

ENVIRONMENTAL IMPACT ASSESSMENT

for

The EnterOcean Guam Facility



Bureau of Planning

Bureau of Planning

Prepared for:

EnterOcean Group, Inc.



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Executive Summary

The EnterOcean facility on Guam will be a tourist oriented, ocean theme park. The facility will consist of several consecutive saltwater tanks stocked with fish, coral, and other organisms. Visitors will be given guided diving tours or semi-submersible submarine rides through these tanks. In addition to the basic saltwater trails, the facility will contain various display aquariums and other recreational areas.

Proposed construction will take place in the vicinity of Gun Beach, Tumon Bay, Guam. The complex will occupy an 18,000 square meter site located 845 feet from the shoreline. Open air saltwater tanks will contain approximately three million gallons of seawater and be supported by a 15,000 gallon per minute ocean water recirculation system. The seawater intake and outlet system will consist of dual thirty inch High Density Polyethylene pipelines, a pumping system, associated intake screens, and an outfall diffuser. The seawater intake will be located beyond the fringe reef at approximately forty feet below sea level. The facility outfall will discharge at approximately sixty feet below sea level.

No marine mammals or other rare/endangered species will be stocked. Species atypical of Guam's waters will be separated from the recirculation system in order to prevent introduction of exotic species into ocean waters via the aquarium outfall.

The following EIA outlines environmental impacts and issues associated with the EnterOcean facility on Guam. No endangered species or other findings were identified which could jeopardize the proposed project.

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SECTION 1

Introduction

SECTION 1

INTRODUCTION

1.0 THE ENTEROCEAN FACILITY - PROJECT OVERVIEW

The EnterOcean Guam Project is a swim through open water tourist aquarium. The facility will consist of several consecutive saltwater tanks stocked with fish, coral, and other organisms. Visitors will be given guided diving tours or semi-submersible submarine rides. In addition to the basic saltwater trails, the facility will contain various display aquariums and other recreational areas. The intent of the project is to function as a high quality tourist attraction and educational resource. As with all planned EnterOcean facilities, a program of cooperative education and research activities will be developed with the University of Guam Marine Laboratory and Territorial school system.

1.1 THE ENTEROCEAN FACILITY - A VISITOR'S EXPERIENCE

After completion of construction, the EnterOcean Guam facility will be able to provide visitors with a selection of activities which will be unique in the world. Visitors will begin their experience with a simulated submarine ride, view the

saltwater trails and aquarium exhibits from an undersea cavern, and will then be offered a chance to personally explore EnterOcean's saltwater trails. Afterwards, visitors will be offered various opportunities for unstructured relaxation. Each of these experiences is described in this section.

1.1.1 Dynamic Motion Submarine

Visitors will begin their journey by entering a Century Submarine, a sophisticated Dynamic Motion Simulator. After being seated and introduced to their surroundings, the submarine simulates a ride through an exciting ride under the oceans of the South Pacific. During the ride they will visit the Marianas trench, travel with a pod of whales, experience the attack of a great White Shark off the Australian Great Barrier Reef, and witness first hand the wonders of the 'deep open' ocean. At the end of their journey, they will exit the submarine into an undersea cavern.

1.1.2 Undersea Cavern

The undersea cavern will display indigenous marine life forms from several different South Sea habitats. From each cavern window, the visitor will have the opportunity to study marine creatures more closely in smaller closed aquarium

displays. Marine biology documents will be present for questions and instruction in their native language. The Undersea Cavern will present six different ocean habitats from Marianas Coral Reefs to Hawaiian Turtles. As visitors travel through the Undersea Cavern they will also be able to view the underwater reef trails allowing them to see groups of people diving in the areas beyond the cavern. In another area, they will be able to see small submarines exploring the reef trail. At this point the visitor will have the opportunity to join in the recreational aspects of the EnterOcean facility.

1.1.3 Diving and Reef Experiences

Visitors will be given the opportunity to purchase a membership in the EnterOcean Club at three different levels, the Ocean Club, EnterOcean Club, and the Ocean Explorer Club. After the Sea Cavern, Ocean Club level members will be directed to a special pier, where they will board an eight passenger semi-submersible. The semi-submersible, while looking very much like a typical submarine does not fully submerge. However, passengers are seated well below the water line giving them the sensation of being completely underwater. This small vessel will be piloted by an experienced guide who will take them on a journey through a South Pacific reef experience. Large viewing windows will give visitors a panoramic view of a thriving marine environment. Ocean Club members will come in close proximity to a wide variety

of sea life, from colorful reef fish to sea turtles to large sharks. Visitors will wear headsets which are connected to a specially designed multi lingual information system and receive lectures concerning the sea life and habitats they are observing.

EnterOcean Club level members will be able to swim with the sea life while fully submerged and breathing compressed air. Both day and night dives will be offered. Club members will be directed to changing rooms where they can prepare for their dive tour. They will then be sectioned into groups of six people and their tour group leader, a trained guide who will instruct them in the use of the Dolphinaire Group Underwater Towing Vehicle. The lesson will be a brief one, since the use of the breathing device and associated underwater headset will be made simple to understand and easy to become accustomed to.

The Dolphinaire vehicle is equipped with hand rails below the surface of the water, arranged so that each guest will have an unobstructed view. Guests will grasp the handrail and be gently pulled along, breathing through the air regulator installed at each passenger station. Each guest will be fitted with a headset, which will provide them with a running commentary on the sea life and habitats they discover as they proceed through the reef trails which comprise the underwater experience.

The underwater trail will be teeming with marine life as

it twists and turns exposing new vistas and habitats, and different marine life forms. EnterOcean participants will be treated to the physical experience of being underwater without danger, the visual experience of seeing the ocean world from the vantage point of the ocean dweller, as well as experiencing the sounds of the marine environment, coupled with an interesting and informative lecture about the habitats and sea life they are witnessing. Whale sounds will be heard as if they come from the deeper ocean near the reef trails. At one point on the trail, the vehicle will proceed into a cave, where the vehicle will pass close to a group of roving sharks, which are safely contained behind transparent acrylic windows. There will be no dangerous currents or waves. The controlled environment and use of the Dolphinaire vehicle will insure the Club Members a safe and secure experience.

1.1.4 Sea Cave Lounge

EnterOcean visitors will also have the opportunity to experience the relaxing and educational atmosphere associated with the Sea Cave Lounge. Members will be entitled to enter the Lounge, a subterranean cavern surrounded by viewing windows into the lagoons and reef trails which members recently toured. In the Sea Cave Lounge, visitors will have the opportunity to relax, enjoy a beverage, snack, converse, and listen to music.

Periodically, a guide will conduct lectures on the natural history of the sea life which Members experienced.

1.1.5 Tropical Island

In stark contrast to the subterranean environment of the Sea Cave, a central island will offer a lush tropical garden surrounded by water. During the day, Club Members will have the opportunity to wander the jungle trails and admire the tropical plants. In the evening, the island will be the scene of special parties, hosted by the EnterOcean staff. Entertainment will include both popular and ethnic music and dance. Food service will be provided, emphasizing Chamorro and other ethnic foods, as well as more conventional items.

1.2 THE ENTEROCEAN FACILITY - PHYSICAL DESCRIPTION

As stated above, the EnterOcean facility will consist of a network of manmade saltwater trails, with containment walls constructed from reinforced concrete. The concrete structures will be camouflaged by artificial rock and coral formations. There will be three principle bodies of sea water, two of which will incorporate island formations designed to create closed loop trails. The third will be smaller, and designed as a habitat for large ocean fish, including sharks, rays, and other predators.

The large lagoons trails, each containing a water surface area of approximately 20,000 square feet, will be arranged so that the inner structural water containment walls define an enclosed dry space of approximately 24,000 square feet in size. Within this space there will be additional smaller display aquariums as well as acrylic underwater viewing windows. Additional dividing walls are used to define passageways. The entire inner building will be naturalized with artificial rock work to create the impression of a winding series of cavern passageways, which open into underwater viewing windows onto the 'ocean' beyond.

The entrance to this cavern network will be through two parallel passage ways, each leading to a small cavern enclosing a subterranean waterway. Located within each cavern will be a Dynamic Motion Simulator platform disguised as a high tech submarine. Each submarine will contain two doors, one for entrance and one for exit. The exit door will connect with passageways leading to the subterranean cavern system.

The roof structure of the cavern will be essentially flat, constructed from heavy reinforced structural concrete. Atop the roof structure will be a three quarter acre 'island' with jungle trees, ground cover, pathways and grassy clearings.

Separated from the structural water containment walls of

one of the two lagoon trails will be third lagoon. This will also be fully naturalized with synthetic rock and corals. This lagoon will be from 3 to 8 feet deep and offers a free snorkeling arena with a simulated ship wreck. Service areas for physical and biological maintenance, underwater vehicle maintenance, and equipment will be located within the containment structures.

The main entry building will be architectural, as opposed to natural, in character. This single story structure will contain the admissions counter, a gift shop, changing rooms for men and women, and the administrative offices. It is designed to allow access to all the active components of the facility, and provide the transition to the different activities available to visitors. Figure 1-1 depicts the surface level of the floor plan. Figure 1-2 portrays the underground plans, and Figure 1-3 illustrates the artist's rendering of the proposed project.

1.3 SEAWATER INTAKE AND OUTFALL SYSTEM

The several lagoons and marine display tanks will contain approximately 3 million gallons of seawater. It will be necessary to pump natural sea water through the lagoons and tanks at a relatively high flow rate (15,000 gpm) to maintain a safe and healthy environment for the population of fish, corals, invertebrates, as well as permit humans to physically share that environment. Seawater will be pumped to the lagoon and returned

The EnterOcean Guam Facility

Ground Floor Plan

グアムにあるエンターオーシャンの施設

THE ENTEROCEAN GROUP

Interactive Marine Recreation Design, Construction and Management

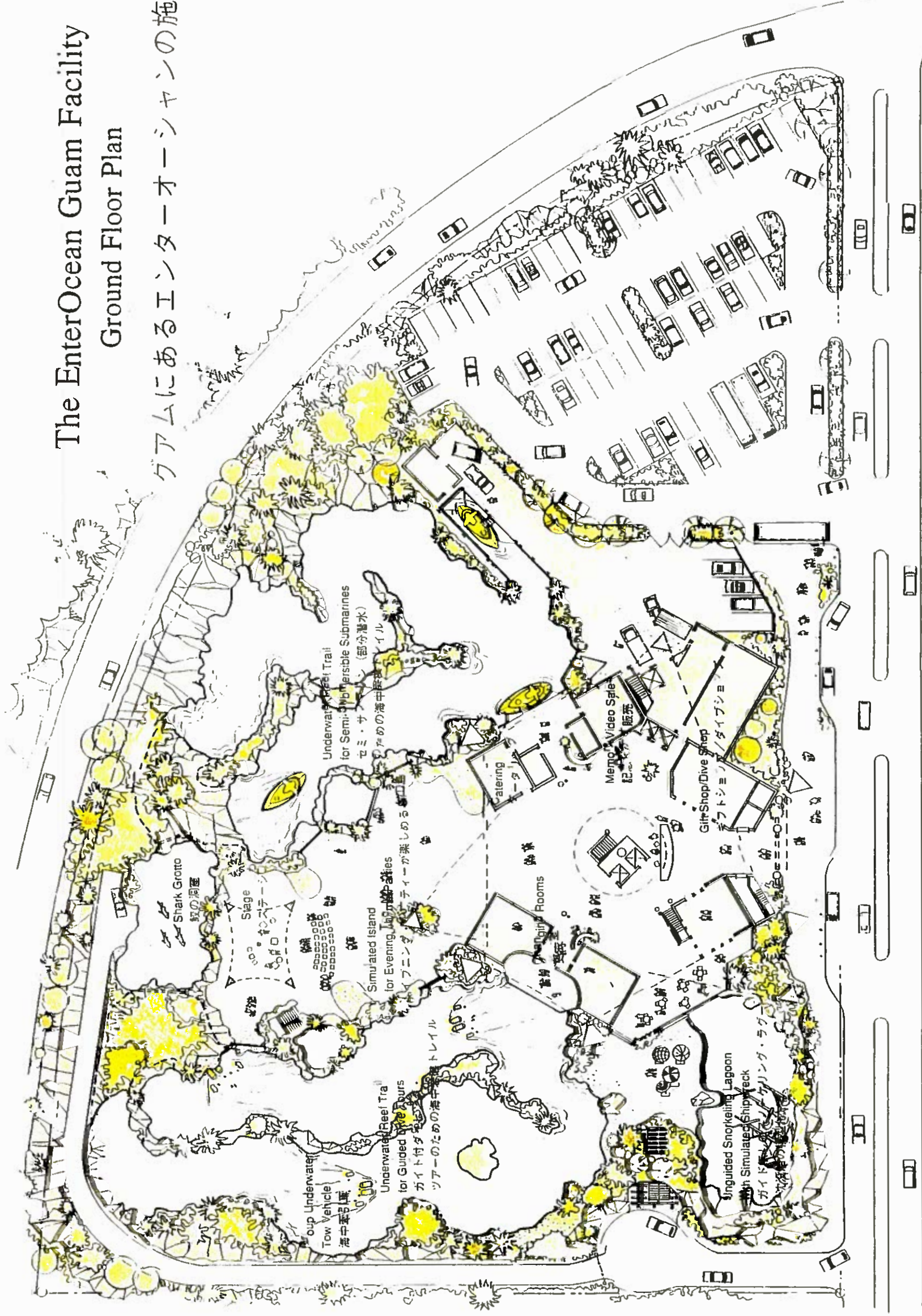
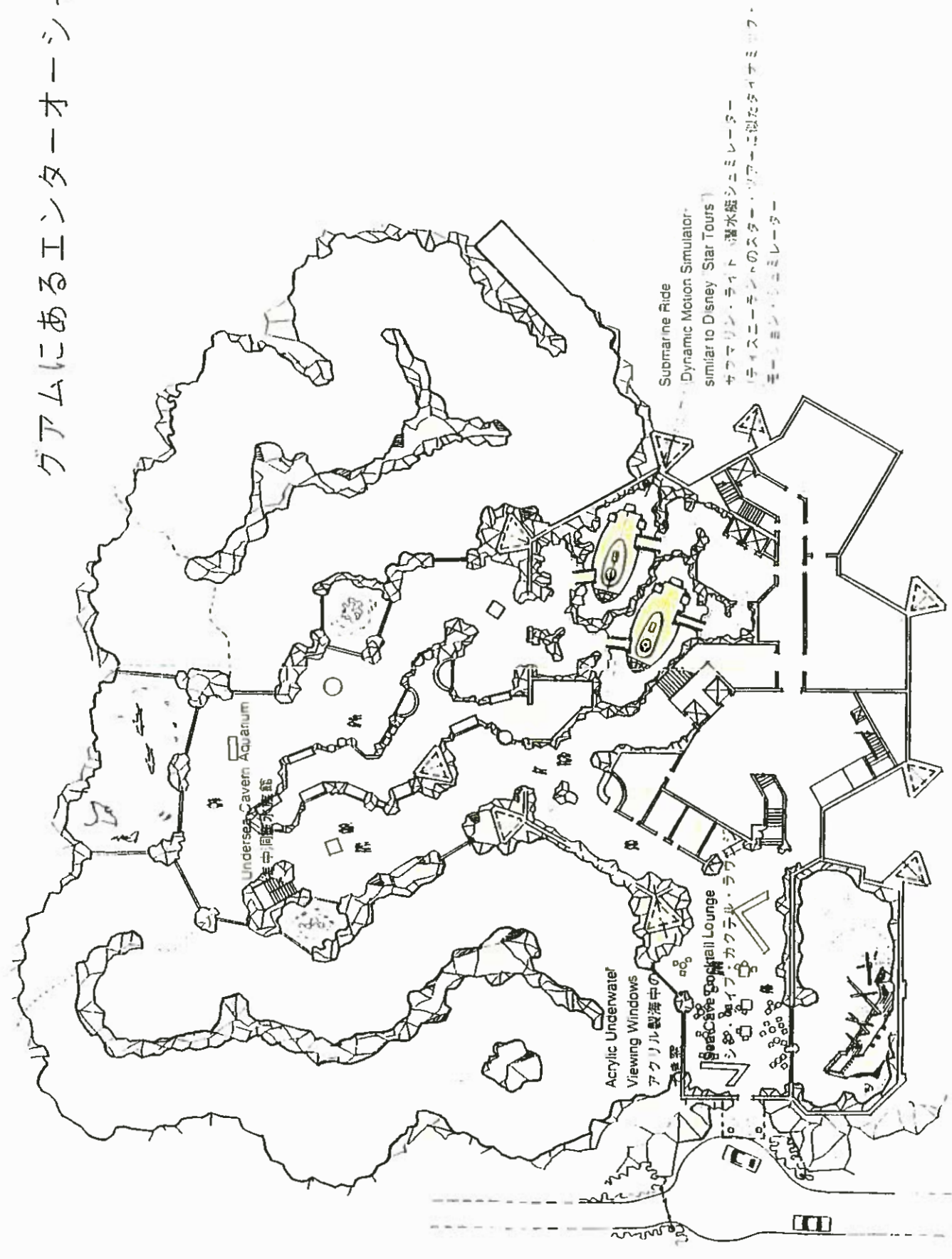


FIGURE 1-1

The EnterOcean Guam Facility

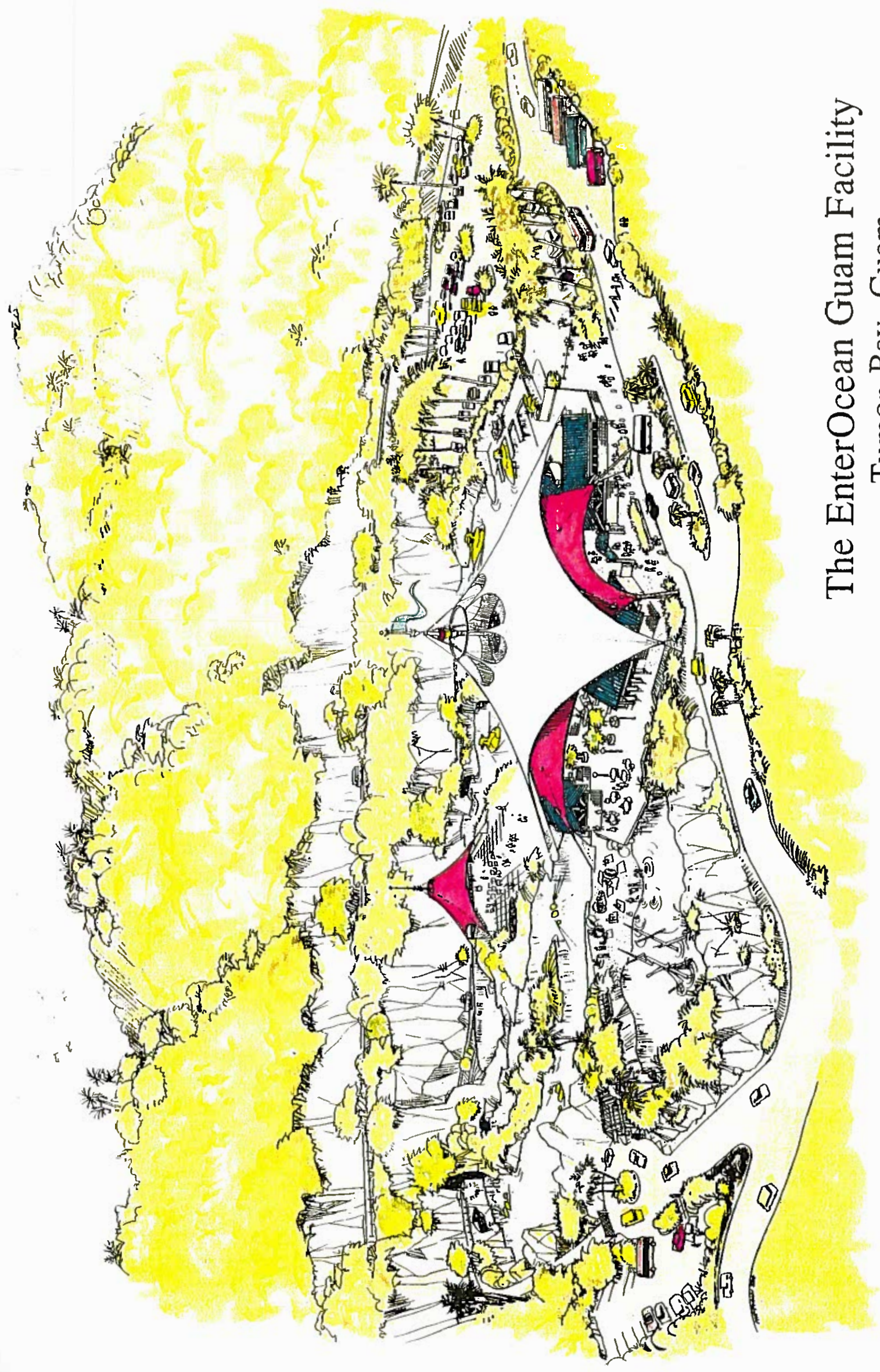
Lower Level Plan

グアムにあるエンターオーションの施設



Submarine Ride
Dynamic Motion Simulator
similar to Disney "Star Tours"
ザマリン・ライト 潜水艇シミュレーター
ディズニーランドのスター・トゥアーズに似たダイナミック・
モーション・シミュレーター

FIGURE 1-2



The EnterOcean Guam Facility
Tumon Bay, Guam

グアムにあるインターオーションの施設

by gravity to the ocean through 30 inch diameter high density polyethylene (HDPE) pipes. This system will provide the lagoons with a turnover or residence time of three hours. Details of the intake and outfall system are discussed under Construction Impacts.

1.4 PURPOSE AND NEED

The United States Territory of Guam, located in the Western Pacific 3,300 miles from Honolulu and 1,500 miles from Tokyo, is one of the premier tourist destinations in the hemisphere. It is within four air hours of nearly three-fourths of the world's population.

Recent tourist demographics favor younger Japanese, which as a group, are more active and water oriented than any other tourist group. Based on 1994 visitor count projections, 73% of Guam's tourists are Japanese. A total of 800,000 Japanese visitors are expected in 1995. Exit interviews conducted in 1992 revealed that 80% of Japanese visitors came to Guam for the 'beautiful seas'. A vast majority of Japanese vacationers in Guam participate in some kind of ocean recreation, including jet ski rental, snorkeling, SCUBA diving, parasailing, and other activities that are provided for the tourist resident population. In 1989, the Guam Visitor Bureau conducted a survey of visitors from Japan. For every visitor who actually experienced a SCUBA

dive, there were 6 more who said they would like to. That year, over 75,000 Japanese visitors experienced SCUBA, out of 680,000 total visitors. Thus, only 11% of Japanese visitors actually enjoyed a SCUBA dive, but 66% said that they would have liked to. An August 1994 visitor index participation index found an increase from the reported 1989 11% to 13%. These figures indicate that the interest in dive tours remains prevalent in Guam and has not been fulfilled by any other available option.

In general, SCUBA diving is limited to only a small percentage of Guam's visitors by several factors. Among these are time, risk of an unsatisfactory experience, and the possibility of injury.

Time and the location of dive spots prove to be a deterrent for many visitors. Visitors must be transported to the area of the dive operator, trained in the use of SCUBA equipment, transported by to the actual dive site, and then experience a dive that may or may not expose them to the natural wonders of the ocean. Their journey back to the hotel from the dive location is repeated, making the excursion tiresome and possibly very lengthy in time.

The risk of an unsatisfactory experience is a factor in an uncontrolled environment. If the weather is not perfect, wave and current action can create stress and endanger the

inexperienced diver. Recent storms can also contribute to poor water visibility. Finally, improperly trained guides can inhibit a successful experience.

There are also many real and perceived dangers inherent in a SCUBA dive. Failure to follow dive regimes can result in embolism or narcosis, which can be painful or fatal. The risks involved in diving are real and should not be taken lightly. Special training and attention is needed for individuals who differ in language and cultural perceptions in order to ensure diving instructions are clearly understood. Breakdowns in communication and errors in interpretation can have serious consequences for the inexperienced diver.

The EnterOcean Facility will provide an alternative means of exploring the marine environment to people unwilling to risk the diving experience. In order to do so, the project seeks to systemically address each of the barriers discussed above.

First, the EnterOcean facility has been designed such that a full 80% of a visitor's time will be spent underwater rather than in transit or training. The project's location is within a few minutes travel time of most visitor's accommodations. Orientation to the specially designed group diving equipment will be completed in minutes.

Additionally, the EnterOcean facility's reef environments will be man made, utilizing state of the art technology to create realistic captive habitats for ocean creatures. Marine life will be consistently there for the visitors' experience. The EnterOcean facility's controlled environment will offer the diver many experiences that they may not be exposed to in the actual ocean. Use of clear acrylic underwater panels will allow safe 'face to face' encounters with sharks and other dangerous denizens of the ocean. Exposure to the marvels of the marine environment will be virtually assured.

Finally, the EnterOcean dive experience has been carefully designed to ensure visitor safety. Participants will 'dive', at snorkel depth, while being towed behind a low speed, guided, group diving vehicle. Participants will breathe compressed air, but at a shallow depth to preclude air embolism or lung expansion injuries. Use of a guided vehicle will prevent participants from harming or being harmed by any of the sea creatures inhabiting the reef environment. This special underwater tow vehicle will also be equipped with a communication system used for both entertainment and education. As an added bonus, information will be presented in the visitor's native language.

People of nearly all ages and physical capabilities will be able to enjoy the EnterOcean dive experience in guaranteed safety. They will be assured a satisfying experience, and

acquire the appreciation that they will have gained knowledge when the experience has ended. Visitors will also walk away knowing that they have not damaged the natural ocean environment. An added incentive is that the cost of the EnterOcean dive experience in both time and money will be considerably less than a conventional introductory SCUBA dive.

1.5 PROJECT LOCATION

The project will be located within the Tumon Bay area of Guam. The actual EnterOcean facility will be constructed inland within the vicinity of Gun Beach at the extreme northern end of Tumon Bay. Project seawater intake and outlet piping will extend into the ocean at Gun Beach. Figure 1-4 shows the general location of the Tumon Bay area of Guam.

1.6 RELEVANT EIS AND EIA'S THAT INFLUENCE THIS ASSESSMENT

- A. Draft Environmental Impact Assessment for Gun Beach Hotel and Condominium Development, Gun Beach, Guam. GMP Associates, Inc. December 1992.
- B. Final Environmental Assessment, Hilton Lagoon Project, Hilton Hawaiian Village, AECOS, Inc. June 1994.

