calculations of housing availability later in this chapter. The families in question could be connected with the project or other military activities. By increasing demand for off-base housing, the project affects the chances of all Navy families searching for quarters on Guam. The number of families coming to Guam is not affected until 1994 because many military families can for the moment afford off-base housing. After 1995, official Navy actions to provide housing are expected to provide housing for Navy families who can no longer compete in the civilian housing market.)

The annual breakdown of military population associated with the new activities would include:

	1994	1995	All Other Years
Military	1,377	1,377	1,377
All Dependents	1,347	1,109	1,455
Employed Dependents	490	404	530
Dependents in Public Schools	318	262	343

EXHIBIT 4-A: MILITARY AND MILITARY DEPENDENTS ASSOCIATED WITH NEW NAVY ACTIVITIES (1)

MILITARY PERSONNEL	1,377
IN HIGH SCHOOL	
Public	1
Private	0
MILITARY DEPENDENTS (2)	1,455
OVER 16	616
Employed	
In Private Sector (3)	397
In Territorial Jobs	98
In Federal Jobs	35
IN SCHOOL (GRADES K-12)	
In Public Schools	343
In Private Schools	66
AGED FIVE & UNDER	387
OTHER (4)	130

NOTES: (1) This table shows the members of the armed forces and their dependents expected to be on Guam if other factors are not considered. See the text for changes in the number of dependents expected due to housing pressure in 1994 and 1995.
Proportions based on 1990 U.S. Census data for military and military dependents on Guam.
(2) Number of dependents provided to Belt Collins by Navy authorities. See text for lower numbers of dependents estimated by CRI for 1994 and 1995, due to limited housing.
(3) Includes non-civil service jobs on military bases.
(4) Includes unemployed dependents over 16 not in school.

SOURCE: U.S. Bureau of the Census, 1992.

For Exhibit 4-A and the above table, CRI used 1990 Census data concerning military dependents to estimate the number of people in the new military population with jobs or in school. This approach bases forecasts only on that part of the military-related population on Guam in which all household members are military or military dependents, as shown in Exhibit 2-H.

4.2.2 Military Demand for Off-Base Housing

CRI forecasts that nearly 400 families transferring to Guam in connection with the new Navy activities would add to off-base housing demand in 1993, as shown in Exhibit 4-B. The number would decrease over time due to Guam's high rents and to the development of new Navy housing.

To estimate military demand for off-base housing, CRI worked from the following assumptions and findings:

(a) Bachelor quarters were not fully occupied in early 1992. The additional population expected by 1995 can be housed on-base, although some personnel will be in more cramped quarters than was recently the case. Most affected with be housing offered to transients -- the number of persons per room in barracks will increase, and some transients will be lodged in a berthing barge, not barracks.

(b) Few or no Navy personnel without dependents will be able or allowed to find housing off-base.

(c) Families of VRC-50 personnel could be housed at Andersen AFB. Navy housing has been full. It is assumed that Navy housing would still be full without the new activities. Hence all the families connected with the new activities, except VRC-50 personnel, could potentially add to demand for off-base housing.

(Recently, three ships in Guam changed from Navy to civilian mariner crews. The civilian mariners are hired from the U.S. Mainland, and have no right to Navy family housing. A number of units on-base occupied by personnel from those ships were vacated. By assuming that none of these units are available, the analysis provides a maximal estimate of the off-base housing impacts of the new Navy activities.)

(d) The 308 housing units to be built as part of the new Navy activities would be ready for occupancy by 1996.

EXHIBIT 4-B: MILITARY DEMAND FOR OFF-BASE HOUSING ATTRIBUTABLE TO NEW NAVY ACTIVITIES

A. NUMBER OF MILITARY HOUSEHOLDS ASSOCIATED WITH NEW NAVY ACTIVITIES (1)

Average Household Size (2)	3.26
Number of Households	645

B. NEW DEMAND FOR OFF-BASE HOUSING (3)

1. Available Military Family Housing

1993 to 1995 (4)	250
1996 and Long Term (5)	558

2. Additional Demand for Civilian Housing from Military (A-B1)

1993 to 1995 (4)	395
1996 and Long Term (5)	87

3. Percentage of Navy Families Able to Afford Market Rents (6)

	1 Bedroom	2 Bedrooms
1993	99.8%	49.5%
1994	87.7%	29.6%
1995	49.0%	15.1%
1996	48.9%	2.7%

4. Estimated Additional Navy Households in Civilian Housing, Adjusted for Affordability (7)

1993	395
1994	347
1995	242
1996 and Long Term	87

NOTES:
(1) Based on 1,377 military billets, 1,455 dependents.
(2) From 1990 Census, for households (on- and off-base) composed entirely of members of the armed forces and military dependents.
(3) Assumes all existing Navy family housing is taken.
(4) This includes housing for VRC-50 personnel at Anderson AFB. It does not include military family housing units recently occupied by Navy personnel who are being replaced by civilian mariners.
(5) After construction of 308 housing units, from the 1993 MILCON authorization.
(6) From Navy projections of demand for off-base housing and consultant forecasts of future rents and housing allowances (for Navy Housing Office). That study assumes that rent increases are not dependent on Navy families' ability to pay.
(7) Based on assumed provision of 115 leased units at controlled rates, and ability of Navy families not housed in leased units to meet market prices. Average of 1-bedroom and 2-bedroom affordability limits used to estimate rental market capture rate.

SOURCES: U.S. Bureau of the Census, 1992; WESTCO/PAC International, Ltd., 1992.

(e) The Navy has offered to lease 115 units from the private sector for a period of at least a year. CRI assumed that (i) those units would be obtained and filled by 1993; (ii) the Navy would continue to lease them so long as demand for off-base housing equals or exceeds the level found in recent years.

(f) Civilian rents are high, and have increased sharply. An appraisal and research firm, acting as consultants to the Navy Housing office, projected continuing rental increases, but at declining rates (WESTCO/PAC, 1992, Vol. II). They further estimated that off-base housing allowances would increase by three percent annually. As a result, rents would increasingly outstrip Navy families' ability to pay.

(g) While Navy personnel are not enthusiastic about on-base housing, many are very dissatisfied with off-base quarters (according to a Quality of Life survey to which 500 responses were received and tabulated in March 1992). Few Navy families would live off-base if on-base accommodations were available.

These assumptions simplify a complex situation. Navy experts monitor off-base housing needs carefully, and project demand for housing in future years. Their projections do not break out a separate impact for new Navy activities. They vary as new information is received, and alternate scenarios are considered.

As of May 8, 1992, 478 Navy households were in units off-base. The "effective housing deficit" for the Navy on Guam in 1994 (demand that cannot be met on-base) has been variously estimated as 335, 529, 555, and 597 (in DD Form 1523s dated 2/19/92, 6/1/92, 5/18/92, and 5/31/92, calculated by Navy Housing on Guam and the Housing Section at Pacific Division Naval Facilities Engineering Command).

These Navy statistics have not been used to develop CRI's analysis of the specific effects of the new Navy activities. They are mentioned here to provide baseline data -- suggesting that there was little Navy family housing available when Subic personnel began to come to Guam -- and to show that the approach taken here is more likely to overestimate the impacts of the new Navy activities than to underestimate them.

4.3 RESIDENT POPULATION AND HOUSING ASSOCIATED WITH NEW ACTIVITIES

4.3.1 Resident Civilian and Military Population

The total military and civilian population associated with the new activities consists of (1) the military families counted above, plus new in-migrants (2) filling positions either created by the new activities or (3) vacated by Guam residents who take positions associated with the new activities.

Exhibit 4-C shows the total population increase living on Guam attributable to the new Navy activities as in the range of 2,700 to 2,900 people. This was calculated from the workforce projections in Exhibit 3-E for direct, indirect, and induced operations employment. The reduced in-migration due to military dependents' contribution to the civilian labor force is estimated conservatively, by assuming that non-military in-migrants would bring very few dependents with them.

(Construction-related workers are excluded from the analysis in this chapter. The construction industry depends on a flow of projects, so a particular project does not bring new in-migration so much as support the industry's continued well-being.)

The resident population associated with the project would amount to less than 2% of Guam's total projected 1995 population, and about 1% of the projected 2010 population.

4.3.2 Total Demand for Off-Base Housing

The overall housing impacts of the new Navy activities are tabulated in Exhibit 4-D. The bottom line of the exhibit -- increased demand of nearly 400 households, falling to about 60 -- should be treated with some caution. While the total demand for off-base housing is as shown, that demand would be distributed among several market niches.

Military demand would largely focus on rental units for which rent plus utilities ("gross rent") would total in the range of $900 to $1,400 (1992 dollars). As Guam rental prices continue to rise, the units available at the lower end of this range would be smaller and more likely to lack full plumbing in the unit. (See Exhibits 2-E and 2-F.) The Navy will only support rentals of housing meeting certain standards, so Navy personnel would be increasingly likely to rent units costing $1,100 or more.

With incomes averaging below those of civilian households, as shown in Exhibit 2-I, the military will increasingly be priced out of the off-base housing market.

The reduction in in-migrant civilian demand shown in Exhibit 4-D would be distributed widely throughout the rental housing market. Many in-migrants live in cramped or dormitory-like facilities. It is likely that others live together in more expensive units, supporting rental costs with several salaries.

EXHIBIT 4-C: RESIDENT POPULATION INCREASE ASSOCIATED WITH NEW NAVY ACTIVITIES*

	1993	1994	1995	1996	1997	1998 and Long Term
MILITARY & MILITARY DEPENDENTS (1)						
Military	1,377	1,377	1,377	1,377	1,377	1,377
Dependents	1,455	1,347	1,109	1,455	1,455	1,455
IMPACT ON CIVILIAN IN-MIGRATION (REDUCTION IN IN-MIGRATION)						
Workers (2)	0	(22)	59	(73)	(73)	(73)
Dependents (3)	0	(7)	19	(23)	(23)	(23)
TOTAL INCREASE	2,832	2,694	2,564	2,736	2,736	2,736

NOTES: * All figures show annual amounts of population increase (or decrease) over pre-project levels. The figures given are, in effect, cumulative. Values in parentheses are negative.
(1) From Exhibit 4-A.
(2) Operations-related workforce, less new military dependent workers brought by Navy.
(3) Estimate from Highway Master Plan: 32 dependents expected to come for every 100 in-migrant workers. This ratio is low compared to that for the overall population, but intended to reflect Guam labor practices.

SOURCE: Wilbur Smith & Associates, in association with Duenas & Swavely, Inc., 1991.

EXHIBIT 4-D: TOTAL OFF-BASE HOUSING DEMAND ASSOCIATED WITH NEW NAVY ACTIVITIES*

	1993	1994	1995	1996	1997	1998 and Long Term
A. MILITARY DEMAND FOR OFF-BASE HOUSING (1)	395	347	242	87	87	87
B. CALCULATION OF IN-MIGRANT CIVILIAN DEMAND						
In-Migrant Workforce Population (2)	0	(22)	59	(73)	(73)	(73)
Civilian Households (3)	0	(7)	20	(24)	(24)	(24)
C. TOTAL OFF-BASE HOUSING DEMAND (A+B)	395	339	261	63	63	63

NOTES: * Values in parentheses are negative.
(1) From Exhibit 4-B.
(2) From Exhibit 4-C.
(3) Estimated by CRI on assumption that 3 workers are found, on average, in new in-migrant worker households.

4.4 DE FACTO POPULATION

4.4.1 Islandwide De Facto Population Impact

The de facto population -- the total population present on Guam at any given time -- associated with the project will include transients on ships and in barracks, as well as residents. The total de facto population associated with the project is calculated on the basis of the resident population impact and a count of project-related transients on the island, as shown in Exhibit 4-E. The de facto population would reach a high point slightly above 3,500 persons in 1993, and would eventually stabilize just over 3,400 persons.

(The count of transients (in Exhibit 1-B) relies on assumptions developed by CRI about the length of time transients are on Guam. To provide a maximal estimate of potential impacts, CRI estimated that military on temporary duty would be present all or most of the year. It is worth stressing that the transient count is, in effect, an average daily census. The actual number of transients will vary throughout the year.)

The transient count is less than 7% of the number of visitors expected on Guam in 1995 and less than 4% of the visitor count for 2010. (See Exhibit 2-N for visitor count projections.)

The top part of Exhibit 4-F shows the project's military population in relation to the overall military presence on Guam in two future years for which projections of military manpower are available. Project military personnel will account for about 15% of the military on Guam.

4.4.2 Population Visiting Urban Areas

An estimate of the military population visiting urban entertainment areas at night is also provided in Exhibit 4-F. The 800-plus visitors to urban entertainment districts associated with the new navy activities account for about a fifth of the total military population in those areas. In short, the project would help to increase the average number of military customers now visiting these districts by about 25%.

Just as the number of military transients on Guam is small in relation to the number of tourists, so the number of military visiting entertainment areas is small in relation to the numbers of tourists and civilian residents in such districts. (However, the military form the bulk of the clients of some bars, while they rarely visit many of the establishments serving the tourist trade.)

Exhibit 4-F estimates the average military population out on the town. The peak population could be somewhat higher. The peak number is constrained by the size of

EXHIBIT 4-E: DE FACTO POPULATION

	1993	1994	1995	1996	1997	1998 and Long Term
Resident Population Associated with Project (1)	2,832	2,694	2,564	2,736	2,736	2,736
Transients on Guam Associated with Project (2)	682	682	682	682	682	682
TOTAL	3,514	3,376	3,246	3,417	3,417	3,417

NOTES: (1) From Exhibit 4-C.
(2) From Exhibit 1-B.

EXHIBIT 4-F: PROJECT-RELATED SHARE OF ESTIMATED MILITARY POPULATION ON ISLAND AND IN ENTERTAINMENT DISTRICTS, 1993 AND 1995

	1993	1995
A. ISLAND TOTAL		
RESIDENT MILITARY (1)		
Total	9,561	10,084
Project-Related	1,377	1,377
TRANSIENTS (1)		
Total	2,372	3,464
Project-Related	682	682
COMBINED TOTAL	11,933	13,548
Project Share	17%	15%
B. VISITING ENTERTAINMENT DISTRICTS OFF-BASE, WEEKENDS (2)		
RESIDENT MILITARY (3)		
Total	2,343	2,472
Project-Related	338	338
TRANSIENTS (4)		
Total	1,444	1,980
Project-Related (5)	488	488
COMBINED TOTAL	3,788	4,451
Project Share	22%	19%

NOTES: (1) Based on Navy estimate (dated 3/27/92) of late 1992 and 1995 total military population on Guam, adjusted to include transients on ships in port and updated estimate of project-related personnel. From recent historical average, an estimated 64 ships with 250 crew are expected to visit Guam annually apart from the project.

(2) All visits to entertainment districts, including all mariners' Liberty days, are assumed to occur on weekends.

(3) Resident military are estimated as spending, on average, 25 weekend days off-base annually.

(4) Non-project transients boarding on bases are estimated as spending 50 days off-base annually. Non-project ships' crews are estimated as enjoying 1.5 days of Liberty per visit.

(5) From Exhibit 1-B. Average daily count of transients off-base in that table calculated for 365 days of the year; figure in this exhibit based on assumption that all off-base visits occur on 102 weekend days per year.

Apra Harbor, which, unlike Subic Bay, is too shallow to allow aircraft carriers to enter and dock. Even if battle group operations and exercises are held in the general vicinity of Guam, the number of ships in harbor might increase by only as many as five. With an average 250 sailors per ship and liberty allowed for half each ship's complement at a time, the number of sailors at peak times would increase by 625 over the average on a weekend night, an increase of only 14% over the estimated 1995 average number of military seeking entertainment off-base.

These calculations are intended to provide a realistic but maximal projection of military personnel in entertainment districts. As discussed in Chapter 7, they ignore factors that could lower the estimates, such as competition from the Northern Marianas for sailors' dollars.

5.0 FISCAL IMPACTS

5.1 APPROACH

The new revenues accruing to the government of Guam (GovGuam) due to the proposed action are estimated in this chapter. The cumulative balance of revenues over costs is projected, using a conservative method, as about $70 million (in 1992 dollars) by the year 2000, and as nearly $100 million in 2010.

In this chapter, fiscal impacts are estimated by totalling new revenues associated with the proposed action, and comparing them to the costs which the government would incur, on average, with the additional visitor and resident populations. This "average cost" approach tends to magnify GovGuam costs, for several reasons, notably:

- Often, the actual marginal cost of extending government services to a larger population is small until a major population increase calls for new facilities. The average cost method ignores economies of scale that can arise with more efficient use of government services and facilities.

- The Navy's specific contributions to Guam's infrastructure as part of the proposed action -- improvements to a sewage treatment plant and a power plant -- are not counted. These arguably amount to both project-associated benefits to GovGuam and factors lowering costs incurred in serving the added population.

5.2 REVENUES

GovGuam would gain additional revenues due to the proposed action amounting to more than $8.2 million annually and to over $110 million cumulatively by the year 2000. (See Exhibit 5-A.) Revenues would accrue through several different mechanisms:

- Navy personnel, their dependents, and other workers associated with the proposed action would pay well over $5 million annually in income taxes;

- Construction firms would pay income and gross receipts taxes, while construction workers would pay personal income taxes (calculated here from 50% of wages, to allow for non-resident workers' wages taxed by the Federal government);

EXHIBIT 5-A: REVENUES TO GOVERNMENT OF GUAM ASSOCIATED WITH NEW NAVY ACTIVITIES

	1993	1994	1995	1996	1997	1998 thru 2010
TOTAL REVENUES	$13,477,568	$31,177,192	$21,988,797	$13,928,723	$8,829,625	$8,141,654
PERSONAL INCOME TAXES						
Direct Operations Wages (Military & Civilian) (1)	$5,560,269	$5,560,269	$5,560,269	$5,560,269	$5,560,269	$5,560,269
Project Construction Workers Wages (2)	$687,239	$1,010,665	$1,974,988	$783,098	$97,380	$0
Indirect & Induced Employment Taxable Wages (3)	$1,322,808	$4,262,597	$2,665,795	$1,360,809	$495,551	$372,575
Military Dependent Non-Project Wages (4)	$0	$0	$0	$0	$140,519	$197,258
CORPORATE INCOME TAX						
Construction (5)	$1,151,750	$5,045,600	$3,309,900	$1,312,400	$163,200	$0
Other Inputs to Local Economy (6)	$365,589	$1,261,369	$776,805	$380,605	$117,243	$79,702
GROSS RECEIPTS TAXES						
Construction (7)	$1,424,000	$6,028,000	$3,560,000	$1,544,000	$192,000	$0
Other Inputs to Local Economy (8)	$1,282,769	$4,425,856	$2,725,630	$1,335,457	$411,378	$278,656
OTHER REVENUES (9)	$912,828	$868,502	$826,477	$861,769	$861,769	$861,769
FEDERAL GRANTS						
School Lunch Program (10)	$47,916	$44,434	$36,633	$47,916	$47,916	$47,916
DoD/DOE Contract (11)	$722,400	$669,900	$552,300	$722,400	$722,400	$722,400

NOTES:
(1) Based on taxable share of wages shown in Exhibit 3-F. Average tax rate calculated as 16.23%.
(2) Wages as shown in Exhibit 3-E; taxed at 16.23%.
(3) Based on indirect and induced workers' incomes, in Exhibits 3-E and 3-F taxed at 16.23%.
(4) Taxes on military dependents' wages, at average Guam pay rates. To avoid possible double count, only the working dependents over the total of direct civilian operations workers, indirect and induced operations workers, and indirect and induced construction workers is counted.
(5) MILCON expenditures, taxed at 34%.
(6) From cash flows due to project spending. Corporate income tax estimated on the basis of Gov Guam records as 28.5% of gross business receipts tax collected on those cash flows.
(7) Assessed at 4% of MILCON.
(8) Estimated using historical gross receipts taxes per person in the labor force adjusted to 1992 dollars using the Guam CPI in 1992 dollars, $2,026 per worker. Total based on indirect and induced workforce, in Exhibits 3-E and 3-F.
(9) Includes Admissions & Excise Tax, Tobacco Tax, Alcoholic Beverage Tax, Fuel Tax, Licenses & Permits, and other charges for public services. Estimated on per capita basis.
(10) National School Lunch Program revenue extrapolated from historical amounts. Project associated revenues allocated on the basis of estimated military dependent school children.
(11) Estimated on assumptions that $4,200 is paid per military dependent pupil, but only 50% of pupils complete survey needed for Gov Guam to gain this revenue.

- Gross receipts taxes would also be generated through the circulation of cash introduced into the economy by Navy and personal spending;

- A range of smaller taxes, fees, and revenues would increase along with population growth;

- Federal funds for school lunches would increase with larger enrollments; and

- Funds from the Department of Defense (DoD) to the Guam Department of Education (DOE) would increase with more military dependents enrolled in the public schools.

  (Exhibit 5-A assumes that the DOE receives funding for only 50% of project-related military dependents in the public schools. This assumption reflects DOE estimates of the department's ability to count military dependents in the schools. With a more effective census of military dependents in public school, project-related revenues from the DoD/DOE agreement could increase by up to $700,000 annually.)

5.3 COSTS

As noted in Section 5.1, an average cost method is used to estimate the costs incurred by GovGuam due to the proposed action. To estimate the average cost, government expenditures are allocated to resident and de facto populations on a per capita basis, as shown in Exhibit 5-B. The per capita costs are then multiplied by the appropriate populations associated with the new Navy activities. (See Exhibit 5-C.)

Since different populations make different demands for government services, Exhibit 5-B identifies specific service populations for each major government function. It hence takes account of the fact that much of the public service costs associated with Navy personnel and their families is borne by the Navy. Some populations make little use of GovGuam services. These are designated as secondary service populations, and treated as consuming half the services (or creating half the need for services), compared to primary service populations.

Exhibit 5-C shows that annual estimated costs reach a high of $5.6 million in 1993. As of 1996, costs stabilize at $5.3 annually.

EXHIBIT 5-B: PER CAPITA ALLOCATION OF GOVERNMENT OF GUAM EXPENDITURES

POPULATION GROUPS, 1990			
RESIDENT POPULATION (1)		TRANSIENTS (2)	
1. Active Duty Military	11,952	5. Tourists & Military/Port Transients	7,550
2. Military Dependents	12,149		
3. Other Civilians	109,051		
SUBTOTAL	133,152		
4. Public School Students	24,118		

FUNCTION	1990 EXPENDITURES	SERVICE POPULATIONS (3) Primary	SERVICE POPULATIONS (3) Secondary	SIZE OF SERVICE POPULATIONS Primary	SIZE OF SERVICE POPULATIONS Secondary	PER CAPITA SPENDING (4) Primary	PER CAPITA SPENDING (4) Secondary	PER CAPITA SPENDING PER POPULATION 1&2. Military & Dependents	3. Other Civilians	4. DoE Students	5. Transients
General Government	$56,438,607	3	1, 2, 5	109,051	31,651	$452	$226	$226	$452		$226
Protection of Life and Property	$54,593,000	3, 5	1, 2	116,501	24,101	$424	$212	$212	$424		$424
Public Health	$27,373,377	3	5	109,051	7,550	$243	$121		$243		$121
Community Services	$25,743,446	3		109,051	--	$236	--		$236		
Recreation	$5,431,303		1, 2, 5	109,051	31,651	$43	$22	$22	$43		$22
Individual & Collective Rights	$11,431,053	3		109,051	--	$105	--		$105		
Transportation	$15,774,836	1, 2, 3, 5		140,702	--	$112	--	$112	$112		$112
Education	$125,724,003	4		24,118	--	$5,213	--			$5,213	
Protection of Environment	$5,861,182	1, 2, 3, 5		140,702	--	$42	--	$42	$42		$42
Economic Development	$12,412,435	3		109,051	--	$114	--		$114		
Transfers to Persons	$79,432	3		109,051	--	$1	--		$1		
Capital Projects	$17,744,514	3	1, 2, 5	109,051	31,651	$142	$71	$71	$142		$71
Interest	$3,484,640	3	1, 2, 5	109,051	31,651	$28	$14	$14	$28		$14
Principal	$1,005,000	3	1, 2, 5	109,051	31,651	$8	$4	$4	$8		$4
TOTAL EXPENDITURES	$363,096,828							$703	$1,950	$5,213	$1,036
ADJUSTED TOTAL (5)								$870	$2,413	$6,453	$1,283

NOTES: (1) From 1990 Census.
(2) From Guam Visitors Bureau estimate, adjusted by including CRI estimate of average daily number of sailors on port visits.
(3) A service population is associated with government spending either by using government services or by creating a need for services that the government meets.
(4) Per capita spending on the secondary population is assumed to be half as much as for the primary population.
(5) Adjusted to 1992 dollars according to Consumer Price Index increases.

SOURCES: U.S. Bureau of the Census, 1992; Guam Visitors Bureau, 1991.

EXHIBIT 5-C: ANNUAL GOVERNMENT COSTS ASSOCIATED WITH THE PROJECT POPULATION

	1993	1994	1995	1996	1997	Long Term
PROJECT-RELATED POPULATION (1)						
Resident Military and Dependents	2,832	2,724	2,486	2,832	2,832	2,832
Other Civilians	0	(29)	78	(96)	(96)	(96)
DOE Students	344	318	262	344	344	344
Military Transients	682	682	682	682	682	682
COSTS (2)						
Resident Military and Dependents	$2,463,321	$2,368,963	$2,162,556	$2,463,321	$2,463,321	$2,463,321
Other Civilians	$0	($70,084)	$187,953	($232,552)	($232,552)	($232,552)
DOE Students	$2,220,014	$2,054,885	$1,693,666	$2,220,014	$2,220,014	$2,220,014
Military Transients	$874,368	$874,368	$874,368	$874,368	$874,368	$874,368
TOTAL	$5,557,703	$5,228,132	$4,918,542	$5,325,151	$5,325,151	$5,325,151

NOTES: (1) From Exhibits 1-B and 4-C.
(2) From Exhibit 5-B.

5.4 BALANCE OF REVENUES OVER COSTS

The project is expected to yield GovGuam a positive cash flow both annually and cumulatively, as shown in Exhibit 4-D. The cumulative balance of revenues over costs would be about $70 million (1992 dollars) as of the year 2000, and nearly $100 million by 2010.

6.0 PUBLIC SERVICES AND RESOURCES

6.1 INTRODUCTION

This chapter deals with impacts on public services and facilities that involve social issues more than technical or engineering problems. The specific services considered here are: education; public safety (including police and fire protection); health (including mental health); and recreation. Other public services will be assessed in the EIS.

The Navy has provided many of the public services needed for its activities and personnel. It continues to provide police and fire protection on its bases, and health, counseling, and recreation services for the military, civilian employees of the Navy, and dependents. Also, the Navy has co-operated with Guam officials in responding to emergencies.

As Exhibit 2-A suggests, the Navy has played an important part in rebuilding Guam and other islands of the Marianas after major typhoons. Also, the Navy has developed water and electric power resources made available to Guam's island authorities.

Public service impacts often depend on location. Work on the new Navy activities would occur on military installations (shown in Exhibit 1-A). The large majority of Navy personnel and dependents associated with the proposed action would live at NAVSTA or Andersen AFB. Civilians and up to 395 military families would live off-base.

Navy personnel living off-base would likely prefer to live near their workplaces (mainly at NAVSTA and Andersen AFB). However, because of the high demand for rental housing, persons associated with the new Navy activities would reside wherever housing could be found throughout Guam. Few would live in the southernmost districts, where commutes are long and housing vacancies rare.

At Apra Harbor Naval Station, 308 new housing units are proposed. Possible sites are shown in Exhibit 1-C.

Because the project's long-term population impacts are an increase in the number of military and military dependents and a small decrease in the in-migrant civilian population drawn to Guam, much of the demand for public services will be met by military institutions.

EXHIBIT 5-D: BALANCE OF GOVERNMENT REVENUES OVER COSTS (1)

	1993	1994	1995	1996	1997	1998	1999	2000
TOTAL REVENUES (2)	$13.5	$31.2	$22.0	$13.9	$8.8	$8.1	$8.1	$8.1
TOTAL COSTS (3)	$5.5	$5.2	$4.9	$5.3	$5.3	$5.3	$5.3	$5.3
ANNUAL BALANCE	$7.9	$26.0	$17.1	$8.6	$3.5	$2.8	$2.8	$2.8
CUMULATIVE BALANCE (4)	$7.9	$33.9	$51.0	$59.6	$63.1	$65.9	$68.8	$71.6

NOTES: (1) All figures in millions of dollars.
(2) From Exhibit 5-A.
(3) From Exhibit 5-C.
(4) Cumulative balance to 2010 (in $s millions): $99.9

6.2 EDUCATION

The Guam Department of Education (DOE) maintains elementary programs at 24 locations, with 14,262 pupils as of September 30, 1991 (according to DOE printouts.) Six middle schools and five high schools enrolled an additional 13,835 pupils. Guam also has ten Catholic schools, six other schools tied to Christian groups, and three Asian language schools. In the 1990-1991 school year, the parochial school system served 5,336 pupils.

During the 1980s, enrollments changed little in southern and central Guam, while they grew in the north. (Elementary school enrollments increased by 11% between 1981 and 1991, high schools by 31%.) However, Guam has built no new public school facility since 1974.

Preliminary projections indicate that the public school population would grow by 20% during the 1990s (unpublished 1991 materials, provided by Dr. Jeffrey E. Shafer, Research, Planning and Evaluation Division, Guam DOE). Growth may not be as concentrated in the north as it was in the 1980s.

IMPACTS. The 343 project-related military dependents attending public schools amount to slightly over 1% of recent DOE enrollments, and about 6% of the total increase in enrollments projected for the 1990s.

Since military dependent children on Guam attend civilian schools, Guam's education system will be the most affected of the island's public services. Conversations with DOE officials indicate that most schools on island are at or near capacity, but the new students can be accommodated in existing and soon-to-be-completed facilities if arrival patterns are staggered (personal communication, Franklin Quitugua, Director, DOE, April 1992).

The DOE was told by the Navy to expect approximately 600 military children accompanying an estimated 1,200 new uniformed personnel by the end of this year. For planning purposes, some DOE estimates use an even higher figure of 800 children (Shafer, 1992). On the basis of 1990 Census proportions of children per military household, CRI has used a figure considerably lower than either of these, estimating only 343 children for 1,377 new uniformed personnel.

If the new school children were located in military housing areas at Andersen, NAS plus Naval Hospital, and NAVSTA, the following schools could be affected:

Elementary	Middle	High
Upi (22%)	Leon Guerrero (8%)	Sanchez (6%)
Yigo (5%)	Johnston (3%)	Washington (1%)
Lujan (10%)	Untalan (1%)	Kennedy (2%)
Agana Heights (1%)	Piti (8%)	Oceanview (6%)
Torres (9%)		
Truman (12%)		
Agat (7%)		
Subtotal: 66%	Subtotal: 19%	Subtotal: 15%

(From estimates developed by Shafer [1992], working with the assumption that 42% of the dependent population would live on-base at Andersen, 42% at NAVSTA, and the remainder at NAS and Naval Hospital.)

Dependents will not necessarily be housed on the bases where new military billets are created. Two sites where additional military families will be located in the next few years are known:

- Some 250 families will be at Andersen by Fall of this year. These families would use existing facilities in nearby Dededo and Yigo: Upi Elementary with enrollment of around 850 students, and Yigo Elementary (950 students); and Leon Guerrero Middle School (950 students). High school students from Andersen will attend Simon Sanchez (with 1,700 students).

- By the end of the school year, 115 families will be at Apusento Gardens in Chalon Pago. Nearby schools include Ordot Elementary (400 students); Johnston Intermediate (1,050 students); and George Washington High School (2,050 students).

  The military families at Apusento Gardens will take the place of other occupants, so little or no change in school enrollment figures could occur in the immediate area.

All or nearly all of the remaining 280 families (43% of the project-related military families) would have to look for housing on the civilian market. Many would likely live in and around NAVSTA, if housing can be found. Adjacent Santa Rita village has two elementary schools (Torres and Truman), with combined capacity for nearly 1,000 students. Two of the possible new housing sites are in Santa Rita. The Polaris Point housing alternative is in Piti. Piti has one middle school with enrollment of about 750.

Agat is also next to NAVSTA and has one elementary school with 900 students and one middle school (300 students). Agat also has the area's only high school -- Oceanview High (approximately 1,000 students) -- which serves the villages from Asan to Umatac, as well as NAVSTA, NAVMAG, and COMNAVMAR.

In Guam's tight housing market, renters live largely where housing is available and affordable -- not necessarily where they would prefer. Accordingly, it is likely that northern Guam schools will see a greater share of new students due to the project than the preceding comments suggest, at least until new housing is built at NAVSTA. The distribution of the anticipated impact -- about 350 additional students in schools -- could be roughly as follows:

	1993 to 1995	1996 and Later
North	150-200	125-175
Central	50-100	0-50
South	75-125	150-200

A new high school for approximately 2,000 students will be constructed in Santa Rita. However, this new school will take approximately three years to build and so will not be ready in time to deal with the initial project-related increase in enrollments. Similarly, a new 400-student elementary school is planned for Piti, but construction will not begin until 1994 or 1995.

Islandwide, approximately 60 new classrooms will be built by September, and another 130 will be completed some time before year's end. The DOE maintains that facilities will be adequate to handle the new students when these additional classrooms are built.

However, there are some concerns about the costs of educating not only the new military students but also the existing ones. Since few of these students remain on Guam to participate in the local workforce, the costs to GovGuam in educating military students is considered heavy. Present policy requires the federal government to subsidize about $4,200 per student, compared to the $5,050 it costs to educate each student, leaving GovGuam to pay for the remainder (personal communication, Dr. Franklin Quitugua, Director, Department of Education, July 1992.) Furthermore, only about half of all military children are counted for credit, since only half of these students complete and return the official census forms required by the DoD contract for payment.

6.3 PUBLIC SAFETY

6.3.1 Police

The Guam Police Department maintains stations in Agana, Dededo, and Agat. The volume of crime on Guam is low in comparison to U.S. cities of comparable size (Guam Police Department, 1991). With 2.5 officers per 1,000 persons on Guam, the department has a larger staff than most of the ten cities of similar size used for comparison (including New Haven, CT, Fort Lauderdale, FL, Reno, NV, Scottsdale, AZ, and Pomona, CA).

The annual rate of offenses committed increased from 85 per 1,000 persons in 1980 to 107.5 in 1990. Offenses involving the military, either as victims or perpetrators, have not followed this trend (unpublished records of Guam Police Department). Between 1987 and 1991, the number of such offenses reached a high of 40 per 1,000 members of the Armed Forces on Guam in 1988, then returned to about 21 per 1,000. Members of the Armed Forces were most likely to be arrested for drunk driving. As victims, they were more likely to suffer from larceny or theft, followed by disorderly conduct and vandalism.

The population increase anticipated due to the proposed action will have little affect on police operations and public safety. To maintain the current ratio of police personnel to the resident population, up to seven additional officers and two civilian employees would be needed.

However, up to half the additional population would live on-base. Since the military have proven much less likely to be involved in criminal offenses (either as victims or as offenders) than the public at large, the additional manpower needed would probably be smaller than estimated here.

Colonel Adolf Sgambelluri, Chief of the Guam Police Department, was confident that the Department could easily handle impacts of the proposed action (personal communication, April 1992). He noted that the military have succeeded in reducing the incidence of drunk driving in recent years. He was confident that his department could respond to problems arising with increased numbers of sailors on liberty, if the police are warned of major visits.

6.3.2 Fire Protection

In an interview with Assistant Fire Chief Frank Cruz of the Guam Fire Department, CRI ascertained that existing civilian fire protection facilities in the communities near Andersen AFB and NAVSTA are more than adequate to deal with the current load as well as with the population associated with the proposed action (May 1992). Assistant Chief

Cruz expects little impact on fire services from the new personnel, except perhaps a slight increase in the number of motor vehicle accidents.

Guam boasts approximately 300 full-time professional civilian firefighters. An additional 60 will be recruited this year. In the areas of the proposed activities, there are on-base military facilities at Andersen, NAVSTA, and NAVMAG, as well as civilian fire stations nearby in Dededo, Yigo, Agat, and Piti. Civilian and military fire stations support each other in emergencies.

6.4 HEALTH

6.4.1 General Services

The 200-bed Guam Memorial Hospital in Tamuning is the island's only civilian general hospital. Small GovGuam health care clinics are located in various spots throughout the island. Out of the communities nearby the activity sites, only Dededo and Santa Rita have regional clinics.

The Navy's 45-bed hospital (NAVHOSP) is in Agana. It serves active duty armed forces personnel on Guam, dependents, and veterans. NAVHOSP also treats emergency civilian cases when necessary. Four branch clinics are located at bases throughout the island, including one each at NAS, NAVSTA, and NAVMAG.

It is expected that the new military personnel will be adequately handled by existing military facilities. Possible health care impacts on Guam's civilian population could include a slight increase in sexually-transmitted diseases and alcohol-related motor vehicle accidents. However, the project's cumulative population impact includes a small decline in demand for civilian in-migrants. It hence could lower future increases in demand for civilian health care services.

Given the number of personnel associated with the proposed action, Karen Cruz -- the Chief Public Health Officer for the Department of Public Health and Social Services -- expects only a slight impact on islandwide health services (personal communication, April 1992).

6.4.2 Mental Health

The only civilian mental health unit is located in Tamuning. Occasionally, military personnel are referred to this unit for marriage counseling but such referrals are few since the military provides most mental health services on-base (personal communication, Marylin Wingfield, Director, Department of Mental Health, April 1992). No direct impacts are expected on the Tamuning civilian unit as a result of the proposed action.

NAVHOSP has its own psychiatric unit that deals with practically all the military's mental health and substance abuse cases. Family and personal stress problems are also addressed by the (Navy) Family Service Center's counseling programs and workshops. At Andersen, the Mental Health Clinic has psychiatric and social work professionals, and the Family Support Center functions as a referral and support agency.

6.5 RECREATION

EXISTING CONDITIONS. Both GovGuam and the military maintain extensive recreation facilities on Guam, including beaches, playing fields, pools, youth centers, and parks.

Tarague Beach, at Andersen AFB, has a patrolled swimming area with picnic facilities and campgrounds. Gab Gab Beach, on the Orote Peninsula is popular among NAVSTA personnel. Snorkeling and diving sites are easily reached from beaches at both Andersen and NAVSTA. Sumay Cove Marina at NAVSTA is open to active duty military and civilian DoD personnel. It has boats for rent, as well as docking facilities for boat owners. The Navy and Air Force each have a golf course. Other on-base recreation resources include swimming pools, tennis courts, gyms, bowling alleys, crafts shops, and movie theaters. Hunting by military personnel and dependents is allowed on parts of Andersen AFB by permit (Reinhardt, 1987). All the major bases have club and restaurant facilities.

During 1992, Navy facilities on Guam will gain recreation and food service equipment being removed from Subic Bay Navy Base.

IMPACTS OF ACTIVITIES AND PERMANENT PERSONNEL. The military population associated with the project, including dependents, has been estimated as about 26% of the current patron count for Navy facilities on Guam. The increased demand for Navy recreation facilities will be less than this figure indicates, since a third of the military population will be based at Andersen AFB and some families will live off-base. At Andersen, the base population was as large two years ago as it will be with the VRC-50 squadron. The added Navy population is not expected to cause significant difficulties for users of recreation facilities.

In the short term, increased demand may limit users' access to facilities such as weight rooms. Navy officials responsible for Morale, Welfare, and Recreation (MWR) have recognized this possibility, and are requesting added funds for facilities and staff. In the long term, staffing commensurate with the patron base is expected. (In terms of the models used in this report, MWR jobs to support the added population count among the

indirect and induced impacts of the project, and are included in the estimates of new employment in Chapter 3.)

Off-base, civilians and military families will use Parks and Recreation facilities. The increased population is small, and not expected to affect any single facility greatly.

The new Navy activities will affect existing recreation facilities at Gab Gab Beach. With explosives loaded and unloaded at Kilo Wharf, the beach will now be closed for approximately 32 days each year.

To mitigate the part-time loss of Gab Gab Beach, the Navy can encourage use of other beaches at NAVSTA. Didi (or "Old Wives") Beach, on the outer side of the Orote Peninsula, is accessible by car and close to base residential facilities. Road improvements and provision of sanitary facilities could be considered in light of increased future use.

IMPACTS OF TRANSIENTS. The transient population associated with the proposed action will have little impact on public recreation facilities. Social impacts of added customers at private off-base entertainment facilities are assessed in the next chapter.

7.0 FURTHER SOCIAL IMPACTS

7.1 INTRODUCTORY COMMENTS

This section of the report deals with potential impacts on less clearcut social topics -- community organization, family life, values and lifestyle. These are critical issues, but hard to address with any degree of scientific accuracy. Some introductory comments are in order:

- Social impact assessment cannot avoid questions of values, and people often disagree about values. We have no absolute standpoint from which to judge impacts as good or bad. We treat impacts that, we believe, most people would call pleasant as "positive," and ones that clearly involve increased effort, anxiety, pain, or disruption in people's lives as "negative." It remains up to the reader to evaluate trade-offs between positive and negative impacts.

- Any analysis of social impacts must stop short of iron-clad predictions because of the inherent uncertainty of social impacts. The purpose of this chapter is to disclose tendencies, dangers, and opportunities rather than to state exactly what will happen.

- Most social impacts are not inevitable -- they can be reduced or avoided. In many cases it is less important to predict social outcomes than to (a) alert authorities and community leaders to the fact that these could occur, and (b) consider how to control them.

- People's expectations of an action count as social impacts, since these would not arise without the proposed action. Whether these are ill- or well-founded, the expectations, hopes, and fears of different members of the community are stirred up during the planning process.

Most of the social impacts discussed in this chapter affect military personnel and dependents immediately. They are the concern of Family Welfare or Support and Morale, Welfare, and Recreation officials. Officers currently responsible for these areas mentioned the potential impacts in interviews with CRI. By discussing the issues here, CRI acknowledges their importance. We are not claiming that Navy authorities have failed or will fail to react to these impacts.

7.2 SPECIFIC SOCIAL IMPACTS

Specific impacts that could affect particular groups and communities are inventoried in this section. In Section 7.3, the overall consequences of these impacts on the wider society are assessed.

7.2.1 Impacts on Military Personnel and Dependents

The proposed action will bring additional members of the Navy community to Guam. Potential impacts of the proposed action on the lives of many of these military personnel and dependents are:

- Problems of family stress due to difficulties in finding and paying for housing, and from trying to live on military incomes in an economy with high prices.

- Separation of military personnel from their dependents -- for months or an entire two-year tour of duty -- if acceptable housing cannot be found on Guam.

- For families with small children, difficulty in finding child care. This problem is especially severe because (a) child care resources are limited in the civilian community; (b) the high cost of living makes it imperative for many military spouses that they find well-paying jobs; (c) day care centers at both Andersen and NAVSTA already do not meet the military community's needs, and must be upgraded; and (d) NAVSTA is currently losing many caregivers who are wives of Proteus sailors. The Holland, which will replace Proteus, has an unusually large number of female crew, including single parents. Holland families are hence likely to add to the current imbalance between supply and demand for child care of all kinds.

  (Dissatisfaction with child care is already strong. In the March 1992 Quality of Life Survey, all subgroups agreed in ranking available child care as unsatisfactory.)

- The opportunities for new experiences and concomitant disruption of routines, anxiety, and stress often involved in a posting to an overseas base.

The military personnel and families now being relocated from Subic will mostly serve on Guam for one tour of duty, then move elsewhere. Their difficulties in adjusting to life on Guam are hence temporary, and not part of the long-term proposed action.

However, many Subic families have roots in the Philippines. Some of these could stay on Guam, because Guam is as close, physically and culturally, to the Philippines as they can come. (The exact number cannot be specified, but CRI expects that no more than 50 families would probably be affected.) For these families, social impacts would include the possibility of maintaining personal ties to the Philippines, ease in finding Filipino foods and other resources (compared to any Navy base region other than Hawaii), and the chance to participate in the local Filipino community.

The Navy is already seeking to lease private units in order to house enlisted families. As part of the proposed action, the Navy plans to build 308 additional housing units on-base. These steps will mitigate some of the problems associated with housing.

Again, the Navy has planned to renovate and expand child care facilities on Guam, and is seeking additional authorizations for child care center expansion. Building and staffing these facilities will mitigate some of the problems Navy families now experience. However, the need for non-center based child care for younger children remains a concern for families and Navy authorities.

7.2.2 Impacts on Off-Base Residential Areas

In Guam's tight housing market, housing allowances are seen by many as giving the military an advantage over civilians, and as an inducement for landlords to raise rents. The Subic relocation was the generally recognized impetus for a recent increase in rental prices. Navy families can draw on housing allowances and their pay to meet increased rents, but they must also confront Guam's high cost of living. High rents and utility costs already make out-of-pocket housing costs expensive for many enlisted personnel -- and this will likely be true for more and more of the military.

The analysis in Chapter 4 emphasized the point that civilian demand is great, and is likely to keep increasing, so that military families will probably be priced out of the housing market in the near future. Navy families who are able to find off-base housing will likely be dispersed throughout the civilian community. Hence no long-term change is expected in particular off-base neighborhoods and communities, with one exception.

The exception is that the Navy has sought authorization to lease 115 units for at least a year for military family housing. The units would likely be in one or two complexes. Tenants who are on month-to-month leases or who lack leases will then have to find housing. Others in the complex(es) will find the social composition of their residential area greatly changed, with Navy families suddenly forming a large part of the neighborhood.

7.2.3 Impacts on Private Employers

The project will bring additional spending in the private sector, resulting in additional income for proprietors as well as the indirect and induced jobs and income analyzed in Chapter 3.

Many of the civilian jobs in the new Navy activities will draw workers away from existing jobs, forcing employers to search for new hires in a tight labor market. Working military dependents outnumber the Navy civilian hires, but are unlikely to fill similar jobs as riggers, materials handlers, and the like.

The proposed action will hence inconvenience some private firms needing semiskilled manual workers. The number of civilian Navy jobs is small enough that no firm is not likely to lose more than one or two workers. Also, Guam had nearly 9,000 operators, fabricators, and laborers in 1990, about 30 times the number of new direct jobs being created for these occupations (U.S. Department of Commerce, 1992).

7.2.4 Impacts on Entertainment Districts

The project would account for as much as 30% of the number of military visitors (both resident on Guam and transient) in entertainment districts such as the bars in East Agana. The most immediate result would be a boost to this part of the economy. A few new facilities could open with more customers nearby. These would presumably be near existing bars catering to the military, in order to attract these customers. No expansion of the districts serving these customers is likely.

Factors tending to minimize the impact of additional sailors on the town include:

- Competition from Saipan and Tinian for military wages. According to a recent, controversial study, Saipan currently has 113 bars, massage parlors, and karaoke clubs where prostitution is accepted (Santos, 1992). Tinian is planning to develop casinos. Any sailors seeking entertainment similar to that found in Olongapo will quickly learn whether Saipan and Tinian tolerate carousing more than Guam.

  The cost of travel to the Northern Marianas will likely limit the number of military visitors, but not stop them. (Mainland U.S. casinos pay to make travel to Las Vegas and Atlantic City inexpensive. Tinian casinos might similarly support gamblers' travel from Guam.)

- For many in the military, Tumon is a district reserved for Japanese vacationers, with high prices and little to offer the military. A tendency to seek entertainment in areas away from the tourist population minimizes the chance of disturbances between military and civilians.

- Navy programs to control use of alcohol and end use of illegal substances have lowered the incidence of dangerous drunken behavior.

Concern has been expressed that some of the project-related military complement would be far more rowdy than the Navy personnel now on Guam. (The Navy Special Warfare Unit [SEALs] is usually singled out as particularly likely to be rowdy.) CRI cannot evaluate these claims. However, we note that (1) Navy officials are aware of this concern, and expect to brief new arrivals on the fact that Guam is less tolerant of rowdy behavior than towns like Olongapo, and (2) personnel based on Guam, such as the Seals detachment, will be under pressure to find places where their preferred form of entertainment is tolerated, rather than give civilian authorities cause to complain. In time, they are likely to find ways to enjoy themselves without undue disruption.