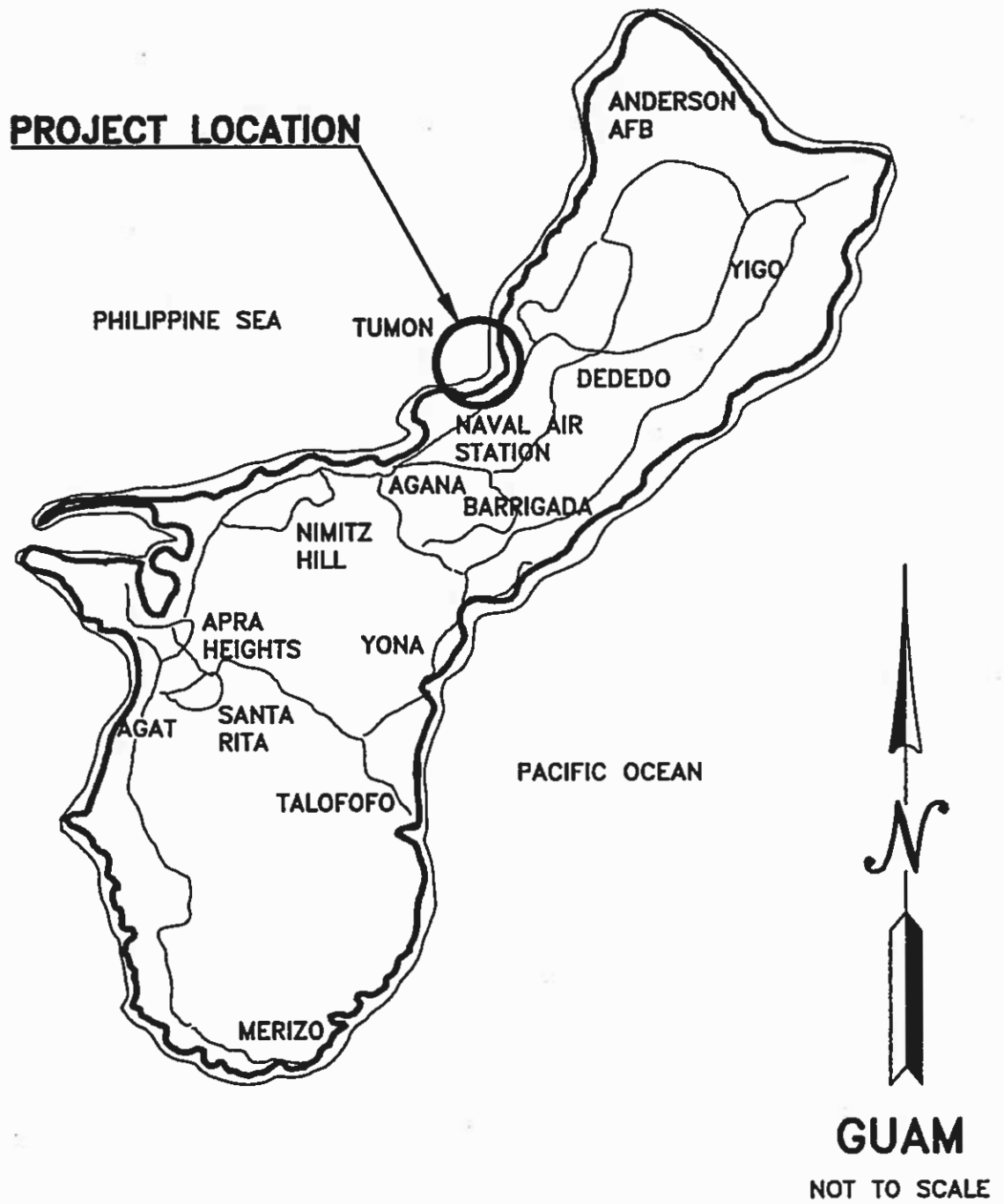


FIGURE 1-4 PROJECT SITE

- C. Final Environmental Impact Assessment for the Landing of High Capacity Digital Submarine Telephone Cables at Gun Beach, Tumon Bay Guam.
- D. Draft Environmental Impact Statement Microdredging of Tumon Bay, Barrett Consulting Group, Inc. July 1988.

1.7 GUAM PERMITS AND IMPLEMENTING AGENCIES

The EnterOcean facility will require the following Government of Guam Permits:

- A. Tentative Development Plan
- B. Territorial Seashore Clearance Application
- C. Submerged Land Easement
- D. Building Permit

Tentative Development Plan approval is granted by the Territory Land Use Commission (TLUC). Territorial Seashore Clearance Application approval is granted by the Territorial Seashore Protection Commission (TSPC). Both applications are administered by the Department of Land Management (DLM). This EIA is intended to accompany these applications. Additionally, both applications are reviewed by the Development Review Committee (DRC) as part of the approval process. The following agencies will review and comment on these applications and the

draft EIA during a 90 day review period.

Department of Land Management
Bureau of Planning
Division of Aquatic & Wildlife Services in the Dept.
of Agriculture
Guam Environmental Protection Agency
Department of Commerce
Department of Parks & Recreation and Territorial
Historical Preservation Officer
Public Utility Agency of Guam
Department of Public Works
Chamorro Language Commission
Guam Fire Department
Department of Public Health and Social Services

Within the first 60 days of this review period, each agency will can formulate a request for additional information. Agency position statements regarding project approval conditions are due within 90 days.

In addition to the Territorial Seashore Clearance Application, the Department of Land Management requires a separate Submerged Land Easement Application which is also reviewed by selected DRC committee members.

Subsequent to the project approval process, the EnterOcean facility will require a Department of Public Works building permit for construction. Completed construction drawings and a construction oriented written Environmental Protection Plan are required. The building permit application must be approved by the following agencies:

Department of Land Management for the conformance
with conditional approval.

Guam Power Authority (GPA)
Guam Telephone Authority (GTA)
Public Utility Agency of Guam for utilities (PUAG)
Department of Public Health (DPH)
Department of Parks and Recreation for
historical preservation.
Division of Aquatic and Wildlife Reservation (DAWR)
for clearing and marine exhibits.
Guam Environmental Protection Agency (GEPA)
for the Environmental Protection Plan (EPP).
Guam Fire Department

1.8 FEDERAL PERMITS AND REQUIRED LOCAL SUPPORTING APPROVALS

The EnterOcean facility will require the following Federal Government permits:

- A. Army Corps of Engineers (ACOE) permit
- B. National Pollution Discharge Elimination System (NPDES) permit

An Army Corps of Engineers (ACOE) permit is required for construction of the seawater intake and outlet structures. The following locally approved documents and applications are required by the Army Corps of Engineers prior to processing a permit:

- A. Section 401 Water Quality Certification
- B. Certificate of Consistency

The project Section 401 Water Quality Certification will

be prepared by the Guam Environmental Protection Agency. The purpose of this certification is to ensure compliance with sections 301, 302, 303, 306, and 307 of the Clean Water Act by allowing local governments to participate in the federal permitting process.

Similarly, a Certificate of Consistency is required by the Guam Coastal Management Program and is issued by the Bureau of Planning. The purpose of this certification is to ensure project compliance with goals and standards of the Guam Coastal Management Program.

A National Pollution Discharge Elimination System (NPDES) permit, issued by the USEPA, is required prior to placing the project aquarium water outfall into operation. No local supporting documentation is required for this permit.

SECTION 2

Alternative Analysis

SECTION 2

ALTERNATIVE ANALYSIS

2.0 PROJECT ALTERNATIVE ANALYSIS

Evaluation of project alternatives is a critical component of the environmental impact assessment (EIA) process. This section outlines and evaluates identified alternatives for the EnterOcean project.

2.1 DESCRIPTION AND SUMMARY OF ALTERNATIVES

Four project alternatives were identified during the environmental assessment process. Three of these alternatives consist of differing project sites. Each site is capable of accommodating the same marine aquarium facility and is located near a source of seawater. These alternative sites differ in proximity for the visitor and resident population, existing development and land use, lift station construction feasibility, expected construction cost, and environmental impact. The fourth project alternative is no action resulting in cancellation of the proposed facility.

2.1.1 1st Alternative, Construction at Gun Beach, Tumon Bay

Construction at Gun Beach is the preferred project alternative for the EnterOcean facility. Property under consideration for the project, Lot 10113-R3, is presently owned by Calvo Enterprises. This lot is located in the northern section of Tumon Bay. Its neighbors include the Naval Reservation, Nikko Hotel and Fafai Beach. Figure 2-1 portrays the adjacent property owners and locality of the proposed project.

The actual EnterOcean project site occupies only a 18,000 square meter (four and one half acre) portion of Lot 10113-R3 located approximately 845 feet from the shoreline. Figure 2-2 portrays the location of the EnterOcean facility within lot 10113-R3. The site is situated along side a picturesque bluff which gives the impression of isolation without the actual inconvenience of detachment from local services. The ocean side of the property fronts Tumon Bay and the Philippine Sea. The shoreline in the area includes an ancient uplifted coral reef forming an extensive reef flat, which drops off quite rapidly into deep waters. Little previous development characterizes the Calvo property which is currently an undeveloped lot.

The Government of Guam has zoned Tumon Bay, including Lot 10113-R3, as a hotel/commercial zone. The proposed project is in accordance with this zoning. As a result of the presence of

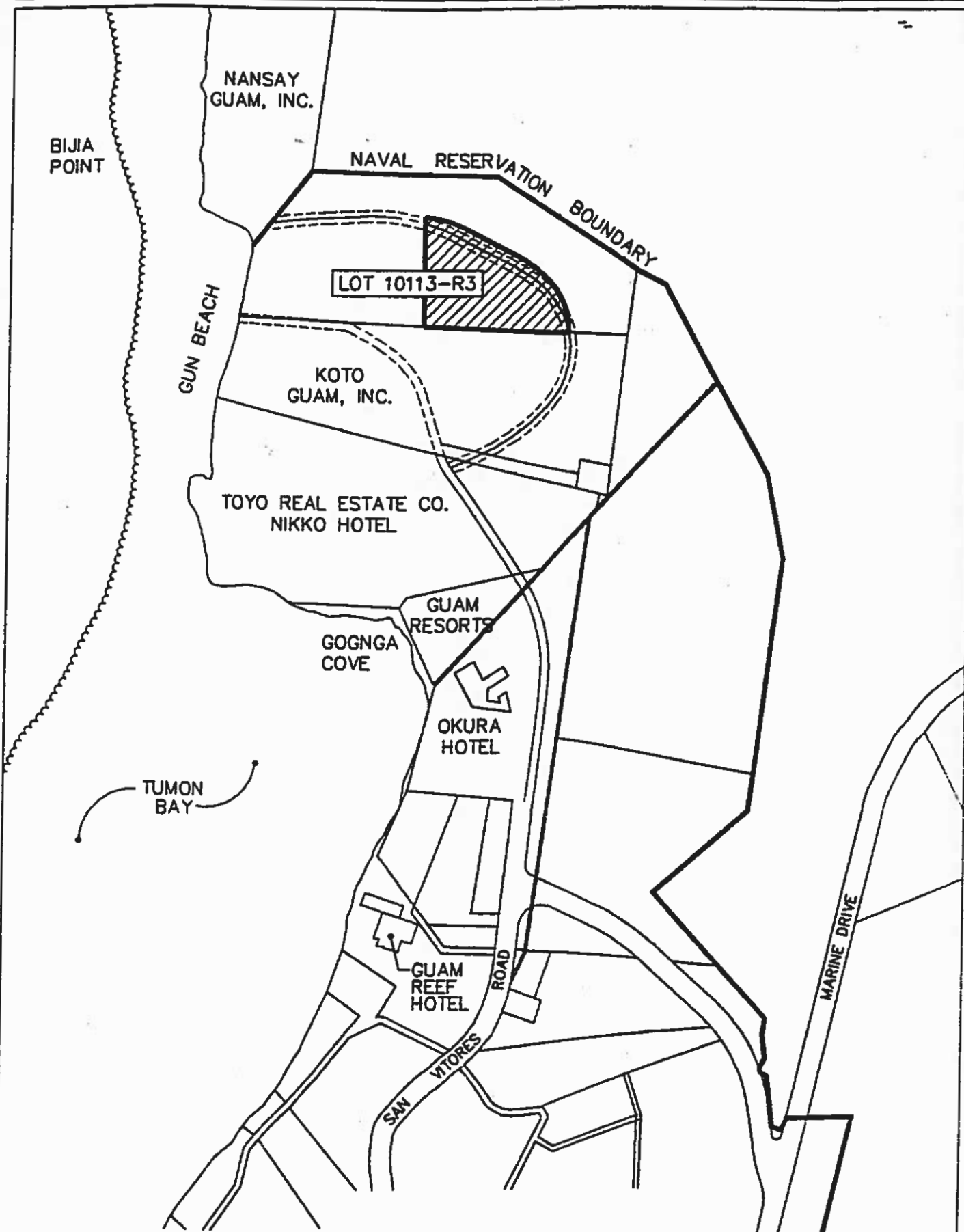


FIGURE 2-1 ADJACENT PROPERTY OWNERS



Hardscape: Hawaii

Custom engineering and construction of natural and synthetic rock structures, biological and aquaculture exhibits, and landscape water features.

Division of THE ENTEROCEAN GROUP
1000 W. ALABAMA ST. #100
AGANA, GUAM 96910-2000

ENTEROCEAN
INCORPORATED

PROPOSED ENTEROCEAN FACILITY GUN BEACH AGANA, GUAM

DATE: 2/1/94
SCALE: 1" = 60'
PROJECT NO.: 94-001
SHEET: 1 OF 1

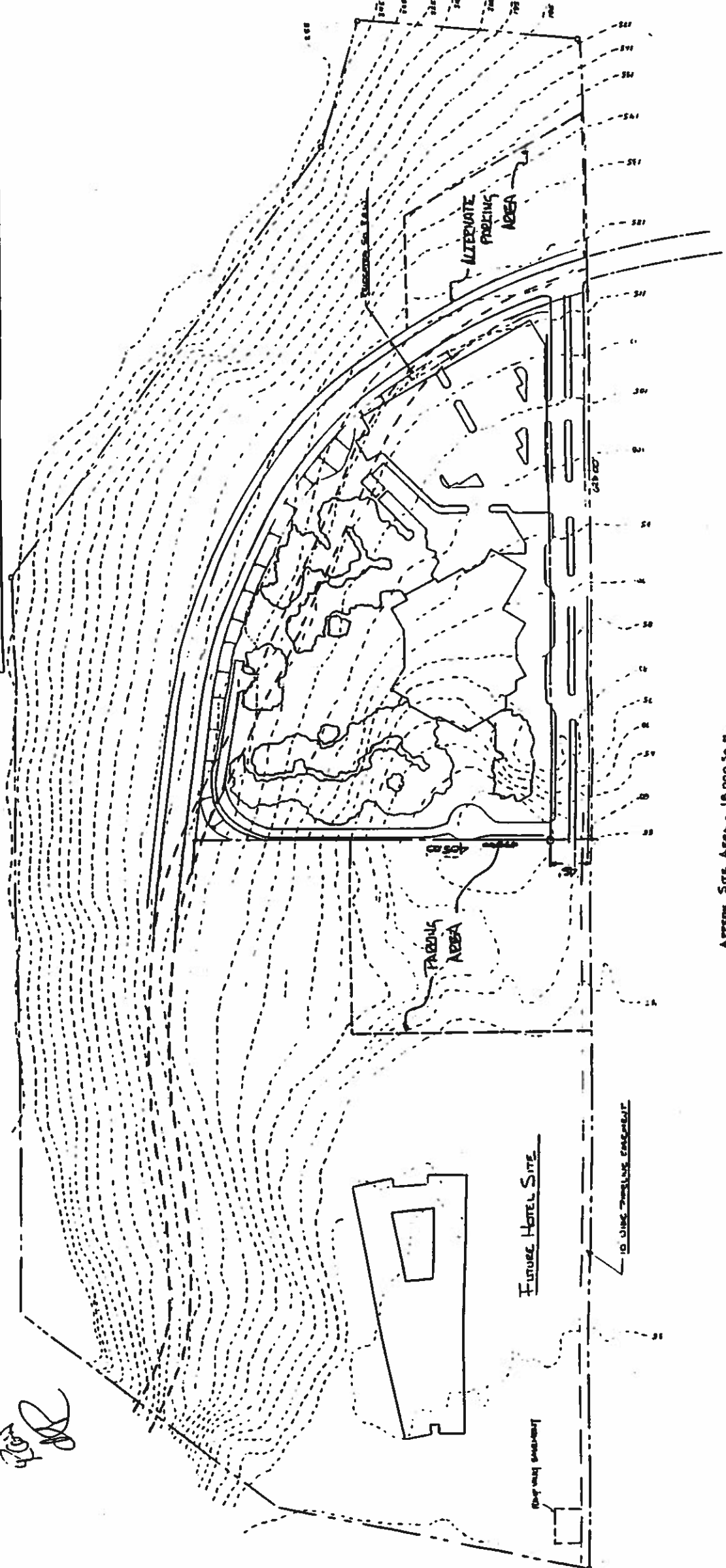
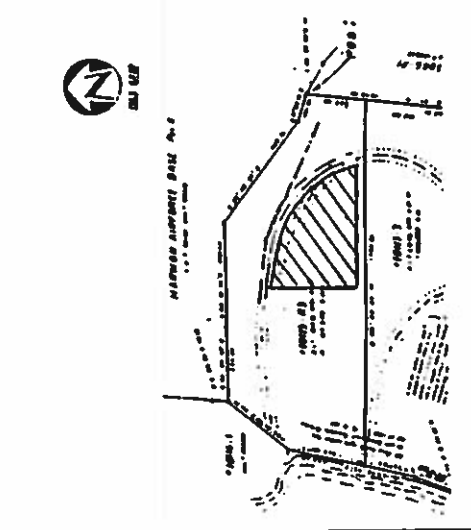
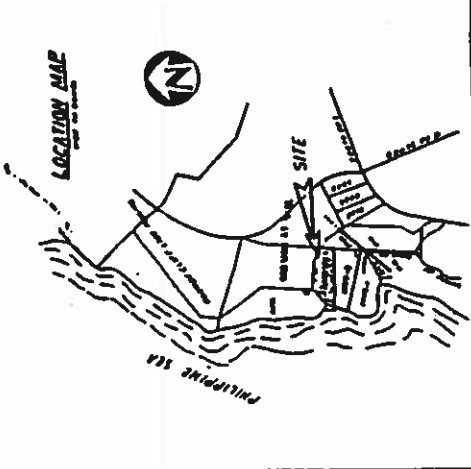


The company assumes no responsibility for the use of the information contained herein for any purpose other than that for which it was prepared.

SHEET TITLE:

SITE PLAN

SHEET NUMBER:



Approx. Site Area - 16,000 Sq. Ft.

**NOTE: FOR GENERAL SITE
ARRANGEMENT ONLY**
(Arrangement of Facility and Circulation
Roadway May Vary From That Shown)

FIGURE 2-2

extensive existing roads, power supply systems, and other utilities, minimal requirements exist for new project related infrastructure. In addition, the proposed project complements previous Tumon Bay planning and construction and will act as an asset to the area's hotel and tourism industry.

Figure 2-1 also portrays the two roadway easements in the Gun Beach area. An existing coral road approximately follows the southern easement. The EnterOcean seawater intake and outfall will be located on a private easement to the north of this existing coral road. The proposed project access road and utility lines will be located in the northern easement. Existing public access to the beach will not be disrupted by the proposed project.

Lot 10113-R3 is within an existing tourist and commercial area. The lot is centrally located and is within close proximity of major attractions, shopping, and recreation areas. This site is conveniently accessible by visitors who travel by car, foot or public transportation. Local residents are also able to conveniently access the area through the major routes that exist on the Island.

2.1.2 2nd Alternative, Construction at Hospital Site, Ypao Point

An alternative location for the EnterOcean facility is the

former hospital site located at Ypao Point. This parcel of land sits upon a high cliff that overlooks the Philippine Sea. The upland area is in an identified seismic fault zone. Recent earthquake activity is visible along the cliff fronting the ocean of Ypao Point where a portion of the gradient fell during the recent earthquake of 1993. The lot is approximately sixty acres in size. Its neighbors include residential developments to the east and south, as well as the Guam Hilton Hotel located to the North.

At the present time, the Ypao Point Hospital site is not available for development. The property is owned by the Government of Guam and consigned to the Chamorro Land Trust Commission restricting commercial development. A public opinion survey was conducted by Merrill & Associates, Inc. in 1992 to determine the public's desire for the future use of this site. This survey determined that 76% of the overall population felt the property should be used for multi-purpose development, meaning both commercial and public use. Additionally, Merrill & Associates recommended through review by the government prior to any final development decision.

The former hospital building has depreciated and is unfit to be used for any purpose. Demolition of the standing structure will require extensive foresight for the removal of asbestos and possibly other hazardous materials.

The existing site environment and its position above sea level are major deterrents for construction of an EnterOcean type facility. Existing development to the east and south is residential. Development of a recreational facility may have adverse effects upon this residential community. The site's elevation, 100 feet above sea level, imposes extra costs and technical difficulties during construction of a seawater intake and outfall system.

2.1.3 3rd Alternative, Construction on Cocos Island

Cocos Island is located approximately 8,000 feet (one and a half miles) offshore of the southern tip of Guam. The island is approximately 232,335 square feet in area. Cocos Island is surrounded by both the Pacific Ocean and Philippine Sea requiring transportation by boat.

One third of Cocos Island has been designated as a bird sanctuary. The remaining portion of the island has been leased by Japan Airlines. Their investment in the area was interrupted by typhoon "Bryan" in 1992 and has since been replaced with a day only recreational center.

2.1.4 4th Alternative, No Action

Analysis of a no action alternative is subjective because of the inability to predict future events. However, if the EnterOcean Group was to relinquish plans for construction of a recreation facility in Tumon Bay, the undeveloped land may be chosen for future hotel, high rise residential, or another type of recreational or commercial use. There is a high probability that such development will ultimately occur based on continuing increases in visitors and hotel occupancy rates.

The Gun Beach site is an exceptional attractive setting that deserves a unique and valued undertaking which would both complement the overall planning of Tumon Bay and provide a new recreational and educational feature for both visitors and residents of Guam. If the no action alternative was exercised, Guam would lose a unique ocean facility which promotes both education and ecotourism. In addition, projected job creation in the areas of aquatic wildlife maintenance, education services, and other ecotourism related areas would not take place under general development.

2.2 SELECTION AND APPLICATION OF EVALUATION CRITERION

Two sets of criteria are used to evaluate identified project alternatives. An analysis of initial screening criteria is used to determine if a project alternative is appropriate for further consideration. Subsequently, refined criteria are used

to evaluate remaining project alternatives. Section 2.2.1 contains the initial screening analysis for the identified EnterOcean project alternatives. Section 2.2.2 contains the refined analysis.

2.2.1 Initial Screening Analysis

As stated above, initial screening is used to determine if a project alternative is appropriate for further consideration. Initial screening criteria used in this analysis were: land ownership, lot size, and ocean intake/outfall feasibility. As a result of this screening analysis, the Ypao Point Hospital location is dropped from further consideration. Discussion of these evaluation criteria is as follows:

A. Land Ownership:

1. Gun Beach:

The Gun Beach site is privately owned by the Calvo Enterprises. The EnterOcean Group has an existing 25 year lease agreement with the option to renew the lease for two consecutive periods of ten years. Project development on the Gun Beach site is feasible without further lease negotiations.

2. Former Hospital Site (Ypao Point):

The former hospital site at Ypao Point is government owned and may not be available for use by a private developer. However, the Government of Guam is actively seeking to identify project alternatives which would remove the existing abandoned hospital and add value to the community. The Government of Guam would presumably consider an EnterOcean type development on the site if offered the correct incentives by the developer. Project development on the Ypao Hospital site is feasible after appropriate negotiation.

3. Cocos Island:

Cocos Island is currently designated as a bird sanctuary. The remainder of the property is leased by Japan Airlines. A sublease with Japan Airlines has currently not been initiated. However, project completion on Cocos island is feasible after appropriate negotiation.

4. No Action Alternative:

Land ownership issues are not applicable to the no action alternative.

B. Lot Size:

1. Gun Beach:

Lot 10113-R3 at Gun Beach is 87,500 square meters in area. Lot size is sufficient for the proposed development.

2. Former Hospital Site (Ypao Point):

The Ypao Point Hospital site is 243,064 square meters in area. Lot size is sufficient for the proposed development.

3. Cocos Island:

The Cocos Island site is 232,335 square meters in area. Lot size is sufficient for the proposed development.

4. No Action:

Lot size issues are not applicable to the no action alternative.

C. Ocean Intake/Outfall Feasibility:

1. Gun Beach:

The reef margin and shoreline fronting the Gun

Beach site has been used by telephone companies AT&T and PacRimWest for the landing of three cables. These cables occupy an existing trench approximately ten feet deep. Construction of a seawater intake and outfall structure is similar, in many respects, to construction of a cable landing. Completion of required seawater recirculation structures is feasible at the Gun Beach site.

2. Former Hospital Site (Ypao Point):

This site is located approximately 100 feet above sea level atop a vertical cliff. Additionally, the shoreline and surrounding waters are not protected by a reef and are directly exposed to strong currents and storm waves. A seawater lift station at this project site will have considerable energy costs because of the elevations involved. In addition, construction is technically difficult because there is no available property at near sea level on which to locate the lift station. Although technically possible, the combination of vertical cliffs and high project site elevation make construction of a seawater intake system non-feasible at this location.

3. Cocos Island:

The Cocos Island site is bordered by a lagoon on one side and faces the Pacific Ocean on the other. Construction of an intake/outfall system into the lagoon area is undesirable due to ecological considerations. Construction directly into the Pacific Ocean is feasible.

2.2.2 Refined Analysis

As previously stated, a refined analysis is used to evaluate remaining project alternatives after completion of a screening analysis. Refined analysis criteria used in this analysis were: project location, proximity to visitors, the existing environment, natural beauty, construction/operations impact, and cost. Remaining project alternatives are evaluated against each refined analysis criteria. However, evaluation criteria are generally not applicable to the no action alternative. Results are tabulated in Table 2.1. Discussion of each evaluation criteria is as follows:

A. Project Location:

The location of the site is critical for the overall planning of the proposed project. Location used as a criterion in site selection assists in determining whether the site meets the project's overall goals.

TABLE 2.1
COMPARISON OF REFINED CRITERIA FOR SITE SELECTION

PROJECT ALTERNATIVES			
CRITERIA	GUN BEACH	COCOS ISLAND	NO ACTION
LOCATION	EXCELLENT	EXCELLENT	N/A
PROXIMITY	EXCELLENT	POOR	N/A
EXISTING ENVIRONMENT	GOOD	POOR	N/A
NATURAL BEAUTY	EXCELLENT	EXCELLENT	N/A
CONSTRUCTION/ OPERATION IMPACT	MED/LOW	HIGH/HIGH	POTENTIALLY WORSE
COST	\$37,000,000	\$39,000,000	N/A

Location takes into consideration: 1) the zoning of the site; 2) its vicinity to the ocean and the existing marine environment; and, 3) it examines the overall location with the entire Island of Guam taken into consideration. The following sections discuss the three remaining alternatives with respect to location.

1. Gun Beach:

The Gun Beach project site is zoned H. The proposed project is in conformance with existing zoning. This site is approximately 845 feet from the shoreline and is fronted by a marginal reef flat. Gun Beach is located in Tumon Bay which is located in the central western coast of Guam. This project location is evaluated as excellent.

2. Cocos Island:

Cocos Island is located approximately 2 miles offshore from the southern tip of Guam. It is surrounded by an ecologically sensitive lagoon, the Pacific Ocean, and the Philippine Sea. A boat is necessary for transportation. A bird sanctuary covers a third of the island, with the remaining portion occupied by an investment with Japan Airlines. Cocos Island is also zoned H. This project location is also evaluated excellent.

B. Proximity to Visitors:

The proximity of the site to visitors is critical because of its role in projecting the success of the project. When taking proximity into consideration, the planner reviews the distance of the site to relative hotels, commercial areas, and neighboring housing districts.

1. Gun Beach:

Gun Beach is given a rating of excellent because it is within a two mile radius of Tumon Bay, the major hotel region.

2. Cocos Island:

Coco's Island is given a rating of poor because it is located well outside of any major hotel district.

C. The Existing Environment

Evaluation of the existing environment involves consideration of the type of environment that surrounds the site and the type of activity that is present. This criteria enables the study to take into consideration the overall planning of the area and allows the proposed development to complement the existing environment.

1. Gun Beach:

The Gun Beach site is within a H zone area and is neighbored by the Nikko and Okura Hotel. Although apparently isolated, hotels, restaurants, and shopping areas characterize the area. The proposed undertaking is complimentary to presently existing development and respectful of the areas scenic beauty. Project development at the Gun Beach location is evaluated as good with respect to the existing environment.

2. Cocos Island:

The Coco's Island site has both a designated bird sanctuary and existing development by Japan Airlines. The presence of a major tourist attraction on an isolated island is not in harmony with the areas existing level of development. Project development at the Cocos Island location is evaluated as poor with respect to the existing environment.

D. Natural Beauty:

The natural beauty criteria is extremely subjective because it involves each individual's perspective. Each alternative site is set in a scenic area and are all justifiable attractive. All sites under

consideration were evaluated as excellent with respect to natural beauty.

E. Construction/Operations Impact:

The environmental impacts of an undertaking are difficult to evaluate independently for each specific site. The amount of impact the environment receives is dependant on the specific alternative site and technology used to develop the area. An evaluation to determine which site would receive minimal impact is one of the goals of responsible planning. Evaluation of this criteria will discuss the possible environmental impacts for each alternative site and the no action alternative. Each site will then subjectively be graded both for the impacts inflicted during the construction phase and those impacts that may occur after project completion.

1. Gun Beach:

a. Project Construction:

The proposed project site requires extensive excavation due to the slope and surrounding bluff. Approximately 150,000 cubic yards of material will be excavated with a portion used for backfill. The remaining fill is expected to be disposed of off site. Removal of

vegetation and alterations to ground cover will result an increased probability of erosion. The removal of flora may effect the coexisting fauna which are expected to take temporary refuge in surrounding areas.