7.3 ISLANDWIDE SOCIAL IMPACTS

The specific impacts noted above are incremental. They involve major changes in the lives of a few military families and possibly families whose rentals will end due to a lease program, but relatively small changes for others. No change in the tenor of military-civilian social relations has been identified on the basis of the specifics of the project.

The fact that the action increases Guam's importance for the U.S. Navy remains to be considered. This raises the specter of increased military control for a society that has sought a measure of autonomy after decades of military rule. The symbolic importance of the proposed action can outweigh, at the level of island politics, the specific socio-economic impacts considered in this report.

Currently, both Republican and Democrat political leaders seek Commonwealth status for Guam. Guam's elected leaders have asked the Federal government to move all military aviation activity to Andersen, so NAS Agana could be decommissioned and turned over to the civilian government. Less established groups advocate increased rights and political status for Chamorros. Families with private land surrounded by military areas seek to be able to use their property as they see fit, not as the military decrees. All these parties hope to see civilians regain control over some or much of the land now held by the military.

The Navy has stated (1) that no "excess lands" slated for eventual transfer to civilians will be used for the project, and (2) that project activities at NAS Agana will not affect the eventual transfer of that base to the Territory (Belt Collins and Associates, 1992).

Also, the project involves no land near the major private lands in North Guam now made useless because they are surrounded by military reservations.

Still, any claims that the project is irrelevant to important island concerns offer little reassurance until, in time, they are seen to be true in fact. The Navy can help to allay public fears by sharing information about its plans, subjecting these to outside review, and finding ways to cooperate with GovGuam in meeting the needs of Guam residents. The EIS process can help to achieve all of these aims. In the long run, Guam's people are likely to assess the Navy's good faith on the basis of responsiveness to concerns and incidents as they arise.

8.0 MITIGATIONS

This chapter includes an independent consultant's assessment of potential steps to mitigate projected socio-economic impacts of the project. This chapter does not imply any commitment to some or all of the steps mentioned. However, many of the mitigation measures discussed herein are already planned or being developed by Navy officials.

Project plans already include extraordinary steps to mitigate potential impacts, notably in the construction of housing, child care facilities, and infrastructure. Also, by bringing military dependents to Guam who will contribute to the local labor pool (but who depend less on GovGuam for public services than do other in-migrants), the project helps to address Guam's problem of labor supply.

Specific mitigation measures are listed under the topic headings used for chapters of this report.

ECONOMIC IMPACTS. If the recent decline in civilian construction continues, the construction program associated with the new Navy activities could help significantly to maintain the prosperity of Guam's construction industry and workforce. Navy policy calls for hiring of U.S. citizens on MILCON projects, making Guam workers' participation in project construction highly likely. Guam construction firms participation in bidding could be maximized by assuring that (a) information about bids and anticipated projects is available on Guam and (b) some of the construction bids are handled by Guam offices, rather than in Honolulu. It appears that both these conditions are now being met, with OICC responsible for much of the project construction planning.

In Guam's tight labor market, any disruption due to hiring for new operations jobs can be minimized by hiring young workers as they enter the job market (rather than key employees in private enterprises). The Navy's apprenticeship program allows such hiring to occur.

POPULATION AND HOUSING. The potential impact of additional families on a tight housing market has been noted. The Navy has taken measures to limit the impact considerably:

- Dependents of Navy personnel being transferred to Guam (apart from families being relocated from the Philippines) can only come to Guam when housing has been found for them, on- or off-base. This regulation (a) insures that no sudden increase in demand will change market conditions and (b) keeps the number of military families on Guam in line with housing resources.

- Renovation of barracks and acquisition of a berthing barge will allow the Navy to house all project military personnel without dependents on military bases.

- The Navy plans to build 308 new family housing units at NAVSTA.

The lease of 115 units at Apusento Gardens helps the Navy house the influx of families from the Philippines. These units will be occupied over the coming months, not all at once. As a result, families moving from Apusento Gardens to other rentals will not all be looking for new homes at the same time.

The analysis in Chapter 4 suggests that, even with the additional 308 units of military family housing planned for NAVSTA, demand for off-base housing will continue. Available projections suggest that such housing may be prohibitively expensive by 1996. If price trends in 1992 and 1993 give some support to those projections, the Navy could consider expanding the supply of family housing on-base, developing new housing through a public/private venture, or continuing its long-term lease arrangement at Apusento Gardens.

In light of the recent volatility of rentals, predictions of future supply conditions are highly uncertain. Hence the estimates of future conditions will need to be monitored, allowing decisions to be made, perhaps by 1994, concerning future housing needs. The Navy Housing Office at PWC tracks both Navy housing demand and the supply of rental units. It will be well placed to re-evaluate housing needs in the near term.

FISCAL/PUBLIC SERVICES AND RESOURCES. Potential impacts on the Guam Department of Education (DOE) can be addressed in several ways:

- DOE authorities need information concerning the number and location of project-related military dependents. An initial briefing was held when Subic rollback plans were announced. In addition, the DOE should be told of plans to house Navy families when these are definite, since the location of new housing will affect particular schools.

- The DOE's census of military dependents in the public schools, used to claim Federal aid under the DOE's agreement with the Federal Department of Defense, currently fails to record many of the military dependent students in DOE schools. The percentage of dependents counted could perhaps be increased if (a) this census were made part of basic student registration procedures, and (b) the Navy and other military agencies explained in briefings to newly arrived families that those children who are in public schools should be counted in the census.

Civilian and military authorities have often cooperated in the past to assure public safety on Guam. Such cooperation should mitigate potential impacts associated with the project. Small increases in public safety personnel may also be needed.

The major project impact on recreation, temporary closing of Gab Gab Beach, will affect Navy personnel and families, not the public at large. It can be mitigated by improving other beach facilities at NAVSTA.

FURTHER SOCIAL IMPACTS. Project impacts on some military families could be far-reaching. Children separated from their Guam-based military parents because housing is not available, or families suffering stress due to relocation, the high cost of living, and difficulties in adjusting to conditions on Guam, will be affected far more than others. Major steps to mitigate family problems include:

- The Navy plans to develop additional family housing (listed above).

- Navy agencies (notably the Family Service Center) can support and counsel military families. Relevant programs and workshops deal with relocation assistance, spouse employment, family problems, stress management, intercultural relations, and financial management. Recently, the last program was not offered because of staff shortages (personal communication, LT CMDR Dave Metzig, Director, Family Service Center, April 1992). Efforts to staff these services fully are recommended to help families new to Guam adjust to the high cost of living.

- The project includes new child care facility construction, in addition to construction already planned. Still, child care is needed now, and family child care is needed in addition to center-based care. Navy and Air Force family support agencies maintain lists of caregivers. Efforts to recruit additional caregivers should also be considered.

  Such efforts could include workshops on registration, aimed mainly at newly arrived military dependents; creation of information packages and other incentives for registered caregivers (dealing, for example, with child-proofing family quarters, and activities for family caregivers); and development of a network of family caregivers which could provide support and information among members.

Generally, impacts of the project on Guam's civilian population are slight. The potential for abrasive civilian/military encounters can be limited through proactive measures (largely continuation or expansion of existing programs):

- Programs to control substance abuse (among both the military and young civilians);

- Intercultural awareness briefings for new arrivals; and

- Informing both permanent and transient military of the recreation opportunities to be found on Guam and in adjacent territories, so they find the recreation they seek in places where such recreation is gladly provided.

(The programs in question already exist. CRI suspects that Navy personnel will quickly learn about recreation available in the general area. Hence these mitigation measures should be effectively in place.)

The apprehension felt by many on Guam that an increase in military activity could threaten the territory's autonomy has been addressed by minimizing new activities at NAS and locating no new activities on land previously declared excess. Several recent actions (e.g., the transfer of power generation facilities to the Guam Power Authority, confrontations between Chamoru political protestors and the military, efforts to declare NAS as surplus) no doubt affect Guam residents' view of their relations to the military. These are not related to the project and are hence not within the scope of this study.

PPENDIX A: CONTACT LIST

ıe following list includes persons interviewed by Community Resources, Inc. from April to June of 1992, and ırsons on Guam who otherwise aided us by supplying information for this analysis. Positions and/or ganizational affiliations are mentioned to indicate the scope and variety of interested parties. In some cases, dividuals were spokespersons for their organizations, in other cases they were not. CRI did not ask agency ıads to provide official statements with regard to the project. The scoping meetings held on May 28, 1992 and e EIS process give people and agencies avenue for official responses to the project.

CONTACT PERSON	POSITION AND/OR ORGANIZATION
Kin Actalle	Deputy Director, Department of Land Management
John Anderson	Planner, Coastal Zone Management, Bureau of Planning
Tony Artero	Principal Broker, Artero Realty Member, Guam Real Estate Commission
Antonio Babauta	Mayor, Agat
Kathy Bain	Consolidated Civilian Personnel Office
John Balajadia	Administrator, Department of Youth Affairs
Peter Barcinas	Director, Department of Commerce
Leland Bettis	Executive Director, Commission on Self-Determination
John Blas	Mayor, Yigo
Eloise Blaza	President, Guam Chamber of Commerce
Dolores Borja	Personnel Support Manager, Housing, Navy Public Works Center (PWC)
Greg Borja	Mayor, Santa Rita
Joe Bradley	Chief Economist, Department of Commerce Advisor, Commission on Self-Determination
Marcello Camacho	Executive Assistant, Territorial Planning Council
Bernadita Camacho-Dungca	Chamoru Nation Traditional Council Coordinator, PEACESAT Guam
Joe Cepeda	Executive Director, Guam Visitors Bureau
Mark Charfauros	Protehi I Tanota (Protect our land)
Chuck Crisostomo	Administrator, Guam Economic Development Association
Fred Crisostomo	Civilian Specialist, OICC Marianas
Frank Cruz	Assistant Fire Chief, Guam Fire Department
Karen Cruz	Chief Public Health Officer, Department of Public Health & Social Services
Manny Cruz	American Federation of Government Employees
Mike Cruz	Chief Planner, Bureau of Planning
Ron Cruz	Inspector, Guam Fire Department
Miriam Gallet	Public Affairs Officer, PWC

CONTACT PERSON	POSITION AND/OR ORGANIZATION
Bill Gibson	Executive Director, Guam Employers Council
John Gilliam	Senior Economist, Department of Revenue & Taxation
LT CMDR Stephanie Goebel	Commanding Officer, Personnel Support Detachment
LT COL Ben Guerrero	Chief of Staff, Guam Police Department
Ed Guerrero	Director, Department of Labor
Joe Gumataotao	Research, Department of Mental Health
LT Heather Halley	Executive Officer, Military Sealift Command, Guam
Isabelle Haggard	Mayor, Piti
David Haigh	Director, MWR, NAVSTA
Susan Ham	Archivist, Bureau of Planning
Jim Hutcherson	Senior Economist, Department of Commerce
Perfecto Jose	Vice President, Black Construction
Pat Lee	Community Relations, COMNAVMAR
Peter Leon Guerrero	Director, Bureau of Planning
Rufo Lugan	Department of Agriculture
Julie Maanao	Research and Planning, Guam Housing and Urban Renewal Authority
LT Rodney Maccioni	Contracts, OICC Marianas
Cecilia Martinez	Equal Opportunity Officer, Consolidated Civilian Personnel Office
Jay Merrill	President, Merrill & Associates Executive Director, Guam Growth Council
LT CMDR Dave Metzig	Director, Family Service Center
CMDR John Moran	COMNAVMAR
Joe Morcilla	Chief Planner, W.B. Flores & Associates
Charles Morris	Administrator, Nutrition Health Services, Department of Public Health & Social Services
LT CMDR Brian Murphy	COMNAVMAR
Cynthia Naval	Economic Research Center, Department of Commerce
MAJ Steven Nigg	Commanding Officer, MWR, NCTAMS
James Phillips	Deputy Commander, MWR, Andersen AFB
LT Juliana Prevatt	COMNAVMAR
MAJ Jas Quattlebaum	Director, Family Support Center, Andersen AFB
Franklin Quitugua	Director, Department of Education
CAPT Bill Rigby	PWC
Joe Rizera	Mayor, Dededo

CONTACT PERSON	POSITION AND/OR ORGANIZATION
Ron Rivera	Chairperson, Organization of People for Indigenous Rights
Donald Rubinstein	Faculty, University of Guam, Micronesian Area Research Center
Linda Sablan	Associate Economist, Department of Commerce
John Salas	Executive Director, Guam Hotel & Restaurant Association Vice-President, Academic Affairs, University of Guam
Vicente San Nicolas	Mayor, Asan
Angel Santos	Chamoru Nation Traditional Council
Fred Santos	General Manager, Guam Mass Transit
Julie Santos	Director, Vital Statistics, Department of Public Health & Social Services
Paul Santos	Infrastructure Engineer, Guam Housing and Urban Renewal Authority
LT CMDR Rick Seeley	VRC-50
COL Adolf Sgambelluri	Chief of Police, Guam Police Department
Jeff Shrader	Research, Department of Education
CMDR Shultz	PWC, OICC Marianas
LT CMDR Randy Solheim	NAVSTA
Raj Sood	Management Analyst, Guam Police Department
LT Keith Spencer	COMNAVMAR
Jerry Stewart	Administrator, Consolidated Civilian Personnel Office
Conrad Stinson	Deputy Director, Department of Education
Karen Storts	Business Manager, Guam Contractors Association
ENS Matt Sylvest	Housing Liason, PWC
Juan Taijito	Director, Agency for Human Resources Development
Fred Tolkes	Engineer, International Bridge Construction
Peter Toves	COMNAVMAR
Lucy Troutman	Director, Housing, PWC
Garland Wilhite	Principal, Oceanview High School
LT CMDR Roger Williams	Director, NCTAMS MWR
Marilyn Wingfield	Director, Department of Mental Health
LT Loretta Winspray	Architecture Review, PWC

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Appendix J

Wetlands Delineation Report

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, PACIFIC OCEAN DIVISION
GUAM OPERATIONS OFFICE, SUITE 905
238 ARCHBISHOP F.C. FLORES STREET
AGANA, GUAM 96910

REPLY TO
ATTENTION OF

June 15, 1993

Guam Operations Office

Mr. Stanley Uehara
Department of the Navy
Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96800-7300

Dear Mr. Uehara:

This is in reference to the DEIS, dated April 1993, for the relocation of activities and facilities from U.S. Naval Base, Subic Bay, and U.S. Naval Air Station, Cubi Point, Republic of the Philippines to the territory of Guam, Mariana Islands.

I have recently inspected the proposed project site for the two MCON P-829P Tomahawk Magazine Inert Storehouses located on Dealy Road, U.S. Naval Magazine, Guam. I have found that the work will not be in wetlands or other waters of the United States; therefore, a Department of the Army (DA) permit is not required.

I understand that all other work will be constructed in such a manner so as to avoid all wetlands. The only remaining work that will require a DA permit is the reconstruction of deteriorated sheet pilings in Apra Harbor. This work can possibly be covered by a Nationwide permit.

Sincerely,

Francis M. Dayton
Chief, Guam Operations Office

WETLAND DELINEATION REPORT

NORTHEAST TIPALAO HOUSING EXPANSION AREA
PWC GUAM PACDIV CONTRACT NO. N62742-92-R-0071 AMP JOB NO. 92105.01

PREPARED FOR

AM PARTNERS, INC.

PREPARED BY

PACIFIC BASIN ENVIRONMENTAL CONSULTANTS, INC.

JANUARY 1993

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FOR

NORTHEAST TIPALAO HOUSING EXPANSION AREA
PWC GUAM PACDIV CONTRACT NO. N62742-92-R-0071 AMP JOB NO. 92105.01

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I. Introduction

The evaluation of wetlands in the Northeast Tipalao Housing Expansion Area (NETHEA) located to the northeast of the existing Tipalao Family Housing on Apra Harbor Naval Complex has been completed (Figure 1). The area of NETHEA is approximately 70 acres and includes five (5) wetland areas (A, B, C, D and E), totalling approximately 11.0 acres (Figure 2). The field work and research were conducted by Michael Subbert, Pacific Basin Environmental Consultants, Inc. (PBEC) staff botanist and wetland specialist. Based on the field data (Appendix A) collected in November and December of 1992 by PBEC personnel, a continuous boundary was flagged and surveyed for each of the five (5) wetlands.

The analysis of the area in question was completed following the recommended procedures outlined in the 1987 Federal Manual for Identifying and Delineating Jurisdictional Wetlands.

Wetland identification procedures generally use the following format:

1. Soils - Soil analysis consists of examining the sub-surface strata of the soil to determine if anaerobic or aerobic conditions exist. This effort can often determine if the area is a wetland even in the dry season.

2. Vegetation - The analysis of plant communities and species which are dependent on a wetland environment or those other plant species which can survive in such an area.

3. Hydrology - This involves the study of water movement. Rivers, creeks or ditches can be involved in this analysis. Indicators of water movement and level such as high water marks on trees or other vegetation are noted. Other drainages such as seeps, aquifer flow and watershed runoff are also examined if necessary.

II. Methodology

A routine methodology approach, combined with a comprehensive approach in difficult areas, was conducted to determine the occurrence or non-occurrence of wetland indicators. The purpose was to identify the existence of hydric soil, hydric vegetation and hydrology indicators along a transect perpendicular to the wetland gradient (Appendix A). Delineation methods which evaluate transitions between non-wetland and wetland areas were applied to the NETHEA project site.

The wetland/upland boundary was determined by the use of paired sample points, with one sample point on the upland side of a tentative wetland boundary and a second on the wetland side of the tentative boundary. The location of the final wetland boundary was determined by the influences of topography, vegetation, soil and hydrology between the two sample points

Figure 2. Map depicting the Northeast Tipalao Housing Expansion Area wetland delineation with location of field transects (T-1 thur T-9).

along the length of the transects. The location of the wetland boundary approximates a point halfway between the pair of sample points which were determined to be upland or wetland. The resultant boundary becomes a line passing through a point between each sample point. Between transects, professional judgment determined the location of the boundary by comparing topography, soils, vegetation and hydrology with the data collected at transect points. The following criteria were used in evaluating the wetland on the NTHEA project site.

* When necessary, soil profiles were observed to a depth of 18-22 inches and recorded using jurisdictional wetland criteria for hydric soils. Generally, the 1987 Manual's procedures and indicators for hydric soils were followed with a few modifications. These include specific parameters pertaining to tropical soil conditions which distinguish between mottling due to wetland hydrology, and variegation caused by normal weathering of parent material. Because of the common nature of mottling in soils on Guam, tentative regional indicators were used to clarify what is considered to be mottling due to hydric soil conditions, (i.e., if mottled, matrix chroma equals 2 or less, and the mottle color value is equal to or less than 4, then the chroma color must be 1 or less. Similarly, if the mottle color value is more than 4, then the chroma color must be less than 1).

* When more than 50 percent of the total number of dominant vegetative species in a transect plot has an indicator status of OBL, FACW and/or FAC, or has a Prevalence Index of 3.0 or less, the area tested was determined to have hydrophytic vegetation.

* The hydrology indicators were those primary and secondary indicators listed in the 1987 Manual. When primary indicators were not observed, best professional judgment along with secondary indicators were used to determine the presence or absence of wetlands hydrology.

III. Findings

A. Soil Analysis

Soil descriptons were obtained from the U.S. Department of Agriculture Soil Survey for the Territory of Guam. The predominant soil units within the Apra Harbor Naval Complex are Inarajan-Inarajan Variant, Guam-Urban land-Pulantat and Pulantat. Inarajan-Inarajan Variant is a soil unit which is listed on the Hydric Soil Map Unit List (May 1990) as having hydric components. Eighteen test pits were dug by hand to a depth of 18 inches when possible. Field descriptions of the soil characteristics found on the site are included in Appendix A.

1. **Wetland A**

Hydric soil indicators which had a matrix chroma of two or less were observed within 18 inches of the surface in sample pit T8P1.

2. **Wetland B**

Hydric soil indicators which had a matrix chroma of two or less, and/or combined with mottling features having Musell value designations of four or less, and associated with chroma designations of one or less were observed within 18 inches of the surface in five sample pits examined (T1P1,T2P1,T3P1, T4P1 and T5P1).

3. **Wetland C**

Hydric soil indicators which had a matrix chroma of two or less combined with mottling features having Musell value designations of four or less, and associated with chroma designations of one or less were observed within 18 inches of the surface in sample pit T6P1.

4. **Wetland D**

Hydric soil indicators which had a matrix chroma of two or less and combined with mottling features having Musell value designations of four or less, and associated with chroma designations of one or less were observed within 18 inches of the surface in sample pit T7P1.

5. **Wetland E**

Hydric soil indicators which had a matrix chroma of two or less and combined with mottling features having Musell value designations of four or less, and associated with chroma designations of one or less were observed within 18 inches of the surface in sample pit T9P1.

B. Vegetation Analysis

Vegetation was examined and data recorded for eighteen sample plot areas. A record of the results may be found in Appendix A. The results of vegetation for the five wetland areas (A, B, C, D and E) are summarized in Table 1. A prevalence index (P.I.) of less than 3.0 was found in nine sample plots (T1P1, T2P1, T3P1, T4P1, T5P1, T6P1, T7P1, T8P1 and T9P1). A herbaceous plant community dominates the areas which includes Wetlands B, C, D and E. Wetland A is composed of a multi-layered plant community dominated by Hibiscus tiliaceus.

C. Hydrology Analysis

In general, observations indicate wetland hydrology is evident within the areas which include all Wetlands A, B, C, D and E. An observable watertable was evident during field visits in early December, presumably a result of the previous month's rainfall that was essentially equal to a peak rainy season month (Figure 3). Hydrology observations were recorded and may be found in Appendix A. An observable watertable or soil saturation at a depth of less than 16 inches was documented in nine test pits (T1P1, T2P1, T3P1, T4P1, T5P1, T6P1, T7P1, T8P1 and T9P1).

Routine Wetland Determination
data form

Project Name Naval Sys. Date 12/9/92

Plot Identifier # Wetland E (T-9 P-1) Investigator MJ Sullivan

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Panicum virgatum	H	FACW	80%	85.5
2. Cyperus iguloi	H	OBL	6	10.5
3. Agrostis alba	H	OBL	6	10.5
4.				
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100 % P.I. 1.60
Hydrophytic vegetation: Y X N Basis:

Soil
Series Munson On hydric soils list? Y X N
Mottled: Y X N Mottle color 10YR 3/1 Matrix color 10YR 3/2
Gleyed: Y N X Gley color Other indicators
Hydric soils: Y X N Basis mucky/clay mineral soil, mucky channel

Hydrology
Inundated: Y N X Depth of standing water NR
Saturated soils: Y X N Depth to saturated soil: 10"
Other indicators: humus and clay mats
Wetland Hydrology: Y X N

Wetland Determination
Atypical situation: Y N X Normal circumstances: Y X N
Wetland Determination: Wetland X Nonwetland
Comments: Depression - lake - river - runoff
under culvert - seasonal moisture regime

Routine Wetland Determination
data form

Project Name Naval Sys Date 12/9/92

Plot Identifier # Wetland E (T-9 P-1) Investigator MJ Sullivan

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Juncus canadensis	T	FACW	65	63
2. Hypolepis sabulosa	H	FACW	55	63
3. Athyrium scribneri	L	FACW	30	38
4.				
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 0 % P.I. 4.0
Hydrophytic vegetation: Y N X Basis: PI > 3.0

Soil
Series Pelmont On hydric soils list? Y N X
Mottled: Y N X Mottle color — Matrix color 10YR 4/3
Gleyed: Y N X Gley color — Other indicators
Hydric soils: Y N Basis chroma > 2

Hydrology
Inundated: Y N X Depth of standing water —
Saturated soils: Y N X Depth to saturated soil: —
Other indicators:
Wetland Hydrology: Y N X

Wetland Determination
Atypical situation: Y N X Normal circumstances: Y X N
Wetland Determination: Wetland Nonwetland X
Comments:

Routine Wetland Determination
data form

Project Name Naval Sta Date 12/8/92

Plot Identifier # Wetland D(T7 P1) Investigator [illegible]

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Phacelia tanacetifolia	H	OBL	70	63.0
2. Acroptilon repens	H	OBL	10	10.5
3. Brassica nigra	H	FAC(U)	60	63.0
4. Cyperus eragrostis	H	FACW	10	10.5
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100% P.I. 1.93

Hydrophytic vegetation: Y X N ___ Basis:

Soil

Series Unknown On hydric soils list? Y ___ N ___

Mottled: Y X N ___ Mottle color 10YR 4/1 Matrix color 10YR 4/2

Gleyed: Y ___ N ___ Gley color ___ Other indicators ___

Hydric soils: Y X N ___ Basis ___

Hydrology

Inundated: ___ Y ___ N ___ Depth of standing water ___

Saturated soils: ___ Y X N ___ Depth to saturated soil: 0" Surface

Other indicators: Muddy, cobble-based riverbank deposit

Wetland Hydrology: Y X N ___

Wetland Determination

Atypical situation: Y ___ N X Normal circumstances: Y X N ___

Wetland Determination: Wetland X Nonwetland ___

Comments:

Routine Wetland Determination
data form

Project Name Naval Sta Date 12/8/92

Plot Identifier # Wetland D(T7-P2) Investigator [illegible]

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Polygonum lapathifolium	H	FACW	60	63.0
2. Polygonum persicaria	H	FACW	40	31.0
3. Mimulus guttatus	H	FACW	15	10.5
4. Nephrolepis pectinata	H	FAC	20	20.5
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 25% P.I. 4.17

Hydrophytic vegetation: Y ___ N X Basis: DT > 3.0

Soil

Series Pescadero On hydric soils list? Y ___ N ___

Mottled: Y ___ N X Mottle color 7.5YR 4/3 Matrix color 10YR 3/1

Gleyed: Y ___ N X Gley color ___ Other indicators ___

Hydric soils: Y ___ N X Basis ___

Hydrology

Inundated: ___ Y ___ N X Depth of standing water NA

Saturated soils: ___ Y ___ N X Depth to saturated soil: NA

Other indicators: ___

Wetland Hydrology: Y ___ N X

Wetland Determination

Atypical situation: Y ___ N X Normal circumstances: Y X N ___

Wetland Determination: Wetland ___ Nonwetland X

Comments:

Routine Wetland Determination
data form

Project Name NAVAL STA Date 12/8/92

Plot Identifier # WETLAND C (T6-P1) Investigator M. Sutter

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Cleyera theaceae	S	FACW	30	38
2. Sambucus Caerulea	H	FAC(W)	60	63
3. Acrostichum aureum	H	OBL	6	10.5
4. Thelypteris interrupta	H	OBL	50	38.0
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100 % P.I. 2.09

Hydrophytic vegetation: Y X N ___ Basis: ___

Soil

Series Inorganic On hydric soils list? Y ___ N ___

Mottled: Y X N ___ Mottle color 10YR 3/1 1/3 Matrix color 10YR 4/2

Gleyed: Y ___ N ___ Gley color ___ Other indicators ___

Hydric soils: Y X N ___ Basis mucky clay = 2 cm organic mottling 10YR 5/1

Hydrology

Inundated: Y ___ N X Depth of standing water ___

Saturated soils: Y X N ___ Depth to saturated soil: 5"

Other indicators: Free water table encountered 8" from surface

Wetland Hydrology: Y X N ___

Wetland Determination

Atypical situation: Y ___ N X Normal circumstances: Y X N ___

Wetland Determination: Wetland X Nonwetland ___

Comments: Natural depression in terrain

Routine Wetland Determination
data form

Project Name NAVAL STA Date 12/8/92

Plot Identifier # Wetland C (T6 P2) Investigator M. Sutter

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Polypodium scolopendria	H	FACU	50	38-0
2. Adiantum tenerum	S	FAC	60	60.0
3. Mikania scandens	V	FACW	20	20.5
4. Nephrolepis hirsutula	H	FAC	20	20.5
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 25 % P.I. 4.30

Hydrophytic vegetation: Y ___ N X Basis: ___

Soil

Series Pulaski On hydric soils list? Y ___ N ___

Mottled: Y ___ N X Mottle color ___ Matrix color 10YR 3/4

Gleyed: Y ___ N X Gley color ___ Other indicators ___

Hydric soils: Y ___ N X Basis ___

Hydrology

Inundated: Y ___ N X Depth of standing water NA

Saturated soils: Y ___ N X Depth to saturated soil: NA

Other indicators: ___

Wetland Hydrology: Y ___ N X

Wetland Determination

Atypical situation: Y ___ N X Normal circumstances: Y X N ___

Wetland Determination: Wetland ___ Nonwetland X

Comments: ___

Routine Wetland Determination data form

Project Name Naval Stn Date 11/30/92

Plot Identifier # Wetland B (TS P1) Investigator MJ Sullivan

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Hyparrhenia rufa	H	FACW	80	85.5
2. Panicum antidotale	H	FACW	40	38.0
3. Thelypteris interrupta	H	OBL	55	63.0
4.				
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100 % P.I. 1.66

Hydrophytic vegetation: Y X N ___ Basis: ___

Soil

Series Lucayan Variant On hydric soils list? Y X N ___

Mottled: Y X N ___ Mottle color 10YR 3/1 Matrix color 2.5Y R2/0

Gleyed: Y ___ N X Gley color ___ Other indicators ___

Hydric soils: Y ___ N ___ Basis ___

Hydrology

Inundated: ___ Y ___ N X Depth of standing water ___

Saturated soils: ___ Y ___ N ___ Depth to saturated soil: ___

Other indicators: ___

Wetland Hydrology: ___ Y ___ N ___

Wetland Determination

Atypical situation: Y ___ N X Normal circumstances: Y X N ___

Wetland Determination: Wetland X Nonwetland ___

Comments: ___

Routine Wetland Determination data form

Project Name Naval Stn Date 11/30/92

Plot Identifier # Wetland B (TS P2) Investigator MJ Sullivan

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Eleusine indica	H	FACU	40	38
2. Cynodon dactylon	H	FAC	20	70.5
3. Melinis minutiflora	H	FAC	20	70.5
4. Celosia velutina	H	FACU	20	70.5
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 25 % P.I. 3.79

Hydrophytic vegetation: Y ___ N X Basis: ___

Soil * see comments Quom Urban

Series ___ On hydric soils list? Y ___ N X

Mottled: Y ___ N ___ Mottle color N/A Matrix color N/A

Gleyed: Y ___ N ___ Gley color N/A Other indicators Compacted fill

Hydric soils: Y ___ N X Basis ___

Hydrology

Inundated: ___ Y ___ N X Depth of standing water N/A

Saturated soils: ___ Y ___ N X Depth to saturated soil: N/A

Other indicators: ___

Wetland Hydrology: ___ Y ___ N X

Wetland Determination

Atypical situation: Y X N ___ Normal circumstances: Y ___ N X

Wetland Determination: Wetland ___ Nonwetland X

Comments: Soil — could not penetrate surface soil shovel — due compact & compound crushed coral fill — put down between sod & bulk

Routine Wetland Determination
data form

Project Name Wetland Stat Date 12/2/92

Plot Identifier # Wetland B (T4 P1) Investigator MM Sibbert

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Hibiscus tiliaceus	T	FACW	70	85-5
2. Lemna sp	H	OBL	90	85-5
3. Thelypteris interrupta	H	OBL	20	20-5
4.				
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100% P.I. 1.55
Hydrophytic vegetation: Y X N ___ Basis: ___

Soil
Series Tuttle Variant On hydric soils list? Y X N ___
Mottled: Y ___ N X Mottle color ___ Matrix color 10 YR 3/1
Gleyed: Y ___ N X Gley color ___ Other indicators ___
Hydric soils: Y X N ___ Basis ___

Hydrology
Inundated: Y X N ___ Depth of standing water 3"
Saturated soils: Y X N ___ Depth to saturated soil: ___
Other indicators: ___
Wetland Hydrology: Y X N ___

Wetland Determination
Atypical situation: Y ___ N X Normal circumstances: Y X N ___
Wetland Determination: Wetland X Nonwetland ___
Comments: 1/7/93 - water table - Gauge at 0" below surface soil saturated to surface

Routine Wetland Determination
data form

Project Name Wetland Stat Date 12/2/92

Plot Identifier # Wetland B (T4-P2) Investigator MM Sibbert

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Ipomea Carnea	L	FACW	30	85.5
2. Millania Scandens	L	FACW	40	38-0
3. Andgonon leptopus	L	UPL	10	38.0
4. Leucaena leucocephala	S	UPL	10	8.5
5. Hibiscus tiliaceus	S	FACW	3	3
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 90% P.I. 3.96
Hydrophytic vegetation: Y ___ N X Basis: ___
Hydrophytic Vegetation

Soil See comments
Series ___ On hydric soils list? Y ___ N ___
Mottled: Y ___ N ___ Mottle color ___ Matrix color ___
Gleyed: Y ___ N ___ Gley color ___ Other indicators ___
Hydric soils: Y ___ N X Basis ___

Hydrology
Inundated: Y ___ N X Depth of standing water NA
Saturated soils: Y ___ N X Depth to saturated soil: NA
Other indicators: ___
Wetland Hydrology: Y ___ N X

Wetland Determination
Atypical situation: Y ___ N X Normal circumstances: Y X N ___
Wetland Determination: Wetland ___ Nonwetland X
Comments: Soil profile to 18" consistent - Bridge of hillside Gauge stopped 2 consecutive weeks no standing water

Routine Wetland Determination
data form

Project Name Naval SRA Date 12/7/92

Plot Identifier # T-3 P-1 Wetland B 4x4 Road Investigator MJ Sibbett

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Polypogon interruptus	H	OBL	30	
2. Hordeum glaucum	H	FACW	75	
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100% P.I. 1.71

Hydrophytic vegetation: Y X N ___. Basis: PI < 30

Soil

Series ___ On hydric soils list? Y ___ N ___

Mottled: Y ___ N ___. Mottle color 10YR 4/1 and 7/2 Matrix color 10YR 4/2

Gleyed: Y ___ N X. Gley color ___ Other indicators ___

Hydric soils: Y X N ___. Basis ___

Hydrology

Inundated: ___ Y ___ N X. Depth of standing water ___

Saturated soils: Y X N ___. Depth to saturated soil: 4"

Other indicators: algal mats - depressions

Wetland Hydrology: Y X N ___.

Wetland Determination

Atypical situation: Y ___ N X. Normal circumstances: Y X N ___

Wetland Determination: Wetland X Nonwetland ___

Comments: ___

Routine Wetland Determination
data form

Project Name Naval SRA Date 12/7/92

Plot Identifier # Wetland B T-3 P-2 Investigator MJ Sibbett

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Agrostis exarata	H	OBL	95	38
2. Hordeum glaucum	H	FACW	30	38
3. Distichlis spicata	H	FAC	15	10.5
4. Bolboschoenus maritimus	H	FACW (OBL)	10	10.5
5. Melaleuca sp.	L	FACW	20	20.5
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 25% P.I. 4.23

Hydrophytic vegetation: Y ___ N X. Basis: ___

Soil

Series Pulmitas On hydric soils list? Y ___ N ___

Mottled: Y X N ___. Mottle color 10YR 3/3 Matrix color 10YR 3/1

Gleyed: Y ___ N X. Gley color 7.5YR 4/4 Other indicators ___

Hydric soils: Y ___ N X. Basis ___

Hydrology

Inundated: ___ Y ___ N X. Depth of standing water ___

Saturated soils: ___ Y ___ N X. Depth to saturated soil: ___

Other indicators: ___

Wetland Hydrology: ___ Y ___ N X

Wetland Determination

Atypical situation: Y ___ N X. Normal circumstances: Y X N ___

Wetland Determination: Wetland ___ Nonwetland X

Comments: ___

Routine Wetland Determination
data form

Project Name Naval Sta — Date 12/7/92

Plot Identifier # T-2 P-1 B37a — Investigator M.J. Sibbet

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Tholypteris interrupta	H	OBL	25	6.3
2. Polystichum munitum	H	FACU	22.5	38
3. Pteridium aquilinum	H	FACU	7.5	10.5
4.				
5.				
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100% P.I. 1.43
Hydrophytic vegetation: Y X N ___. Basis: _____

Soil
Series _____ On hydric soils list? Y X N ___
Mottled: Y X N ___. Mottle color 2.5YR 3/6 Matrix color 2.5YR 2/0
Gleyed: Y ___ N ___. Gley color 10YR 3/1 Other indicators _____
Hydric soils: Y ___ N ___. Basis _____

Hydrology
Inundated: Y ___ N X. Depth of standing water _____
Saturated soils: Y X N ___. Depth to saturated soil: 0-12"
Other indicators: _____
Wetland Hydrology: Y X N ___.

Wetland Determination
Atypical situation: Y ___ N X. Normal circumstances: Y X N ___.
Wetland Determination: Wetland X Nonwetland _____
Comments: _____

Routine Wetland Determination
data form

Project Name Naval Sta — Date 12/7/92

Plot Identifier # T-2 - P2 B37a — Investigator M.J. Sibbet

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Jasmine	L	UPL	7.5	20.5
2. Coleonema pulchrum	L	FACU	22.5	38.8
3. Lolium perenne	S	UPL	2.5	10.5
4. Poa pratensis		FACU	7.5	10.5
5. Myoporum laetum	L	FACU	7.5	20.5
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 0% P.I. 4.31
Hydrophytic vegetation: Y ___ N X. Basis: _____

Soil
Series See Comments On hydric soils list? Y ___ N ___
Mottled: Y ___ N ___. Mottle color _____ Matrix color _____
Gleyed: Y ___ N ___. Gley color _____ Other indicators _____
Hydric soils: Y ___ N X. Basis _____

Hydrology
Inundated: Y ___ N X. Depth of standing water _____
Saturated soils: Y ___ N X. Depth to saturated soil: _____
Other indicators: _____
Wetland Hydrology: Y ___ N X.

Wetland Determination
Atypical situation: Y ___ N X Normal circumstances: Y X N ___.
Wetland Determination: Wetland _____ Nonwetland X
Comments: Plot located on full slope of swale area. Soil sandy mix of large rock, gravel and topsoil. Soil indicators for

T-1 P-1 B48b

SOIL DESCRIPTION				
PROFILE	MOIST COLOR	TEXTURE	MOTTLING	MISC: (roots, pores, concretions, organics)
0-2	10YR 3/2	Clay	10YR 3/1 C-1d	Many fine roots
3-10"	10YR 4/2		10YR 4/1 5YR C-1d	few medium on coarse roots
>10"	Coral sand pan			

Routine Wetland Determination
data form

Project Name NAVAL STATION Date 12/7/92

Plot Identifier # T-1 P-2 B84-b Investigator MJ Sabol

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

4x4 guadd

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Cenchrus incertus	S	UPL	≥ 5%	63
2. Bacopa monnieri	H	FACW	7 1/6	20.5
3. Boerhavia diffusa	L	FACU	7 1	3
4. Mikania scandens	L	FACW	7 1/6	10.5
5. Nephrolepis hirsutula	H	FAC	7 1	3
6. Bidens alba	H	FACU(NI)	7 1/6	10.5
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 100% P.I. 4.54
Hydrophytic vegetation: Y___ N X. Basis: _____

Soil Series Pulaski On hydric soils list? Y___ N___
Mottled: Y X N___. Mottle color 10YR 5/3 Matrix color 10YR 3/1
Gleyed: Y___ N X. Gley color N/A Other indicators _____
Hydric soils: Y___ N X. Basis _____

Hydrology
Inundated: Y___ N X. Depth of standing water _____
Saturated soils: Y___ N X. Depth to saturated soil: _____
Other indicators: _____
Wetland Hydrology: Y___ N X.

Wetland Determination
Atypical situation: Y___ N X. Normal circumstances: Y X N___.
Wetland Determination: Wetland _____ Nonwetland X
Comments:
Soil pit 0-5" continuous matrix 10YR 3/1 mixed with medium to small coral pieces at 5" encounter hard pan (impenetrable with shovel)

Naval Station

Evaluator MA Sullivan

& Plot # T-1 P-1 (B-486)

Date 12/7/92

Circumstances? Mow 4x4 gudies

Cover	>95%	>76%	>51%	>26%	>16%	>6	>1%
	98.0	85.5	63	38	20.5	10.5	3

	NWI status	Obl (1)	FacW (2)	Fac (3)	FacU (4)	Upl (5)
	OBL	85.5				
	FACU				3.0	

drat 1: 85.5 0 0 3.0 0

d Occurences?

	NWI status	Obl (1)	FacW (2)	Fac (3)	FacU (4)	Upl (5)
	OBL	85.5				
	OBL	38.0		1		
	FAC (UPL)			10.5		
	FACW				30	

ral 2: 85.5 0 10.5 30 0

d Occurences?

	NWI status	Obl (1)	FacW (2)	Fac (3)	FacU (4)	Upl (5)
		85.5				
				20.5		
		106.5				

ral 3: 85.5 0 20.5 20.5 0

Occurences?

	NWI status	Obl (1)	FacW (2)	Fac (3)	FacU (4)	Upl (5)
		85.5				
		10.5				
		96.0	0	0	0	0

ral 4:

Occurences?

rences w/known indicator status ___ X 100 = ___ %

ances

P.I. Quadrat 1 = 1.10
P.I. Quadrat 2 = 1.19
P.I. Quadrat 3 = 1.59
P.I. Quadrat 4 = 1.0
Mean Prevalence Index 1.34

Std. Dev: = 0.37
Std Error = 0.18
Standard Error < 20? Yes X No ___

Naval Station

Plot Identifier # T-1 P-1 (B-486) Date 12/7/92 Investigator MA Sullivan

SOILS

Yes	No	
	X	Texture above 18 inches: depth: X non-sandy ___ sandy SCS Series mapped: ___
	X	Is matrix chroma ≤1? Matrix color 10 YR 4/2
X		If mottled, matrix chroma ≤2, mottle chroma ≤1 and value ≤4? If yes, depth range 0-10" Mottle color 10 YR 4/4 3/2
	X	If mottled, matrix chroma ≤2, mottle chroma <1 and value >4? If yes, depth range ___ Mottle color ___

All soil textures (complete regardless of texture)

	X	Soil saturated at or near surface all of the year? (peraquic moisture regime)
	X	Aquic moisture regime at suborder level?
	X	Sulfidic odor? If yes, depth? ___
	X	Histic epipedon: >30% organic in an 8-16" layer near soil surface (>20% in sandy soil)

Non-sandy soils (do not complete if soil is sandy)

	X	Organic soil (Histosols): >50% in top 32"?
	X	Gleyed? If yes, predominant color(s) ___ mottled ___ depth range ___ continuous ___ depth range ___
		Fe or Mn concretions >2mm diameter within 3" of surface?

Sandy soils (complete only if texture is sandy)

		Organic pan? If yes, depth ___
		Vertical dark organic streaks (may stain fingers)
X		Summary: Hydric soil?

HYDROLOGY

Yes	No	
	X	Inundated? If yes, depth ___
X		Water table encountered? If yes, depth to water table 6" (Describe root abundance, size, and location on back)
		Can water be squeezed or shaken from the surface soil?
X		Algal mats present?
		Oxidized rhizospheres
		Sulfidic odor? If yes, depth ___
		Aerenchyma tissue, prop roots, pneumatophores, hypertrophied lenticels, or floating stems or leaves?
		Channels or other indicators of flow patterns observable?
		Drift/debris lines present?
		Watermarks or sediment on vegetation, detritus, structures?
X		Shallow root systems, ~~adventitious roots~~?

*Secondary indicator

X		Summary: Wetland hydrologic regime?

Notes: Soil saturated at 3" observed water accumulating in shovel pit at 6" presumably to underlying clay

Soil - mixed with coral fragments pebble size and [illegible]

Routine Wetland Determination
data form

Project Name NAVAL STA WETLAND Date 12/1/92

Plot Identifier # WETLAND (A) A1a-A8a T-B9 Investigator MS/RS
(C) A4b-A8b

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Hibiscus	T	FACW	80	85.5
2. Acrostichum	H	OBL	25	20.5
3. Polypodium Spp	H	FACU	20	20.5
4. Cocos Nucifera	T	FAC	15	70.5
5. Colubrina asiatica	V	FAC	10	70.5
6. Mikania	V	FAC	5	3.0
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 33% P.I. 2.46
Hydrophytic vegetation: Y X N ___. Basis: PI < 3.0

Soil
Series Inkram Variant On hydric soils list? Y X N ___
Mottled: Y X N ___. Mottle color 10YR 2/1 Matrix color 10YR 2/1
Gleyed: Y ___ N X. Gley color ___ Other indicators ___
Hydric soils: Y X N ___. Basis Low Chroma < 2

Hydrology
Inundated: Y X N ___. Depth of standing water 2-4" in some areas seasonal
Saturated soils: Y X N ___. Depth to saturated soil: 8"
Other indicators: Saturated soil at 10"
Wetland Hydrology: Y X N ___.

Wetland Determination
Atypical situation: Y ___ N X Normal circumstances: Y X N ___
Wetland Determination: Wetland X Nonwetland ___
Comments: depression area along cliff - area seasonally inundated - hydric soils evident in bottom of depression - top edge of slope used to mapped boundary

Routine Wetland Determination
data form

Project Name Naval Sta Date 12/1/92

Plot Identifier # Wetland A (T-B9) Investigator MS/Subbota

Vegetation (list dominant species in each vegetation layer with known NWI indicator status and estimate of percent cover in three feet radius).

Species	Veg. Layer	NWI Status	% Cover	Mid. pt.
1. Sacchum spontaneum	H	FAC(W)	40	39.0
2. Colubrina asiatica	S	FACU	20	22.5
3. Cocos nucifera	T	FAC	55	63.0
4. Mikania scandens	L	FACW	20	80.5
5. Nephrolepis hirsutula	H	FAC	10	10.5
6.				
7.				
8.				
9.				
10.				

% species OBL, FACW and/or FAC: 40% P.I. 3.68
Hydrophytic vegetation: Y ___ N X. Basis: PI > 3.0

Soil
Series Pulantat On hydric soils list? Y ___ N X
Mottled: Y X N ___. Mottle color 7.5YR 4/4 Matrix color 10YR 3/3
Gleyed: Y ___ N X. Gley color ___ Other indicators ___
Hydric soils: Y ___ N X. Basis Making chroma > 2

Hydrology
Inundated: Y ___ N X. Depth of standing water ___
Saturated soils: Y ___ N X. Depth to saturated soil: ___
Other indicators: ___
Wetland Hydrology: Y ___ N X.

Wetland Determination
Atypical situation: Y ___ N X Normal circumstances: Y X N ___
Wetland Determination: Wetland ___ Nonwetland X
Comments: ___

Table 3. List of Plant Species Identified for the Northeast Tipalao Housing Expansion Are.