Appendix A lists the specific species recorded in the Botany Study that will be affected.

Project construction will result in extension of the existing access road, use of energy resources, accumulation of solid waste, and potable water use. An increase in vehicle traffic, workers, and the use and storage of construction equipment will effect noise level and air quality, resulting in the disruption of the existing environment and an increase in resource use.

Construction of the intake/outfall structure will inflict a loss of marginal reef and marine wildlife, reduce water quality, and restrict recreational activity in the area due to the large crane and barge. With the appropriate mitigation measures, erosion plan, and environmental protection plan, the expected impacts are minimal. The value given to the environmental impact criterion during the construction phase is medium.

b. Project Operation:

The nature of the completed facility is such that environmental impacts will be kept to a minimum. Expected impacts will occur with increased visitor and vehicle traffic affects to noise and air quality, solid waste accumulation, resource use, and the introduction of flora species into the area due to landscaping.

The intake/outfall structure will have minimal impact on water quality, marine life, and the neighboring reef. Studies of similar facilities in Hawaii and California indicate that there is no expected change in temperature, pH, density, salinity, or organic/inorganic water quality parameters between the existing seawater and the outfall seawater. A value given to the environmental impact criterion for project completion is low.

2. Cocos Island:

a. Project Construction:

The Cocos Island site is located one and a half miles offshore from the most southern tip of the Guam. Transportation to the island is

by boat. Excavation and construction required for the proposed project will place a high demand on energy, labor, and other resources. The removal and displacement of vegetation and wildlife may have an adverse effect on the bird sanctuary which shares the island. The increase of erosion will effect water quality, ground cover, and the existing environment. Expansion and implementation of utilities will have impacts both on the marine and terrestrial ecosystems of the island of Guam and Cocos Island. Construction of the intake/outfall structure will take place in the area of a sensitive lagoon environment. Reduction in water quality during the marine construction may have adverse impacts on the reef and wildlife. Introduction and increase in traffic to Cocos Island will contribute to the expected impacts. The proposed facility will require extensive precautions and comprehensive mitigative measures during construction. The value given to the environmental impact criterion is high for the construction phase.

b. Project Operation:

The environmental impacts which the completed project are projected to have on Cocos Island's environment are similar to those described for Gun Beach. However, due to the sensitive marine ecosystem, the bird sanctuary, and the remoteness of the site; the environmental impacts are expect to substantially alter the existing environment. Based upon the sensitivity of this site, the value given to this criterion is high.

3. No Action Alternative:

The no action alternative would leave the Gun Beach site in its current undeveloped state. No adverse impacts would result, however, no benefit to the community would occur either. There would be no fiscal benefits, no innovative and unique recreational facility introduced to the island of Guam. Additionally, potential future impacts from other, more conventional development would be as great or greater than the proposed EnterOcean facility.

F. Cost:

The cost of the EnterOcean facility is partly determined by the specific excavation and construction

work required. Cost differs with each alternative site due to the existing environmental conditions. Alternative project sites have been analyzed with respect to the projected cost.

1. Gun Beach:

The cost of grading, excavation, construction of the structural and mechanical features, and the installation of the intake/outfall system will be approximately 4 million dollars. Total project cost is an estimated 37 million dollars.

2. Cocos Island:

The cost of grading, transporting materials, providing water and utility services, construction of the structural and mechanical features and a intake/outfall system will be approximately 5 to 6 million dollars. Total project cost is an estimated 39 million dollars.

2.3 SITE ELIMINATION ANALYSIS

The analysis to determine the most suitable alternative site is a fundamental component of the EIA. The exercise of evaluating the alternatives provides an assurance that the best location for the proposed undertaking has been given fair

scrutiny and review. The process of elimination of the alternative sites has been based on the screening and refined criteria analysis described in sections 2.2.1 and 2.2.2. These criteria investigated factors which involved environmental concerns, location and proximity of each site, seawater access, existing development, and the issue of cost.

Initial screening analysis removed the Ypao Point Hospital alternative from further consideration due to seawater intake feasibility concerns. The two remaining alternative sites and the no action alternative were measured against one another using the refined criteria analysis displayed in Table 2.1. The comparison of differing criteria against each other in site selection is subjective in nature. However, the proposed Gun Beach project site was rated as superior or equal to all other considered alternatives in every evaluation category. Based upon this analysis, the Gun Beach site has been determined as the most appropriate site for the proposed undertaking.

SECTION 3
Existing Environment
at Gun Beach, Tumon Bay

SECTION 3

EXISTING ENVIRONMENT AT GUN BEACH, TUMON BAY

3.1 PHYSICAL CONDITIONS

The following section outlines the existing environment for the proposed site, Gun Beach. The information is derived from a Botanical Survey by Botanical Consultants (1991), an Archaeological Inventory Survey by PHRI (1992), and Environmental Baseline Survey by PBEC, Inc. (1992). In association with the University of Guam Marine Laboratory, "Coral Communities, Macroinvertebrates and Bottom Cover on the Fore Reef at Gun Beach" by Pauley et. al. (1994), and "Fore Reef Fishes" by Steven S. Amesbury (1994) are used for the purpose of this EIA. These surveys are enclosed in the Appendices at the end of this report.

3.1.1 General

A. Terrestrial

Gun Beach is located in the north end of Tumon Bay and South of Dos Amantes Point, which is also known as Two Lovers Point. The Gun Beach lot, 10113-R3, fronts a beach approximately 1,000 feet long and is backed by a gently sloping coconut grove which adheres to steep cliffs that rise to the limestone plateau

characteristic of northern Guam. The total lot area is approximately 87,500 square meters and the proposed project site is 18,000 square meters in area.

B. Marine

Gun Beach is approximately 14 meters (45 feet) wide and extends from Biija Point to Dos Amantes Point. There are high limestone outcrops that form steep cliffs at the shore. The beach is moderately steep and comprised of coarse limestone sand with some rubble.

The ocean fronting the Gun Beach site is characterized by an old uplift coral reef. The shallow reef flat, exposing at low tides, extends some 140 meters (460 feet) off the shore at Gun Beach. At the reef margin or outer edge of the reef flat, the bottom drops away quickly to a depth of around 3 meters (10 feet), then slopes downward to a sandy terrace at around 36 meters (120 feet) depth (Duenas & Assoc., 1993).

The coastal area at Gun Beach is comprised of a sandy beach front and a 100 meter wide, low intertidal to shallow subtidal reef flat that is dominated by a lightly dissected reef pavement and is largely devoid of loose sediments. The reef flat lacks a well

developed reef crest and gives way to the fore reef in a zone characterized with poorly developed spur and groove. On basis of geomorphology and coral communities, the fore reef can be divided into three major zones: 1) a shallow reef front, to a depth of 2 to 4 meters; 2) a relatively flat, even reef terrace between 3 - 15 meters; and 3) a steeper deep reef slope starting around 15 meters depth and continuing to considerably greater depths. These three zones were surveyed in the vicinity of the AT&T cable.

The marine environment dominates the proposed project site and includes a relatively narrow, 6 meter (20 ft) wide intertidal zone. Currents measured in the proposed project vicinity are generally slow with variable direction. Wind driven waves are normally under 2 meters (6 ft); however, higher waves may be associated with periodic storms. Severe waves are sometimes associated with a mean range of 0.5 meter (1.6 ft) and a diurnal range of 0.7 meter (2.3 ft) (Randall and Holloman, 1974). These tides create tidal currents at Gun Beach, described by Duenas & Assoc., (1993) as flowing basically seaward in a westerly direction.

3.1.2 Geology

The Gun Beach area was formed by the slumping of the limestone bedrock. This formed the steep cliffs and the sloping shelf extending into the ocean. The limestone is of the Mariana formation, which is a very porous and weathered rock. The limestone bedrock is exposed on most of the cliff face and scattered areas of the plateau.

The predominant soil formation is Ritidian - Rock Outcrop. The Ritidian soil covers about half of the surface. The secondary soil is Shioya loamy sand which is found along the beach where it can be deposited by wave action. Shioya soil is much deeper than the Ritidian soil and much more evenly graded. Both soil types are permeable and have low levels of available water.

3.1.3 Topography

A. Terrestrial

The Gun Beach has two distinct topographical regions, the seashore and coconut grove. These follow a gradually slopping area which is surrounded by steep slopes rising to the northern Guam plateau. The slopes range from 2% near the shore, to 24% at the base of the cliffs, to over 80% along cliff faces.

The existing road into the Gun Beach area crosses a saddle on the adjacent ridge. This saddle where Nikko Hotel is located provides the most gradual slope into the Gun Beach site.

B. Marine

Gun Beach is approximately 14 m (45 ft) wide and extends unbroken from Bihia Point to Gongna Point on which the Hotel Nikko sits. These points are high limestone outcrops that form steep cliffs at the shore just north of Tumon Bay. Gun Beach, also known as Fafai Beach, is moderately steep and comprised of coarse limestone sand with some intermixed rubble.

A shallow reef flat extends some 140 meters (460 feet) off the shore at Gun Beach. Most of the reef flat is dominated by a lightly dissected reef pavement and is largely devoid of loose sediments (Paulay, et al., 1994). The reef flat can be divided into two zones: an inner reef flat of mostly subtidal, sand bottom and an outer reef flat of mostly limestone, substantial portions of which uncover at low tide. Areas of sandy bottom extend seaward through the outer reef flat where a manmade trench carries an international cable into deep water and close to Bijia Point. This latter area is described as a "wide, shallow channel that

exits the reef front" (PBEC, 1992), although the existence of a channel in the reef off Bijia Point is doubtful.

The reef flat lacks a well developed reef crest and gives way to the fore reef in a zone with poorly developed spur and groove. On the basis of geomorphology and coral communities, the fore reef can be divided into 3 major zones: 1) a shallow reef front, to a depth of 2m to 4m, 2) a low sloping, reef terrace between 3 and 15 m, and 3) a steeper deep reef slope starting around 15 m depth and continuing to considerable greater depths (Paulay, et al., 1994). At the reef margin (outer edge of the reef flat), the bottom drops away quickly to a depth of around 3 meters (10 feet), then slopes downward to a sandy terrace at around 36 meters (120 feet) depth (Duenas & Assoc., 1993). However, the fore reef slope also comprises a terrace-like surface with a seaward edge at around 10 meters (33 feet) depth (Paulay, et al., 1994).

3.1.4 Climate

The general pattern of the temperature, precipitation, relative humidity, and wind direction on the island of Guam can

be obtained from the climatic records maintained and compiled by the NOAA Weather Service Meteorological Observatory at the Naval Air Station (NAS).

A. Temperature

Based on a 38 year period (1945-1982) obtained from NAS, Guam is characterized by a mean annual temperature of 81.2 F. The mean monthly temperature at NAS over this 38 year period ranged from 79.9 F in February to 82.2 F in June. The average maximum temperature was highest during the month of June at 86.0 F. The average minimum temperature was lowest during the month of February at 74.5 F.

B. Rainfall

During a period of 43 years (1945-1987), the mean monthly precipitation ranged from 3 inches in March and 13 inches in September. The mean total annual rainfall is 89 inches. The dry season falls between December and June, while the wet season falls between August and October. The months of July and November serve as the transitional months. During the dry season, the mean monthly precipitation ranged from 3 inches to 6 inches. The mean monthly precipitation during the wet season ranged from 12 inches to 13 inches. During 1945 to 1987, monthly mean rainfalls

of 10 inches and 8 inches fell in July and November (Duenas & Assoc., 1993).

C. Relative Humidity

During a 10 year period (1973-82), the mean monthly relative humidity at 0700 in the morning ranged from 83 percent in January and February, to 89 percent July through to September. At 1300 in the early afternoon, the relative humidity ranged from 66 percent in March to 77 percent in August. As expected, the higher humidity occurred during the rainy season.

D. Wind

Based on 38 years of observations between 1945 and 1982, the easterly tradewinds are dominant from April to December. The prevailing wind from January to March is from the east northeasterly direction. The higher average wind speed, 7.4 to 9.4 mph, occurs during the dry season in December to June. Tropical storms and typhoons are most prevalent during the wet season, however, typhoons can occur during the dry season. Although Gun Beach is sheltered from prevailing winds because of its location below the level of the northern plateau, storms approaching from the west can have a strong impact on the area.

3.1.5 Currents

The North Equatorial Current is influenced by the prevalent northeast tradewinds and sweeps past Guam towards a westerly direction. The current splits at the north or northeast corner of the island, and flows around both the north and south ends. Thus, the predominant current seaward of the reef margin, off of Tumon Bay, should be significantly towards the southwest direction. The temporary reversal of current direction related to tidal changes is a common phenomenon in Guam marine waters, and is expected to occur in Tumon Bay.

An Environmental Baseline Survey performed for Gun Beach indicates that the currents are generally slow and direction was extremely variable during both low and high tides (PBEC, Inc., 1992). The study concluded that the currents in the general area are not strong during most days. However, currents in the area are known to be extremely dangerous at unpredictable times of the year and during high storm wave action.

3.1.6 Water Quality

The waters off Gun Beach are classified by the Guam Environmental Protection Agency (GEPA) as M-2 marine waters (GEPA 1992). M-2 waters are considered by GEPA as areas of "good" water quality. Water in this category must be of sufficient

quality to allow for the propagation and survival of marine organisms, particularly shellfish, corals, and other reef related resources. Other important and intended uses, according to GEPA, include mariculture activities, aesthetic enjoyment, and compatible recreation inclusive of whole body contact and related activities. GEPA maintains water quality criteria that are applicable to the Territorial waters. Table 3.1 shows the water quality criteria applicable to the proposed project area.

The near shore reef flat was surveyed in 1992 (PBEC. Inc., 1992) and some limited water quality measurements were made. Samples were collected from just below the water surface close to low water on the flood tide (Sept 24, 1992), and close to high tide on the ebb tide (Sept 29, 1992). Results are presented in Table 3.2. The values range from 1.14 to 12.50 NTU for turbidity and from 2.4 to 18.5 mg/l for suspended solids.

In order to characterize the existing water quality of the project site, AECOS Inc. cooperated with the University of Guam (UOG) to collect and analyze water sample from the stations distributed from the near shore area out to approximately 50 meters (165 feet) seaward of the reef margin. The stations used to evaluate water quality patterns, shown in Figure 3-1, are grouped into several categories based upon their location relative to the reef.

GUAM WATER QUALITY STANDARDS FOR M-2 (MARINE - GOOD) WATERS TABLE 3.1		
Criteria	Standard	Allowable Deviation
Fecal Coliform Bacteria	70/100 ml (30 day ave) 400/100 ml (absolute)	
pH	7.0 - 9.0	+/-0.5 pH
Orthophosphate	0.05 mg/l	
Nitrogen	0.20 mg/l	
Dissolved Oxygen	75% saturation (typically 4.6 - 5.0 mg/l)	
Salinity	Ambient	+/- 10% from ambient
Filterable Solids	20 mg/l expect by natural causes	+10% from ambient
Turbidity	Ambient	+1.0 NTU from ambient
Temperature	Ambient	+/- 1.0 degree centigrade
Pesticides		1% of 24 hour LC50 (most sensitive species) (or Federal EPA standard if lower)
Toxic Substances (126 Section 307 EPA Toxic Pollutants)		5% of 96 hour LC50 (absolute) 1% of 96 hour LC50 (24 hour average) (or Federal EPA standard if lower)
Aluminum	0.20 mg/l	
Ammonia	0.02 mg/l	
Barium	0.50 mg/l	
Boron	5.00 mg/l	
Bromine	0.10 mg/l	

TABLE 3.1 (continued)		
Bromate	100 mg/l	
Chlorine (total residual)	0.00 mg/l	
Fluoride	1.50 mg/l	
Iron	0.05 mg/l	
Manganese	0.02 mg/l	
Sulfide	0.005 mg/l	
Tributyltin	0.010 ug/l	once every three years, average
	0.356 ug/l (one hour average)	once every three years, average

Table 3.2 Water quality measurements on the reef flat fronting Gun Beach. Samples were taken from four stations on two dates in September, 1992. Samples were tested for turbidity (NTU) and suspended solids (mg/l). See Figure 3-1 for location of stations.				
STATION	TIDE	TURBIDITY (NTU)	SUSPENDED SOLIDS (mg/l)	
9/24/92				
1	Low incoming	1.90	2.4	
2	Low incoming	1.62	8.5	
3	Low incoming	12.5	18.5	
4	Low incoming	4.25	8.6	
9/29/92				
1	High outgoing	1.39	5.4	
2	High outgoing	1.56	8.6	
3	High outgoing	1.14	8.4	
4	High outgoing	1.31	18.2	

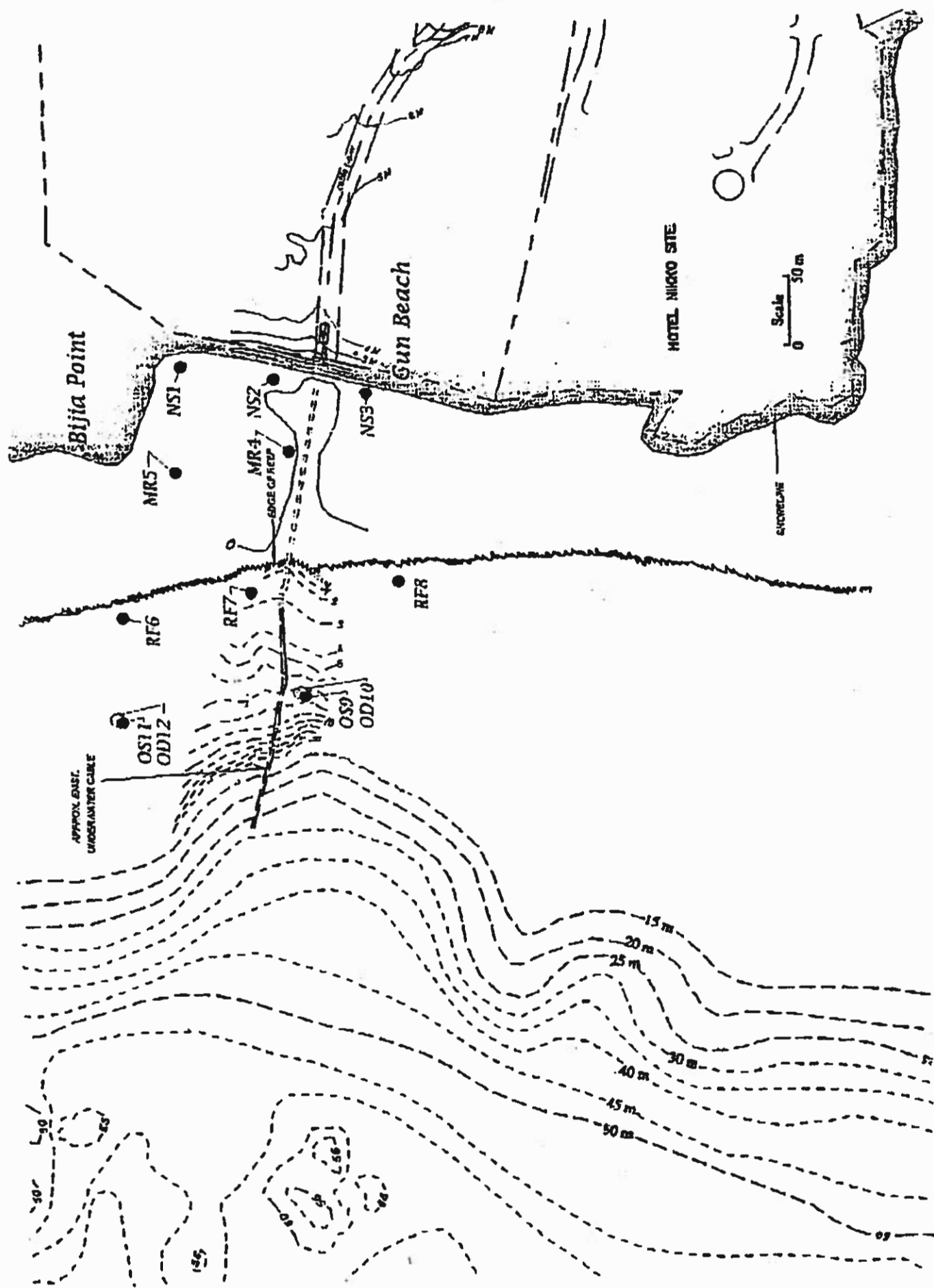


FIGURE 3-1
WATER QUALITY SAMPLE LOCATIONS
OFF GUN BEACH, NOV. 20, 1994.

The present analysis of the water quality conditions in the waters off Gun Beach is based on one set of samples collected at 12 stations on November 29, 1994. Figure 3-2 portrays the studies performed off shore of Gun Beach. The analytical results are portrayed in Table 3.3. The data is categorized into shoreline sets, mid reef sites, the ocean sites located just off the front of the reef, and the ocean sites located off shore. Table 3.4 and 3.5 display the non-nutrient and nutrient water quality summaries from the samples collected. The arithmetic means were calculated for the temperature, salinity, and dissolved oxygen and, the geometric means were calculated for the remaining water quality parameters. The parameters, temperature, pH, turbidity, suspended solids, chlorophyll α , and nutrients, tend to decrease in value with distance from the shore. For example, salinity decreases from the shore. However, dissolved oxygen showed no trend with distance from shore.

All of the sample values were well within the range of water quality criteria for M-2 waters with the exception of the dissolved oxygen. DO saturation was less than 75% at Station MR5, Station OS9, and Station OD12. Turbidity levels at Stations NS1, NS3, and MR5 were more than 1 NTU higher than any of the other stations, but ambient turbidity across the reef flat probably is frequently higher than in the waters seaward of the reef.

PBEC, INC.,
1992 STUDY

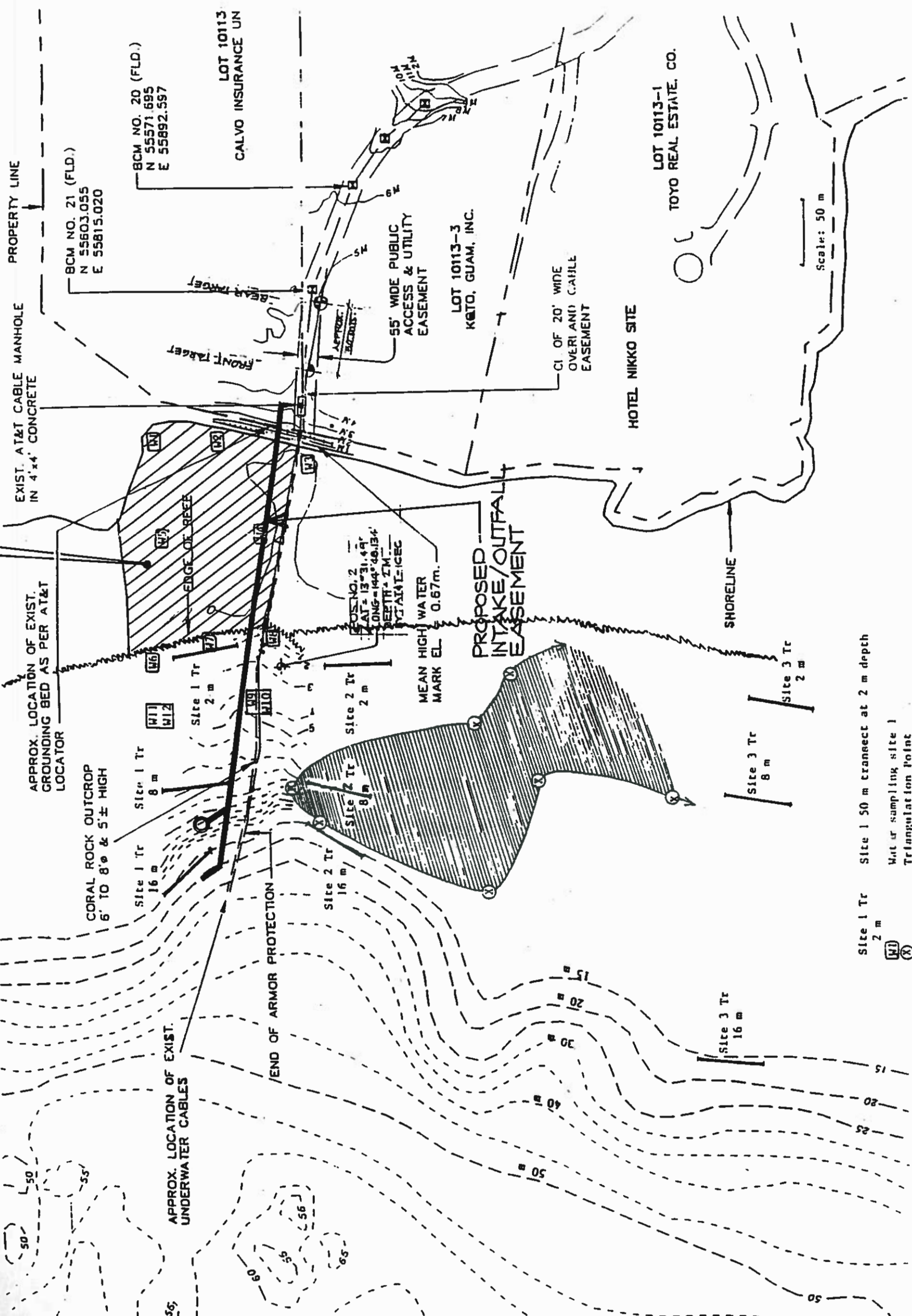


FIGURE 3-2
ENVIRONMENTAL
BASELINE STUDY
GUNBEACH
GUAM

Table 3.3 Analytical results, sea water samples off Gun Beach, Guam.

Shoreline Sites (located at approximately 2 meters off the shoreline)

Station	Depth	Time	Temp (oC)	SAL. (ppt)	D.O. (% sat)	D.O. (mg/l)	pH	TURB. (ntu)	TSS (mg/l)	NO ₃ +NO ₂ (mg/l)	NH ₃ (mgN/l)	Total N (mgN/l)	Ortho-P (mg/l)	Total P (mg/l)	CHL & (µg/l)
NS1	0.2m	1520	29.7	33.77	89	2.22	10.3	0.044	0.003	0.044	0.003	0.211	0.004	0.013	0.32
NS2	0.2m	1535	29.1	34.31	82	5.1	8.42	0.84	10.2	0.021	0.022	0.198	0.009	0.010	0.17
NS3	0.2m	1530	29.4	34.30	82	5.2	8.46	2.58	9.1	0.012	0.002	0.140	0.008	0.014	0.41

Mid Reef Sites (located at approximately the middle of the reef flat)

Station	Depth	Time	Temp (oC)	SAL. (ppt)	D.O. (% sat)	D.O. (mg/l)	pH	TURB. (ntu)	TSS (mg/l)	NO ₃ +NO ₂ (mg/l)	NH ₃ (mgN/l)	Total N (mgN/l)	Ortho-P (mg/l)	Total P (mg/l)	CHL & (µg/l)
MR4	0.2m	1600	28.4	34.57	77	5.6	8.35	0.44	4.1	0.003	0.001	0.105	0.007	0.010	0.22
MR5	0.3m	1542	29.5	33.87	63	5.5	8.41	1.78	3.9	0.014	0.002	0.132	0.006	0.010	0.19

Ocean Sites (located just off the front of the reef)

Station	Depth	Time	Temp (oC)	SAL. (ppt)	D.O. (% sat)	D.O. (mg/l)	pH	TURB. (ntu)	TSS (mg/l)	NO ₃ +NO ₂ (mg/l)	NH ₃ (mgN/l)	Total N (mgN/l)	Ortho-P (mg/l)	Total P (mg/l)	CHL & (µg/l)
RF6	0.5m	1129	28.0	33.17	79	6.8	8.29	0.22	3.1	0.022	0.002	0.116	0.007	0.010	0.10
RF7	0.5m	1117	28.0	34.56	80	6.9	8.27	0.46	1.1	0.007	0.002	0.137	0.006	0.009	0.10
RF8	0.5m	1102	28.0	34.55	95	7.1	8.27	0.31	1.3	0.005	0.002	0.131	0.005	0.010	0.19

Ocean Sites (located offshore)

Station	Depth	Time	Temp (oC)	SAL. (ppt)	D.O. (% sat)	D.O. (mg/l)	pH	TURB. (ntu)	TSS (mg/l)	NO ₃ +NO ₂ (mg/l)	NH ₃ (mgN/l)	Total N (mgN/l)	Ortho-P (mg/l)	Total P (mg/l)	CHL & (µg/l)
OS9	0.5m	1232	28.0	34.51	69	5.3	8.25	0.23	0.5	0.004	<0.001	0.126	0.005	0.009	0.17
OD10	7.0m	1242	27.7	34.58	57	5.5	8.24	36	2.3	<0.001	<0.001	0.133	0.004	0.009	0.13
OS11	0.5m	1140	27.9	34.45	80	6.2	8.26	0.31	4.5	0.005	<0.001	0.128	0.004	0.011	0.15
OD12	7.0m	1155	27.8	34.58	81	6.3	8.23	0.24	3.7	<0.001	<0.001	0.129	0.004	0.010	0.16

TABLE 3.4
NON-NUTRIENT WATER QUALITY SUMMARIES FROM SAMPLES COLLECTED OFF GUN BEACH

STATION GROUP	DEPTH (m)	TEMP (oC)	SALINITY (o/oo)	pH	D.O. (mg/l)	D.O. (% sat)	TURBIDITY NTU	TSS (mg/l)	ChL a (ug/l)
NS1/NS2/NS 3	0.2	29.4	34.13	8.42	5.2	84	1.69	9.9	0.28
MR5/MR4	0.3	29.1	34.22	8.42	5.6	70	0.88	4.0	0.20
RF6/RF7/RF 8	0.5	28.0	33.87	8.28	6.9	80	0.32	1.8	0.10
OS9/OS11	0.5	28.0	33.87	8.28	5.8	75	0.27	1.5	0.14
OD10/OD12	7.0	27.9	34.58	8.24	5.9	69	0.29	2.9	0.16
GRAND MEANS		28.7	34.13	8.35	5.9	80	0.71	4.6	0.18

TABLE 3.5
NUTRIENT WATER QUALITY SUMMARIES FROM SAMPLES COLLECTED OFF GUN
BEACH

STATION GROUP	DEPTH (m)	NO3 + NO2 (ug/l)	NH3 (ug/l)	TOTAL N (ug/l)	PO4 (ug/l)	TOTAL P (ug/l)
NS1/NS2/NS3	0.2	22	2	180	7	12
MR5/MR4	0.3	6	1	119	6	10
RF6/RF7/RF8	0.5	12	2	126	6	9
OS9/OS11	0.5	4	0.05	127	4	10
OD10/OD12	7.0	0	0.05	131	4	9
GRAND MEANS		7	0.8	146	6	11

Comparison of the mean values indicate that there is a natural break in the distribution patterns for a number of the parameters, such as temperature, suspended solids, turbidity, and pH. This allows the data to be further condensed or regrouped into "reef flat" (Stations NS1, NS2, NS3, MR4, and MR5) and "offshore" (all other stations) regions for the practical considerations and statistical analyses of water quality. Table 3.6 and 3.7 demonstrate the parameter values for non-nutrients and nutrient water quality data for the regions titled reef flat and offshore.