FAMILY	GENUS/ SPECIES		STATUS
Araceae	*Alocasia*	*macrorrhiza*	FAC
Arecaceae	*Cocos*	*nucifera*	FACU
	Heterospathe	*elata*	NI
Caesalpiniaceae	*Cassia*	*alata*	FACU
Casuarinaceae	*Casuarina*	*equisetifolia*	FACU
Compositae	*Mikania*	*scandens*	FACU
	Bidens	*alba*	NI
	Eupatorium	*odoratum*	FACU
	Pluchea	*fosbergii*	FAC
	Pluchea	*indica*	FAC
	Pluchea	*symphytifolia*	FAC
Convolvulaceae	*Impomea*	*indica*	FACU
Cyperaceae	*Cyperus*	*polystachyos*	FAC
	Cyperus	*brevifolius*	FAC
	Cyperus	*odoratus*	FACW
	Scirpus	*littoralis*	OBL
Euphorbiaceae	*Glochidion*	*marianum*	FACU
Malvaceae	*Hibiscus*	*tiliaceus*	FACW
Mimosaceae	*Leucaena*	*leucocephala*	UPL
	Mimosa	*pudica*	FACU
Pandanaceae	*Pandanus*	*tectorius*	FAC

FAMILY	GENUS/ SPECIES		STATUS
Poaceae	*Chloris*	*radiata*	FACU
	Eleusine	*indica*	FACU
	Dactyloctenium	*aegyptium*	UPL
	Panicum	*muticum*	FACW
	Pennisetum	*polystachion*	UPL
	Panicum	*maximum*	FACU
	Paspalum	*orbiculare*	FAC
	Saccharum	*spontaneum*	FAC (NI)
Polygalaceae	*Antigonon*	*Leptopus*	UPL
	Polygonum	*minus*	FACW
Oleaceae	*Jasminum*	*marianum*	UPL
Polypodiaceae	*Acrostichum*	*aureum*	OBL
	Nephrolepis	*hirsutula*	FAC
	Thelypteris	*interrupta*	OBL
	Polypodium	*scolopendria*	FACU
Rhamnaceae	*Colubrina*	*asiatica*	FACU
Verbenaceae	*Clerodendrum*	*inerme*	FACW
	Stachytarpheta	*jamaicensis*	FACU

Table 1. Summary of Vegetation Data For Northeast Tipalao Housing Expansion Area, Apra Harbor Naval Complex

SAMPLE POINT LOCATION	DOMINANTS METHOD[1]	PREVALENCE INDEX (Standard Error)[2]
WETLAND A		
T8P1	--	2.46 (--[3])[4]
T8P2	40%	3.68 (--[3])
WETLAND B		
T1P1	--	1.36 (0.18)
T1P2	0%	4.54 (--[3])
T2P1	100%	1.43 (--[3])
T2P2	0%	4.31 (--[3])
T3P1	100%	1.71 (--[3])
T3P2	20%	4.23 (--[3])
T4P1	100%	1.55 (--[3])
T4P2	20%	3.96 (--[3])
T5P1	100%	1.66 (--[3])
T5P2	25%	3.79 (--[3])
WETLAND C		
T6P1	100%	2.09 (--[3])
T6P2	25%	4.30 (--[3])
WETLAND D		
T7P1	100%	1.93 (--[3])
T7P2	25%	4.31 (--[3])
WETLAND E		
T9P1	100%	1.80 (--[3])
T9P2	0%	4.00 (--[3])

[1] Percent of dominant species which are FAC, FACW or OBL. Vegetation is hydrophytic if this figure >50%.

[2] Prevalence index and standard error. Vegetation is hydrophytic if the prevalence index <3.0. The standard error must be ≤ 0.20 if sampling is adequate.

[3] The "Routine Form" was used because the status of the vegetation is readily apparent, and no standard error was calculated.

[4] Prevalence index was used because only one of two dominant species exceeded cover class two, and the dominants method would be subject of significant bias.

IV. Discussion

Wetlands must have indications of each of the following three parameters: hydrophytic vegetation, hydric soils and wetland hydrology. Table 2 summarizes the status of the three parameters at the sample points located along the wetland gradient for each of the wetland areas (A, B, C, D and E). It is clear from the data that a readily perceived seperation between wetland and non-wetland parameters exists along a wetland gradient in each of the designated wetland areas. Figure 2 presents a wetland boundary consistent with the results discussed above.

In each of the wetland areas A, C, D and E, one transect was used to evaluate wetland parameters. The cummulative total area of these four wetland areas is estimated to be less than 0.40 acres. Only one transect was necessary for placement of an accuarte boundary because of the small size, the clearly decernable topography breaks, and the characteristic hydrophytic vegetation indicators.

Placement of the wetland boundary around Wetland B required a more intensive effort because of its size (approximately 10.8 acres) and variability. Starting at the western end of the equipment storage area (Figure 2), the wetland/non-wetland gradient follows a topograhy break created by the placement of construction related fill along the north and east sides of the wetland. The southern portion of the wetland boundary then turns west along Granada Avenue and follows the edge of the road fill before it turns in a northwesterly direction. This southwestern portion of the wetland boundary follows a naturally distinct topographic and vegetative break which converges into finger-like protrusion encompassing a distinct channel in the west end of Wetland B.

V. Conclusion

Vegetation, hydrological indicators and soil all indicate the presence of five wetland areas (totalling approximately 11.0 acres) in the designated project boundaries of the Northeast Tipalao Housing Expansion Area. Officially documented and recorded wetlands were designated on National Wetland Inventory maps within this project area. The guidelines required by the Federal Government were followed to establish the wetland boundaries for this project area. This was accomplished by using the 1987 Federal Manual for Identifying and Delineating Jurisdictional Wetlands.

A field verification of the wetland boundary line was conducted on 11 December 1992 with the ACOE representative and PBEC. Frank Dayton, ACOE Chief of Operations was present to inspect and verify the location of the wetland boundary that had been delineated earlier by PBEC. Verbal agreement between ACOE representatives and PBEC concurred that the wetland boundary was properly located.

Perry and Assoc. have surveyed the inspected wetland boundary and have provided an original mylar of the wetland with survey data (metes and bounds). This map was presented to the Guam ACOE for signature. The map was signed on January 11, 1993 by Frank Dayton, ACOE Chief of Operations as an accuarate representation of the wetlands within the Northeast Tipalao Housing

Table 2. Three Parameter Summary For Northeast Tipalao Housing Expansion Area, Apra Harbor Naval Complex

Sample Point	Hydrophytic Vegetation	Hydric Soil	Wetland Hydrology	Wetland Designation
WETLAND A				
Transect 8				
T8P1	YES	YES	YES	YES
T8P2	NO	NO	NO	NO
WETLAND B				
Transect 1				
T1P1	YES	YES	YES	YES
T1P2	NO	NO	NO	NO
Transect 2				
T2P1	YES	YES	YES	YES
T2P2	NO	NO	NO	NO
Transect 3				
T3P1	YES	YES	YES	YES
T3P2	NO	NO	NO	NO
Transect 4				
T4P1	YES	YES	YES	YES
T4P2	NO	NO	NO	NO
Transect 5				
T5P1	YES	YES	YES	YES
T5P2	NO	NO	NO	NO
WETLAND C				
Transect 6				
T6P1	YES	YES	YES	YES
T6P2	NO	NO	NO	NO
WETLAND D				
Transect 7				
T7P1	YES	YES	YES	YES
T7P2	NO	NO	NO	NO
WETLAND E				
Transect 9				
T9P1	YES	YES	YES	YES
T9P2	NO	NO	NO	NO

Expansion Area. Supporting documentation including data on vegetation, soils and hydrology, is provided in the Appendix to this report.

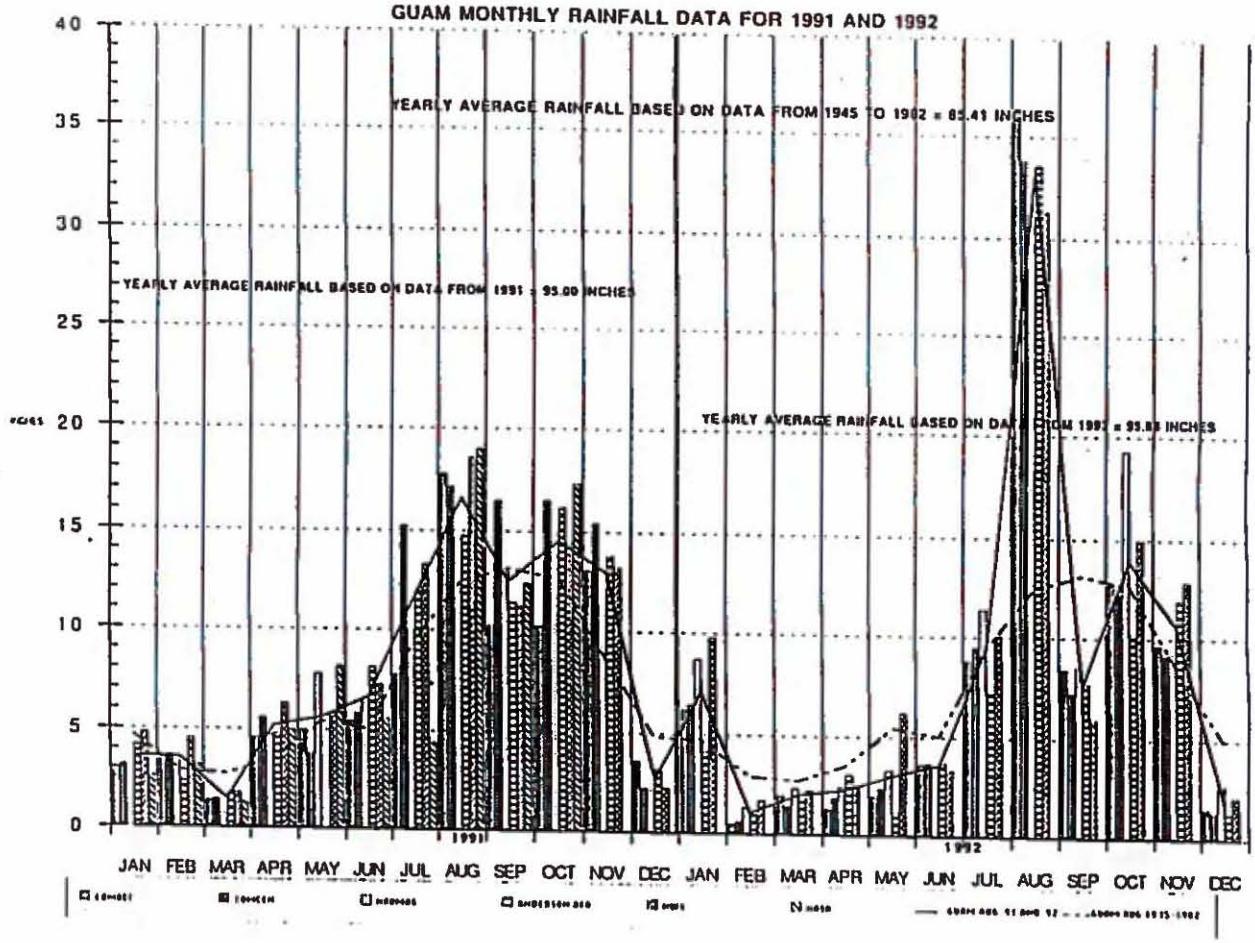

Figure 3. Guam Rainfall Data: January 1991 to December 1992

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Appendix K

Noise Study

AIRCRAFT NOISE SURVEY FOR NAVAL AIR STATION AGANA, GUAM

March 1993

HMMH Report No. 292470

Alan G. Hass
Lee K. Bennett

Prepared For:

Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

Prepared by:

Harris Miller Miller & Hanson Inc.
429 Marrett Road
Lexington, Massachusetts 02173

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1. INTRODUCTION

In January 1993, Belt Collins & Associates contracted Harris Miller Miller & Hanson Inc. (HMMH) to conduct an aircraft noise survey at the U. S. Naval Air Station (NAS) at Agana, Guam. The purpose of this noise survey was to support the environmental impact document for NAS Agana. This study determines the noise impacts of Fleet Logistics Support Squadron 50 (VRC-50) conducting field carrier landing practice (FCLP's) at NAS Agana as opposed to conducting them at Anderson Air Force Base where VRC-50 is based. The study determines baseline noise levels from existing air operations at Agana and the potential noise levels with the addition of the VRC-50 FCLP operations.

This report presents the results of the noise survey for NAS Agana, Guam. Agana is a joint use air station serving not only the U. S. Navy but also the commercial needs of the island through the Guam International Air Terminal. Consequently, air activity includes military operations as well as air carrier jet and turboprop operations. Because of this mixture of aircraft, this study not only addresses the total noise exposure from all operations but also examines the military and civilian components of total noise exposure. This report summarizes that analysis.

Section 2 discusses the noise metric used to define the noise exposure and also describes the computer program used to compute the noise metric. Section 3 describes the air station and its activities. Section 4 presents aircraft operations, runway use, flight tracks, and flight track use. Finally, Sections 5 and 6 present the existing and future noise exposure contours.

2. DEVELOPMENT OF NOISE CONTOURS

2.1 Relevant Aircraft Noise Metrics

The noise exposure metric used in this report is known as the Day Night Average Sound Level (L_{dn}). The units of L_{dn} are decibels.

The noise of each individual event is accounted for in a separately defined metric that integrates the changing sound level over time as, for example, when an aircraft approaches a site, flies overhead, and then continues off into the distance. These integrated sound levels for individual operations are referred to as Sound Exposure Levels (SELs), and in the calculation of L_{dn}, are added together on an energy basis (i.e., logarithmically), one for each aircraft operation occurring during a typical busy 24-hour period.

To account for the heightened subjective response and increased intrusiveness of events occurring during the nighttime (defined as 2200 to 0700 the following day), the L_{dn} calculation procedure penalizes each nighttime event as if it were 10 decibels louder. Thus, shifting daytime operations into nighttime hours has the effect of increasing L_{dn}, even when the total number of operations remains constant.

Finally, L_{dn} values around an air station are normally presented not just for a single 24-hour period, but rather for a typical busy 24-hour period reflecting an average of operations over the course of a full year. This is done to obtain a stable representation of the noise environment, free of fluctuations in wind direction, runway use, temperature, aircraft performance, and total airfield activity, any one of which can influence noise exposure levels significantly from one day to the next. The accumulation of noise computed in this manner provides a quantitative tool for comparing overall noise environments and developing compatible land use plans. The levels are often depicted as contours connecting points of equal value, usually in 5 decibel increments from 60 or 65 dB up to 75 or 80 dB.

2.2 Computer Prediction Models

Two major computer programs have been used in the preparation of the L_{dn} noise contours for NAS Agana. Both were developed under contract to the U.S. Air Force which serves as the lead Department of Defense agency for aircraft noise modelling.

OMEGA 10 is used to generate the Sound Exposure Levels (SELs) of individual military aircraft operations at different distances to the aircraft and at different engine power settings and airspeeds, each of these affecting the loudness and duration of the event.

Together with a standard military aircraft data base known as NOISEFILE 5.1, OMEGA 10 provides the noise data for each specific aircraft operation modelled at a given facility. Alternatively, these data can be developed empirically from noise measurements or can at least be checked against noise measurements to assure accurate modelling of local operations.

During the preparation of noise contours for NAS Agana, the Integrated Noise Model (INM) database (Version 10) was used as the source of noise data for all commercial aircraft modelled. The INM is a program developed by FAA for modelling aircraft noise at civilian airports. The INM database (Version 10) represents the most current database for civil aircraft.

The final computation of L_{dn} values for the set of operations comprising the activity at NAS Agana was accomplished with NOISEMAP 6.1. This program computes L_{dn} values at individual grid points around the facility using the noise data from OMEGA 10, the INM database, plus airport geometry that includes the runway layout, flight track locations, and aircraft climb profiles. Separate plotting software was used to generate the L_{dn} contours from the grid of the computed noise exposure levels.

Development of noise contours for the facility thus required detailed knowledge of the operations that generate noise at NAS Agana. Required information included:

- Number of operations per day by aircraft type;
- Estimates of runway use by aircraft type;
- Locations of flight paths;
- Percent use of each arrival and departure path and, for military aircraft, of each traffic pattern; and
- Military aircraft power settings, speeds, and altitudes for departures, arrivals and patterns.

3. DESCRIPTION OF NAS AGANA AND ITS ACTIVITIES

3.1 Location

NAS Agana is located on a modest plateau near the middle of the island of Guam on the eastern edge of the Philippine Sea. The airfield is two miles east of the center of the city of Agana and is bordered immediately to the north and west by the town of Tamuning and to the south by the town of Barrigada. To the northeast, east, and southeast are other military installations including Anderson Air Force Base and Harmon, Marbo and Communication annexes and the U.S. Naval Communications Station at Barrigada.

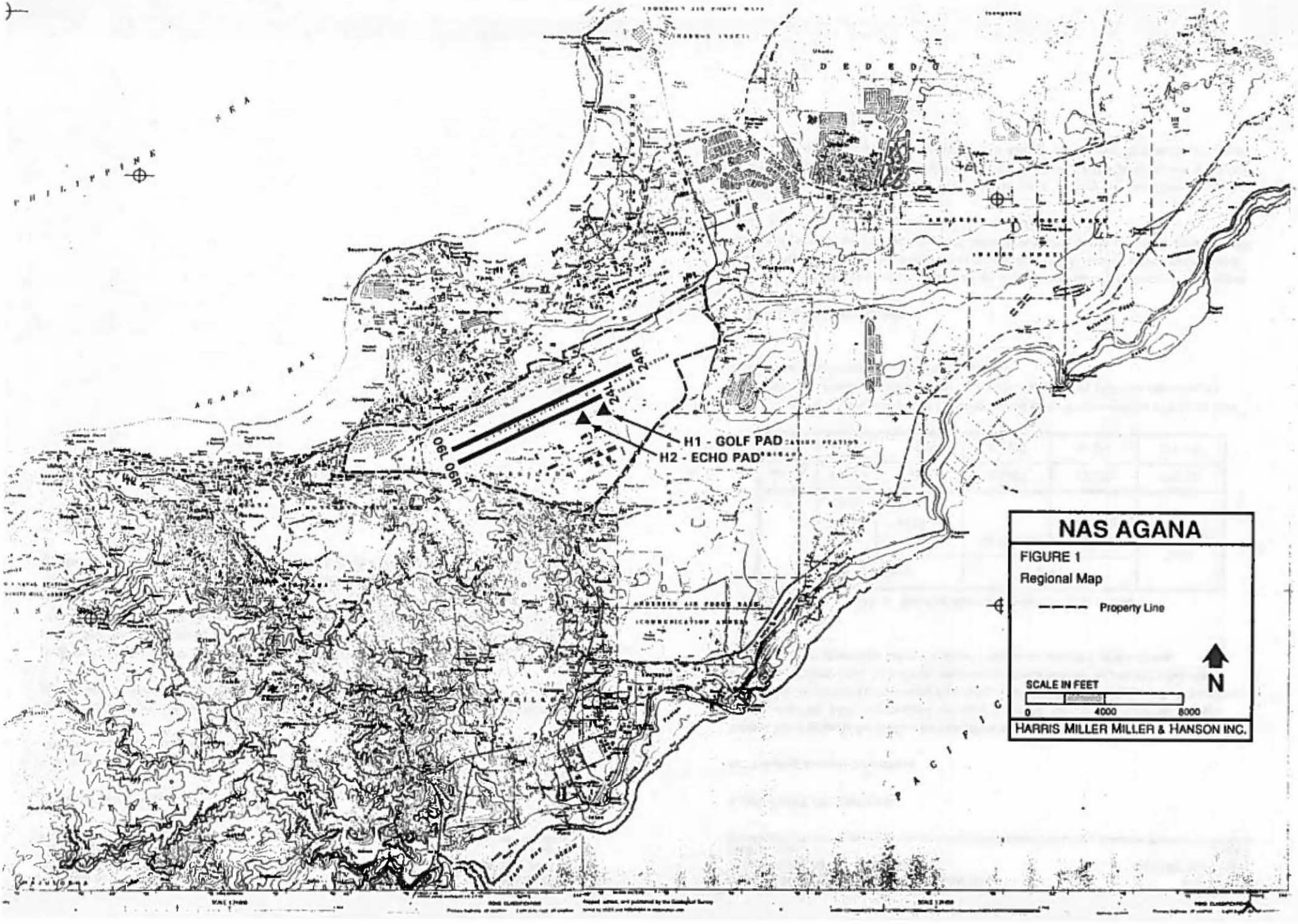
Much of the land on these military installations is sparsely populated as is the mountainous area south and west of Agana that comprises portions of the Apra Harbor Naval Reservation and the Nimitz Hill Annex. Beyond Tamuning, two miles north of NAS Agana, is the coastline of Guam, opening on Agana Bay, Tumon Bay and the Philippine Sea.

Figure 1 presents NAS Agana and its surroundings on a U. S. Geological Survey map reduced to a scale of 1 inch = 4,000 ft.

3.2 Physical Description of the Airfield

The "airside" portion of the station includes a single set of parallel runways, aligned on magnetic headings of 063° and 243°. The primary runway at NAS Agana is the northernmost parallel, 10,000 in length and designated 06L/24R. The secondary runway, 8,000 in length, separated from the primary runway by 750 feet and is designated 06R/24L. There are also two departure and arrival areas for helicopters, designated Golf 1 (H1) and Echo 2 (H2), near the northeastern end of Runway 06R/24L.

Elevations on the airfield generally range from 240 to 300 feet above Mean Sea Level, or approximately 100 to 150 feet above the elevations of much of the surrounding terrain. Official airfield elevation is 298 feet. Weather is warm and humid with little variation. 1988 averages of 81°F and 79% relative humidity were used in modelling sound propagation losses for the study.


H1 - GOLF PAD
H2 - ECHO PAD
06L 06R
24L 24R
NAS AGANA
FIGURE 1
Regional Map
Property Line
SCALE IN FEET
0
4000
8000
N
HARRIS MILLER MILLER & HANSON INC.

3.3 General Activities

Currently there are one P-3 squadron (VQ-1), one S-3 squadron (VQ-5), and one H-46 helicopter squadron (HC-5) stationed at NAS Agana.

As mentioned earlier, NAS Agana also serves as the civil airport of the island. Consequently, there is significant commercial jet activity, including B747, B727 and DC-10 aircraft.

In general, jet activity both by military aircraft and by air carriers is conducted on the primary 10,000 foot runway, the predominant direction of operation being to the northeast on 06L. Light aircraft and helicopters are usually separated from the heavier aircraft through their use of the shorter runway, 06R/24L, and these aircraft, too, operate predominantly to the northeast. Overall runway usage of the 06R/06L was estimated by NAS Agana operations personnel to be greater than 90% as a result of the prevailing easterly winds and the existence of the ILS on 06L.

4. AIRCRAFT OPERATIONS

4.1 Existing Annual Operations

Table 1 below presents the total annual operations logged at NAS Agana for the period August 1991 through July 1992, broken down according to general classification of the aircraft type. This period was chosen as the existing base case, since VRC-50 started flying FCLP operations at Agana in August 1992. In addition, numerous typhoons between August and November, 1992, resulted in abnormally lower operations levels in the aftermath of the storms.

Table 1. Existing Aircraft Operations (8/91 - 7/92)

	Military		Civil		Total Operations
	Navy/ Marine Corps	Other Military	Air Carrier	General Aviation	
Annual	34,431	240	22,765	22,280	79,716
Daily	94.332	0.658	62.370	61.040	218.400

Therefore, it was decided that the last five months would not be representative of existing base case conditions. Hence, the period from August 1991 through July 1992 was chosen as the existing base year for contour development purposes.

4.2 Existing Daily Operations

HMMH determined that air carrier operations are the dominant noise contributor at NAS Agana. Because these operations are scheduled, they operate at a predictable level throughout the week. As a result, average busy day at Agana was assumed to be total annual operations divided by 365 days. This makes average busy day equivalent to average annual day.

To determine the number and type of "Navy/Marine Corps" military operations levels for the base year, HMMH obtained information from air traffic control (ATC) personnel and pilots from the S-3, P-3 and H-46 squadrons stationed at NAS Agana. The information from these sources

was analyzed in a step-by-step process to establish the breakdown of base case operations by aircraft and type of operation. Agana personnel also provided information for the "Other Military" aircraft and type of operation.

The base case operations levels for civil aircraft, "Air Carrier", consists of commercial jet and commuter turboprop aircraft. An August, 1992 commercial jet schedule, obtained from the Guam Airport Authority (GAA) was used to determine daily operations by commercial aircraft[1]. The GAA also provided information on the miscellaneous civil aircraft, "General Aviation".

Table 2 presents average daily operations for the existing base case, for all modelled aircraft at NAS Agana.

4.3 Future Daily Operations

Future Navy operations at NAS Agana includes the existing base case operations (Table 2) plus the arrival of VRC-50 aircraft that will operate out of Anderson Air Force Base, but conduct FCLP operations at NAS Agana. These operations began in August, 1992. Squadron personnel estimated operations levels for the S-3 and C-2 aircraft performing FCLP's at NAS Agana. Total daily operations (at NAS Agana) for the VRC-50 S-3 and C-2 aircraft are presented in Table 3. This is based upon squadron estimates of six-months of carrier qualifications and six-months of minimal or normal FCLP activity. This average daily level of activity will be added to the existing level of activity as presented in Table 2, resulting in the level of operations for the future case.

1 Guam Airport Authority, Monthly Flight Schedule, August, 1992.

Table 2. Existing Case Average Daily Operations, by Aircraft Type

Aircraft Category	Aircraft Type	Departures	Arrivals	T & G*	Total
NAVY/MARINE - BASED (Note: S-3 T&G Patterns includes FCLP Patterns)	P-3	1.710	1.710	46.842	50.262
	S-3	0.920	0.920	10.716	12.556
	H-46	1.424	1.424	19.234	22.082
	Sub-Total	4.054	4.054	76.792	84.900
NAVY/MARINE - TRANSIENT	C-130	2.358	2.358	0.000	4.716
	C-12	0.944	0.944	0.000	1.888
	H-1	0.236	0.236	0.000	0.472
	C-9	0.471	0.471	0.000	0.942
	S-3	0.471	0.471	0.000	0.942
	F-14	0.236	0.236	0.000	0.472
	Sub-Total	4.716	4.716	0.000	9.432
OTHER MILITARY	P-3	0.198	0.198	0.000	0.396
	C-130	0.131	0.131	0.000	0.262
	Sub-Total	0.329	0.329	0.000	0.658
AIR CARRIER/ COMMUTER	B747	3.128	3.152	0.000	6.280
	DC10/L1011	9.351	10.232	0.000	19.583
	B727	15.934	14.518	0.000	30.452
	DC8	0.360	0.334	0.000	0.694
	B737	0.612	0.569	0.000	1.181
	SD330	1.800	2.380	0.000	4.180
	Sub-Total	31.185	31.185	0.000	62.370
GENERAL AVIATION	C172	30.520	30.520	0.000	61.040
	Sub-Total	30.520	30.520	0.000	61.040
GRAND TOTAL		70.804	70.804	76.792	218.400

(*) T & G operations include one takeoff and one landing for each pattern flown. Divide the number shown by two to get the number of patterns.

Table 3. Future Case VRC-50 Average Daily Operations, by Aircraft Type

Aircraft Type	Departures	Arrivals	FCLP's	Total
S-3	1.225	1.225	14.696	17.146
C-2	1.027	1.027	12.329	14.383
GRAND TOTAL	2.252	2.252	27.025	31.529

4.4 Runway Use

4.4.1 Military

Runway utilizations for all aircraft types were obtained from the previous aircraft noise survey at Agana, but were updated by air traffic control personnel. They are presented in Table 4 for the P-3 aircraft. Runway use for H-46 helicopters, including the use of the H1 and H2 helicopter pad area, is shown in Table 5. (Helicopters operations from H1/H2 tend to depart to and arrive from the north or south and do not necessarily following a runway heading.) Runway use for the S-3 aircraft is presented in Table 6. Runway use for other military aircraft (modelled as C-130, C-12, F-14, and C-9) is presented in Table 7.

Table 4. Runway Use For P-3 Operations

Runway	Arrivals	Departures	T&G's
6L	72%	67%	21%
6R	24%	29%	75%
24R	2%	3%	3%
24L	2%	1%	1%
Total	100%	100%	100%

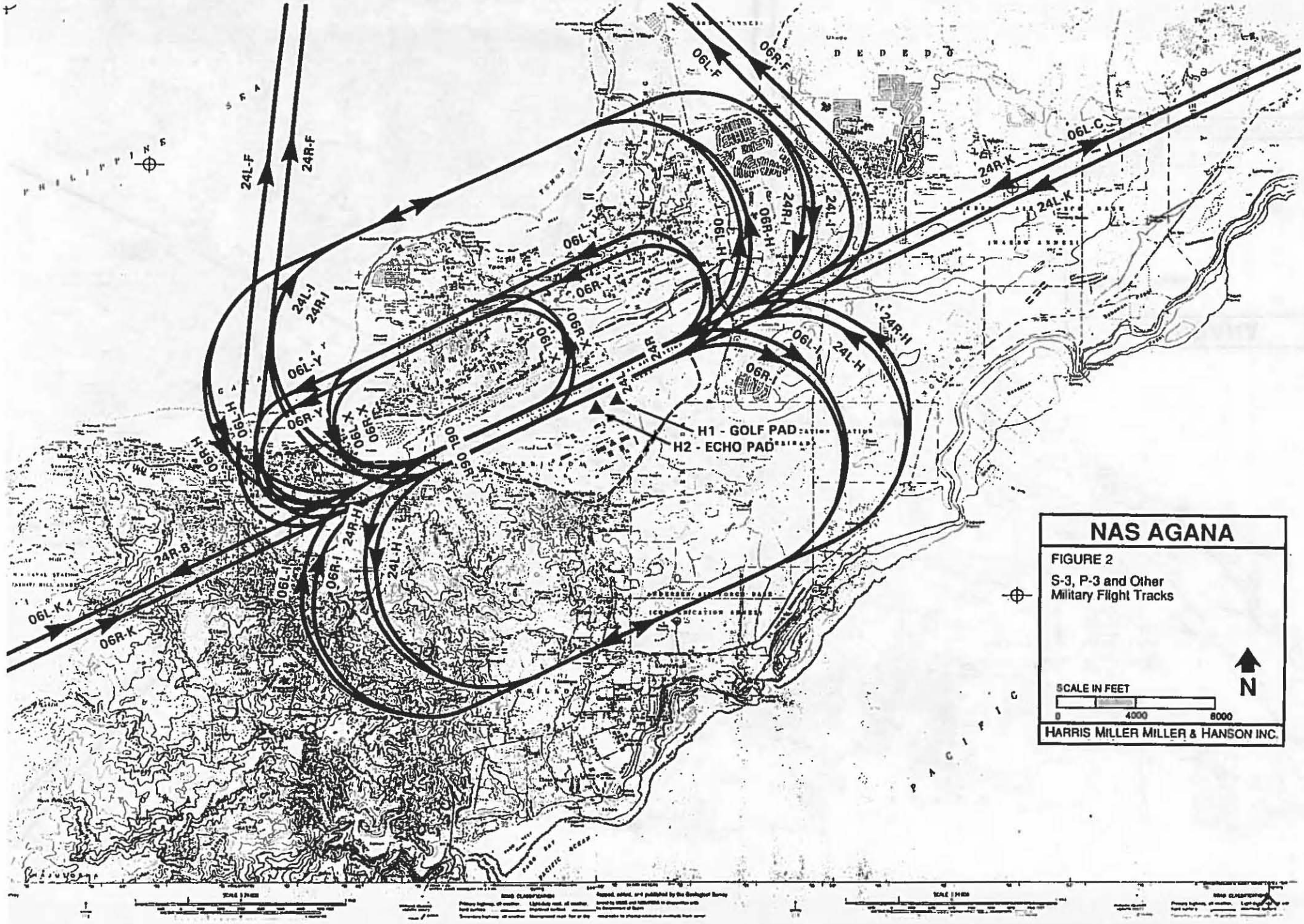
Table 5. Runway Use For H-46 Operations

Runway	Arrivals	Departures	T&G's
6L	0%	0%	10%
6R	50%	0%	80%
H1	10%	10%	0%
H2	40%	90%	10%
Total	100%	100%	100%

H1 - Golf 1 Helicopter Pad Area
H2 - Echo 2 Helicopter Pad Area

Table 6. Runway Use For S-3 Operations

Runway	Arrivals	Departures	T&G's/FCLP's
6L	54%	40%	20%
6R	40%	54%	80%
24R	3%	3%	0%
24L	3%	3%	0%
Total	100%	100%	100%


24L-F
24R-F
06L-F
06R-F
24L-I
24R-I
06L-I
06R-I
06L-Y
06R-Y
06L-X
06R-X
06L-H
06R-H
24L-H
24R-H
24L-K
24R-K
06L-K
06R-K
06L-C
24R-B
H1 - GOLF PAD
H2 - ECHO PAD
PACIFIC OCEAN
NAS AGANA
FIGURE 2
S-3, P-3 and Other
Military Flight Tracks
SCALE IN FEET
0
4000
8000
N
HARRIS MILLER MILLER & HANSON INC.

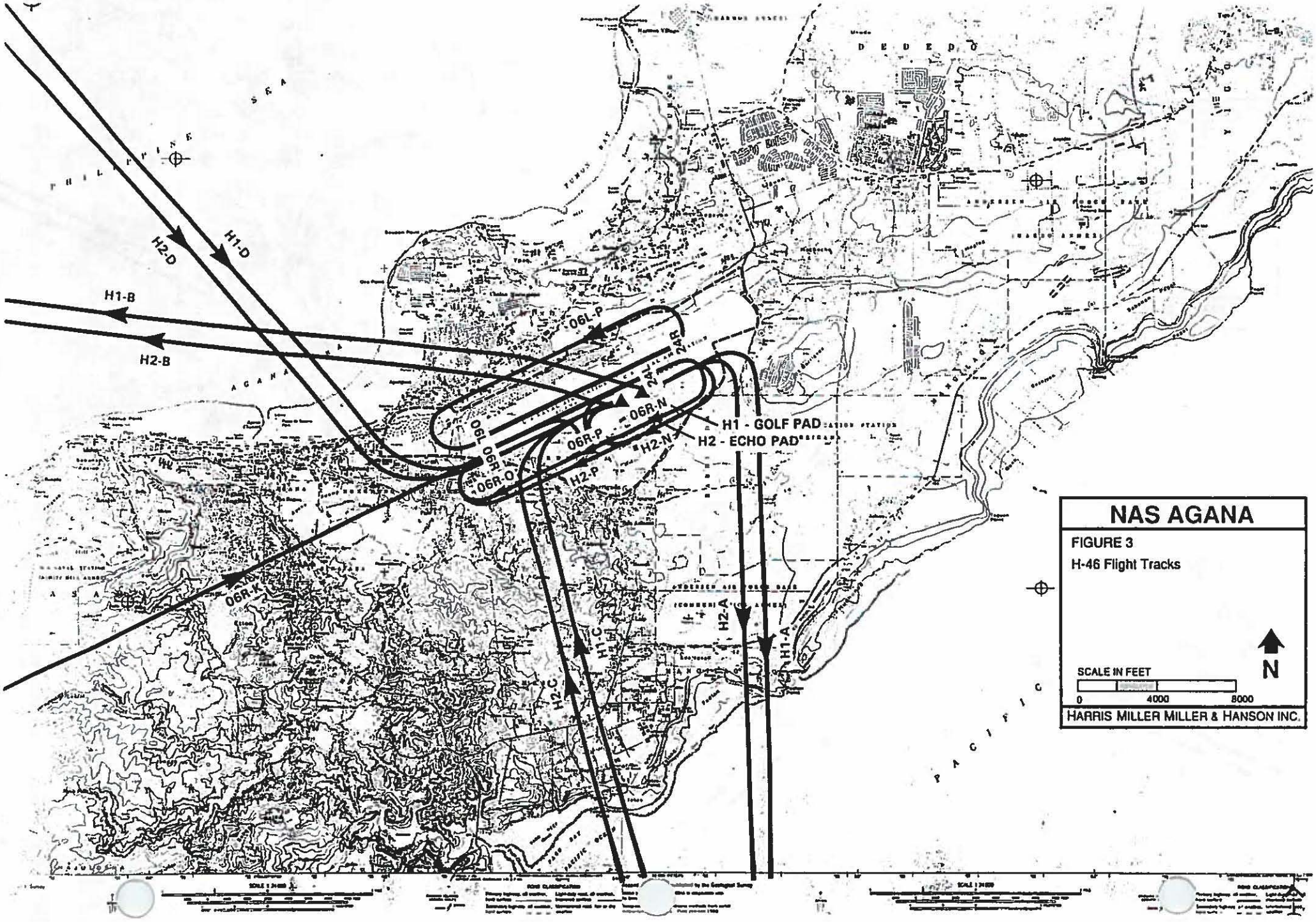

H1-D
H2-D
H1-B
H2-B
06L-P
06R-N
06R-P
06L-O
06R-O
H2-N
H2-P
06R-K
H1-C
H2-C
H2-A
H1-A
H1 - GOLF PAD
H2 - ECHO PAD
NAS AGANA
FIGURE 3
H-46 Flight Tracks
SCALE IN FEET
0
4000
8000
N
HARRIS MILLER MILLER & HANSON INC.

Table 7. Runway Use For Other Military Operations

Runway	Arrivals	Departures	T&G's
6L	97.3%	97.3%	0.0%
6R	0.0%	0.0%	0.0%
24R	2.7%	2.7%	0.0%
24L	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%

4.4.2 Air Carrier

For calculation of departure runway use for air carrier aircraft, normally wind rose data and estimates of duty runway percentages from daily tower logs would be used. However, the air carrier runway use from the previous noise study was used, with ATC tower personnel providing updates to the numbers. Table 8 presents these runway use estimates.

4.5 Flight Tracks & Flight Track Use

4.5.1 Military - Existing Case w/o VRC-50

Flight tracks and flight track use were determined by aircraft type from the flight tracks in the previous noise study. Pilots from the based S-3, P-3 and H-46 squadrons and discussions with ATC personnel and field observations confirmed that the tracks are still valid. Figure 2 presents the modelled flight tracks for S-3, P-3, and Other Military aircraft types. Figure 3 presents the modelled flight tracks for H-46 aircraft. Tables 9, 10, 11, 12, and 13 present the modelled operations by flight track for the based S-3, P-3, H-46 and other military aircraft, respectively. The modelled operations by flight track represent the data used as input to the NOISEMAP computer program.

Table 8. Runway Use For Air Carrier Operations

Aircraft	Daytime		Nighttime	
	6L	24R	6L	24R
Departures				
B747	100.0	0.0	68.5	31.5
DC10/L1011	98.4	1.6	81.2	18.8
DC8	100.0	0.0	90.0	10.0
B727/B737	91.2	8.8	87.8	12.2
Prop.	97.3	2.7	97.3	2.7
Arrivals				
All Aircraft	97.3	2.7	97.3	2.7

Table 9. S-3 Operations by Flight Track

Operation Type	Runway	Track	% Use By Runway	Day	Night	Total
Departures	06L	06L-F	100	0.361	0.007	0.368
	06R	06R-F	100	0.486	0.010	0.496
	24R	24R-F	100	0.027	0.001	0.028
	24L	24L-F	100	0.027	0.001	0.028
			Sub-Total	0.901	0.019	0.920
Arrivals	06L	06L-K	100	0.486	0.010	0.496
	06R	06R-K	100	0.361	0.007	0.368
	24R	24R-K	100	0.027	0.001	0.028
	24L	24L-K	100	0.027	0.001	0.028
			Sub-Total	0.901	0.019	0.920
Touch & Goes	06L	06L-H	80	1.392	0.028	1.420
		06L-I	20	0.348	0.007	0.355
	06R	06R-H	80	5.565	0.114	5.679
		06R-I	20	1.392	0.028	1.420
			Sub-Total	8.697	0.177	8.874
FCLP's	06L	06L-X	75	0.276	0.000	0.276
		06L-Y	25	0.092	0.000	0.092
	06R	06R-X	75	1.106	0.000	1.106
		06R-Y	25	0.369	0.000	0.369
			Sub-Total	1.842	0.000	1.842
TOTAL S-3 OPERATIONS				12.341	0.215	12.556

Table 10. P-3 Operations by Flight Track

Operation Type	Runway	Track	% Use By Runway	Day	Night	Total
Departures	06L	06L-F	100	1.123	0.023	1.146
	06R	06R-F	100	0.486	0.010	0.496
	24R	24R-F	100	0.050	0.001	0.051
	24L	24R-F	100	0.017	0.000	0.017
			Sub-Total	1.676	0.034	1.710
Arrivals	06L	06L-K	100	1.206	0.025	1.231
	06R	06R-K	100	0.403	0.008	0.411
	24R	24R-K	100	0.033	0.001	0.034
	24L	24L-K	100	0.033	0.001	0.034
			Sub-Total	1.675	0.035	1.710
Touch&Goes	06L	06L-H	80	7.712	0.157	7.869
		06L-I	20	1.928	0.039	1.967
	06R	06R-H	80	27.543	0.562	28.105
		06R-I	20	6.886	0.141	7.027
	24R	24R-H	80	1.102	0.022	1.124
		24R-I	20	0.275	0.006	0.281
	24L	24L-H	80	0.367	0.008	0.375
		24L-I	20	0.092	0.002	0.094
			Sub-Total	45.905	0.937	46.842
TOTAL P-3 OPERATIONS				49.256	1.006	50.262

Table 11. H-46 Operations by Flight Track

Operation Type	Runway/ Pad	Track	% Use By Runway	Day	Night	Total
Departures	H1	H1-A	20	0.027	0.001	0.028
		H1-B	80	0.112	0.002	0.114
	H2	H2-A	20	0.251	0.005	0.256
		H2-B	80	1.005	0.021	1.026
			Sub-Total	1.396	0.028	1.424
Arrivals	H1	H1-C	8	0.011	0.000	0.011
		H1-D	92	0.128	0.003	0.131
	06R	06R-K	100	0.698	0.014	0.712
	H2	H2-C	50	0.280	0.005	0.285
		H2-D	50	0.280	0.005	0.285
			Sub-Total	1.397	0.027	1.424
Touch&Goes	06R	06R-P	5	0.754	0.015	0.769
		06R-N	50	7.540	0.154	7.694
		06R-O	45	6.787	0.138	6.925
	06L	06L-P	100	1.885	0.038	1.923
	H2	H2-N	90	1.696	0.035	1.731
	H2	H2-P	10	0.188	0.004	0.192
			Sub-Total	18.850	0.384	19.234
TOTAL H-46 OPERATIONS				21.644	0.438	22.082

Table 12. Transient & Other Military Departure Operations by Flight Track

Operation Type	Runway	Track	% Use By Runway	Aircraft Type	Total Ops.		
					Day	Night	Total
Departures	06L	06L-C	100	P-3	0.189	0.004	0.193
				C-130	2.372	0.051	2.423
				C-12	0.900	0.018	0.918
				H-1	0.225	0.005	0.230
				S-3	0.449	0.009	0.458
				C-9	0.449	0.009	0.458
				F-14	0.225	0.005	0.230
	24R	24R-B	100	P-3	0.005	0.000	0.005
				C-130	0.066	0.002	0.068
				C-12	0.025	0.001	0.026
				H-1	0.006	0.000	0.006
				S-3	0.012	0.000	0.012
				C-9	0.012	0.000	0.012
				F-14	0.006	0.000	0.006
TOTAL TRANSIENT & OTHER MILITARY DEPARTURE OPERATIONS					4.941	0.104	5.045

Table 13. Transient & Other Military Arrival Operations by Flight Track

Operation Type	Runway	Track	% Use By Runway	Aircraft Type	Total Ops.		
					Day	Night	Total
Arrivals	06L	06L-K	100	P-3	0.189	0.004	0.193
				C-130	2.372	0.051	2.423
				C-12	0.900	0.018	0.918
				H-1	0.225	0.005	0.230
				S-3	0.449	0.009	0.458
				C-9	0.449	0.009	0.458
				F-14	0.225	0.005	0.230
	24R	24R-K	100	P-3	0.005	0.000	0.005
				C-130	0.066	0.002	0.068
				C-12	0.025	0.001	0.026
				H-1	0.006	0.000	0.006
				S-3	0.012	0.000	0.012
				C-9	0.012	0.000	0.012
				F-14	0.006	0.000	0.006
TOTAL TRANSIENT & OTHER MILITARY ARRIVAL OPERATIONS					4.941	0.104	5.045

4.5.2 Air Carrier & General Aviation

Air carrier jet flight tracks were determined by aircraft type from the flight tracks in the previous noise study. ATC personnel confirmed that the tracks are still valid. In addition, HMMH used initial heading information for all destinations of commercial jet aircraft departing from Guam in determining departure flight tracks.

Arrival air carrier jet flight track use is based on the previous noise study and on discussions with ATC personnel, point of origin of arriving aircraft and field observations.

All commuter turboprop aircraft and single-engine piston general aviation aircraft were modelled as departing straight out and arriving straight in.

Figure 4 presents the modelled flight tracks for air carrier and general aviation aircraft. Tables 14, 15, and 16 present the modelled operations by flight track.

4.5.3 Military - Future Case VRC-50 Only

Tables 17 and 18 present the modelled operations by flight track for the VRC-50 S-3 and C-2 aircraft. The modelled operations by flight track represent the data used as input to the NOISEMAP computer program.