In general, water quality was good for both the offshore and reef flat areas. The small differences in mean values for most parameters indicate that water in the reef area was flushed and replaced with offshore water over a short time period. Strong long shore currents were observed in the near shore waters moving in a southerly direction and exiting the reef area and rapidly replaced with offshore waters.

Although the survey revealed modest mean differences between the reef flat and offshore waters, some significant differences ($P < 0.01$) were found in the two areas for some of the parameters in Table 3.5. The significant differences in temperature, turbidity, and suspended solids between the reef flat and the waters seaward of the reef are significant for the purpose of this project. In each of these cases, the high values

table 3.6 and table 3.7 were found in the reef flat area,

3.1.7 Hydrology

The limestone bedrock at Gun Beach is very porous and does not allow for the formation of streams or ponds to occur. Rainwater percolates through the limestone down to the saturation zone and then flows laterally to the shoreline. It emerges from cracks and fissures along the intertidal and subtidal zones. A study by Emery (1962) found the groundwater discharge rate to be 1.5 cubic feet per second at the adjacent Gogna Beach. This rate is expected to be found at Gun Beach because of similar geologic features.

3.1.8 Archaeological Features

A. Methods

An inventory survey of the property was conducted by the firm of Paul H. Rosendahl, Inc., PHRI, in 1992. This study consisted of a complete ground survey of the project area which included excavations of 22 backhoe trenches along the beach stand, and 45 shovel test pits on the limestone terrace. The purpose of the survey was to identify areas of archaeological artifacts and features of significance. The

TABLE 3.6
NON-NUTRIENT WATER QUALITY DATA MEANS RECALCULATED FOR REEF FLAT AND
OFFSHORE SAMPLE AREAS

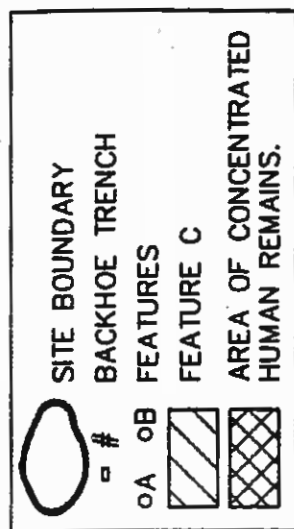
	TEMP (°C)	SALINITY (o/oo)	D.O. (% sat)	D.O. (mg/l)	pH	TURBIDIT Y NTU	TSS (mg/l)	Chl a (µg/l)
REEF FLAT	29.2	34.16	79	5.3	8.42	1.30	6.9	0.25
OFFSHORE	27.9*	34.53	76	6.1*	8.25	0.29*	1.9*	0.16*

TABLE 3.7
NUTRIENT WATER QUALITY DATA REGROUPED AND RECALCULATED FOR REEF FLAT
AND OFFSHORE SAMPLE AREAS

	NO ₃ + NO ₂ (µgN/l)	NH ₃ (µgN/l)	TOTAL N (µgN/l)	PO ₄ (µgP/l)	TOTAL P (µgP/l)
REEF FLAT	29.2	34.16	79	5.3	1.30
OFFSHORE	27.9*	34.53	76	6.1*	0.29*

importance in the recognition of archaeological objects is to ensure that a thorough historical understanding of the area is developed, the elimination of impacts during the construction phases, and the application of future mitigation methods. This process is in accordance with recommendations made by the Guam Historic Preservation Office (GHPO). This section summarizes the findings of the inventory survey with reference to the specific areas related to the construction and completion of the undertaking. PHRI Archaeological Inventory Survey is include in this EIA as Appendix B.

A total of five prehistoric sites and two historic sites are identified in Figure 3-3. The largest prehistoric site previously identified by the GHPO is Site No. 66-04-0001, and contains both World War II features and prehistoric materials. The other four sites are much smaller in area and represent only a few notable features. These sites are referred to as Site Nos. 66-04-0615 through 0618. The specific sites that the proposed undertaking will effect are 66-04-0615 and 66-04-0617. For the purpose of this study, the method of radiocarbon dating has been used.



PROJECT AREA BOUNDARY

66-04-0618

66-04-0617

66-04-0615

66-04-0616

66-04-0001

GUN BEACH ROAD

SITE ACCESS ROAD

BACKHOE TRENCH

0 100 200 400 600 200m

CONTOUR INTERVAL - 50ft

BIJIA POINT

PHILIPPINE SEA

FIGURE 3-3
ARCHAEOLOGICAL SITES

B. Prehistoric Sites

Site 66-04-0615 is located on raised limestone terrace in the eastern portion of the project area. Portable remains recovered include prehistoric ceramics, marine shell and thermally altered rock. Feature B is a large piece of coral rock located on the eastern edge of Feature A. The Base is firmly buried in the black soil with approximately 0.50 m extending above ground surface. Feature A is identified as a midden area, or refuse pile. Feature B is an unidentifiable coral monument. It is unknown whether the two features are related in significance.

PHRI's Archaeological Inventory Survey has classified Feature A as having a Tentative Functional Interpretation (TFI) being habitation. Feature B's TFI is unknown. The Cultural Resource Management Value for both features is high in scientific nature and low in both Interpretive and Cultural Resource Management perspectives.

Site 66-04-0617 is a cave located on the edge of a large depression at the western edge of the raised limestone terrace. The entrance to the cave is small, 0.5 m high by 0.5 m wide. The opening of the cave is located beneath a large banyan tree which grows on the eastern edge of the depression. The interior of the cave measures approximately 6.0 m deep, 5.0 m wide,

and 0.85 m high. A sparse scatter of prehistoric ceramics, land and marine shell and nonhuman bone was noted within the cave and on the surface in the surrounding vicinity. The nonhuman vertebrate remains recovered from this site are assumed as not being of prehistoric cultural origin.

PHRI's Archaeological Inventory Survey has classified this site as habitation and is given a high value for scientific research and a low value for both interpretive and cultural nature. The PHRI survey has described the concerned sites as having a General Significance Assessment for information content only, with further data collection recommended.

3.2 BIOLOGICAL DESCRIPTION

3.2.1 Flora

A. Terrestrial Flora

The vegetation of Guam's limestone plateau has been influenced by a multitude of factors. Although pre-European population had an influence on the vegetation, the arrival of Europeans, World War II and the introduction of alien species, has given Guam significant modifications in the vegetation type. These impacts are visible in the presence of

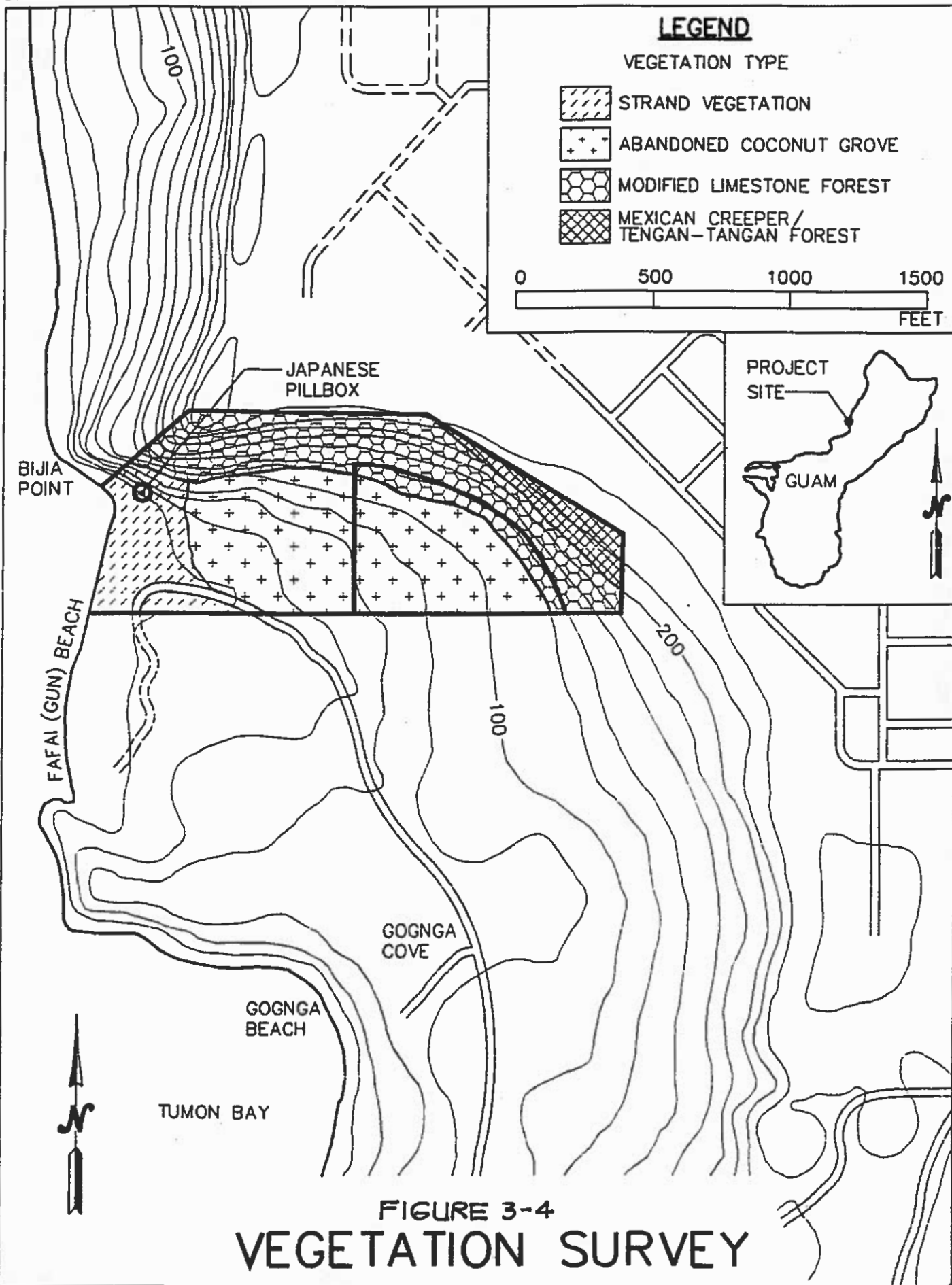
introduced and secondary plants within the existing forest. Today Guam's forests are categorized as being modified rather than solely replaced.

1. Mexican Creeper/Tangantangan Community

The forest vegetation at the top of the cliff along the northeastern property line has been cut down as shown Figure 3-4. This 20 meter wide swath was trimmed and the area has grown back with Tangantangan tress and Mexican creeper (*Antigonon leptopus*) vines. Both Tangantangan and Mexican creeper are recently introduced species. Figure 3-4 shows that the proposed undertaking will not be effecting this vegetation.

2. Modified Limestone Forest Community

The cliff face below the Mexican creeper/Tangantangan community is vegetated by a modified limestone forest. The forest is deemed modified because the area is so small that many of the large trees usually associated with limestone forests are absent and a fair number of introduced species are present. The largest trees found here are Pandanus and Fagot (*Neisosperma oppositifolia*). These large trees enable the



epiphytic fern colonies to be present. The understory contains smaller trees and shrubs such as Cycad, PaiPai, Ixora and (*Eugenia*) species, as well as many ferns. Seedlings and vines make up the ground layer vegetation. The northern cliff is steep and rocky and is unable to support tree growth. The predominant vegetation on the cliff areas is ferns.

3. Abandoned Coconut Grove:

Figure 3-4 demonstrates that the central portion of the property contains an abandoned coconut grove. This grove was probably cultivated previously and has become overgrown with neglect. The mature trees include Breadfruit, Pandanus, Pago, African tulip and Custard apple trees. The ground cover is ferns, Mile-a-minute vine (*Eupatorium*), and coconut seedlings.

From the point where Gun Beach Road crosses the site and to the west, the persisting coconut plantation is very disturbed and the vegetation which grows among the trees consists of introduced grasses such as Elephant grass, wild sugar and Mission grass.

4. Strand Community:

There is a small area of strand vegetation extending inland about 15 meters from the high

tide line. This area permits visitors to access the beach by vehicle which has damaged the vegetation extensively. The ground vegetation is primarily Beach Morning glory, Bermuda grass and wire grass. A few shrubs and trees are found, although none of the trees are large. The varieties include Hunig, Pandanus, Kamachile, Nonak and Nanaso.

5. Endangered Species:

No listed or proposed, threatened or endangered plant species (USFWS 1990, GEPA 1987) were found during the study. No such plants have been reported from this site and there is no evidence to support the notion that endangered species may be present in this area.

B. Marine Flora

Only the shallow reef flat is an area of significant algal growth off Gun Beach. The inner reef flat, extending 30 meters (100 ft.) off shore, is mostly sand bottom overlaying limestone. The outer reef flat, where limestone substratum uncovers on low tides, is an algal rich zone dominated by mats of *Boodlea composita*, *Gelidiella acerosa*, and *Gelidiopsis intricata*. A total of fourteen species of fleshy and encrusting algae were identified in a previous survey

of the reef flat (PBEC, Inc., 1992). Most species were found in both the near shore and the outer parts of the reef flat, although only green alga, *Cladophora fascicularis*, was more abundant inshore than offshore. A survey made in 1993 (Duenas & Assoc., Inc., 1993) identified algal assemblages along the trench cut across the reef flat off Gun Beach for the submarine communications cable. In general, the sandy bottom of the trench supported few species of algae. However, a total of nineteen species of algae were identified from mostly along the limestone rock margins. The green alga, *Boodlea composita*, and the brown alga, *Paduba boryana*, were most conspicuous, along with a turf (a dense, closely cropped or low-growing assemblage of species) of *Gelidiopsis intricata*, *Gelidium divaricata*, *Amphiroa fragilissima*, and *Jania capillacea*. Near the outer part of the trench, *Mastophora rosea*, *Galaxaura marginata*, and *Halimeda opuntia* were common.

The survey by Duenas & Assoc., Inc. (1993) also identified algal assemblages along the cable route down the frontal slope of the reef where a total of seventeen species were recorded. *Galaxaura marginata* and *Liagora* cf. *farinosa* were the dominant species at around 3 meters (10 ft.) depth. Between 3 and 30 meters (10 to 100 ft.), *Porolithon* sp., *Microcoleus*

lyngbyaceus, *Schizothrix calcicola*, *Halimeda discoidea*, and *H. opuntia* were the most prominent.

3.2.2 Fauna

A. Terrestrial Fauna

The terrestrial fauna of the Gun Beach area is limited to small reptiles and mammals because of the limited area and human activities. Geckos, skinks and chameleons are common at Gun Beach, as throughout the Tumon area. Rats, mice and shrews may be found in the area, typically follow the pattern of human population. The largest animals that may be found are feral dogs and cats, which are more likely to be in densely populated areas. The Appendix 6 lists birds and terrestrial fauna.

The Division of Aquatic and Wildlife Resources, Department of Agriculture have stated that the native forest birds on Guam can only be found in the isolated forests on the northern part of the island. The only native bird that might be found at Gun Beach is the Yellow Bittern. A previous EIS for the microdredging of Tumon Bay (Barrett 1988) did not find Yellow Bitterns anywhere in the Tumon Bay area.

The Golden Plover is the most common shore bird on Guam and can be found occasionally at Gun Beach. These birds prefer open grassy areas and are more common on the cliff top plateau than the beach area. Other shorebirds that may be found in the Gun Beach area are the Ruddy Turnstone, Whimbrel and Reef Heron. Shorebirds are not generally common in the Tumon Bay area because of the disturbances made by beach cleaning, pedestrians and the on going construction activities.

Several introduced birds that have become common on Guam may be found on the site. The Eurasian Tree Sparrow, Black Drongo and Philippine Turtle Dove may inhabit the forested areas. White (Fairy) Terns have been seen at nearby Dos Amantes Point and nesting on the cliff. A complete listing of the birds of the area is included in the appendix 6.

B. Marine Fauna

The frontal slope of the fringing reef was surveyed in November 1994 by a team of biologists from the University of Guam Laboratory in order to describe the environment into which the intake and outfall pipes will be placed.

The sandy, inner reef flat is characterized by the sea cucumber, *Holothuria leucospilota*. Foraminifera, shelled amoeboid protozoans, are abundant everywhere on the reef flat, and the shells (called tests) are a significant contributor to the beach sand. Corals are rare and restricted to the margins of small boulders. Coral colonies are most numerous and species diversity greatest on the reef flat off Biija Point where the depth is slightly more than for the outer reef flat generally (PBEC, Inc., 1992). Because this area is not uncovered by most low tides, the reef flat here is more conducive to coral growth.

A total of 18 coral species were observed on the reef flat during the 1992 survey (PBEC, Inc., 1992). Corals were most abundant and diverse on the more seaward parts of the outer reef flat, beyond the zone of dense algae growth. The greater prevalence of holes and depressions in the limestone and the substantial wave wash even at low tide, are cited as reasons for the improved coral growth here as compared with the more landward parts of the flat. The most common species on the reef flat is identified as *Psammocora obtusangulata*. Also common is *Porites lutea*. Small, encrusting colonies of *Leptastrea purpurea* are common on the inner parts of the reef flat where suitable

substratum exists. Duenas & Assoc., Inc. (1993) noted only two live coral heads in the cable trench extending off Gun Beach, while recording eleven species from the reef margin in the general vicinity of the trench.

A variety of echinoderms, including seven species of sea cucumber, have been identified from the reef flat off Gun Beach (PBEC, Inc. 1992). In addition to the *Holothuria leucospilta* mentioned above, *Stichopus cholronotus*, *Actinopyga echinites*, and *A. mauritiana* were common, the latter two particularly on the seaward portion of the outer reef flat. Duenas & Assoc., Inc. (1993) noted *Holthuria atra*, *Actinopyga echinites*, and *Bohadshia marmorata* "...adjacent to ledges along the [cable] trench". Sea urchins (*Echinothrix diadema* and *Echinometra mathaei*) and sea stars (*Linckia laevigata*) are present, but not particularly abundant in this area (PBEC, Inc. 1992). The most abundant mollusks on the reef flat are the money cowry, *Cypraea moneta*, and a small mussel. A large topshell (*Trochus niloticus*) was noted in about 12 meters (40 ft.) of water on the reef front.

A survey of the reef front off Gun Beach (Pauley et. al., 1994) was undertaken in detail to assess the

potential impacts construction and operation of proposed sea water intake and outfall pipes will have on biological assemblages. The whole of the fore reef is dominated by hard substrata, with sand and rubble constituting <5% cover at all but one survey transect location (Site 2, at 16 meters, recorded at 9% - see Figure 3-2). Turf algae, coralline algae, corals, and sponges (mostly the "coral killer sponge", *Terpios hoshinota*) dominate the substratum, their relative abundance apparently dependant mostly on 1) depth and 2) location of extensive *Porites rus* stands.

The three shallow transects (Figure 3-2) are similarly dominated by the turf algae, with coralline algae abundant (28-34%), coral cover moderate (6-17%), and sponges rare (<2%). The dominant coral species vary somewhat among the three sites, although *Galazaea fascicularis*, *Goniastrea retiformis*, *Leptoria phrygia*, and *Stylocoeniella arrnata* are common at all transects. *Acropora* was rare at this depth, although several *Acropora* species are abundant on the shallowest reef front (<1m). Coral colony size is generally small at 2 meters (6 ft.) depth.

At 8 meters (26 ft.) depth considerable variation is evident among transect sites, due mainly to the

presence of extensive *Porites rus* stands at Site 3, and, especially at Site 2. In these stands, corals (largely *Porites rus* - 33-51%), and sponges (largely *Terpios hoshinota* - 24-30%) dominate the bottom. At Site 1, turf algae dominate and two coral species, *Leptastrea purpurea* and *Porites lobata* contribute over two thirds of the 15% coral cover. The considerable abundance of large corals at Sites 2 and 3, but not Site 1 is due to the abundance of large (0.5-2.5 m across) *P.rus* colonies.

As revealed by the tow surveys, the corals *Porites rus* is generally common along the seaward edge of the reef slope terrace, at least for several hundred meters both north and south of the AT&T cable path. All three 16 meters (52 ft) depth transects were in zones of moderate to high *P. rus* abundance. *Porites rus* dominates the bottom on the terrace in a large patch starting about 20 meters (65 ft) to the south of the cable path and continuing for considerable distance to the south (Figure 3-2). The 8 meter (26 ft) transects at sites 2 and 3 were in this assemblage, and the shallowest transect at Site 3 also had moderate *P.rus* cover. The boundaries of this *P.rus* community are abrupt at some locations, but more gradual and thus subjective at others.

The deepest (16 m or 52 ft) locations were all situated at the start of the deep reef slope, past the seaward edge of the frontal slope terrace. *Porites rus* is common in this area along the entire reef front surveyed, but does not usually reach as high cover as it does in the areas of the terrace where it dominates the substratum. At the deep transects, bottom cover is dominated by algae (36-71%), with corals forming moderate cover (13-20%). At sites 1 and 2, *Porites rus* dominated (96-97% of total coral cover), and sponges (mostly *Terpios hoshinota*) were also abundant (31-33% bottom cover). There is a strong correlation between the abundance of *P. rus* and sponges among the nine locations. *Leptastrea purpurea* and several *Porites* species were among the most common other corals at all three deep sites.

Between 9 and 22 species of coral were encountered per transect (6 points), yielding a total of 49 species among the 576 points surveyed. The shallowest locations tended to have the greatest species richness, although this fact may be due in part to the relative rarity of *P. rus* at shallow depths, because this coral species so dominates many of the deeper sites.

A total of 26 macroinvertebrates (individuals or colonies > 5 cm) species were encountered within the 900 m² surveyed. Of these, the holothurians, *Actinopyga mauritiana*, *Stichopus chloronotus*, and *Echinothrix diadema* occurred most commonly (>0.1/m² population densities at least at one location). *Actinopyga mauritiana* is a characteristic inhabitant of reef fronts and occurred at a population density of 0.22 to 0.34 per m² at the three shallowest locations and absent in the transects at all deeper locations. All the other common species preferred the shallowest locations also. In contrast, the economically important holothurian, *Holothuria nobilis*, was encountered only within the deepest transects.

Much of the reef front off Gun Beach is fairly typical for Guam, with low to moderate coral cover, typical depth related coral zonation, and common echinoids and holothurians. The presence of extensive stands of *Porites rus* in such a fore reef setting, with correspondingly high coral cover is less widespread. On Guam, such dense *P. rus* stands are usually encountered in more protected inner reef environments, such as Apra Harbor and the Piti Bombholes, although they also occur at some fore reef sites. In contrast to surrounding coral communities, *P. rus* stands are

less diverse in their coral faunas perhaps because 1) this coral excludes others by its high cover, and 2) because of the correlated high abundance of the sponge *Terpios hoshinota*, which can rapidly overgrow and kill corals (Plucer-Rosario, 1988; Rutzler & Muzik, 1993). *Porites rus* however, contributes considerably to the topographic relief of the reef, as it makes colonies several meters high with abundant crevices. This allows for the development of a rich invertebrate cryptofauna observable on night dives in this area. Fish abundance also may be correlated with this topographic complexity, and the highest fish abundance was observed at Site 2, also the area of the most extensive *P. rus* stands.

An earlier survey conducted on the reef flat off Gun Beach identified 42 species of fishes on two visits to the area (PBEC, Inc., 1992). Abundant in schools were goatfish (*Mulloides flavolineatus*) and rabbitfish (*Siganus spinus*). Particularly abundant on the outer reef flat on high tide were *Chrysiptera glauca*, *Halichoeres trimaculatus*, and *Rhinecanthus triostegus*. The reef flat is characterized particularly by wrasses (ten species) and damselfishes (seven species). Results of fish surveys conducted in November 1993 along the route of the AT&T submarine communication

cable are presented in Duenas & Assoc., Inc. (1993). Fish surveys on benthic transects arranged across and down the reef front (Figure 3-1) in the project area were undertaken recently by Amesbury (1994) , the results of which are summarized as follows.

The reef front areas surveyed off Gun Beach had a diverse fish fauna. A total of 142 species were observed during the recent surveys. In general fewer species were found at the 2 meter (6 ft) depth transects than at the deeper sites. However, overall there was little difference in species richness among the three sites. The fish communities appear to be thriving at all three sites.

Fish abundance averaged approximately 1.5 fish/m², but there was considerable variability from transect to transect. Site 2 exhibited higher fish densities at all depths than did the other sites. Perhaps more important than depth or location influencing fish abundance was topographic relief: the flatter, more featureless areas, harbored fewer fishes than did areas with irregular bottom.

The damselfishes (Pomacentridae) were the numerically dominant fish group. Five damselfish species,

Plectroglyphidodon lacrymatus, *Stegastes fasciolatus*, *Pomacentrus vaiuli*, *Chrysiptera traceyi*, and *C. leucopoma*, accounted for 75% of all fishes counted along the transects. These are all small, site-attached species which feed primarily on algae. Some fairly large, harvestable species were also seen, including various species of surgeonfishes (family Acanthuridae), the jack, *Caranx melampygus*, the emperor, *Lethrinus xanthurus*, various species of goatfishes (family Mullidae), and various species of parrotfishes (family Scaridae).

Spinner dolphins (*Stenella longirostris longirostris*) are known to reside in Tumon Bay. Several recent sightings of these dolphins in pods of up to 30 individuals are reported in Duenas & Assoc., (1993) off the Hotel Nikko Guam and Double Reef. However, Tumon Bay is not considered a critical habitat for spinner dolphins. All marine mammals are protected under the Federal Marine Mammal Protection Act (MMPA).

The threatened green sea turtle (*Chelonia mydas*) and endangered hawksbill turtle (*Eretmochelys imbricata*) potentially inhabit the marine waters off Tumon Bay. Although Tumon Bay is not considered a sea turtle nesting area (Duenas & Assoc., 1993), an unidentified

sea turtle was seen by Amesbury (1994) near the project site (Site 3) during marine transecting.