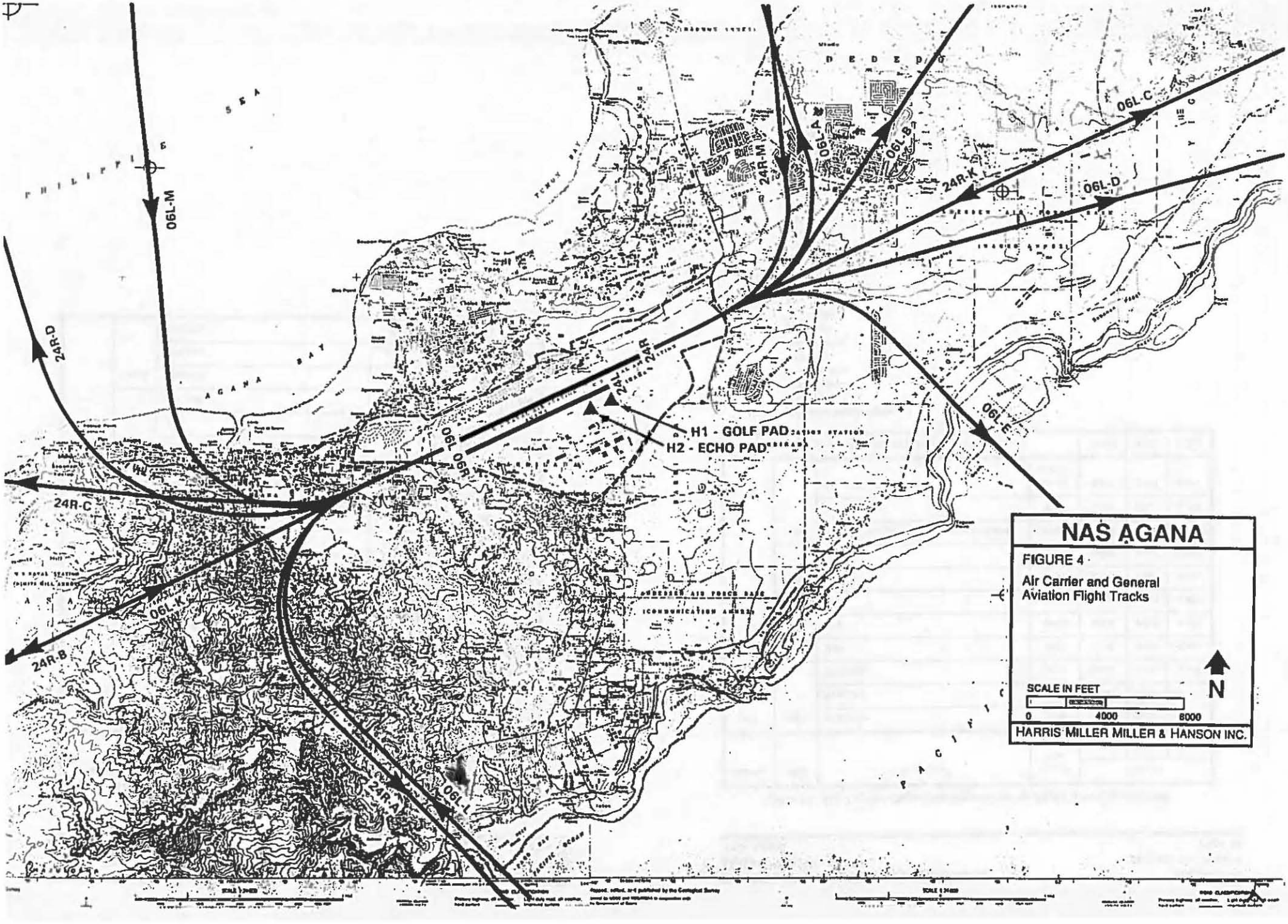

06L-M
24R-D
24R-C
06L-K
24R-B
24R-A
06L-L
24R-M
06L-A
06L-B
06L-C
24R-K
06L-D
06L-E
06L 06R
24L 24R
H1 - GOLF PAD
H2 - ECHO PAD
NAS AGANA
FIGURE 4
Air Carrier and General Aviation Flight Tracks
SCALE IN FEET
0
4000
8000
N
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Table 14. Air Carrier Departure Operations by Flight Track

Runway	Track	Destinations*	Aircraft Type	Total Ops.		
				Day	Night	Total
06L	06L-A	SDJ,NGO,OKA,YAP,FUK,SEL,TPE	B727	6.101	0.443	6.544
		MNL	B737	0.164	0.000	0.164
		NRT,OSA	B747	1.079	0.961	2.040
		MNL	DC8	0.360	0.000	0.360
		NRT,MNL,NGO,CTS,HKG	DC10/ L1011	3.505	1.343	4.848
	06L-B	SPN,ROR,ROP	B727	5.969	0.789	6.758
		SPN	B747	0.000	0.246	0.246
		SPN	DC10	1.027	0.642	1.669
	06L-C	HNL	B747	0.144	0.000	0.144
		HNL	DC10	0.619	0.000	0.619
		ROP,SPN	SD330	0.753	0.123	0.876
	06L-D	HNL	B747	0.143	0.000	0.143
		HNL	DC10	0.619	0.000	0.619
		ROP,SPN	SD330	0.753	0.123	0.876
	06L-E	TKK,POM	B727	1.017	0.158	1.175
		TKK,KSA	B737	0.132	0.253	0.385
		SYD,DPS	DC10	0.566	0.380	0.946

Table 14. Air Carrier Departure Operations by Flight Track (continued)

Runway	Track	Destinations*	Aircraft Type	Total Ops.		
				Day	Night	Total
24R	24R-A	TKK,POM	B727	0.098	0.022	0.120
		TKK,KSA	B737	0.012	0.035	0.047
		SYD,HNL	DC10	0.020	0.088	0.108
	24R-B	YAP	B727	0.041	0.000	0.041
		DPS	DC10	0.009	0.000	0.009
		SPN	SD330	0.041	0.007	0.048
	24R-C	MNL	B737	0.016	0.000	0.016
		MNL	DC10	0.004	0.068	0.072
	24R-D	SDJ,NGO,ROP,SEL,SPN,OKA,TPE,FUK,ROR	B727	1.125	0.171	1.296
		NRT,OSA,SPN	B747	0.000	0.555	0.555
		NRT,NGO,SPN,HKG,CTS	DC10/ L1011	0.070	0.391	0.461
TOTAL AIR CARRIER DEPARTURE OPERATIONS				24.387	0.798	31.185

(*) Air Carrier Origins/Destinations
SDJ - Sendai
NGO - Nagoya
OKA - Okinawa
YAP - Yap
FUK - Fukuoka
SEL - Seoul
TPE - Taipei
MNL - Manila
NRT - Narita (Tokyo)
OSA - Osaka
CTS - Sapporo
HKG - Hong Kong
SPN - Saipan
ROR - Koror
ROP - Rota
HNL - Honolulu
TKK - Chuuk
POM - Port Moresby
KSA - Kosrae
SYD - Sydney
DPS - Bali

Table 15. Air Carrier Arrival Operations by Flight Track

Runway	Track	Origins*	Aircraft Type	Total Ops.		
				Day	Night	Total
06L	06L-K	MNL,YAP	B727	0.717	0.000	0.717
		MNL	B737	0.000	0.261	0.261
		MNL	DC8	0.163	0.000	0.163
		MNL,DPS	DC10	0.555	0.751	1.306
	06L-L	TKK,POM	B727	0.751	0.456	1.207
		TKK,KSA	B737	0.294	0.000	0.294
		SYD	DC10	0.000	0.424	0.424
	06L-M	TPE,OKA,FUK,SEL,NGO,ROR,SPN	B727	7.864	4.339	12.203
		SPN,NRT,OSA,HNL	B747	1.436	1.631	3.067
		HNL	DC8	0.000	0.163	0.163
		HNL,FUK,SEL,NGO,NRT,SPN,HKG,CTS,NRT	DC10/ L1011	5.874	2.381	8.255
		ROP,SPN	SD330	2.316	0.000	2.316
24R	24R-K	TKK,POM	B727	0.021	0.012	0.033
		TKK,KSA	B737	0.007	0.000	0.007
		HNL	B747	0.009	0.000	0.009
		HNL	DC8	0.000	0.004	0.004
		HNL,SYD	DC10	0.020	0.024	0.044
	24R-M	MNL,YAP,TPE,OKA,FUK,SEL,NGO,ROR	B727	0.237	0.121	0.358
		MNL	B737	0.000	0.007	0.007
		SPN,NRT,OSA	B747	0.031	0.045	0.076
		MNL	DC8	0.004	0.000	0.004
		MNL,DPS,FUK,SEL,NGO,NRT,SPN,HKG,NRT	DC10/ L1011	0.129	0.074	0.203
		ROP,SPN	SD330	0.064	0.000	0.064
TOTAL AIR CARRIER ARRIVAL OPERATIONS				20.492	10.693	31.185

Table 16. General Aviation Operations by Flight Track

Operation Type	Runway	Track	% Use By Runway	Day	Night	Total
Departures	06L	06L-C	100	29.696	0.000	29.696
	24R	24R-B	100	0.824	0.000	0.824
			Total	30.520	0.000	30.520
Arrivals	06L	06L-K	100	29.696	0.000	29.646
	24R	24R-K	100	0.824	0.000	0.824
			Total	30.520	0.000	30.520
TOTAL GENERAL AVIATION OPERATIONS				61.040	0.000	61.040

Table 17. VRC-50 S-3 FCLP Operations at NAS Agana

Operation Type	Runway	Track	% Use By Runway	Day	Night	Total
Departures	06L	06L-F	100	0.698	0.000	0.698
	06R	06R-F	100	0.527	0.000	0.527
			Total	1.225	0.000	1.225
Arrivals	06L	06L-K	100	0.698	0.000	0.698
	06R	06R-K	100	0.527	0.000	0.527
			Total	1.225	0.000	1.225
FCLP's	06L	06L-X	75	6.284	0.000	6.284
	06L	06L-Y	25	2.094	0.000	2.094
	06R	06R-X	75	4.739	0.000	4.739
	06R	06R-Y	25	1.579	0.000	1.579
			Total	14.696	0.000	14.696
TOTAL VRC-50 S-3 FCLP OPERATIONS				17.146	0.000	17.146

Table 18. VRC-50 C-2 FCLP Operations at NAS Agana

Operation Type	Runway	Track	% Use By Runway	Day	Night	Total
Departures	06L	06L-F	100	0.585	0.000	0.585
	06R	06R-F	100	0.442	0.000	0.442
			Total	1.027	0.000	1.027
Arrivals	06L	06L-K	100	0.585	0.000	0.585
	06R	06R-K	100	0.442	0.000	0.442
			Total	1.027	0.000	1.027
FCLP's	06L	06L-X	75	5.271	0.000	5.271
	06L	06L-Y	25	1.757	0.000	1.757
	06R	06R-X	75	3.976	0.000	3.976
	06R	06R-Y	25	1.325	0.000	1.325
			Total	12.329	0.000	12.329
TOTAL VRC-50 C-2 FCLP OPERATIONS				14.383	0.000	14.383

4.6 Aircraft Performance Characteristics and Runups

Aircraft performance characteristics for military aircraft, namely power settings, speeds and altitude profiles, were based on the previous noise study and were obtained from pilots stationed at NAS Agana. The S-3 and C-2 noise and performance profiles are based primarily on data originally developed for NAF El Centro, CA. Aircraft performance characteristics for the VRC-50 aircraft undertaking FCLP operations at Agana were collected specifically for this study and were based on pilot interviews. These characteristics are important because they affect the noise levels produced by an aircraft. Because of low numbers of operations, measured noise data for individual military aircraft events was not an adequate statistical base for analysis and verification of performance characteristics provided by pilots.

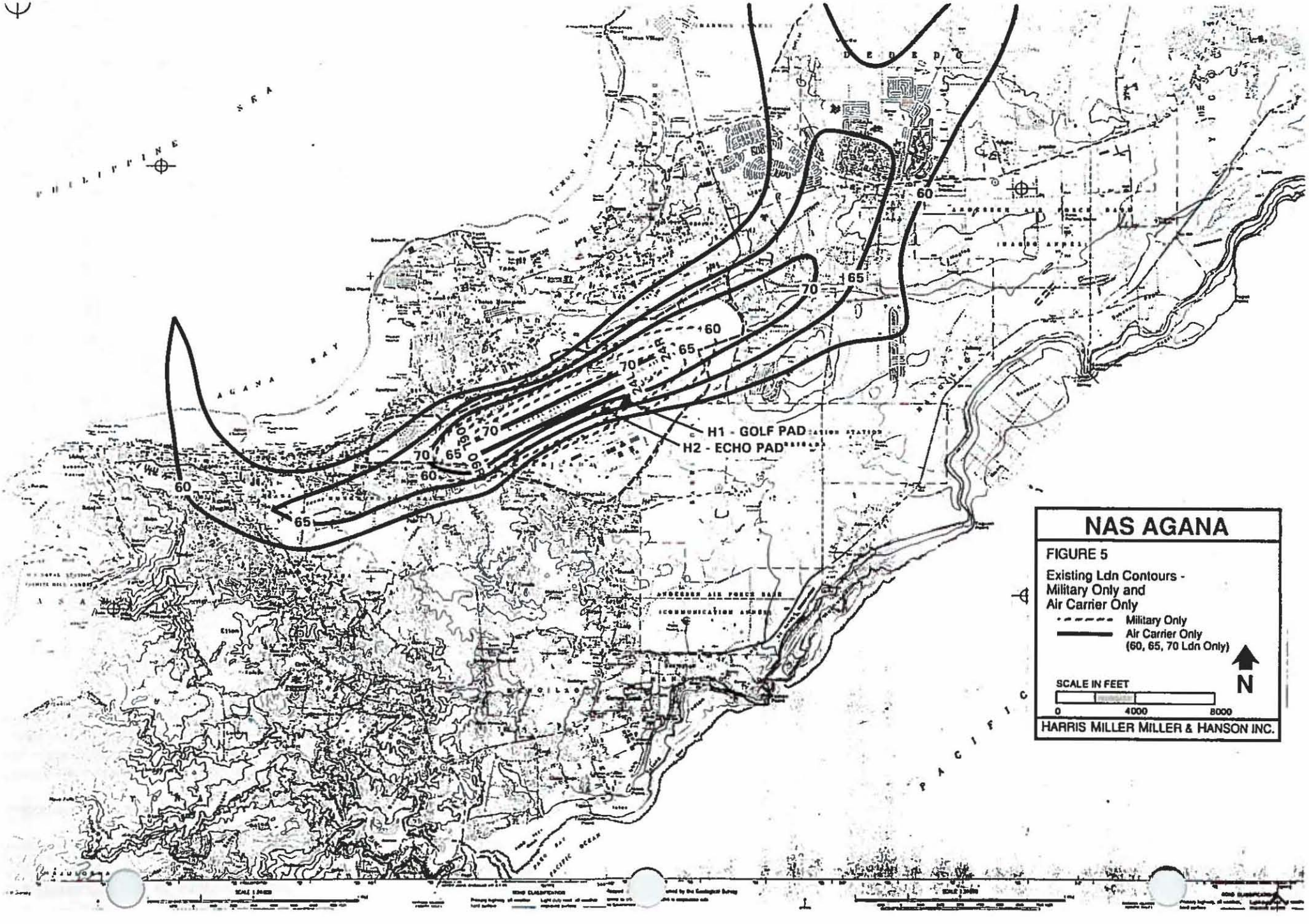
The P-3 noise and performance profiles are based primarily on data originally developed for NAS Brunswick, ME. Noise levels predicted from those same modelling assumptions have been observed to match well with data collected subsequently at NALF Crows Landing, CA and NAS Barbers Point, HA. Similarly, noise and performance data for the H-46 were primarily derived from a noise study at OLF Imperial Beach, CA.

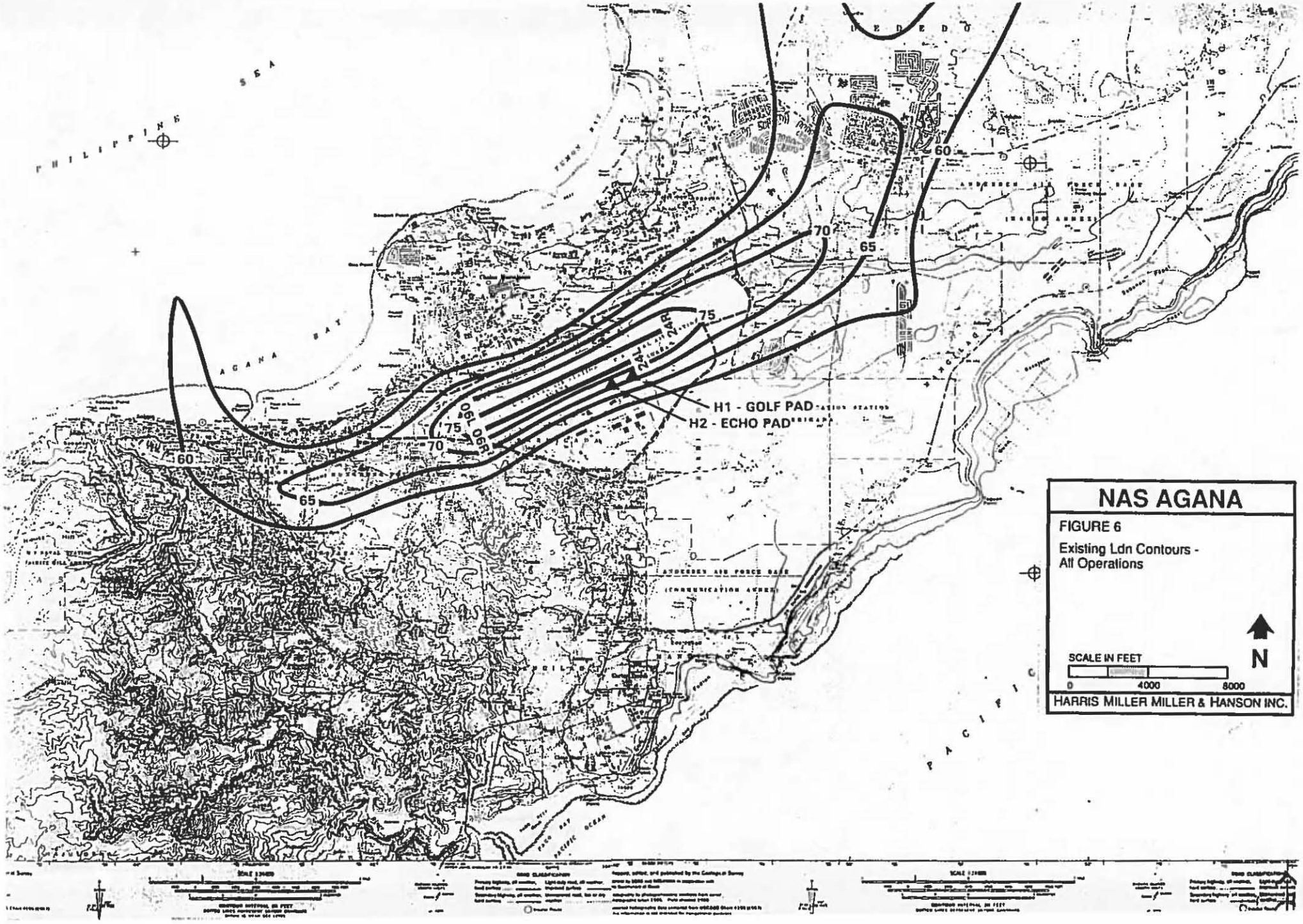
Base personnel indicated that no high power turns (runups) are currently conducted by military or civil aircraft at NAS Agana, so noise and performance data for this type of activity was not needed.

For air carrier aircraft, the Integrated Noise Model database V.10 was used as the source of all noise and performance data. As discussed in Section 2, INM database V.10 represents the most current civil fleet noise database.

5. EXISTING CASE L_{dn} NOISE CONTOURS

Figure 5 presents the updated computer-generated L_{dn} contours developed for military operations only and air carrier operations only. These contours were based on the existing base case annual average daily operations and related data discussed in the preceding sections. Figure 6 presents the existing L_{dn} contours for all operations, i.e. military and air carrier combined.

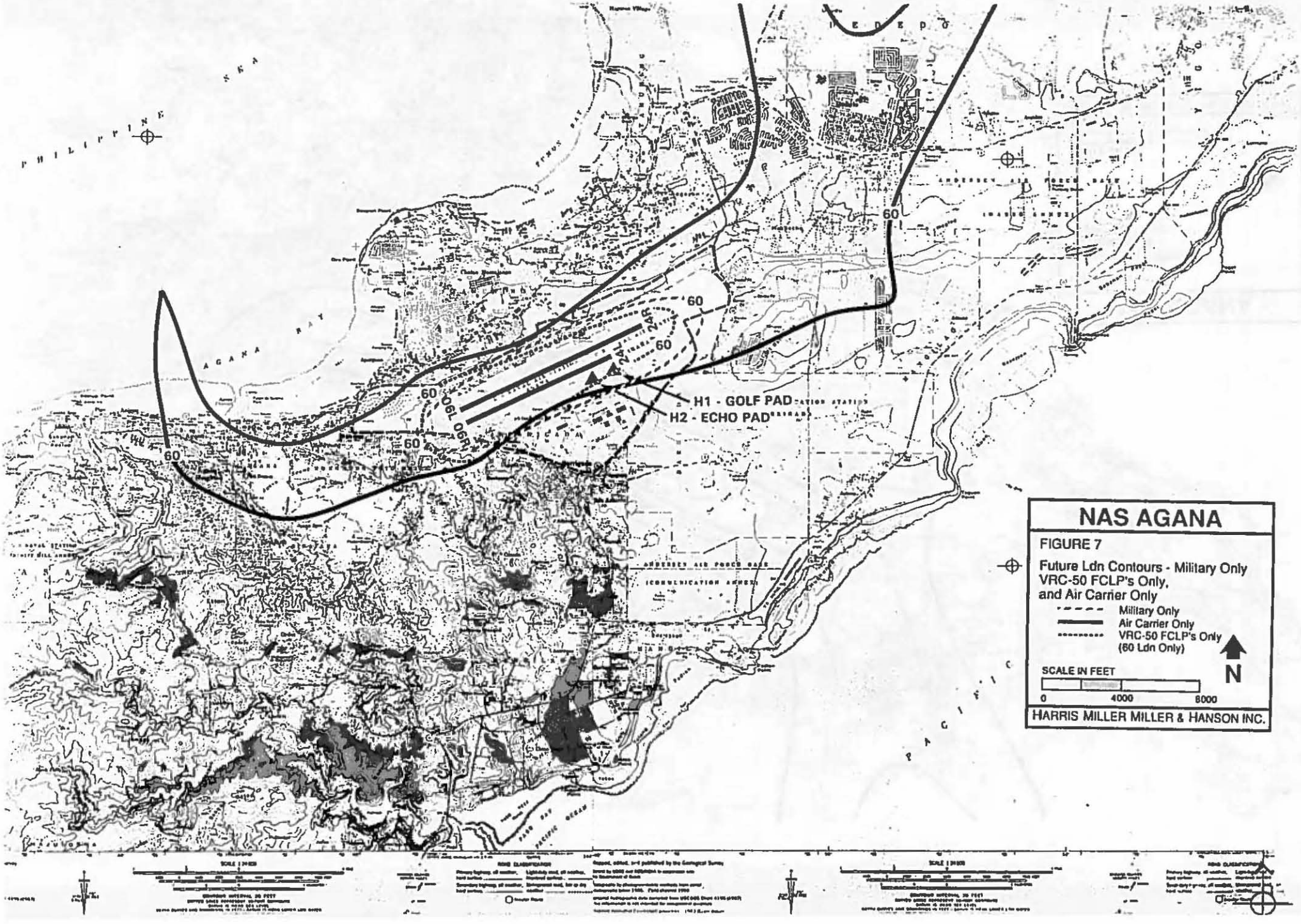

PHILIPPINE SEA
AGANA BAY
PACIFIC OCEAN
60
65
70
H1 - GOLF PAD
H2 - ECHO PAD
NAS AGANA
FIGURE 5
Existing Ldn Contours -
Military Only and
Air Carrier Only
Military Only
Air Carrier Only
(60, 65, 70 Ldn Only)
N
SCALE IN FEET
0
4000
8000
HARRIS MILLER MILLER & HANSON INC.

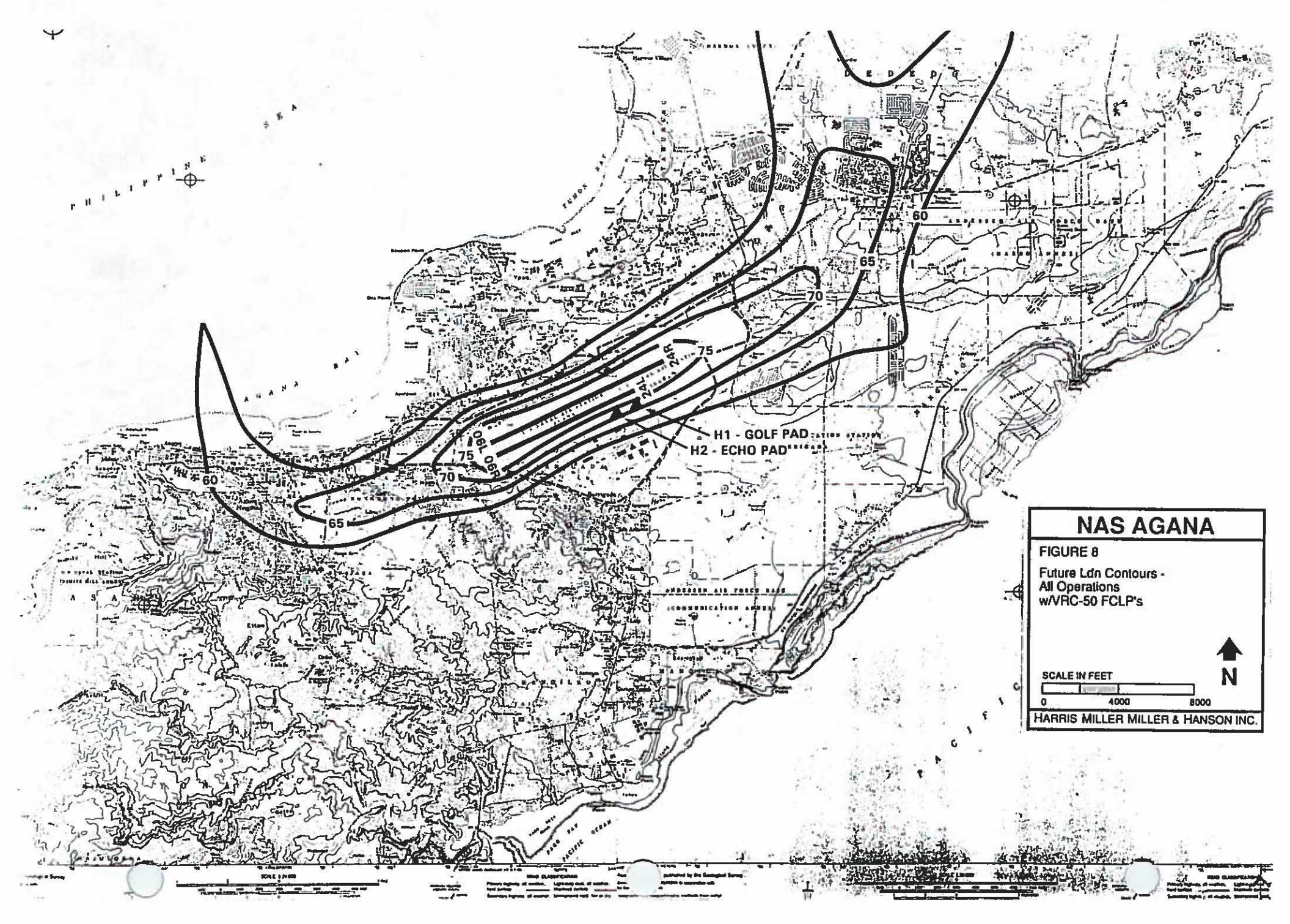

PHILIPPINE SEA
AGANA BAY
PACIFIC OCEAN
60
65
70
75
H1 - GOLF PAD
H2 - ECHO PAD
NAS AGANA
FIGURE 6
Existing Ldn Contours -
All Operations
N
SCALE IN FEET
0
4000
8000
HARRIS MILLER MILLER & HANSON INC.

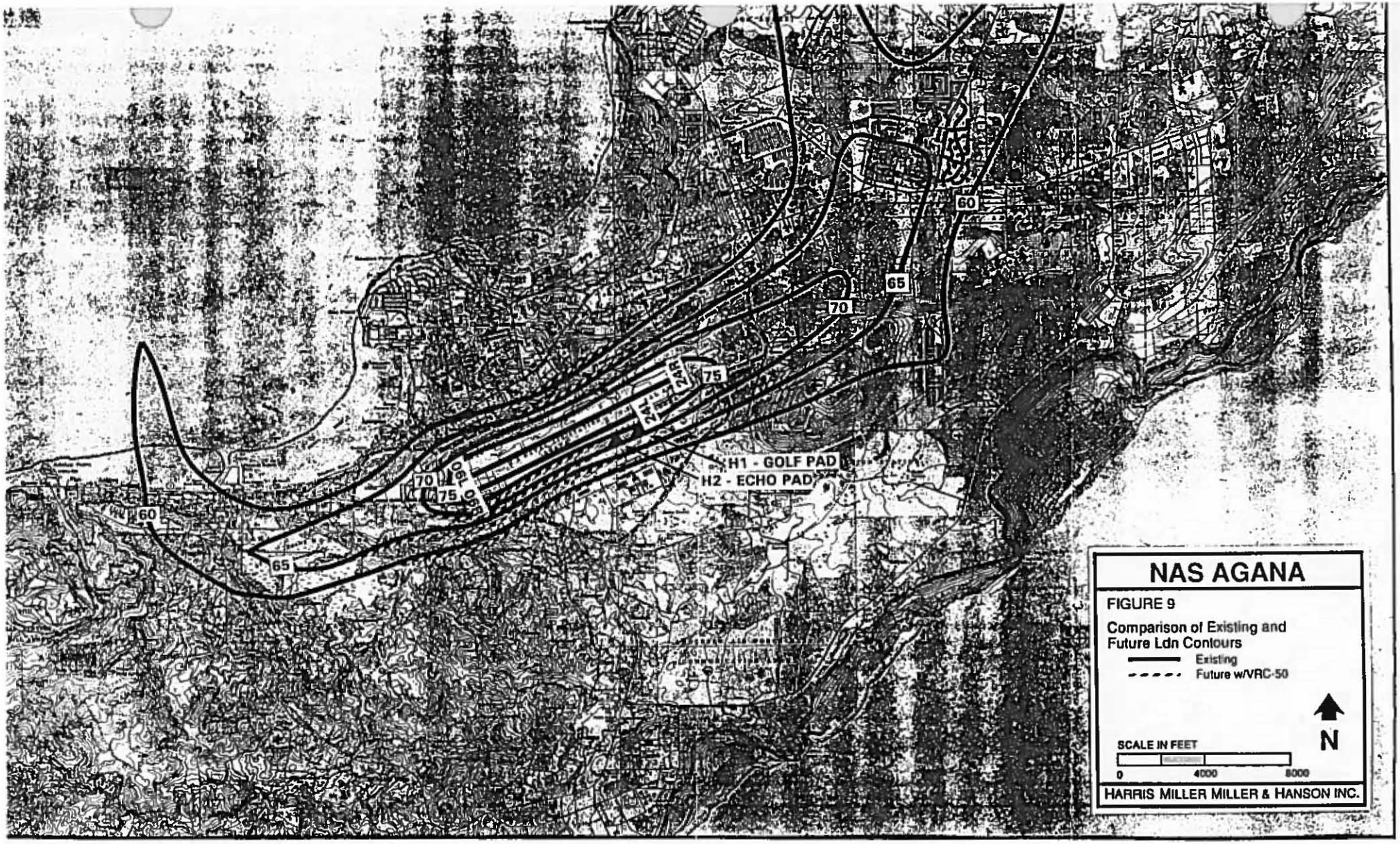
6. FUTURE CASE L_{dn} NOISE CONTOURS

The resulting future L_{dn} contours for Military Only (without VRC-50 operations), VRC-50 FCLP's Only, and Air Carrier Only are shown in Figure 7. The future All Operations (military w/ FCLP and air carrier combined) L_{dn} contours are presented in Figure 8. Figure 9 compares the L_{dn} contours for the existing base case and the future case with VRC-50 FCLP operations.

A review of Figure 7 reveals that the air carrier operations would still dominate the noise environment at NAS Agana, even with the addition of VRC-50 FCLP operations. In fact, the FCLP operations of VRC-50 are comparable to all other military operations at Agana. Figure 9, which compares the existing and future contours, reveals that the VRC-50 FCLP operations would cause an insignificant increase (less than 1.5 dB) in the noise environment at Agana. This increase is confined to the area immediately adjacent to the base and results from the small range of the VRC-50 FCLP pattern tracks.


PHILIPPINE SEA
AGANA BAY
PACIFIC OCEAN
60
60
60
60
60
60
NAVAL NAR
H1 - GOLF PAD
H2 - ECHO PAD
ANDERSEN AIR FORCE BASE
NAS AGANA
FIGURE 7
Future Ldn Contours - Military Only
VRC-50 FCLP's Only,
and Air Carrier Only
Military Only
Air Carrier Only
VRC-50 FCLP's Only
(60 Ldn Only)
N
SCALE IN FEET
0
4000
8000
HARRIS MILLER MILLER & HANSON INC.


60
65
70
75
75
70
60
65
24L
24R
H1 - GOLF PAD
H2 - ECHO PAD
NAS AGANA
FIGURE 8
Future Ldn Contours -
All Operations
w/VRC-50 FCLP's
SCALE IN FEET
0
4000
8000
N
HARRIS MILLER MILLER & HANSON INC.


60
65
70
75
H1 - GOLF PAD
H2 - ECHO PAD
NAS AGANA
FIGURE 9
Comparison of Existing and Future Ldn Contours
Existing
Future w/VRC-50
N
SCALE IN FEET
0
4000
8000
HARRIS MILLER MILLER & HANSON INC.

Appendix L

Guam Coastal Zone Management Assessment

BUREAU OF PLANNING
Setbision Mamplaneha
GOVERNMENT OF GUAM
AGANA, GUAM 96910

JUL 09 1993

Mr. Stanley Uehara
Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96806-7300

Hafa Adai Mr. Uehara:

I appreciate receiving such a prompt response from you in reference to our concerns on NAPRA facilities proposed for NAS Agana.

We are somewhat at a loss as to how the federal consistency review should proceed based on the inclusion of NAS on the Base Realignment and Closure (BRAC) Commission list. While the list must still be approved by the President and by Congress, it is highly likely that the NAPRA facility will have to be relocated elsewhere as it appears to be in conflict with the purpose of the closure.

However, based on your response to our concerns, we are granting a positive determination for consistency with the Guam Coastal Management Program for all of the activities proposed for relocation from Subic Bay to Guam. While it would seem beyond our ability or right to determine consistency for an activity which now conflicts with and/or contradicts the stated, official position of a Commission appointed by and on behalf of Congress, we are doing so with the understanding that NAPRA facilities will be relocated away from NAS within the time frames for relocation/closure determined by Congress.

Si Yu'os Ma'ase',

CARMELITA C. BLAS
Acting Director

Commonwealth Now!

GUAM COASTAL MANAGEMENT PROGRAM
ASSESSMENT FORMAT

DATE OF APPLICATION: March 5, 1993

NAME OF APPLICANT: U.S. Navy—Pacific Division Facilities Engineering Command

ADDRESS: Pearl Harbor, Hawaii 96860-7300

TELEPHONE NO.: Mr. Stan Uehara, Code 232 (808) 471-9338

TITLE OF PROPOSED PROJECT: Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines

COMPLETE FOLLOWING PAGES

FOR BUREAU OF PLANNING ONLY:

DATE APPLICATION RECEIVED: _____

OCRM NOTIFIED: _____ **LIC. AGENCY NOTIFIED:** _____

APPLICANT NOTIFIED: _____ **PUBLIC NOTICE GIVEN:** _____

OTHER AGENCY REVIEW REQUESTED: _____

_____

_____

DETERMINATION: ( ) **CONSISTENT** ( ) **NON-CONSISTENT** ( ) **FURTHER INFORMATION REQUESTED**

OCRM NOTIFIED: _____ **LIC. AGENCY NOTIFIED:** _____

APPLICANT NOTIFIED: _____

ACTION LOG: 1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

DATE REVIEW COMPLETED: _____

GUAM COASTAL MANAGEMENT PROGRAM
ASSESSMENT FORMAT

DEVELOPMENT POLICIES (DP):

1. Shore Area Development

Intent: To insure environment and aesthetic compatibility of shore area land uses.

Policy: Only those uses shall be located within the Seashore Reserve which:

— enhance, are compatible with or do not generally detract from the surrounding coastal area's aesthetic and environmental quality and beach accessibility; or

— can demonstrate dependence on such a location and the lack of feasible alternative sites.

Discussion: **No significant impacts to Guam's shore areas are anticipated as a result of the proposed actions. The only developments occurring close to the shore area will be within the Apra Harbor Complex, an area that has been previously developed and heavily disturbed. The proposed development in this area is compatible with the existing land uses and is dependent on this location as the new facilities will serve support functions for Apra Harbor's military operations.**

2. Urban Development

Intent: To cluster high impact uses such that coherent community design, function, infrastructure support, and environmental compatibility are assured.

Policy: Commercial, multi-family, industrial, and resort-hotel zones and uses requiring high levels of support facilities shall be concentrated within urban districts as outlined on the Land Use Districting Map.

Discussion: **Proposed developments are consistent with land use zones within the respective bases. Andersen Air Force Base will receive only one new building which will be located in the northern portion of the airfield next to existing buildings. All development within Apra Harbor will occur within the presently developed Complex area. New housing around Apra Harbor will be located adjacent to the existing family housing area. Two missile magazines and one inert storehouse are scheduled for construction at Naval Magazine, all of which will be placed along existing roadways near existing facilities.**

3. **Rural Development**

Intent: To provide a development pattern compatible with environmental and infrastructure support suitability and which can permit traditional lifestyle patterns to continue to the extent practicable.

Policy: Rural districts shall be designated in which only low density residential and agricultural uses will be acceptable. Minimum lot size for these uses should be one-half acre until adequate infrastructure including functional sewering is provided.

Discussion: **New operations and facilities will be confined to the military bases on Guam. No development associated with this project will occur in rural or agricultural areas, and any effects to these areas resulting from the proposed projects will be negligible.**

4. **Major Facility Siting**

Intent: To include the national interest in analyzing the siting proposals for major utilities, fuel, and transport facilities.

Policy: In evaluating the consistency of proposed major facilities with the goals, policies, and standards of the Comprehensive Development and Coastal Management Plans, the Territory shall recognize the national interest in the siting of such facilities including those associated with electric power production and transmission, petroleum refining and transmission, port and air installations, solid waste disposal, sewage treatment, and major reservoir sites.

Discussion: **The overall interests of Guam were taken into consideration in the siting of major facilities associated with the proposed actions, and the number of new major facilities was kept to minimum. Existing major facilities in the Apra Harbor Complex will be expanded to accomodate the relocation. Increased power generation will be achieved through an expansion of the existing Orote Power Plant along with the installation of power substations, power mounds, and primary and secondary electrical lines. Modifications will be made to the existing Apra Harbor Sewage Treatment Plant, as well as to the existing sewage pumping and collection system, to allow for increased capacity due to the new facilities and operations on the base.**

5. **Hazardous Areas**

Intent: Development in hazardous area will be governed by the degree of hazard and the land use regulations.

Policy: Identified hazardous lands, including floodplains, erosion-prone areas, air installations, crash and sound zones and major fault lines shall be developed only to the extent that such development does not pose unreasonable risks to the health, safety, or welfare of the people of Guam, and complies with the land use regulations.

Discussion: **All land use regulations with regard to hazardous areas were applied to the proposed developments. In terms of natural hazards, no development associated with the proposed actions will take place within a floodplain, tsunami inundation zone, or erosion-prone area. Naval Magazine is located near a fault line, but construction and the configuration of munitions will be carried out to minimize the potential for damage. Concerning man-made hazards, no new facilities will be built within the existing Surface Danger Zones, Accident Potential Zones, or Electromagnetic Radiation Zones, and no new operations will require modification of their current respective boundaries. With the exception of Naval Magazine, Explosive Safety Quantity Distance Arcs (ESQD) will remain intact at all of Guam's military bases, and no new facilities or operations will be impacted by them. The new missile magazines and inert storehouse at Naval Magazine will be constructed within the existing ESQD Arcs and will require a slight expansion of the arcs to the northwestern portion of the base, well within the base boundaries. Because they are confined to the military bases, proposed developments will pose no risk to the health, safety, and welfare of the people of Guam. (EIS Chapter 4.12—Natural and Man-made Hazards)**

6. Housing

Intent: To promote efficient community design placed where the resources can support it.

Policy: The government shall encourage efficient design of residential areas, restrict such development in areas highly susceptible to natural and man-made hazards, and recognize the limitations of the island's resources to support historical patterns of residential development.

Discussion: **Recognizing the current conditions of the Guam housing market, the Navy proposes to construct 300 family housing units in the Apra Harbor Complex. The units will be clustered in two developments on either side of the existing Tipalao Family Housing. This residential area is situated safely away from all natural and man-made hazards and features the necessary infrastructure elements to support the additional units. Housing improvements at Andersen Air Force Base consist of interior renovations to the existing Bachelor Officers' Quarters (BOQ) and Staff Non-Commissioned Officers' Quarters (SNCOQ).**

7. Transportation

Intent: To provide transportation systems while protecting potentially impacted resources.

Policy: The Territory shall develop an efficient and safe transportation system, while limiting adverse environmental impacts on primary aquifers, beaches, estuaries, and other coastal resources.

Discussion: **Because the majority of the new facilities and personnel relocated to Guam are based in the Apra Harbor Complex, this area will feel the greatest strain on its transportation facilities. The other bases on the island will experience no major impacts to their transportation capabilities. Due to the increased vehicle trips and traffic congestion, the Navy will consider improvements to two major intersections within the Apra Harbor Complex. The improvements will also boost the efficiency of the transportation system. No new roads or transportation systems are proposed for development.**

8. Erosion and Siltation

Intent: To control development where erosion and siltation damage is likely to occur.

Policy: Development shall be limited in areas of 15% or greater slope by requiring strict compliance with erosion, sedimentation, and land use districting guidelines, as well as other related land use standards for such areas.

Discussion: **All land use districting guidelines and standards with regards to erosion and sedimentation were considered in siting of the new facilities. Most of the proposed development will occur in areas which have been previously developed and therefore pose little threat to cause erosion and siltation. Andersen Air Force Base will require limited grading for its new facilities to the north of the main airfield, but this area is relatively flat, well-drained, and free from runoff and erosion problems. New facilities around the Apra Harbor Complex area will be developed in high density, built-up areas with the necessary drainage capabilities. The new housing units may pose a problem due to the grading required for construction, but the slopes in the area are generally flat enough to keep runoff at a minimum, and mitigation measures will be implemented to avoid adverse effects. Conscientious construction practices will be employed to reduce site erosion and sedimentation.**

RESOURCES POLICIES (RP)

1. Air Quality

Intent: To control activities to insure good air quality.

Policy: All activities and uses shall comply with all local air pollution regulations and all appropriate Federal air quality standards in order to ensure the maintenance of Guam's relatively high air quality.

Discussion: **Emissions generated by the VRC-50 squadron, with the exception of carbon monoxide, will be less than the significant emission rates determined by the EPA for stationary sources. Despite the higher rates of carbon monoxide, these emissions will be dispersed over a large area and substantially diluted. Exceedance of ambient air quality standards will not occur.**

Emissions from the expansion of the Orote Power Plant appear capable of complying with the National Ambient Air Quality Standards as well as the Guam Air Quality Standards. According to emissions analyses, "de minimus" levels will be exceeded. The proposed expansion constitutes a "major source" within an attainment area, thus requiring one year of pre-construction continuous air monitoring and a Prevention of Significant Deterioration review, respectively. Mitigation for the potential air quality impacts include limiting the sulfur content of the fuel used in the power plants, raising the stack heights, using manufacturer-specific emission rates instead of industry-average EPA values, implementing enforceable limitations on operating hours or fuel consumption, and installing emission controls. (EIS Chapter 4.7—Air Quality)

2. Water Quality

Intent: To control activities that may degrade Guam's drinking, recreational, and ecologically sensitive waters.

Policy: Safe drinking water shall be assured and aquatic recreation sites shall be protected through the regulation of uses and discharges that pose a pollution threat to Guam's waters, particularly in estuarine, reef, and aquifer areas.

Discussion: **No proposed projects or actions will take place on groundwater or aquifer recharge areas, so no impacts to drinking water resources are anticipated. However, surface and marine waters may be impacted by the construction activities on and around Orote Point and Apra Harbor. Prudent construction practices will help to minimize runoff from construction sites, and measures will be taken to prevent contaminants from newly developed facilities**

from entering streams and eventually Apra Harbor. In addition, the increased risk of spills in Apra Harbor due to the higher level of activity will be mitigated through continued implementation of the Navy's comprehensive Spill Prevention Control and Counter-measure Plan. The proposed increase in flow capacity and additional effluent from the expanded sewage treatment plant will not have a significant additional effect on the marine environment. (EIS Chapter 4.5—Water Quality)

3. **Fragile Areas**

Intent: To protect significant cultural areas, and natural marine and terrestrial wildlife and plant habitats.

Policy: Development in the following types of fragile areas shall be regulated to protect their unique character.

- historical and archaeological sites
- wildlife habitats
- pristine marine and terrestrial communities
- limestone forests
- mangrove stands and other wetlands

Discussion: **The historical and archaeological sites of Guam will experience only indirect impacts as a result of the proposed actions. Measures will be taken to preserve and protect any historic resources located within the vicinity of proposed construction.**

Wildlife habitats in the northernmost portion of the island which provide nesting areas for the endangered Mariana crow and the Mariana fruit bat may be affected by the field-carrier landing practices (FCLPs) proposed for Andersen Air Force Base. Section 7 consultation is being carried out with the U.S. Fish and Wildlife Service. A six-month monitoring program is being undertaken by the Navy in cooperation with the USFWS and the Guam Division of Aquatic & Wildlife Resources to determine the effects of these flight activities on the endangered species.

With the exception of the proposed family housing at Apra Harbor, all new development will take place on previously developed lands which hold little value in terms of pristine marine and terrestrial communities. The areas sited for the family housing feature a limited number of animal species, none of which are endangered, as well as one endangered tree species and two rare plant species. Direct impacts to the endangered and rare plant species will be avoided by locating construction away from them and by establishing buffer zones to protect ecologically sensitive areas. No construction will occur on wetlands which have been delineated in the proposed housing area.

The limestone forests around Andersen Air Force Base and on Orote Point will not be directly affected by the proposed actions. No construction will occur in these forest areas. Indirect impacts resulting from nearby construction and pedestrian activities will be mitigated.

4. Living Marine Resources

Intent: To protect marine resources in Guam's waters.

Policy: All living resources within the territorial waters of Guam, particularly corals and fish, shall be protected from over harvesting and, in the case of marine mammals, from any taking whatsoever.

Discussion: **No harvesting of living marine resources will occur in association with the proposed actions. Construction of new facilities around Apra Harbor along with the expansion of the wastewater treatment plant, training activities of the Explosive Ordnance Disposal Mobile Unit Five and Naval Special Warfare Unit One, and the increased risk of oil spills may adversely affect living marine resources, but measures will be taken to reduce the likelihood of occurrence. Such measures include conscientious construction practices to keep runoff from project sites to a minimum, GEPA and DAWR monitoring of new training activities, and the continuance of the Spill Prevention Control and Countermeasure Plan to curtail spills and other harmful incidents. (EIS Chapter 4.6—Marine Environment)**

5. Visual Quality

Intent: To protect the quality of Guam's natural scenic beauty.

Policy: Preservation and enhancement of, and respect for, the island's scenic resources shall be encouraged through increased enforcement of and compliance with sign, litter, zoning, subdivision, building, and related land use laws. Visually objectionable uses shall be located to the maximum extent practicable so as not to degrade significant views from scenic overlooks, highways, and trails.

Discussion: **All proposed developments will occur in areas featuring similar facilities performing related functions. With the exception of Apra Harbor, current view planes will be preserved around all areas scheduled for any type of construction. The views around Apra Harbor may be altered by two 43-foot high stacks associated with expansion of the Orote Power Plant and the 300 additional family housing units. The new stacks will be located adjacent to the existing power plant and stacks, and the new housing will be located adjacent to an existing family housing area, so the new structures**

will be consistent with their surroundings. New housing units will be limited to two stories, and the visual factor will be taken into account in the siting analysis. (EIS Chapter 4.9—Visual Setting)

6. Recreation Areas

Intent: To encourage environmentally compatible recreational development.

Policy: The Government of Guam shall encourage development of varied types of recreational facilities located and maintained so as to be compatible with the surrounding environment and land uses, adequately serve community centers and urban areas, and protect beaches and such passive recreational areas as wildlife and marine conservation areas, scenic overlooks, parks and historical sites.

Discussion: **The Navy and Air Force provide sufficient recreational facilities (i.e. beaches, golf courses, swimming pools, weight rooms, playing fields, boating docks, etc.) on their respective bases that satisfy the increased demand from new personnel on Guam. Civilian parks and recreation areas will not be adversely impacted by the proposed actions. Military facilities will experience only a moderate increase in use. The only recreation area adversely impacted by the proposed actions will be Gab Gab Beach, which will have to be closed for an additional 32 days each year due to its proximity to the munitions loading and unloading areas at Kilo Wharf. The Navy will encourage use of other beach facilities along Dadi or "Old Wives" Beach during the closures. Discharge from the expanded sewage treatment plant will not affect any public recreational beach.**

7. Public Access

Intent: To ensure the right of public access.

Policy: The public's right of unrestricted access shall be ensured to all non-federally owned beach areas and all Territoria! recreational areas, parks, scenic overlooks, designated conservation areas and their public lands; and agreements shall be encouraged with the owners of private and federal property for the provision of releasable access to and use of resources of public nature located on such land.

Discussion: **All proposed actions will take place on military installations. No non-federally owned beach areas, territorial recreation areas, parks, scenic overlooks, conservation areas, or public lands will be affected.**

8. Agricultural Lands

Intent: To stop urban types of development on agricultural land.

Policy: Critical agricultural land shall be preserved and maintained for agricultural use.

Discussion: **Urban development of agricultural lands is not part of the proposed actions. Proposed projects will occur within military installations and will not affect the agricultural lands of Guam. Expanded ESQD arcs at Naval Magazine may come in close proximity to surrounding agricultural lands, but these delineations will have no impact on agricultural activities.**