3.3 LAND AND MARINE USE

The Gun Beach property is adjacent to and accessed from Tumon Bay, the center of tourism on Guam. The cliff top property is military property used for recreation and housing. Attractive Tumon Bay has always been a popular spot for visitors and residents. The following sections describe the existing land and marine activities.

3.3.1 Surrounding Uses

A. Land

Tumon Bay is a highly developed area where the tourism industry is centered. In 1994, over 5,000 rooms are available for occupancy in the immediate Tumon area. The areas between hotels are developed with shops, restaurants, apartments and a few single family homes.

In the immediate vicinity of the proposed undertaking is the Nikko Hotel, the Okura Hotel, and the Sun Route Oceanview. There are two adjacent lots, northwest of Gun Beach is Lot 10116-1 owned by Nansay Guam, Inc., and the immediate southern Lot 10113-3 owned by Koto

Guam, Inc. At this time both of the adjacent lots are vacant, and no future plans to develop are known.

The land at the top of the cliff to the north and east of the subject lot, is part of the Harmon Annex of Anderson Air Force Base. Baseball diamonds have been erected for public use and a few homes are still occupied in the immediate area. There are currently no plans for additional development of this land.

B. Ocean

Gun Beach is accessible to many marine-oriented activities. Duenas & Assoc., (1993) reported observing various recreational activities occurring during morning hours, including SCUBA diving, snorkeling, swimming, fishing, surfing, body boarding, and jet skiing. The site is used most frequently by divers and snorklers who follow the route of a submarine cable over the reef margin. Local fishermen fish the area with throw nets, rod and reel, and gill nets. Beach users are mostly residents of the area, but tourists occasionally walk from the beach fronting the Hotel Nikko Guam to the northern end of Gun Beach or enter the water along the northern cliff to visit Fafai Beach (Duenas & Assoc., 1993).

3.3.2 Future Plans

There are no secure plans for the adjacent lots surrounding the Gun Beach site. Studies for further development in the area have been initiated; however, there have been no commitments made regarding further hotel and housing development.

3.3.3 Existing Utilities

A. Water Supply

The primary supply line for water in the Tumon Area extends down Tumon Loop Road and San Vitores Avenue. When the Nikko and Okura Hotels were constructed, a twelve inch diameter water line was installed on the upper end of San Vitores or Gogna Road.

B. Wastewater System

The Tumon Area Water and Wastewater System Association (TAWWSA) are funding the construction of a new collection system, pump station and force main known as the Gun Beach/Fafai Wastewater System. The pump station is proposed to be located on the adjacent property along the existing road.

Currently the Nikko and Okura Hotels, and other commercial buildings, are served by an 8" diameter

gravity sewer which ultimately discharges to the Fujita Sewage Pump Station.

C. Road Capabilities

Access to the Gun Beach development will be along upper San Vitores Road and a new road extending from the end of San Vitores to the proposed Nansay development. The proposed road will be two lane, 24 feet wide, with a 50 foot wide easement.

D. Electrical Power

The electrical power to the project will be supplied from the existing transmission line extending to the Nikko Hotel. This line is a 13.8 kVA transmission line with a capacity well in excess of the current demand.

3.3.4 Community Characteristics

Tumon Bay has a resort feeling with the large hotels, shop and restaurants focused on the tourist. There are a number of private residences most of which are multifamily apartment units. The upper Tumon area on top of the cliff is heavily developed with commercial activities. The proposed undertaking will maintain and add to the present community atmosphere.

3.3.5 Unique Features

A. Beach

Gun Beach has a somewhat isolated feeling because of the separation from the main beach by Gogna Point and the encircling cliffs. EnterOcean plans to excavate the area so that the cliffs and rock out crops display a natural and complementary landscape. Public access to the beach will be maintained and improved upon the existing easement.

B. Archaeological Features

The predominant historical feature is the Japanese anti-aircraft gun turret from which the beach got its common name. The turret is a reinforced concrete bunker built against the northern cliff face on the property. The gun itself is rusty but intact. This turret is on the National Historic Record. The undertaking will not disturb this site.

Prehistoric archaeologic sites have been identified on the property. The proposed undertaking will not effect the majority of the sites, those that are within the undertaking's boundaries are detailed in section 3.1.8. However, the largest site located to the left of the undertaking, is functionally interpreted as a permanent habitation site with two

distinct occupational groupings. The stratified prehistoric ceramics, marine shell, thermally altered rock, flaked lithics, shell and stone tools, human remains and possible remnants of a disturbed latte set. The remainder of the sites are isolated and relatively small including surface and subsurface scatters of prehistoric ceramics, rock overhangs, and a cave.

The proximity and similarities in ceramic and apparent ages of the archaeological sites suggest components of a Latte Phase coastal settlement system. The remains appears to be a coastal village with temporary, intermittent or less intensively utilized habitation areas associated with but peripheral to the permanent settlement.

SECTION 4
Environmental Consequences
During Construction

SECTION 4

ENVIRONMENTAL CONSEQUENCES DURING CONSTRUCTION

4.1 DESCRIPTION AND SUMMARY OF CONSTRUCTION

The EnterOcean Group anticipates beginning construction in mid 1995 with an expected opening date of mid 1997. Required construction activities are described in the following section. The anticipated construction times of some activities overlap.

4.1.1 Site Work and Utilities

Because the proposed project site is on a hillside, approximately 100,000 cubic yards of material has to be excavated and removed to reach the facility elevation of +80 mean lower low water level (MLLW). An additional 50,000 cubic yards of material has to be excavated and removed during construction of the below grade seawater tanks and exhibit area. A portion of the materials will be held on site to backfill retaining walls; the remainder will be hauled off site. Excavation should take approximately nine months.

Concurrently with mass excavation, the extension of Gognga Road and the EnterOcean access road will facilitate extending water, sewer forcemain, electric, and telephone systems. These activities are expected to take six months and

will be completed shortly after roadway earthwork. Paving and landscaping will take place just prior to project completion.

4.1.2 Intake/Outfall System

Piping beneath exhibit slabs will be installed, tested and temporarily capped while other areas of the facility are being built. Other work associated with the intake/outfall will begin at the intake pump station and continue toward the ocean and facility concurrently. Two high density polyethylene (HDPE) pipes will be used for the intake and outfall. Nominal pipe diameter will be 30 inches. Construction dewatering may be required.

The pipeline alignment on land is a ten foot wide corridor adjacent to the southern boundary of lot 10113-R3. The intake pump station will be located on this corridor and 140 feet inland from the ocean side property boundary. The pump station is at elevation of 13 feet above MLLW.

The intake pipe extends seaward from the pump station for approximately 1090 feet and terminates at two intake structures placed at the 40 feet contour below MLLW. This site is seaward from the wave break zone. The ocean intake system will be constructed using dual intake towers. Each tower is a polygon holding six 3 ft. high x 4 ft. wide fiber reinforced plastic

(FRP) screens mounted on a 10 ft. square concrete base. Water face velocity at the intakes will be approximately 0.5 feet per second (fps). The intake screens prevent fish and other objects from entering the pipeline. The size and number of inlets are designed to keep intake velocities below normal current velocities to prevent small fish as well as divers from being held by suction to the pipeline.

The outfall pipe extends approximately 1240 feet seaward from the pump station. Both pipelines lie in a corridor located approximately parallel to and north of the AT&T submarine cable. Distance between the pipeline corridor and submarine cable varies from 28 to 50 feet. The outfall terminates at a diffuser at the 66 feet contour below MLLW. The ocean outfall system will be constructed using a single outlet diffuser identical in construction to an intake tower. Water face velocity at the outlet will be approximately 1.0 feet per second. Both intake towers and the outlet diffuser will be anchored to the seafloor.

Trench excavation for the intake and outfall will be done using a hydraulic rock chipper from the pump station until just beyond the reef flat. The remainder of the intake and outfall pipelines will be installed on top of the seafloor using a commercially available stainless steel anchoring system. Foundations for intake and outlet towers will be precast offsite and installed from an offshore platform. Total installation is

expected to take two months under favorable weather conditions.

4.1.3 General Facility Construction

After completion of subslab mechanical work, base slabs and retaining wall footings can be started. Construction effort will be concentrated on the seawater tanks and remaining concrete structural components. Installation of acrylic seawater tank windows, mechanical and electrical systems, and the EnterOcean entrance pavilion will begin after completion of structural concrete. Saltwater tanks and trails will be waterproofed and leak tested. Basic structural concrete construction is expected to take 9 months.

4.1.4 Exhibit Finishes

Aquarium rockwork and artificial coral can begin as soon as basic concrete construction is complete. The aquarium, submarine simulator cavern, and "Sea Cave Lounge" walls and ceilings will be clad in glass, fiberglass, reinforced concrete (GFRC); and the GFRC wall back filled with grout. Other exhibits will be done using carved gunite. Rockwork activities together contain 130,000 man hours representing about 35-40% of the total facility construction effort. Total rockwork installation is expected to take 11 months.

4.1.5 Canopy Placement, Exhibit Shops, Restaurants and Administration Buildings

Construction of the large canopy over the administration buildings, snack bar, gift shop, and restaurants will begin after basic structural concrete work. Any number of smaller canopies can be installed at a later date. Construction of the large canopy is expected to take 3 months.

Upon the completion of the main pavilion canopy, construction of underlaying retail shops may proceed. Shop construction is expected to take 9 months.

4.2 PHYSICAL CHANGES

Physical changes to the environment resulting from construction activities are discussed in the following section.

4.2.1 Soils and Geology

The existing bluff that is located on the northern and eastern portion of the project site will be steepened in order to bring the proposed project site to grade. Resulting man-made cliffs will be sculpted and naturalized in order to provide a pleasing appearance. These naturalized cliffs will provide the visual background for the project's saltwater trails.

Extensive excavation will also be required in order to construct saltwater tanks. Tanks will be constructed below grade within stable horizontal rock formations resulting from initial site work . Required drilling and chipping will be performed in compliance with local regulations to minimize noise and dust generation. Overall stability of the rock will not be affected by the project's underground features.

Soil types on site are Ritidian outcrop and Shioya loamy sand. Soil coverage is shallow with an underlying limestone bedrock. Both soils are weathered and porous. Mitigation measures will be implemented to deter and avoid soil erosion.

4.2.2 Hydrology

There are no streams or special hydrology features at the proposed project site. Soils and underlaying bedrock are highly permeable allowing rapid percolation of storm water. During construction, runoff from the EnterOcean project will be collected in temporary storm water retention basins. No runoff will be diverted from the project site.

No permanent withdrawal or reduction in groundwater flow is proposed. Use of storm water retention basins will leave the area's existing hydrology essentially undisturbed. During construction, dewatering may be necessary for excavation of the

intake and outfall pipelines and the project pump station. Excess water will be discharged into storm water retention basins where it will percolate back into the water table.

4.2.3 Noise

Construction activities involved with the proposed project are similar to those generated by previous construction in Tumon. The relative isolation of the proposed project will mitigate much of the construction noise.

4.2.4 Visibility

The only property which will have its view affected is the undeveloped Harmon Annex. The proposed undertaking will not exceed the height of the surrounding cliff and will block the view of any neighbor toward the ocean.

4.2.5 Pollutants

There will be no unusual levels of air or water pollutants generated by project construction. Further details regarding waste disposal during construction will be specified by the project's Environmental Protection Plan submitted with the Building Permit Application.

4.2.6 Archaeological Features

The historical and archaeological features that would be disturbed during construction are a coral monument, a midden area, and a cave. The coral monument and midden area are known as site 66-04-0615, shown in Figure 3-3. The small cave is site 66-04-0617. Both sites contain pre-historic matter which include scattered ceramics and marine shell. These archaeological features are located on or very close to the surface. Clearing will disturb and expose the articles. The recommended actions of collecting and recording the artifacts will sufficiently assemble relevant information. These two sites are not suitable for preservation or interpretation for visitors.

Archaeologists will be on site during the initial excavations to record the findings of any further artifacts uncovered. The proposed undertaking will not effect the Japanese pillbox that is a World War II landmark.

4.3 BIOLOGICAL CHANGES

4.3.1 Terrestrial Fauna and Flora

A. Flora

The abandoned coconut grove will be the vegetation community most effected by the development. The

present classification of the grove is 'modified' due to human activities. The trees have a high value for landscaping and can be readily transplanted elsewhere. Figure 3-4 shows the modified forest found in the proposed project site. A narrow portion of the forest will be affected by project construction. Removal of this portion of the forest would have a minimal impact of the existing limestone forest.

B. Fauna

The birds and animals inhabiting the property will be temporarily displaced by construction activities. Many species will more than likely return once the proposed project is completed because of their adaption to the human environment. Undeveloped properties along side and north-west of the project could act as a refuge for displaced fauna.

4.3.2 Marine Environment

Marine construction impacts are dependent on two factors:

1) the types of biota located within the proposed area of construction; and 2) physical changes to the environment caused by construction. This section evaluates expected impacts to

marine biota based on marine site surveys and preferred method of construction. Additional information on construction methods including an analysis of alternatives is contained in section 4.8.

Three surveys, PBEC Inc. (1992), Duenas & Associates (1993), and a University of Guam Study (1994), have been conducted in the project area. Sections 3.2.1B, and 3.2.2B summarize the results of these surveys. The PBEC study describes the environmental baseline for the reef flat. The University of Guam (UOG) study concentrates on the marine environment beyond the reef flat. Figure 3-2 shows the PBEC study area, transects surveyed by the University of Guam, the location of a large *Porites rus* coral colony, and the proposed intake/outfall alignment. Large coral colonies are avoided entirely by the proposed alignment.

Beginning with the shoreline, no study has identified any use of the beach area by nesting turtles, seals, or other marine organisms. Moving towards the ocean, the 1992 PBEC survey assesses the first one hundred feet of reef flat as having "no corals and few organisms of any kind in this zone." Therefore, no significant construction impact is expected in this area. According to the same study, the outer reef flat (beginning at about 250 feet from shore) is mostly covered with thick mats of algae due to exposure at low tides. The same study identified

several species of invertebrates which may also be relocated prior to construction.

Beyond the reef flat, site one transects from the University of Guam study effectively characterize the proposed intake and outfall area. Bottom coverage is typically algae. Percent bottom cover figures from these transects are summarized in table 4.1. The dominant species of hard coral is *Porites rus*. A total of less than 10 hard coral species were identified. Macroinvertebrate populations densities are summarized in table 4.2.

The University of Guam survey of Fore Reef Fishes at Gun Beach describes fish communities as thriving at the proposed construction site. Fish abundance appears to be 188 per 100 square meters of seafloor. A total of 48 fish species were identified at transect site one. Fish populations are expected to be unaffected by construction.

As previously discussed, the seawater inlet and outlet pipes will cross the reef flat by conventional cut and cover. Potential construction impacts may be caused by the physical act of trenching, turbidity and siltation effects from the excavation, and the visual impact of recovering the excavated area with concrete. In general, environmental impacts will be limited to the actual construction corridor. Silt curtains,

TABLE 4.1
PERCENT OF BOTTOM COVER AT SITE 1

DEPTH	SPECIES			
	ALGAE	CORALLINE	CORALS	PORIFERA
6.5 FT (2M)	60.4	33.3	6.3	0%
26.25 FT (8M)	74.6	7	14.6	0.63
52.5 FT (16M)	38.4	13.8	15.1	30.8

TABLE 4.2
MACROINVERTEBRATE POPULATION DENSITIES (PER M²)

SPECIES	DEPTH		
	2M	8M	16M
<i>Actinopyga mauritiana</i>	156	0	0
<i>Holothuria nobilis</i>	0	0	9
<i>Stichopus chloronotus</i>	32	0	0
<i>Echinometra mathaei</i>	0	14	0
<i>Echinostrephus aciculatus</i>	198	211	0
<i>Echinothrix diadema</i>	46	14	0
<i>Culcita novaeguineae</i>	0	0	5
<i>Linckia guildingi</i>	0	0	5
<i>Fromia milleporina</i>	0	5	0
<i>Tridacna maxima</i>	0	9	0
<i>Cerithium columna</i>	0	5	0
<i>Conus</i> sp.	0	5	0
<i>Conus miles</i>	0	9	0
<i>Drupa rubusidaeus</i>	0	14	0
<i>Nudibranch</i> sp.	0	9	0
<i>Trochus niloticus</i>	14	0	0
<i>Vasum ?turbinellum</i>	0	5	5

construction only during low tide, and other environmental protection measures will effectively limit turbidity effects. Damage to organisms can be avoided through relocation. Additional damage can be avoided by using construction matting under tracked equipment. Visual problems associated with backfilling the excavated trench with concrete can be mitigated by sculpting finished concrete to match its surroundings.

Pipeline construction beyond the reef flat will have minimal impact. Above the seabed construction activities are limited to anchor drilling, attaching appropriate mounting hardware, and securing the pipeline in place. In addition to the actual pipelines, intake and outlet structures will disturb an additional 300 square feet of area. Silt curtains, relocation of affected organisms, and other mitigative measures can effectively limit environmental damage.

4.4 INFRASTRUCTURE

4.4.1 Water and Wastewater

A twelve inch diameter water line exists on the upper end of Gognga Road. A temporary water meter will be installed at the end of the 12 " diameter water main near the Nikko Hotel to allow water for clean up and dust control.

During the construction phase, and in accordance with the Public Utility Agency of Guam, a permanent six inch water line will be installed to allow potable water and provide fire protection. Chemical toilets will be installed for construction workers.

4.4.2 Roads

During the construction phase, the public easement to the EnterOcean site will be graded to accommodate a two lane gravel road. Paving is expect to take place in nine months. Appropriate dust control measures, silt fences, and sedimentation basins will be used until the road is complete.

In general, the existing beach access road on lot 10113-3 will not be affected during construction. Sections of the access road near the Nikko Hotel will be improved as part of the project access road. Road construction in these sections will be phased to allow continuous public access to the beach.

4.4.3 Electrical System

The contractor's electrical needs will be supplied by generator or temporary electrical power until permanent power lines can be installed to the project site. All electrical power connections will be approved by the Guam Power Authority (GPA).

4.4.4 Telephone

During the construction phase, temporary phone lines will be installed to the project field office. All telephone connections will be approved by the Guam Telephone Authority (GTA).

4.4.5 Solid Waste

Solid wastes comprise all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. The construction of the proposed undertaking will generate 150,000 cubic yards of fill that will require off site removal. An approved disposal site will be located to accommodate the solid waste generated from ground cover clearings, excavations, and general construction debris. Collection and disposal will be contracted to a private waste collection firm.

4.4.6 Storm Water Management

During the construction phase the loss of ground cover will increase storm water run off and the potential for erosion. These impacts will be counteracted by appropriate measures such as silt fences, temporary diversion around construction areas,

and sedimentation basins. These measures will be documented in detail in the Erosion Control Plan, which will be part of the construction documents.

4.5 FISCAL IMPACTS

Construction of this project will generate positive fiscal impacts for the island of Guam by increasing: 1) total revenues on the island; 2) household income; and 3) government revenues.

Total revenue is the sum of the actual construction cost plus revenue generated by businesses providing goods and services to the contractor. Total revenue can be quantified by the product of the construction cost and an output multiplier for commercial construction. An output multiplier of two is typical (Dept. of Planning and Economic Development, State of Hawaii April 1983). For the purpose of this proposed project, total revenue is \$37 million x 2 = \$74 million.

Household income is generated by the contractor's payroll (a direct effect), payroll increases in businesses servicing the contractor (an indirect effect), and payroll increases in the business community at large (a induced effect). Unfortunately sufficient statistics are not available for Guam's economy to

estimate an output multiplier. Application of an off island based multiplier may not be appropriate since significant portions of Guam's construction work force are foreign (H-2 workers) while most regions are predominantly local.

Government revenues are directly generated from the project through the gross revenue tax (GRT), applied to the total revenue generated by the project, plus permit and plan checking fees. Government revenue for this project is estimated at \$2,973,200 GRT plus \$171,526 from building permit fees (Rate schedule for permit and plan checking fees set forth in UBC 1994, Section 107). Additional government revenues are generated from personal income taxes on household income. Unfortunately, sufficient statistics for Guam's economy are not available to quantify these revenues.

4.6 SOCIOECONOMIC IMPACTS

The Environmental Impact Assessment takes into consideration the definition of the entire environment which including physical, social and economical aspects. The following sections are intended to review the impacts the construction will have upon the community, both socially and economically.

4.6.1 Employment

The demand for employment will increase with the construction of the EnterOcean project. This demand will be met by a combination of local hiring, foreign workers, and the temporary immigration of specialized craftsman for installation and start up of mechanical and electrical equipment. The net result will be an increase in goods and services provided by local business plus an additional induced activity in the local economy.

4.6.2 Hospital Services

The Guam Memorial Hospital will be informed of construction activities at Gun Beach. This medical facility is located approximately 2 miles from the proposed construction site. Worker safety is a first priority and all applicable rules and regulations will be enforced. If required, medical facilities on Guam are available to treat work related injuries.

4.6.3 Neighborhood

Adjacent lots at the Gun Beach site are currently undeveloped. Figure 2-1 shows the owners of neighboring property. Remaining portions of lot 10113-R3 are vacant. There are no other specific development plans for the remainder of this lot at the present time.

4.6.4 Population

Construction will have a negligible effect on the population of Guam. Use of foreign construction labor mitigates against permanent immigration of workers.

4.7 TRAFFIC IMPACTS

The existing easement will be graded and improved at the onset of construction. This will enable construction vehicles and other equipment to enter the area without further damaging the environment. The majority of construction equipment will remain on site and thus eliminate excessive congestion.

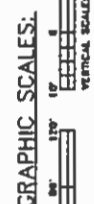
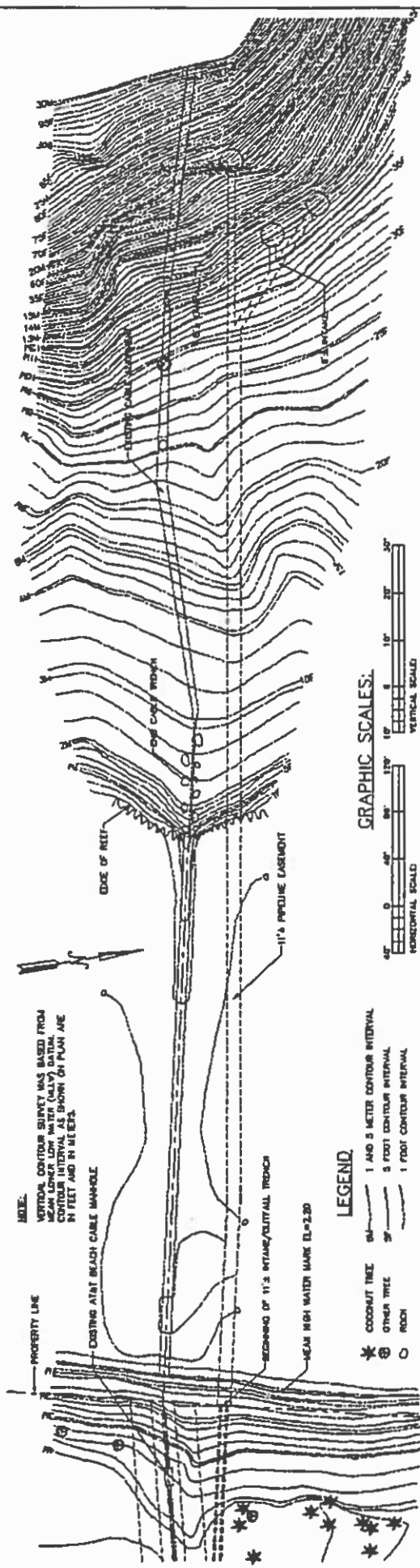
Expected traffic increases during the construction phase will travel almost exclusively along San Vitores Road and Marine Drive. Traffic will primarily consist of commuting workers, material delivery, and removal of excavated material. During excavation, truck traffic is estimated at thirty vehicles per day or one truck every fifteen minutes. Impacts from increased traffic include emissions increases, noise, and the additional vehicle parking on site during construction shifts. These impacts are considered to be insignificant based on the predominantly urban characteristics of the Tumon Bay area.

4.8 INTAKE/OUTFALL FACILITY

Preliminary design for the intake/outfall structure included the tasks of determining an appropriate location for the pipeline alignment, preliminary design of inlet and diffuser structures, and evaluation of wave and current forces on submerged structures. Construction alternatives were also addressed.

Two general construction methods are available; Horizontal Directional Drilling (HDD) and conventional cut and cover. Three alternatives for securing the pipelines along the reef margin and reef terrace were also analyzed. These were: 1) concrete encased trench; 2) concrete anchors; and 3) stainless anchors. Preliminary designs have also been prepared for the intake and outfall structures. All design alternatives have been evaluated using wave force analysis and can withstand a 41 foot deep ocean design wave. This wave generates a 26.8 foot wave at the diffuser site and 27.6 foot wave at the intake structure. Probability of the Gun Beach area receiving a design strength ocean wave is 20% within a fifty year period. A reduced plan and profile for the stainless steel anchor and HDD pipeline installation options are shown at Figures 4-1 and 4-2, respectively.

Both methods of construction use identical intake and outfall sites. Two ten foot square intake towers will occupy 200 square feet of the sea floor. Intake tower size was calculated



- LEGEND**
- * COGNATE TREE 1 AND 5 METER CONTOUR INTERVAL
 - OTHER TREE 5 FOOT CONTOUR INTERVAL
 - ROCK 1 FOOT CONTOUR INTERVAL

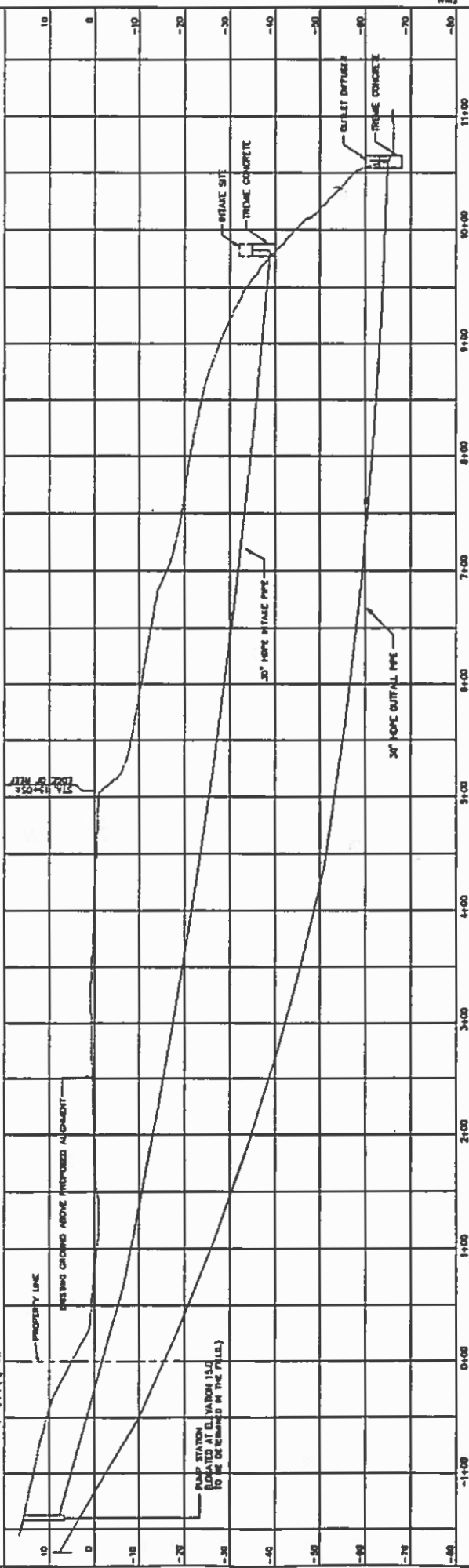
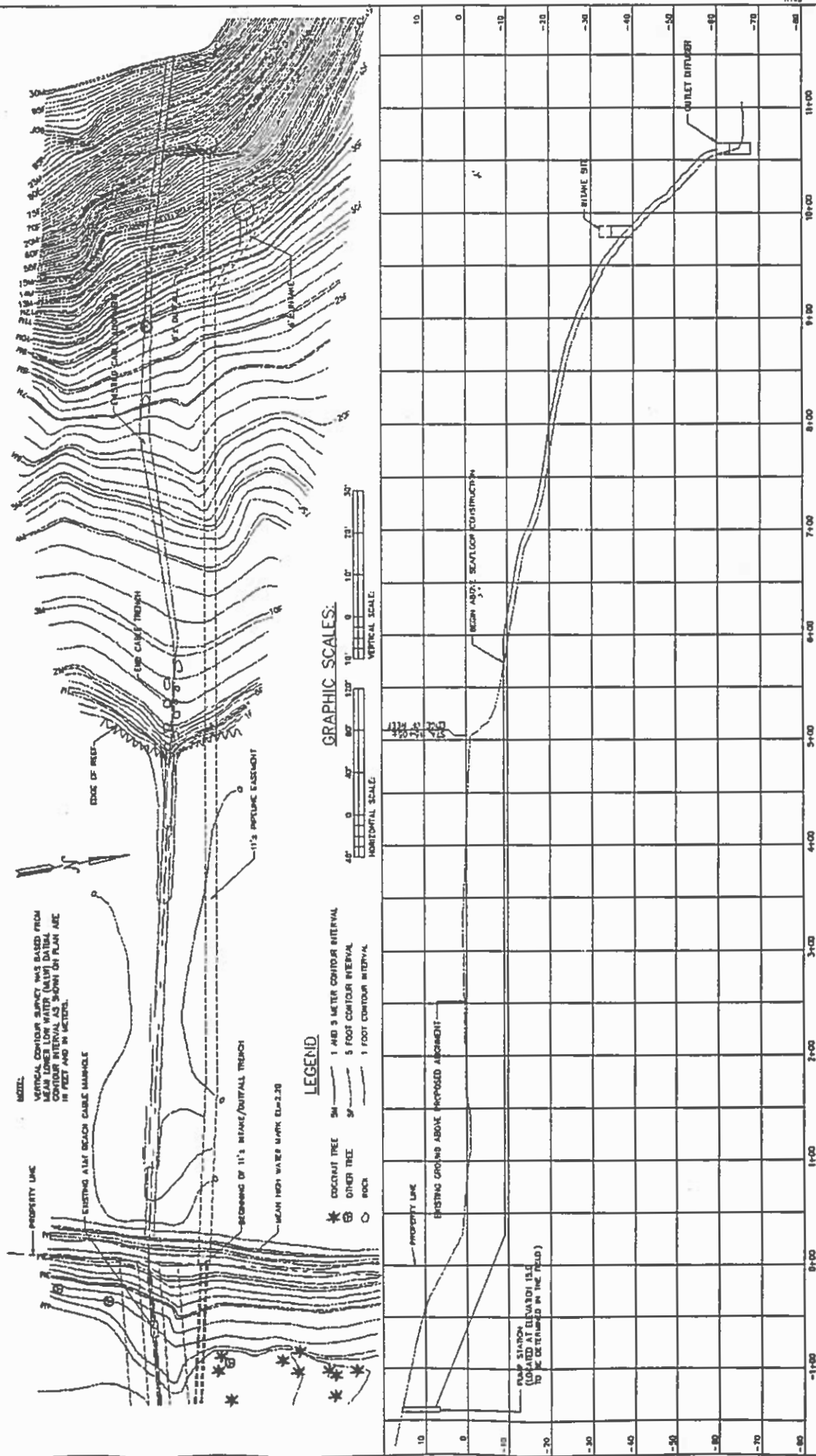


FIGURE 4-1 SCHEMATIC OF INTAKE/OUTFALL WITH HORIZONTAL DIRECTIONAL DRILLING (HDD)



based on the maximum allowable water velocity which would not disturb fish (0.5 feet per second) and the required water intake rate (15,000 gallons per minute). Excavation will be required to anchor the towers. An identical tower will house the outfall distributor occupying an additional 100 square feet of seafloor.

The cut and cover/stainless steel anchor method will have greater environmental impacts than the HDD method. Cut and cover excavation across the reef flat will destroy a section of the existing weathered coral rock and any associated biota. Pipeline anchoring systems will destroy small sections of the seafloor. Mitigation methods include relocating coral and invertebrates where possible, sedimentation control, and other standard ocean construction practices. Cut and cover construction beyond the reef flat, rather than an anchoring system, was rejected as an alternative because it is environmentally destructive. Stainless steel anchors were selected over concrete anchors because they are smaller and less disruptive.

Horizontal Directional Drilling (HDD) is the a second, alternative means of pipeline construction. In general, HDD does not disturb the seafloor. Physical construction impacts are limited to intake screen and outlet diffuser construction. Additional turbidity effects occur from the escape of drilling fluid, typically bentonite. Horizontal Directional Drilling in coral formations is problematic. The drilling process requires

solid rock formations to maintain downhole drilling fluid pressure. Cracks or fissures can cause the release of large amounts of bentonite, a resulting build up of heat and cuttings near the cutting head, and preclude completing the excavation. Voids or pockets of soft material can cause the directionally controlled cutting head to lose control, separate from the drill stem, and again preclude completing the excavation. Additionally, the neighboring cast iron armored ATT cable could potentially cause very serious problems with magnetic sensors used to guide the cutting head.

4.9 CUMULATIVE IMPACTS

A cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonable foreseeable future actions. A cumulative impact can result from individually minor but collectively significant actions taking place over a period of time. This section will evaluate the possible cumulative impacts that may occur during the construction phase of the EnterOcean facility. Possible cumulative effects are evaluated under the sections of measurement criteria, positive and negative cumulative impacts; and avoidable and unavoidable cumulative impacts.

4.9.1 Impacts Compared to Measurement Criteria

A. Positive

Expected cumulative impacts on the economy are generally positive as the development of these projects greatly increase employment, and are beneficial for the goods and service industry on the island of Guam. Government revenues will be enhanced by payments of employee and employer income taxes, real estate taxes and gross receipt taxes. Also additional income will be generated by the license fees and utility payments generated by the undertaking.

B. Negative

During the construction phase of the project there will be several short-term negative environmental impacts. The following is a list of expected construction related impacts.

1. An estimated 150,000 cubic yards of material will be removed off site. It is expected that the material will be sold to other projects on the island. Value engineering during design will be used to reduce the amount of excavation to a minimum.
2. Excavated material to be used for back fill will

be temporarily stored on adjacent areas of lot 10113-R3.

3. Some short term erosion from the project site will occur as water flows over areas disturbed by construction.
4. There will be destruction and alternation of vegetation within a narrow portion of the modified limestone forest and abandoned coconut grove.
5. Noise related to the construction is likely to disturb fauna in the immediate area. There are no residents at the project site, therefore, the impact on people should be minimal.
6. Some erosion along the access road is likely to occur during the extension and implementation of utility services.
7. Air Quality will be affected by emissions from motorized equipment and dust generated by the movement of machinery. These impacts are expected to be minor and short term and will not affect human populations.
8. Dislocation of fauna along the access road and at the project will occur as a result of increased human activity.
9. Trench excavations for the intake/outfall structure will temporary disturb approximately a

ten foot section along the southern property line. This will stretch alongside the property line towards the ocean. A proper guardian rail will be placed to prevent accidental entrance into this area until work is completed, approximately a two month period.

10. Intake/Outfall trenching will destroy an eleven foot wide corridor across the reef flat. Additional collateral damage will be minimized by proper environmental protection measures.
11. A barge mounted excavator will be used to complete the portion of the trench not accessible from land and outfall/inlet towers. The use of this equipment to dredge the trench will have an impact on the coral reef and marine biota. These impacts include increased siltation, and destruction of coral and biota that cannot be successfully relocated.
12. To secure the barge located offshore, lines and anchors will be placed along the sea floor. The secure lines should have no significant impact on marine wildlife. Visual signs and well marked tags will notify the public of the secure lines.

4.9.2 Avoidable and Unavoidable Impacts

A. Avoidable

The temporary disturbances that are associated with dust, exhaust and noise from operation of heavy equipment can be minimized through implementation of precautionary measures and appropriate control techniques. Excess erosion and runoff during construction can also be minimized by implementation of an effective erosion control plan.

B. Unavoidable

Impacts that are unavoidable include loss of vegetation and a portion of reef habitat. Other unavoidable impacts include an additional stress on utilities - electricity and potable water, congestion and increase in traffic.

4.10 MITIGATION MEASURES

4.10.1 Environmental Protection Measures

A. Erosion Control Plan

All earth moving activities in the Territory shall be conducted in a manner that prevents accelerated land erosion, transportation of sediment to and along waterways, and siltation of rivers, estuaries and marine waters. The area of land to be graded at one time during development shall be kept to a minimum. No graded area shall remain unstabilized for a period exceeding two months. Temporary ditches, dikes, mats, vegetation and or mulching shall be used to protect critical areas during construction. All disturbed areas, slopes, and banks must be stabilized as soon as possible after the final grade has been completed. Storm water runoff from disturbed areas of a project shall be collected and diverted to facilities for removal of sediment prior to discharge to any surface or marine waters of the Territory of Guam. All erosion and sedimentation shall be maintained by the permittee until stabilization is complete. All grading shall be scheduled during periods of low precipitation and staged to minimize the time span that soil is exposed. An erosion control netting or blanket mat may be required along with normal mulching practices to protect the graded and planed areas until a strong vegetative cover is established.

Erosion and sediment control plans shall be prepared as set forth in Section IV B of the Soil Erosion and Sediment Control Regulations of 1985 and submitted to the Guam Environmental Protection Agency in time to allow 14 working days for review. At the end of the 14 day review period, GEPA shall approve or disapprove the Erosion Control Plan. Any condition attached to such approval shall be complied with in full, unless subsequently waived by GEPA. Lack of agency comments within the designated time shall constitute approval. Any notice of a disapproval must contain any and all reasons for such disapproval.

B. Air Quality

Dust shall be kept to a minimum at all times, including non-working hours, weekends and holidays. Soil at the project site, haul roads and other areas disturbed by the contractors operations shall be sprinkled or treated with dust suppressor as necessary dust control. No power brooming will be permitted. Vacuuming, wet sweeping, wet mopping, or wet power brooming shall be used instead. Air blowing will be permitted only for cleaning non-particulate debris such as reinforcing bars. No sandblasting will be permitted unless the dust therefrom is confined. Only wet cutting of concrete blocks,

concrete and asphalt will be permitted. No necessary shaking of bags will be permitted where concrete mortar and plaster milling is done.

C. Marine Environment Protection

Potential short term as well as long term impacts (i.e., permanent displacement can be mitigated in the construction phase. The trenching corridor width should be limited to the minimum needed for excavation equipment to operate safely. Trenching and installation should avoid live coral reef to the maximum extent possible. Care will be taken during construction to avoid areas of dense coral heads and algal growth. If avoidance is not possible, then some of the larger coral heads may be selected for transplantation into adjacent areas of equivalent habitat. Potential foraging areas for sea turtles, i.e., areas of dense algae or sea grass beds, will also be avoided to the extent possible. Observers (snorkelers) will be posted in the water to ensure that no rare, threatened, or endangered species (i.e., sea turtles) are present during construction. If any such species are sighted in the immediate vicinity, then construction will be halted until the animals have cleared the area.

Impacts by vessel anchoring operations may be minimized by restricting the vessel to anchor only one time in as deep water as possible, with a minimum number of anchors. Impacts may be further decreased by buoys and pennant lines attached to the anchors and anchor handling vessels. If the pipe laying vessel must move to a different location along the pipeline corridor, the anchor handling vessel should raise the anchor vertically by pulling on the anchor pennant, moving to the new position, and lowering the anchor, thus decreasing the amount of dragging across the sea floor. Utilizing a wide anchor pattern spread would enable the vessel to move to various positions along the pipeline corridor by alternately loosening one set of anchor lines while taking up the slack on the other lines. Use of a shore-based, "deadman" anchor may also assist in vessel positioning. In this case, a large weight or anchor is placed on shore and a line strung to the pipeline laying vessel. Winching the anchor line to the deadman pulls the vessel closer to shore along the pipeline corridor. A potential impact associated with this positioning system is damage to coral along the reef flat and slope due to anchor line sweep.

Impacts to water quality are expected to be localized and of very short duration and should not, therefore,

significantly impact biological resources in the area. Nevertheless, all construction activities will be conducted in accordance with the best management practices (BMP) for such activities. A retention screen suspended by floats and anchored securely to the sea floor will be deployed around the project area during marine construction activities to prevent excess siltation in the near shore waters, which will be carefully monitored according to an approved water quality monitoring plan.

Marine recreational activities will be curtailed for a short period of time (approximately one month) during construction. Appropriate signage will be required prior to and during construction to notify the public of these activities. Only a small, localized area of the beach will be closed to the public during this time, and future use will not be impacted. Offshore diving and surfing sites are not usually by shoreline facility locations and, therefore, do not require mitigation.

D. Archaeological Mitigation Plan

An Archaeological Mitigation Plan may be required during the removal of the ground cover. This will depend on the given significance of the two archaeological sites

described in section 4.2.6.

SECTION 5
Environmental Consequences
After Complete Construction

SECTION 5

ENVIRONMENTAL CONSEQUENCES AFTER COMPLETE CONSTRUCTION

5.1 PHYSICAL EFFECTS

5.1.1 Noise

There will be an increase in volume of noise introduced to this area. The activities of music, dance, picnics, and the general actions of patrons will produce an increase in noise volume generated. Noise from the EnterOcean facility will be similar to that from other commercial structures in the Tumon Bay area. Additionally, the site is located in the northern corner of Tumon Bay and at a reasonable distance from other hotels, no residential units exist in the area, and a bluff protects the site from the neighboring Harmon Annex. The impact of noise in the area is assessed as insignificant.

5.1.2 Visibility

The completed facility will have a canopy tent housing the main retail section of the facility. The canopy will not extend over 35 feet in height and will be designed to withstand high winds and heavy rain. The Harmon Annex Naval Base, located on the top of the bluff, will continue to be able to see the ocean and surrounding landscape. The impact of the project on

visibility is assessed as insignificant.

5.1.3 Pollutants

No chemicals or cleaning compounds will be used inside the actual saltwater trails in order to preclude discharge into the ocean. Chemicals and cleaning solvents will be used in other situations as appropriate. Common pesticides and herbicides will be used as needed in order to maintain landscaping. Filter backwash systems, if used, will discharge into the sanitary sewer system. In general, pollutants will be disposed of by trash collection or sewage collection system.

5.2 BIOLOGICAL EFFECTS

5.2.1 Terrestrial Fauna and Flora

A. Flora

The EnterOcean facility will not introduce any plant species not already present on Guam. Common landscape maintenance practices will be followed. The presence of the undertaking will not adversely or significantly impact Guam's vegetation.

B. Fauna

The birds and animals that were disturbed during construction will have the opportunity to rehabilitate the EnterOcean facilities landscaped areas. Relative isolation of the Tropical Island section will make it possible for some birds to nest without disturbance by the brown tree snake. In general facility operations will have no significant impact on Guam's fauna.

5.2.2 Marine Biota

It is expected that coral polyps and other sessile invertebrates will eventually colonize the intake and outfall pipelines, effectively creating a habitat on the artificial substratum that could potentially enhance biological resources in the area. Pipeline maintenance measures will include period inspections and possible repair of the anchor system, especially after major storms. Although currently not a design feature, periodic replacement of cathodic protection anodes may also be required. Additional maintenance may involve physical cleaning of intake screens by brushing. In general, intake and outfall pipeline systems, including intake screens, will be designed to be maintenance free.

No marine species not already present in Micronesian waters will be present in the EnterOcean facility's large

saltwater tanks. Exotic species, if present, will be kept in separate, smaller, detached aquarium. The EnterOcean project will not introduce exotic species into Guam's waters by outfall discharge.

5.3 WATER QUALITY IMPACTS

The EnterOcean water feature has been designed for continuous water flow. In these types of flow-through systems, the discharge of an effluent is more or less constant. The degree of change in water quality between the supply point and the discharge point is partly a function of the residence time of the water (how long water remains in the system on average). Where residence time is short, water quality characteristics of the discharge may be more a function of the supply water quality than of processes taking place within the system. High flow rates and short residence times are usually designed into systems intended to support decorative fishes and other organisms as a means of insuring good water quality and healthy biological communities within the system.

The high quality of source water (taken from the ocean seaward of the reef margin) and the high volume of the flow (i.e., rapid turnover within the facility) ensure that the discharge water quality remains high. Previous experience with similar systems may be used to assess the water quality of the

discharge. One source of comparable information is from large, commercial marine aquaria. Attempts to gather relevant data from several aquaria of this type have generally met with problems related to analytical procedures. Predicting water quality changes in the water flowing through a facility such as the EnterOcean swim through lagoon is difficult because measurements that would be of interest in assessing aquarium impacts on have not been routinely made at other existing facilities. The problem is exacerbated by the limited analytical experience most laboratories have with sea water as a matrix and the relatively low concentrations of the analytes of interest (nutrients and suspended solids primarily). Nevertheless, to assess the impacts on water quality after project completion, a review of studies monitoring the Monterey Bay Aquarium, California; Mauna Lani Resort, Island of Hawaii; and the Water Quality Monitoring Report for Ihilani Resort & Spa, Hawaii (February 1994) are used to evaluate and compare possible effects the intake/outfall structure will have on the waters off of Gun Beach.

5.3.1 Monterey Bay Aquarium, California

The Monterey Bay Aquarium is in a Temperate Zone and draws water from Monterey Bay in Northern California. The system intake consists of two 2,000 gpm capacity pumps drawing sea water from a depth of 55 feet. Because this "raw" sea water frequently cannot meet water clarity needs within the aquarium, an internal

recirculation/filtration system capable of filtering at a rate of up to 5,700 gpm is utilized. Exhibits contain variable proportions of filtered and unfiltered sea water to meet needs and changing inflow water quality. Some subsystems used to display mammals (e.g. sea otters) and/or non native species are entirely or substantially isolated from the flow through system. The usual discharge rate is 1,850 gpm, directed to a tidal basin at the shore fronting the facility. Backwash from the various filter systems is also fed into the tidal basin, where dilution on the order of 74x with overflowing sea water occurs before discharge into Monterey Bay. Even during filter backwashing (approximately 1.67% of the time) the sea water overflowing into the bay is of better quality than the receiving water (David Powell, 1994).

Water quality monitoring was undertaken for a time after the facility was first built. Review by U.S. EPA and the California Regional Water Quality Control Board determined that no discharge permit (e.g. NPDES permit) was required for the system. Table 5.1 summarizes the data provided from four sampling events in 1986, five in 1987, and one in 1988, and two in 1989. These data were provided by the Monterey Bay Aquarium. Only months between November and March inclusive are covered by these measurements. For temperature and pH, average measurements is presented; for nitrate + nitrite, ammonia, phosphate, and silicate, the values presented are geometric means. A simple t-

TABLE 5.1
SUMMARY AND COMPARISON OF INTAKE AND DISCHARGE MONITORING
RESULTS FROM THE MONTEREY BAY AQUARIUM

		TEMP °C	pH	NO ₃ +NO ₂ ug/l	NH ₃ ug/l	PO ₄ ug/l	Si ug/l
Raw Sea Water	means n=	11.7 8	7.9 12	150 14	23 14	66 12	351 9
Return Sea Water	means n= p=	12.0 8 0.61	7.9 12 0.42	379 14 0.0007	27 14 0.34	43 12 0.47	366 9 0.75

Test was performed to evaluate the means (i.e., the question was asked: are the means from the intake and discharge sides significantly different?). It is generally accepted that a *P* value of 0.05 (that is 5%) or less is indicative of a significant difference between means compared using this statistical test, and these values are given in bold type. The results, expressed as a probability value (*P*) provide no indication that the aquarium system either added or removed the measured substances from the water with the exception of the nitrate + nitrite values. Thus for these analytes and properties, the aquarium appears not to have any effect on temperature, pH, or nutrients other than nitrate + nitrite. From these limited monitoring measurements, nitrate + nitrite appears to be added to the sea water as it flows through the system.

5.3.2 Mauna Lani Resort, Island of Hawaii

Measurements of water quality in decorative water features located at the Mauna Lani Resort on the Island of Hawaii were made in June 1991 and May 1992 (AECOS, 1992) to provide a basis for assessing water quality implications of discharges from these types of systems. The Mauna Lani systems support relatively large numbers of fishes and are typical of successful decorative marine pond features.

The Bungalows outdoor salt water pond system at the Mauna

Lani Resort consists of a series of concrete-lined waterways separated by weirs and fed from waterfall structures and subsurface jets. The system's source water is a deep well located on site, which provides saline groundwater at a salinity of 33.5 parts per thousand (ppt; measured by refractometer on May 24, 1991). The well pumps supply about 2,400 to 2,450 gpm of this saline groundwater to the system. The surface area of the system is estimated at 66,000 square feet and the average depth is 2.5 feet; thus, the volume of the system is about 1.2 million gallons. In 1991, the number of fishes in the system channels and ponds was estimated at 11,000. In 1992, the estimated count was 8,000 fishes. These were a mixture of mostly herbivores and included manini and milkfish. A number of young green sea turtles (*Chelonia mydas*) were present in 1991.

A second pond system is located partly inside the hotel. Shallow marine ponds are an integral part of the "tropical garden" setting of the Mauna Lani Hotel Lobby. These ponds are fed from a well that inputs just outside the north side of the building and exits outside the building on the south side. Most of the ponds are inside the atrium like lobby of the hotel. This system is older than the Bungalows system. The shallower well provides water that is more brackish than the Bungalows system. The total volume of the Lobby system is about 23,000 gallons. Water is supplied at 360 gpm (two wells with this rating are present, but ordinarily only one is in operation at a time).

Residence time of the water in the system is thus about one hour. The total number of fishes at the time of the study was estimated 10,000 individuals.

Water quality measurements were made on two occasions. On June 5, 1991, a series of water quality samples were collected from intake and discharge points between 0900 and 1530 hours to assess changes in water quality that occurred as water flowed through the Bungalows system. This study was repeated on May 27-28, 1992 to cover a 24 hour period and to include measurements of both the Bungalows and the Lobby Pond systems. Results of these studies are summarized in Table 5.2 with average (arithmetic or geometric mean) values. The terms "IN" and "END" refer to inlet samples and end of system (just before discharge) pond samples (two of each location for the Bungalows); "SUMP" refers to sample collected from a receiving sump for the discharge from the two Bungalows systems.

Averaged numbers for the temperatures recorded at the inlet and outlet sides of the systems combine both daytime heating and nighttime cooling of the water as it flows through a system. The increase of nearly 2°C between inlet and outlet seen in May 1991 is influenced by the fact that measurements were made only during daylight hours. Results of the 24 hour sampling in 1992 suggests that a smaller average increase in temperature occurs in the ponds.

TABLE 5.2
MEAN AND GEOMETRIC MEAN VALUES FROM THE MAUNA LANI RESORT STUDIES

PARAMETER	SAMPLE LOCATION				
	IN(1)	END(1)	IN(2)	END(2)	SUMP
JUNE1991 BUNGALOWS (N=4)					
Temperature (°C)	21.8	23.4	21.7	23.9	23.1
TSS (mg/L)	----	5.7	----	5.6	4.5
DO (mg/L)	4.7	6.2	6.1	6.8	9.3
NO ₃ +NO ₂ (ug N/L)	87	2	89	4	2
NH ₄ (ug N/L)	2	8	1	8	6
Total N (ug N/L)	179	165	152	202	161
PO ₄ (ug P/L)	41	24	46	26	24
Total P (ug P/L)	43	35	46	41	34
May 1992 BUNGALOWS (n=8)					
Temperature (°C)	25.1	25.8	25.2	26.5	25.9
pH	7.8	7.7	7.8	7.7	7.8
TSS (mg/L)	0.9	2.6	0.7	5.8	3.8
DO (mg/L)	3.4	5.0	3.5	4.6	4.9
NO ₃ +NO ₂ (ug N/L)	129	96	151	67	92
NH ₄ (ug N/L)	5	18	6	7	8
Total N (ug N/L)	230	217	242	224	193
PO ₄ (ug P/L)	51	45	55	32	39
Total P (ug P/L)	44	48	55	45	42
Chlorophyll (ug/L)	----	2.35	----	2.89	1.44
May 1992 LOBBY (n=8)					
Temperature (°C)	25.6	26.0			
pH	7.8	7.9			
TSS (mg/L)	1.1	2.4			
DO (mg/L)	5.4	5.1			
NO ₃ +NO ₂ (ug/L)	664	624			
NH ₄ (ug N/L)	6	9			
Total N (ug N/L)	812	763			
PO ₄ (ug P/L)	75	95			
Total P (ug P/L)	64	62			
Chlorophyll (ug/L)	----	1.56			

The pH of the water changed little between inflow and outflow when measurements are reduced to an average value. While both arms of the Bungalows system measured a Ph 0.1 unit less than the inlet water, the sump value (just below the outlet measuring points) averaged the same as the inlet water. The Lobby system average was 0.1 unit higher at the outlet than at the inlet. Curiously, despite the difference in salinity of these two pond systems, the pH values were not very different and about 0.3 to 0.5 units below typical open ocean values. A desirable pH range for maintaining animals in both brackish and sea water systems is 8.0 to 8.3 (Spotte, 1979). The low pH at the Mauna Lani is a consequence of chemical reactions within the groundwater body and is thus not easily remedied.

Total suspended solids (TSS) increased as water flowed through the systems, but results were highly variable. Considering the nature of the systems, variation in TSS is expected. The release of particulate depends upon a number of managed and unmanaged factors, and "typical" values will probably be difficult to define for these systems.

Average oxygen in the water was increased across a diurnal cycle in the Bungalows system, but not in the Lobby system. The difference is probably related to reduced photosynthetic activity in the indoor system as compared with the outdoor (Bungalows) system.

The nutrient results are interesting in several respects. The fairly substantial reduction in inorganic nitrates and phosphates observed in 1991 was not so great in 1992, presumably due to real difference in the dynamics of the primary producers (algae) in the systems. Owing to management practices, or "natural" cycles, the uptake of inorganic nutrients probably changes with time in these systems. Possibly also contributing was a greater concentration of nitrate plus nitrite in the well water in 1992 as compared with 1991. On the other hand, ammonia, a product of aquatic animal excretions, increased in all cases. Total nitrogen (N) and total phosphorous (P) results are variable, with slight average increases in some cases and slight average decreases in all others. The 24-hour measurements suggest a decrease in total Nitrogen as water flows through the system. About half of the total Nitrogen is accounted for as inorganic nitrate, nitrite, and ammonia.

Changes in water quality between influent and effluent points can be expressed as the percent differences. A positive percentage indicates a contribution to the effluent by the system. A negative value indicates removal, uptake, or conversion; that is, the amount in the effluent is less than that supplied by the influent. For the ponds at the Mauna Lani on the days surveyed, most parameters were reduced in concentration as the water flowed through the system. Not surprising, particulate (TSS) and ammonia were exceptions. These results compare in a

general way with marine aquaculture facilities (Table 5.3; values after CTSA, 1990), where increases in ammonia and TSS are the most substantial changes effected on the supply water by the biomass of cultured organisms. In the latter, nitrate tends to be mostly unchanged, but all other parameters show increases. Decorative pond systems and aquariums resemble aquaculture to the extent that both share a common purpose of maintaining living aquatic organisms. Aquaculture management promotes the maximum, healthy growth of biomass of the cultured species as a primary purpose. Decorative and display pond management places a higher premium on water clarity, which is a goal consistent with minimizing effluent water quality impacts on receiving waters.

5.3.3 Ihilani Resort, Island of O'ahu

The nearshore waters in the vicinity of the Ihilani Resort & Spa in Oahu's Ewa District have been monitored extensively as part of compliance requirements with a Section 401 Water Quality Certification. This resort maintains large decorative, outdoor fish ponds into which sea water from an adjacent lagoon is pumped. Outflow is directed to a pipe located at the ocean shore. The volume of the ponds is about 300,000 gallons (1,135,500 liters) and inflow (and discharge) approaches 1000 gpm. The water residence time is approximately 5 to 6 hours.

TABLE 5.3
PERCENT DIFFERENCE IN THE CONCENTRATIONS OF PARAMETERS
BETWEEN INFLUENT AND EFFLUENT WATERS¹

	BUNGALOWS 1991		BUNGALOWS 1992		LOBBY 1992	MARIN E FISH AQUAC ULTUR E ²
	(1)	(2)	(1)	(2)		
NO ₃ +NO ₂	-98	-96	-26	-56	-6	9
NH ₄	300	700	260	17	50	831
Total Nitrogen	-8	33	-6	-7	-6	100
PO ₄	-41	-43	-12	-42	27	92
Total Phosphorus	-19	-11	9	-18	-3	165
TSS	--	--	189	728	118	350

1 - Percent difference is calculated from : ((END-IN/IN) x 100

2 - Aquaculture values for Hawaii after CTSA (1990)

Water quality sampling was initiated on November 15, 1993, during construction of the discharge pipe, and continues at a frequency of two events per month. Table 5.4 depicts the mean values of data acquired during December 1993 to January 1995. Station "Lagoon" represents the daytime quality of the water pumped into the decorative fish ponds. Station "Outfall" represents water collected within 2 meters of the discharge (end of outfall pipe), within the zone of initial dilution for the outfall. Starting in June 1994, sampling of the water exiting the ponds was initiated, providing an "Effluent" sample. Station "1S" is water at the ocean shore at a point 150 meters south of the outfall, representing a control station. Water quality was measured for a time at a second shoreline "control" station to the north ("1N"). Monitoring at this second control station was discontinued after it was demonstrated that mean water quality values were identical to those of Station 1S.

For most of the analyses, the differences between stations are subtle. However, after 29 consecutive sampling events, a very good comparison between lagoon water (site of the intake station) and ocean water (Sta. 1S) can be made. In the lagoon, salinity is very slightly depressed and nutrients (particularly nitrate + nitrite) are slightly enriched compared with the ocean. Ground water influx is believed to cause these differences. Comparison of mean silicate values (442 ug Si/l in the lagoon; and, 216 ug Si/l at the ocean shore) supports the

TABLE 5.4
SUMMARY OF 1993-1995 WATER QUALITY DATA COLLECTED
OFF THE IHILANI RESORT & SPA SHORELINE

	LAGOON (INTAKE)	STATION 1S (CONTROL)	OFF OUTFALL	POND EFFLUENT
Distance offshore (meters)	1	1	1	n/a
Depth (meters) (n=)	0.2 29	0.2 29	0.2 29	n/a 16
Temperature (°C)	25.1	25.3	25.1	25.5
Salinity (ppt)	34.47	34.60	34.54	34.34
DO (mg/l)	6.7	6.8	6.7	6.5
pH (pH units)	8.14	8.18	8.16	8.10
Turbidity (ntu)	2.30	1.29	2.09	4.25
TSS (NFR) (mg/l)	4.9	3.9	5.8	8.1
Nitrate + nitrite (ug N/l)	32	7	16	59
Ammonia (ug N/l)	8	8	10	10
Total N (ug N/l)	160	155	195	202
Total P (ug P/l)	16	14	16	20
Silicate	442	216	336	601
Chlorophyll (ug/l)	0.37	0.37	0.51	0.63

NOTE: Temperature, salinity, dissolved oxygen, and pH are mean values; All others are calculated as geometric mean values

groundwater influx explanation. The lagoon is, on average, more turbid than the ocean near shore. There is no difference for day time dissolved oxygen (DO), ammonia, or chlorophyll measurements between the lagoon and ocean.

The sample labeled "Off Outfall" provides indication of the influence of the pond discharge on the near shore waters. However, the results from the station labeled "Pond Effluent" are a better measure of the quality of the water discharged from the Ihilani Resort & Spa pond system because the "off outfall" sample is a mixture of the discharge and the ocean water at the end of the pipe. The record from the "effluent" station is shorter than that of the other stations. To provide an accurate comparison, Table 5.5 shows mean values for all parameters measured at "Lagoon" and "Effluent" from the sixteen occasions when both were sampled. This table also includes the results (*P* values) of t-Test comparisons of the means. Values of 0.05 or less are generally considered to indicate a significant difference by this test and are shown in bold type in Table 5.5

For the means presented in Table 5.5, a significant difference is indicated for the salinity, turbidity, nitrate + nitrite, ammonia, total N, silicates, and chlorophyll. Changes in temperature, DO, pH, TSS, and Total P are not significant. In all the cases of statistically significant change, except for salinity, the analyte shows an increase as water flows through

TABLE 5.5
COMPARISON OF INTAKE ("LAGOON") AND DISCHARGE ("EFFLUENT") MEANS
AND SIGNIFICANCE FOR THE PERIOD JUNE 1994 THROUGH JANUARY 1995
(n=16)

	Temp (°C)	Sal (ppt)	DO (mg/l)	pH	TURB (ntu)	TSS (mg/l)
INTAKE	25.8	34.53	6.7	8.12	2.11	5.4
DISCHARGE	25.5	34.34	6.5	8.10	4.25	8.1
t-test Pvalue	0.53	0.0025	0.38	0.14	0.015	0.17
	NO ₃ +NO ₂ ug N/l	NH ₃ ug N/l	Total N ug N/l	Total P ug P/l	SiO ₃ ugSi/l	Chi.a ug/l
INTAKE	32	7	160	16	412	0.35
DISCHARGE	59	10	202	20	601	0.63
t-test Pvalue	0.002	0.02	0.005	0.056	0.001	0.010

NOTE: Temperature, salinity, dissolved oxygen, and pH are mean values; All others are calculated as geometric mean values.

the system. In essence, the system appears to be adding small amounts of nutrients (particularly nitrates). It is possible that the increase in silicates and nitrates relate to the slightly lower salinity of the discharge. In order for the system to "lose" salt, fresh water must be added. The intake sampling station is located near the surface above the intake structure and could underestimate intake salinity by measuring slightly less saline and therefore less dense surface water. Rainfall is a source of fresh water to the ponds, although the system is located in a dry area where evaporation nearly always exceeds rainfall. The ponds do not receive runoff from roofs or other areas which would differentially contribute to the discharge as compared with the lagoon surface at the intake. The watering system for the surrounding gardens does spray into the ponds when operating. This action could result in inputs of fresh water, nitrates, and silicates. Nitrates and silicates can be expected to be higher in fresh water as compared with lagoon water. This airborne irrigation water is a very likely the cause of some of the differences between intake and outlet sides, and an irrigation water sample could provide valuable information on the degree of contribution.

A supplementary sampling was undertaken over a two week period in January 1995 to clarify the turbidity and TSS values in the sea water passing through the Ihilani Resort and Spa system. Because of difficulties establishing a representative sampling

location for the sea water source, samples have been collected from a rock revetment in the vicinity of the intake structure. Concern was expressed by the system designer that these surface samples might be underestimating particulate (measured as nephelometric turbidity and total suspended solids) in the inflow. Consequently, samples were collected from the surface (normal monitoring Sta. "Lagoon") and at the 2 m depth (close to the intake structure depth) for comparison. Additional samples were obtained from the lagoon entrance channel where it has been proposed to move the intake structure in order to improve water quality. A fourth sampling was made from the effluent for comparison with the influent water quality. The results of this special sampling are tabulated in Tables 5.6 and 5.7 .

These data show that both turbidity and TSS in the lagoon, where the sea water is obtained, are elevated at a depth of 2 m relative to the surface samples. Thus, the mean values for these parameters shown in Table 5.4 are very likely underestimates of the values in the water drawn into the system. The difference is such that the system appears to be releasing less suspended material (TSS = 4.3 mg/l) to the effluent stream than is coming in (TSS = 5.8 mg/l); the opposite conclusion would be drawn considering only the Table 5.4 or Table 5.5 values. These results suggest that the installation of a sampling spigot on the inflow line would provide better estimates of incoming water quality for most parameters.

TABLE 5.6
TURBIDITY (ntu) MEASURED IN SPECIAL SAMPLES
FROM OVER A TWO WEEK PERIOD AT IHILANI RESORT & SPA

DATE	LAGOON AT INTAKE SURFACE	LAGOON AT INTAKE 2 m	LAGOON AT CHANNEL 2 m	EFFLUENT FROM PIPE
01/11/95	1.36	1.16	----	2.01
01/12/95	1.97	2.26	----	2.12
01/13/95	1.28	3.00	0.38	1.62
01/16/95	1.64	2.44	0.32	1.72
01/17/95	0.98	1.46	0.46	1.02
01/18/95	1.01	1.29	0.52	1.52
01/20/95	0.96	1.38	0.64	1.47
01/23/95	0.60	0.80	0.39	1.05
01/24/95	1.20	1.52	1.18	----
Geometric Mean	1.16	1.58	0.51	1.52
Std. Dev.	0.62-1.64	1.05-2.38	0.33-0.78	1.16-1.99

TABLE 5.7
TOTAL SUSPENDED SOLIDS (mg/l) MEASURED IN SPECIAL SAMPLES
FROM OVER A TWO WEEK PERIOD AT THE IHILANI RESORT & SPA

DATE	LAGOON AT INTAKE SURFACE	LAGOON AT INTAKE 2 m	LAGOON AT CHANNEL 2 M	EFFLUENT FROM PIPE
01/11/95	3.6	5.0	----	4.3
01/12/95	4.5	5.3	----	5.0
01/13/95	2.8	8.1	2.9	3.3
01/16/95	2.8	4.7	5.1	4.2
01/17/95	2.8	6.2	1.2	4.2
01/18/95	1.8	4.7	3.0	4.8
01/20/95	2.5	4.0	2.6	5.7
01/23/95	3.2	7.2	5.3	3.4
01/24/95	5.3	8.5	18.2	----
Geometric Mean	3.1	5.8	3.9	4.3
Std. Dev	2.3-4.3	4.4-7.5	1.7-9.0	3.6-5.2

Table 5.8 presents a comparison matrix for the means in Table 5.6 and Table 5.7. Table 5.8 values are *P* values for a *t*-test comparison of means. It is generally accepted that a *P* value of 0.05 (that is 5%) or less is indicative of a significant difference between means compared using this statistical test, and these values are given in bold type. Of primary interest for the present analysis of discharge impacts on the environment is the comparisons between surface and 2 m depth samples in the lagoon. For turbidity, the results indicate that differences are not significant. For total suspended solids, the surface versus deep means are significantly different. In effect, these results say that the concentration of fine particulate (i.e., cloudiness) is homogeneous in the water column; the surface and 2 m deep samples are from the same water mass. However, other particulate, perhaps fine sands that would tend not to be measured by a nephelometric turbidimeter because of high settling velocity, are more concentrated near the bottom and therefore, underestimated at the "Lagoon" station for the monitoring program.

The decorative ponds have been populated slowly with fishes and the biomass of fish is well below maximum, so it remains to be seen what the impact of the system will be on near shore water quality when a higher biomass is present in the ponds. It is clear that the water quality of the lagoon can be detected in some of the means from the outfall station. The

TABLE 5.8
PROBABILITIES (P) FROM t-TEST COMPARISONS OF THE GEOMETRIC
MEANS IN TABLES 5.6 & 5.7 FOR TURBIDITY AND TOTAL SUSPENDED SOLIDS

	LAGOON SURFACE	LAGOON 2 m	LAGOON CHANNEL	EFFLUENT
LAGOON SURFACE	TURBIDITY→ TSS↓	0.106	---	---
LAGOON 2 m	0.0004		0.0001	0.83
LAGOON CHANNEL	---	0.20		---
EFFLUENT	---	0.019	---	

salinity means are particularly interesting because of the degree of accuracy in the measurements. Although the difference between the lagoon and the ocean is only around 0.2 ppt, this difference is statistically significant ($P=0.0025$). Before the northern control station was discontinued, both control location means (Station 1S and 1N) were within 0.01 of 35.56 ppt. The outfall mean (presumably a varying mixture of the lagoon and ocean waters) is presently 34.54 ppt and the lagoon is 34.47 ppt. If these values represent real differences as opposed to analytical variation, then the outfall samples represent an average mix of 5 parts ocean water and one part pond (lagoon) water. This is a reasonable result given the location of the "outfall" sample in relation to the end of the pipe. A similar initial dilution estimate results from consideration of the means from 16 events previously tabulated (i.e., $5 \times 34.53 = 172.65$ $+ 34.34 = 207.00 \div 6 = 34.50$; very close to the outfall salinity of 34.54 ppt).

5.3.4 EnterOcean Guam Facility

Essentially all of the potential impacts to water quality are associated with effluent discharge from the "aquarium" system. Based on the three examples discussed above, any difference in water quality between the discharge waters and the receiving body resulting from operation of the proposed Guam EnterOcean facility are projected to be slight. Small increases

in suspended solids, turbidity, inorganic nutrients, and chlorophyll can be expected. Discharge nutrients will be rapidly assimilated in the receiving waters as the offshore waters are nutrient limiting for the primary producers (algae). A benthic algal community may develop near the discharge site, but this would certainly be cropped and kept in check by herbivorous reef dwellers. Similarly, any increase in the offshore phytoplankton production as the result of nutrient assimilation together with the phytoplankton (chlorophyll) discharge in the effluent would effectively be grazed by the food limited zooplankton community.

The use of offshore waters as the intake for the aquarium has the primary advantage that particulate (suspended solids and turbidity) and nutrient (N and P) levels will be minimal. This will assure the clearest waters for the facility and an excellence baseline for discharge back into the offshore environment. Since the proposed turnover rate of the water system is high (once every three hours), changes in water quality, especially particulate and nutrients which are the main concern, should be minimal. Significant changes in salinity and temperature are not anticipated in a well maintained and balanced system. Dissolved oxygen levels and percent saturation should not be a problem either within the system or the discharge, and mechanical aeration will be provided if necessary.

5.4 INFRASTRUCTURE

5.4.1 Water Systems

Maximum total fresh water consumption is calculated at 400 fixture units which is equivalent to 130 gallons per minute. Based on wastewater engineering references, the average daily cold water consumption will be approximately 11,250 gallons. Fresh water will be used in the facility's restrooms and shower facility (for guests to rinse off before entering and after exiting the swim through attraction). Shower fixtures will be outfitted with water conservation devices, and toilet fixtures will be ultra-low flush (1.6 gallons per flush) type. Fresh water will also be used for the kitchen facility and for landscaping maintenance.

Fire protection provision, including automatic sprinkler system, is for 500 gallons per minute rate utilizing 6"0 pipe.

Both domestic water and fire protection will be serviced by a 6" water main connected to an existing water main in front of Nikko Hotel.

5.4.2 Waste Water Systems

Waste water from the EnterOcean Facility will flow by 4" forcemain to a manhole vicinity by the Nikko Hotel. Sewage will

then flow by gravity to the Fujita Pump Station. Maximum total load is calculated at 220 fixture units. At 11,250 gallons average daily cold water consumption, the average waste water load will be approximately 10,000 gallons daily.

5.4.3 Roads

The access road for this project will be developed and constructed within an existing easement leading towards a proposed future hotel resort to the north. The portion of the access road to the EnterOcean project would be an extension of Gogna Road. The newly developed EnterOcean access road will "deadend" at the project site. Since this development is at the northernmost end of San Vitores, there is no existing traffic which will be impacted. Existing and proposed roadways will be sufficient to accommodate the increased traffic from the EnterOcean facility.

5.4.4 Electrical Systems

The proposed EnterOcean Facility will receive electrical energy from GPA's Tanguisson station. The total computed demand load for the facility is 877 kva. The recommended transformer size to serve this complex would be 1,000 kva. There is an existing 13.8 kva, 3 phase overhead primary line servicing the Nikko and Okura Hotels. This line would be extended and terminated on a riser pole at the EnterOcean Facility. The project itself would use a 1,000 kva Pad Mounted Distribution

Transformer with 13.8 kva primary and 480/277 volts secondary voltage.

5.4.5 Telephone

The installation of telephone service into the area will adhere to the required GTA standards. The impacts that this activity will have upon the environment include an increase in resource use, additional load, and the intrusion of concrete poles. These are assessed as having no significant impact.

5.4.6 Solid Waste

Solid wastes comprise all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. The solid waste generated from the proposed recreational facility and restaurant services will be comprised of paper, cardboard, plastics, food waste, glass, metals, special waste including bulky items, white goods, and landscaping wastes.

Evaluation of a similar sea life recreational center with restaurant services, located in Hawaii, with approximately 1,800 to 2,200 visitors per day is used to estimate the expected solid waste generation for the completed facility. The Hawaii based recreational center is serviced by two 6 cubic yard disposal trucks, daily (based on a six day week). Based on the similarities in type of waste generation and the estimated visitor count, the proposed EnterOcean facility is expected to

generated approximately 8-12 cubic yards of waste per day.

The solid waste will be picked up by private collectors and taken to designated landfill sites. The owner of the proposed facility will adhere to and promote any future recycling program available on the island. It also may be possible for food materials to be collected and taken to local farmers for livestock feed. No unusual or hazardous materials will be incorporated into the municipal solid waste generated from the EnterOcean facility.

5.4.7 Storm Water Management

The total acreage of the EnterOcean Facility development is approximately 4.16 acres. The planning and engineering of the stormwater run-off generated by the development and subsequent design of drainage facilities will follow Guam's drainage planning policies contained in the following documents:

- Guam Storm Drainage Manual, Chapter II
- Guam Environmental Protection Agency "208 Water Quality Management Plan"

Conceptually, stormwater run-off from all land surface areas (buildings roof, parking lot, open areas, and others) totalling approximately 1.4 acres will be managed and contained within boundaries of the development. Appropriate landscaping

will aid in stormwater infiltration. Stormwater collected from pavement, roofs, and other areas will be contained on site in underground stormwater retention and percolation chambers. The aquarium seawater outfall will not be used to discharge stormwater (except rain which falls directly into the open seawater tanks).

5.5 FISCAL IMPACTS

The operation of the EnterOcean facility will generate positive fiscal impacts in three area: 1) increase in total sales or revenue in the island economy; 2) increase in household income; 3) increase in government revenues through fees and taxes.

It is estimated in the first year of operation that direct revenues will be \$6 million. A commercial output multiplier of two is typical (Department of Planning and Economic Development, State of Hawaii, 1983). Based on this multiplier, total revenue for Guam would be \$12 million annually.

Commerce statistics also estimated that each dollar spent by a visitor will ultimately increase the total house hold income on Guam by 74 cents. This amount includes the: 1) project operating payroll; 2) portion of the payroll of businesses providing goods and services (an indirect effect); and, 3)

portions of payrolls for those businesses impacted by the economic activity. The total annual increase in household income is \$4,440,000,000.

Similarly, a total of 11 percent of visitor expenditures contribute to government revenue through a combination of gross receipts tax on direct, indirect and induced transactions, payroll taxes and revenue taxes. The project is expected to contribute a total of \$660,000 annually to the government revenue or approximately 1/10 of 1 percent of the governments total collections.

5.6 SOCIOECONOMIC IMPACTS

5.6.1 Employment

With the completion of construction and opening of the EnterOcean facility, a demand for specialized employment will provide opportunities to a wide range of professionals. Table 5.9 portrays the positions, background and experience qualifications, and number of people expected to be employed. This list describes a variety of specialists, promotional positions, and maintenance workers. The completed facility is expected to employ 184 people. An additional 110 jobs will also be generated through indirect and induced effects.

TABLE 5.9
PROJECTED EMPLOYMENT FOR COMPLETED ENTEROCEAN FACILITY, GUAM

POSITION	BACKGROUND EXPERIENCE	NUMBER OF PEOPLE
VP/Gen. Manger	Management	1
Admin. Asst.	Management	1
Accounting/Personnel		
Controller	Accounting	1
Chief Accountant	Accounting	1
Personnel Manger	Human Resources	1
Admin. Asst.	Business	1
Accounting Clerks	Accounting	6
Sales/Marketing		
Manager-Sales/Marketing	Marketing Mgt	1
Supervisor-Receptionists	Management	1
Asst. Supervisor-Reception	Management	1
Manager-Retail Sales	Sales Management	1
Asst. Mgr.-Retail	Sales Management	1
Manager-Club Sales	Sales Management	1
Asst. Mgr.-Club Sales	Sales Management	1
Receptionists	General	14
Retail Sales Personnel	General	12
Tour Operations		
Manager-Tour Operations	Ocean Sol./Management	1
Manager-Dive Tour Ops.	Ocean Sciences	1
Asst. Mgr.-dive Tour Ops.	Ocean Sciences	1
Manager-Semi-Sub Ops.	Ocean Sciences	1

TABLE 5.9 (continued)

POSITION	BACKGROUND EXPERIENCE	NUMBER OF PEOPLE
Asst. Mgr.-Semi-Sub Ops	Ocean Sciences	1
Dive Tour Leaders	Ocean Sciences	13
Dive Tour Attendants	Ocean Sciences	8
Semi-Sub Operators	Ocean Sciences	8
Semi-Sub Attendants	Ocean Sciences	8
Entertainment		
Entertainment Director	Entertainment Mgt.	1
Entertainers	Entertainment	6
Science and Education		
Director-Science/Education	Marine Biology	1
Curator	Marine Biology	1
Asst. Curator	Marine Biology	1
Biologist	Marine Biology	1
Bio-Technician	Marine Biology	1
Fish Collector	Marine Biology	2
Manager-Education	Marine Biology	1
Chief Docents	Marine Biology	1
Docents	Marine Biology	6
Food and Beverage Operations		
Manager-Food & Beverage	F&B Management	1
Manager-Sea Cave Lounge	F&B Management	1
Asst. Mgr.-Sea Cave	F&B Management	1
Manager-Snake Shop	F&B Management	1

TABLE 5.9 (continued)

POSITION	BACKGROUND EXPERIENCE	NUMBER OF PEOPLE
Asst. Mgr.-Snake Shop	F&B Management	1
Manager-Catering	F&B Management	1
Food and Beverage Personnel	General	44
Maintenance		
Maintenance Manager	Engineering	1
Mechanic	Maintenance Engr.	1
Electrician	Electrician	1
Electronics Tech.	Electronics	1
Grounds Maint. Personnel	Landscape Maint.	2
Transportation		
Transportation Manager	General	1
Drivers	General	18

The increase in employment will have an impact on the local economy, housing, and infrastructure. This increase should not be regarded as having a negative impact, but rather an opportunity that will open avenues for many local residents in Guam. The proposed undertaking also allows for the introduction of professionals from around the world who can increase and improve the exposure Guam receives globally.

5.6.2 Public Schools and Educational Facilities

It is the intention of the EnterOcean facility to introduce school children, university students, and professionals to the educational aspects of the facility. A planned schedule will be initiated that allows a student to frequent the facility and become familiar with marine life and its role in the Pacific realm. Students will be given an opportunity to visit the facility with their classmates and teachers at a discounted admission rate.

The EnterOcean group has began informal discussions with members of the University of Guam to explore opportunities for shared resources and university involvement in a cooperative planning and maintenance schedule. This will allow the University of Guam to receive exposure to and research wildlife maintenance in an aquarium setting. The EnterOcean facility will

benefit from University knowledge and research.

5.6.3 Police and Fire Services

The completed facility will place a demand on local services for routine inspection and a thorough introduction of the facility and its components to police and fire workers. This will ensure the safety and health of workers and patrons during an emergency situation. An introduction of the design and operation of the facility can be given to police and fire workers prior initial opening of the facility. The benefits of these workers becoming familiar with the facility will be an advantage for any routine and emergency situation.

5.6.4 Hospital Services

The Guam Memorial Hospital, GMH, is located approximately 2 miles from the facility. This is within a close proximity to the EnterOcean facility. Emergency services at the hospital are available for medical assistance in an emergency or similar situation. Although the EnterOcean Group is confident that its diving and marine activities are safe and the probability of injury is very small, there is an adequate hospital to serve the needs of visitors. The EnterOcean facility should have no significant impact on the hospital services.

5.6.5 Neighborhood

The completed facility will generate activity in the area that did not exist prior to development. However, through the process of site evaluation, the EnterOcean facility has planned its objectives to complement the surrounding neighborhood. Most of the facility's services are directed towards the visitor population that resides in Tumon Bay. The project's immediately surrounding neighbors are the Harmon Annex, situated above the bluff, and the Nikko and Okura Hotel. The impact the facility on these adjacent properties will include increased traffic, an increase in land use, including beach and reef area, an increase in noise production, and additional strain on utility services. Through comprehensive planning and dedication to required mitigation measures, it is anticipated that the facility will not generate significant impacts to the existing neighborhood.

5.6.6 Population

The completed facility will generate a demand for specialized employment and this will generate a need for off-island workers. Although residents of Guam will be preferentially recruited for employment, a demand for specialized employees will have an effect on the population on the island.

Both direct and indirect impacts will result from an influx of off-island workers. Direct impacts include an increase in the demand for housing, goods and services, childcare and health care, and other necessities. A burden will be placed on the road system and infrastructure services.

It is an important to address the need to hire and train local workers. This may draw laborers from other productive activities such as agriculture or fishing, however, it will provide opportunities for upward mobility to members Guam's community.

5.7 TRAFFIC IMPACTS

5.7.1 Trip Generation

Traffic analysis estimates the total average weekday passenger vehicle traffic generated by the EnterOcean facility as 230 vehicle trips, with 115 entering and 115 exiting. Based on 15 operating hours per day, the average weekday hourly vehicle traffic generated is 16 vehicle trips per hour, with eight entering and eight exiting.

The weekday morning peak hour of the adjacent street will generate a total of 1 vehicle trip, with 1 entering and 0

exiting. The weekday afternoon peak hour of the facility will generate 14 vehicle trips, with 8 entering and 6 exiting.

The average total Saturday vehicle traffic generated by the development will be 610 trips, with 305 entering and 305 exiting. Based on the facility operating 15 hours per day, the average Saturday hourly traffic generated is 40 trips per hour, with 20 vehicles entering and 20 exiting. The Saturday peak hour will generate 64 vehicle trips, with 37 entering and 27 exiting.

The average total Sunday vehicle traffic generated by the development will be 578 trips, with 289 entering and 289 exiting. Based on the facility operating 15 hours per day, the average Sunday hourly vehicle traffic generated is 38 trips per hour, with 19 vehicles entering and 19 vehicles exiting. The Sunday peak hour will generate 60 vehicle trips, with 26 entering and 34 exiting.

The Saturday peak hour will generate the maximum vehicle traffic, with 64 trips, 37 entering and 27 exiting. With a total of 210 vehicle parking spaces on site, the Saturday peak hour traffic load can be accommodated. Traffic flow will not be congested since there is sufficient parking for all vehicles entering and exiting.

5.7.2 Roadway Adequacy

The access road for this project will be developed and constructed within an existing roadway easement to the north and along unimproved portions of Gogna Road. The project access road will connect to San Vitores and come to a "deaden" at the EnterOcean facility. Existing public access to Gun Beach will be maintained. Since this development is at the northernmost end of San Vitores, there is little existing traffic which will be impacted. The traffic impact of this development will be the total traffic discussed in the Trip Generation section, above, until future projects are constructed in the Gun Beach area.

In December 1991, a traffic study was prepared by Wilbur Smith Associates for the Department of Public Works. The report, Guam 2010 Highway Master Plan - Tumon Bay Traffic Study, includes as assessment of existing conditions, forecasted future development, future year capacity analysis, improvement options, preferred strategy and recommendations. The access road for the EnterOcean development is the tail end of Gogna Road. Roadway Adequacy, as defined in the 1991 report, "refers to the ability of the roads, intersections, and traffic control devices to process traffic demand". This concept is measured through conducting capacity analysis at major intersections. The 1991 report includes intersection capacity analysis techniques as outlined in the 1985 Highway Capacity Manual to analyze the adequacy of the signalized intersections within the study area. These procedures provide a quantified level of service (LOS)

which describes traffic conditions by intersection delay. These conditions are defined by the letters "A" through "F", with "A" being excellent (no delays) traffic conditions, and "F" equating to congested, unstable traffic flow with excessive driver delay.

The results of the intersection capacity analysis conducted at the San Vitores/Gogna Road intersection is level of service rating of "B" during the AM peak hours and an "E" during the PM peak hours.

Since the peak hour (of adjacent street) volumes generated by this development are 1 vehicle trip in the morning peak hour and 14 vehicles trips in the afternoon peak hour, there should be no significant impact on the level of service at this intersection. The volume/capacity ratios at this intersection are 0.68 for the AM peak hour and 0.93 for the PM peak hour, indicating that there is an additional capacity available at this intersection.

5.7.3 Parking Calculations

Total parking required for the EnterOcean facility is 182 spaces. Current design provides a total of 210 standard, 8 ½ feet x 19 feet, parking spaces. An additional 8 disabled parking spaces, 3 bus parking spaces, and 4 loading/unloading areas will also be provided. Detailed parking calculations are at Appendix

In addition to the private parking spaces provided, the facility will operate a shuttle service utilizing six, 25 passenger, jitneys. Five jitneys will make pick ups at all large hotels in the Tumon Bay area, the sixth jitney will service the Tamuning hotels.

5.8 CUMULATIVE IMPACTS

A cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (CEQ Regulations 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over time. This section evaluates impacts that will occur during operation of the facility. These impacts are discussed in the following sections.

5.8.1 Impacts Compared to Measurement Criteria

A. Positive

The many positive impacts this project will have on Guam include a wide range of issues. These include financial gain and an increase in visitor attractions, educational and research promotion, local employment and worldwide exposure.

Potential synergistic effects of water pollution from discharges can inhibit coral recolonization on excavated surface based on studies in Pala Lagoon, Samoa (Helfrich, 1975) and Kaneohe Bay, O'ahu (Maragos, 1972, Maragos et al., 1985). In the Kaneohe Bay example, recolonization was accelerated after removal of sewage outfalls in a nearby lagoon. However, no cumulative effects of the proposed discharge on water quality are anticipated at or near the discharge point, because water quality of the discharge is expected roughly equal source water quality. Properties of the discharge will always be dependant upon the quality of the water brought in to the system. The opportunities for offshore mixing and dispersion are ample at Gun Beach, and no substances added to the discharge by operation of the facility would accumulate around the discharge point.

With the completion and operation of the project, there will be an increase in employment, income generation, real estate taxes, and tax revenue. The recruitment of local employment will allow for new mobility within the island's employment infrastructure. An unique facility will characterize Tumon Bay and will provide the visitors of Guam with

an adventurous and educational experience not received elsewhere in the world. The facility will expose many individuals, especially schoolchildren, to aspects of marine biology and influence their perspective of wildlife through a safe and respectful experience.

It is projected that the EnterOcean facility will produce a successful breeding stock of fish and other marine life. The EnterOcean intends to initiate a cooperative research program with the University of Guam which will provide students and researchers with the access to the marine wildlife at the EnterOcean facility. This facility will provide many opportunities for applied marine research into aquarium systems.

B. Negative

As with the construction of the facility, the completed project will have cumulative effects that may have a negative impact on the environment. These projected negative impacts are listed as below.

Imported labor can have a number of negative cumulative impacts including additional burden on

social services, infrastructure systems, and housing demand.

An increase in tourist activity may have negative impacts on the environment if they are not avoided or mitigated. These may include enhanced access to the Gun Beach area and use of the reef. Other tourist activities that produce careless waste may lead to additional pollution along the beach and ocean, and eventual degradation of the water quality within Tumon Bay

Long term erosion could become a concern if the proper Erosion Mitigation Plan is not initiated and practiced through development. The cumulative effects that may result in the inattentive efforts to restrict erosion would include land subsidence, soil and vegetation degradation, destruction to coastal and marine waters, erosion to marginal reef, and depreciation of marine wildlife. The negative cumulative impacts should be curtailed through the use of proper mitigation measures

Landscaping of the facility must be consistent with the existing environment, and able to produce and sustain healthy vegetation without being heavily

dependant on fertilizers and pesticides. Run off of landscaping chemicals could have a foray of cumulative effects on the environment. These include exposure to toxicity that may lead to species and habitat loss and a decrease in water quality in Tumon Bay.

Impacts associated with the changes in land use and structures may have negative impacts on the environment. These include increased exposure to visitors, loss of habitat, increased run off and erosion, and a change in ecosystem structure. Impacts associated with land use changes may also lead to an increase in the public health risk, for example ciguatera in reef wildlife.

5.8.2 Avoidable and Unavoidable Impacts

A. Avoidable

Avoidable impacts are those that can be averted by correct planning and the proper mitigation measures. This would include avoidance of excessive erosion and run off from easements and cliff areas, and the implementation and maintenance of air and water quality standards.

Avoidable impacts also include the waste of marine wildlife and the maintenance of sustainable stock through a healthy and well supervised aquarium environment.

B. Unavoidable

Harvesting of marine wildlife for the facility. All harvesting or purchasing will be done in accordance with Fish and Wildlife rules and guidance. No marine mammals will be stocked.

5.9 MITIGATION MEASURES

5.9.1 Marine and Biological Maintenance

Suspended solids and turbidity are the only water quality parameters that will not be directly assimilated by the receiving waters. Filtration of the effluent waters prior to discharge could effectively remove much of the suspended solids, but would not effectively reduce turbidity and, therefore, is not a feasible alternative. Effective mixing and dispersion upon discharge is probably the most suitable means of neutralizing measurable differences between effluent and the receiving water body. It should be emphasized that, based on measured water quality at Gun Beach, all projected effluent discharges from the

EnterOcean facility are expected to meet Guam Water Quality Standards for M-2 waters in the pipeline.

The proposed EnterOcean project will consist of several different marine environments each populated with marine animals typical of the habitats provided. Fish will be free to distribute themselves freely, with the exception animals kept in the predator tank, which is confined and separated from human participants. Overall, the minimum water volume per animal is anticipated to be on the order of 100 gallons, putting the maximum capacity of the attraction at approximately 20,000 individual fish and larger invertebrates. The following habitat areas and species are planned.

A. Shore to Reef: A sand bottom, populated by bottom feeders such as rudderfish (nenu or *Kyphosus cinerescens*) mullet (*Mugil* sp.), milkfish (*Chanos chanos*), and perhaps goatfishes (Mullidae). These are mostly schooling species that feed on inhabitants in the sand bottom.

B. The Reef Margin: Rugged, simulated rock and coral providing habitat space to colorful but common reef fishes such as butterflyfishes (*Chaetodon* spp.), triggerfishes (humuhumu; Balistidae), surgeonfishes (*Acanthurus* spp. such as manini), and tang (*Zebrasoma*

flavescens), that feed mostly upon algal growth, with lesser numbers of species which feed on small invertebrates.

C. Beyond the Reef: Deeper channel areas when pelagic fish such as ulua and papio (*Caranx* sp.), kahala (*Seriola* sp.), Hawaiian salmon, and mahimahi (*Coryphaena hippurus*) will swim by the diver groups. Safely contained behind thick acrylic glass panels in the Predator Tank will swim larger animals such as blacktip reef sharks (*Carcharhinus melanopterus*), manta rays (*Manta* sp.), and hammerhead sharks (*Sphyrna* sp.). The tank will be specially designed for these constantly swimming animals.

Specific species selections will be based on both availability and the ability of the animals to thrive in controlled environments. Water system will be operated by experienced personnel with backgrounds in aquarium systems. Animals will be maintained on special diets with measured amounts of food distributed to ensure good health and to prevent the release of excessive food particles which, if uneaten, could end up as detritus either in the facility or in the discharge.

The water system has been designed to exchange all of the water in the facility once every three hours. This water comes

directly from the ocean and will carry in it many small organisms such as plankton and propagules of algae, crabs, corals, anemones, molluses, worms, etc. that will develop populations within the underwater trails. These organisms will contribute to the ecology of the system and to the maintenance of some of the captured animals. Animals that settle out on internal, submerged surfaces will be "selected" naturally from the plankton as species that are adapted to living under the conditions developed within the waterways (which will generally be "calmer" than ocean reef environments subjected to constant wave action).

A variety of sources will supply marine animals for the facility. Because the sea water system is an open one, only species naturalized in Guam marine environments will be used. The Marine Laboratory at the University of Guam will be contracted to grow and supply invertebrates such as corals and fishes from ongoing aquaculture research programs. Other animals will be obtained either from permitted collectors around the island, or will be collected by the permitted collection staff employed by the facility itself. Care will be taken to ensure that natural reef systems are not damaged or depleted in the process. Emphasis will always be on utilizing species that can be readily maintained in the facility. Only those animals kept in the predator tank will be "unusual". Rare or unusual species prone to do poorly in captivity will not be used in the facility. The success of the venture and enjoyment of the participants is

not dependent upon presenting a changing array of animals, but on displaying an abundance of healthy animals typical of Guam's coral reefs.

APPENDIX A
Botanical Survey (1991)

BOTANICAL SURVEY REPORT FOR THE GUN BEACH HOTEL SITE
TUMON BAY, GUAM

for

GMP - ASSOCIATES
TANAKA BUILDING
AGANA, GUAM

by

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INTRODUCTION

The Gun Beach Hotel Site is located north of Gun Beach Road and extends from Gun Beach to the Okura Hotel Tennis Court and north to the brow of the cliff.

A botanical survey was undertaken in July, 1991 to collect technical data, to describe and map the existing vegetation types, to compile an inventory of the flora, and to search for plants which have been proposed or listed as rare, threatened or endangered (USFWS 1990, GEPA 1987).

METHODS

Data collection was carried out by a two man field team. The field survey included three traverses of the cliffs, two transects from Gun Beach to the eastern boundry and two traverses of the strand area. Four vegetation types were found and are described.

LITERATURE REVIEW

The study site is located on the northern plateau of the island of Guam and slopes east to west (USN 1986) with some minor local surface irregularities. The soil of this sloping limestone hillside area is very shallow and well drained. It is made up of two soil types, Guam cobbley clay loam with rounded rock fragments and frequent limestone outcrops, and Ritidian-Rock Complex (USDA 1988). Ritidian-Rock Outcrop Complex of this type is considered to be quarriable.

There is no specific literature on the vegetation of the northern plateau of Guam. Both Stone (Stone 1970-71) and Fosberg (Fosberg 1960) have presented general discussions of past botanical collections made in the archipelago and of those who made them. In addition, Fosberg has offered the following explanation for the present condition of the forests of Guam's limestone plateaus:

"It is difficult to be certain of the character of the original vegetation, even of the hard limestone areas. Guam has been inhabited by man for possibly several thousand years, but of this period virtually nothing is known except for the last 430 years. For most of the latter period, until 1941, the total population has not been large, but at the time of Magellan's visit in 1521 there must have been tens of thousands of aborigines. The influence of these people on the vegetation is hard to estimate but could not have been negligible. Since Magellan's time, although the population has been smaller, the people have been much better equipped to destroy the forests. Also, since that time they have been ably assisted by the cattle, goats, deer, and other four-footed animals brought by the European conquerors. The actual changes effected by these influences up through 1941 cannot be well traced, but undoubtedly the local diversity of the forest types growing on an essentially uniform substratum and in the absence of much climatic variation is one result.

Beginning with the Japanese invasion in 1941, the rate of change in most of the vegetation types on Guam was enormously accelerated. Battles were fought in the forests with highly destructive modern weapons. Enormous areas were cleared and scraped by bulldozers and changed permanently.....

Because of the presence, virtually everywhere, of species that generally occur in secondary vegetation and even of introduced plants, such as *Triphasia*, *Cestrum* and *Carica*, and because of the uneven, brushy nature of almost all of the remaining forests, it seems best to regard the present-day forests on the plateaus and terraces as modified. In a few places the disturbance may not have been great enough to change the structure and composition entirely, but as a whole what is presently growing on these areas is considered to be modified forest. Probably much of it is not truly secondary, if this term is taken to mean forest that follows clearing."

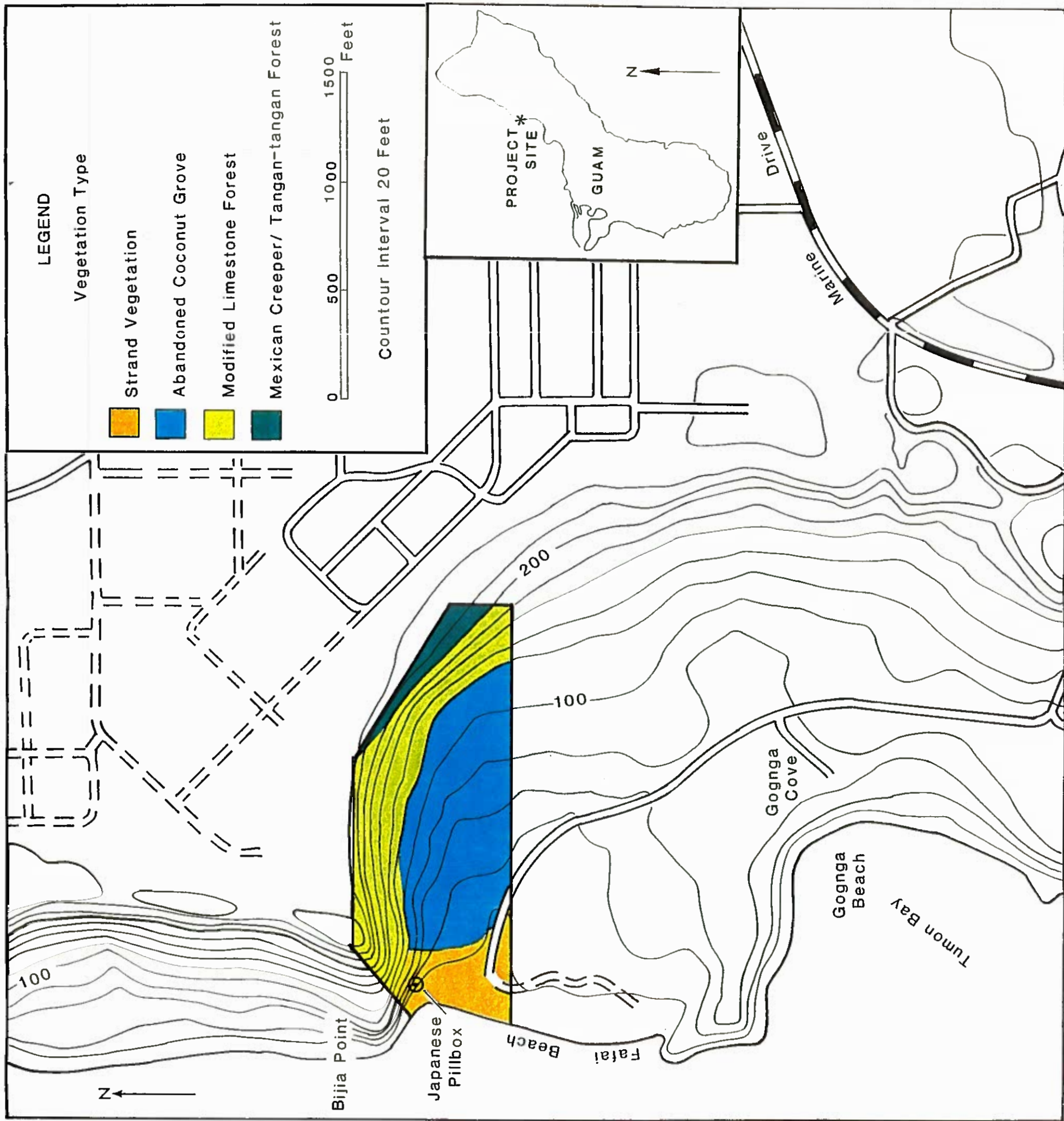
Later, in his classification of vegetation for general purposes, Fosberg (1967) recognized many of the forest types of Guam. In recent years, some detailed studies on some of the vegetation types have been carried out and published by students of the University of Guam (Raulerson 1981). Other publications have referred to the flora of the island and most have included some very general remarks about the limestone forests of northern Guam (Gresset 1963, Fosberg, Sachet & Oliver 1979, 1982, 1987). However, literature based on floristic, ecological or biogeographical studies in the area is lacking.

VEGETATION TYPES

Four vegetation types were found on the site (Figure 1). From the eastern boundry along the brow of the cliff on the northern boundry to just past the westernmost building, the forest has been trimmed for about 20 m down the cliff. This has apparently been done to provide a scenic view of the Tumon Bay area. Today, the vegetation of this trimmed swath is Mexican Creeper/Tangantangan (*Antigonon leptopus* H&A/*Leucaena leucocephala* (Lam.) deWit) (Figure 1). Except for some fairly abundant Guam daisy (*Bidens alba* Fosc.) along the upper edge, there is very little else (Figure 2).

From the down hill edge of the Mexican creeper/tangantangan community and westward from its western edge to the Bijia Point, the cliff vegetation is Modified Limestone Forest (Figure 1). The vegetation is deemed to be modified because the area is so small that many of the really big trees associated with limestone forest are absent and a fair number of introduced species are also found in the community (Figure 3). However, there are some fairly large *Neisosperma oppositifolia* (Lam.) Fosc. & Sachet, *Ficus* spp., *Pahong* (*Pandanus dubuis* Sprengel), *Pandanus tectorius* Park, Sprengel, and *Ahogao* trees, many of which support epiphytic fern communities. The understory includes *Cycas circinalis* L., *Pai-pai* (*Guamia mariannae* (Safford) Merr.), *Ixora triantha* Volkens, and *Eugenia* spp., and some very big fern colonies. The ground layer is mostly seedlings and a tangle of *Bejuco halum-teno* vines (*Flagellaria indica* L.).

West of the Mexican creeper/Tangantangan Community the cliff becomes a precipice (Figure 4) and although there are some large trees growing out of



the rock, the most common vegetation is ferns. The base of this cliff is often huge, karst boulders.

From the eastern boundry to base of the cliff leading to Bijia Point the plant community is Abandoned Coconut Grove (Figure 1). The Niyog or coconut trees (*Cocos nucifera* L.). trees range in size from seedlings to mature, nut producing trees 12 to 15 m in height (Figure 5). Most of the mature trees are festooned with epiphytic fern colonies. There are understory trees such as pahong, Dokdok (*Artocarpus incisus* (Thunb.) L. f. Suppl., *A. mariannensis* Trecul.), African tulip (*Spathodea campanulata* P. de Beauvois), Pago (*Hibiscus tiliaceus* L.), Bullock's heart and sugar apple (*Annona reticulata* L. and *A. squamosa* L.) trees. The ground layer is Mile-a-minute vine (*Mikania scandens* (L.) Willd.), *Eupatorium odoratum* L., mixed ferns, an occasional ground orchid (*Nervilia aragoana* Gaud.), and many coconut seedlings.

At about the 100 m level a broad canyon crosses the property. The substrate is karst and the edges of the canyon or ditch are composed of very large limestone boulders. In this area the coconut trees drop out, but are again found below the rough karst and continue to the strand.

From the point where Gun Beach Road crosses the study site, the persisting coconut plantation is very disturbed and the vegetation consists of introduced grasses such as elephant grass (*Pennisetum purpureum* Schum.), wild sugar (*Saccharum spontaneum* L.), mission grass (*Pennisetum polystachyum* Schultes, and coconut trees.

A small colony of Strand Vegetation is to be found from the high tide line to about 15 m inland (Figure 1). Because the area is a very popular



Figure 2. Mexican Creeper/Tangantangan.



Figure 3. Modified Limestone Forest.



Figure 4. Ferns Inhabit the Steep Limestone Cliffs.



Figure 5. Vegetation of the Abandoned Coconut Groove is Very Lush.

swimming beach, the Strand Vegetation is badly damaged by cars. However, some plants do persist (Figure 6). The ground layer along the beach is principally Alalag-tasi or beach-morning-glory (*Ipomoea pes-caprae* L.) Roth.), mixed grasses such as gama or Bermuda grass (*Cynodon dactylon* (L.) Pers.), Las-aga (*Thuarea involuta* (Frost.f.) R. Br. ex R. & S.) and beach wire grass (*Eleusine indica* L.). There is the occasional Beach heliotrope or Hunig (*Tournefortia argentea* L.), some Kafu or Pandanus (*Pandanus tintorius* Park), young Kamachile (*Pithecellobium dulce* (Roxb.) Benth), Nonak (*Hernandia sonora* L.), and Nanaso (*Scaevola taccada* (Gaertn.) Roxb.), none of which become very large.



Figure 6. Vegetation of the Strand is Damaged by Cars and Beach Goers.

USDA. 1988. Soil Survey of Territory of Guam. University of Guam.

USN. 1986. Master Plan NAVCAMS WESTPAC. Guam, Mariana Islands.

SPECIES LIST

The plant families in the following species list have been alphabetically arranged within four groups, Ferns, Gymnosperms, Monocotyledons, and Dicotyledons. The genera and species are arranged alphabetically within families. The taxonomy and nomenclature follow that of Fosberg, Sachet & Oliver (1979, 1982, 1987) and Stone (1970-71). For each taxon the following information is provided:

1. An asterisk before the plant name indicates a plant introduced to Guam since Magellan or by the aborigines.
2. The scientific name.
3. The Chamorro name and or the most widely used common name.
4. Abundance ratings are for this site only and they have the following meanings:

Uncommon - a plant that was found less than five times.

Occasional - a plant that was found between five to ten times.

Common - a plant considered an important part of the vegetation

Locally abundant - plants found in large numbers over a limited area. For example the plants found in grassy patches.

This species list is the result of an extensive survey of this site during the summer hot season (July 1991) and it reflects the vegetative composition of the flora during a single season. Minor changes in the vegetation will occur due to introductions and losses and a slightly different species list would result from a survey conducted during a different growing season.

LIST OF ALL PLANT SPECIES FOUND ON THE GUN BEACH HOTEL SITE

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE
FERNS		
POLYPODIACEAE		
<i>Asplenium polyodon</i> Frost.f.		Occasional
<i>Asplenium nidus</i> L.		Locally abundant
<i>Belvesia spicata</i> (L.f.) Mirb. ex Copel.		Common
<i>Davallia solida</i> (Forst. f.) Swartz	Pugua-machena	Locally abundant
<i>Nephrolepis acutifolia</i> (Desvaux) Christ		Locally abundant
<i>Nephrolepis hirsutula</i> (Forst.) Presl	Sword fern	Common
<i>Polypodium punctatum</i> (L.) Sw.		
- <i>Microsorium punctatum</i> (L.) Copel.		Common
<i>Polypodium scolopendria</i> Burm. f.		Common
- <i>Phymatodes scolopendria</i> (Brum.) Ching		
<i>Pteris tripartita</i> Sw.		Occasional
<i>Pyrrosia adnascens</i> (Swartz) Ching		Locally abundant
<i>Thelypteris dentata</i> (Forsk.) E. St. John		Occasional
<i>Thelypteris opulenta</i> (Kaulf.) Fosb.		Occasional
GYMNOSPERMAE		
<i>Cycas circinalis</i> L.		Locally abundant
ANGIOSPERMS		
MONOCOTYLEDONES		
ARACEAE - Aroid Family		
* <i>Alocasia macrorrhiza</i> (L.) D. Don	Papao apaca	Locally abundant
CYPERACEAE - Sedge Family		
<i>Cyperus ligularis</i> L.		Occasional
<i>Cyperus polystachyos</i> Rottb.		Occasional
<i>Fimbristylis cymosa</i> R. Br.		Occasional
<i>Fimbristylis dichotoma</i> (L.) Vahl		Occasional
DIOSCOREACEAE - Yam Family		
* <i>Dioscorea esculenta</i> (Lour.) Prain & Burkill	Yam	Locally abundant
FLAGELLARIACEAE		
<i>Flagellaria indica</i> L.	Bejuco halum-tano	Common

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE
GRAMINEAE - Grass Family		
* <i>Cenchrus echinatus</i> L.	Sandbur	Locally abundant
* <i>Chloris inflata</i> Link	Finger grass	Occasional
* <i>Chrysopogon aciculatus</i> Retz.	Infuk	Occasional
* <i>Cynodon dactylon</i> (L.) Pers.	Grama	Common
* <i>Dactyloctenium aegyptium</i> (L.) Beauv.	Crowfoot grass	Occasional
* <i>Eleusine indica</i> (L.) Gaertn.	Ragi	Common
* <i>Eragrostis tenella</i> (L.) R. & S.	Lovegrass	Common
* <i>Panicum maximum</i> Jacq.	Guinea grass	Locally abundant
* <i>Paspalum paniculatum</i> L.		Occasional
* <i>Pennisetum polystachyum</i> (L.) Schultes	Mission grass	Common
* <i>Pennisetum purpureum</i> Schum.	Elephant grass	Common
* <i>Saccharum spontaneum</i> L.	Wild cane	Occasional
* <i>Sporobolus diander</i> (Retz.) Beauv.	Rat tail grass	Locally abundant
* <i>Sporobolus fertilis</i> (Steud.) Clayton		Locally abundant
* <i>Trichachne insularis</i> (L.) Nees	Cotton grass	Occasional

LILIACEAE - Lily Family

<i>Cordyline terminalis</i> (L.) Kunth	Ti plant	Occasional
<i>Hymenocallis litoralis</i> (Jacq.) Salisb.	Lirio	Locally abundant

ORCHIDACEAE - Orchid Family

* <i>Spathoglottis plicata</i> Bl.		Common
<i>Taeniophyllum mariannense</i> Schltr		Common
<i>Zeuxine fritzii</i> Schltr.		Uncommon

PALMAE - Palm Family

<i>Cocos nucifera</i> L.	Niyog	Common
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PANDANACEAE - Pandanus Family

<i>Pandanus tectorius</i> Park	Pahong	Common
<i>Pandanus dubius</i> Sprengel	Pahong	Common

ANGIOSPERMS

DICOTYLEDONES

ANNONACEAE - Custard-apple Family

<i>Annona reticulata</i>	Bullock's heart	Occasional
<i>Annona squamosa</i>	Sugar apple	Occasional
<i>Guamia mariannae</i> (Safford) Merrill	Pai-pai	Occasional

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE
APOCYNACEAE - Periwinkle Family		
<i>Alyxia torresiana</i> Gaud.	Nanago	Uncommon
<i>Neisosperma oppositifolia</i> (Lam.) Fosb. & Sachet		Occasional
BORAGINACEAE - Heliotrope Family		
<i>Heliotropium indicum</i> L.	Bergen	Common
CASUARINACEAE - Ironwood Family		
<i>Casuarina equisetifolia</i> L.		
- <i>Casuarina litorea</i> L. (Fosberg)	Gago	Common
CARICACEAE - Papaya Family		
* <i>Carica papaya</i> L.	Papaya	Common
CELASTRACEAE - Bittersweet Family		
<i>Maytenus thompsonii</i> (Merr.) Fosb.	Luluhut	Occasional
COMPOSITAE - Sunflower Family		
* <i>Bidens pilosa</i> L.		
- <i>Bidens alba</i> of Fosb.	Beggar's tick	Common
<i>Conyza canadensis</i> (L.) Cronq.	Horse-weed	Locally abundant
<i>Chromolaena odorata</i> (L.) King & Rob.		
- <i>Eupatorium odoratum</i> L.		Common
<i>Mikania scandens</i> (L.) Willd.	Mile-a-minute vine	Common
* <i>Pluchea odorata</i> (L.) Cass.		Uncommon
<i>Synedrella nodiflora</i> (L.) Gaertn	Saigon	Locally abundant
<i>Vernonia cinerea</i> (L.) Less.	Chaguan-Sta.Maria	Occasional
* <i>Wedelia trilobata</i> (L.) Hitchc.		Locally abundant
COMBRETACEAE - Terminalia Family		
<i>Terminalia catappa</i> L.	Talisai	Uncommon
CONVOLVULACEAE - Morningglory Family		
<i>Ipomoea indica</i> (Burm. f.) Merr.	Fofgu	Occasional
<i>Ipomoea littoralis</i> Blume	Lagun-tasi	Uncommon
<i>Ipomoea pes-caprae</i> L.	Beach morningglory	Locally abundant
<i>Ipomoea triloba</i> L.	Fofgu	Occasional
<i>Operculina ventricosa</i> (Bert.) Peter	Alalay	Locally abundant
CUCURBITACEAE - Gourd Family		
<i>Momordica charantia</i> L.	Almagoso	Common

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE
EUPHORBIACEAE - Spurge Family		
* <i>Euphorbia cyathophora</i> Murray	Dwarf poinsettia	Locally abundant
* <i>Euphorbia hetrophylla</i> L.		Locally abundant
* <i>Euphorbia hirta</i> L.	Golondrina	Common
<i>Glochidion marianum</i> Muell.-Arg.	Chosgo	Occasional
* <i>Manihot esculenta</i> Cranz.	Mandicka, Tapioca	Locally abundant
<i>Melanolepis multiglandulosa</i> Reichb. f.	Alom	Occasional
* <i>Phyllanthus acidus</i> (L.) Skeels	Iba	Uncommon
* <i>Phyllanthus amarus</i> Schum. & Thon.	Maigo-lalo	Common
<i>Phyllanthus marianus</i> Muell.-Arg.	Gaogao-uchan	Locally abundant
GOODENIACEAE		
<i>Scaevola sericea</i> Vahl		
= <i>Scaevola taccada</i> (Gaernt.) Roxb.	Nanaso	Locally abundant
HERNANDIACEAE - Hernandia Family		
* <i>Hernandia sonora</i> L.	Hernandia	Uncommon
LAURACEAE - Laural Family		
* <i>Cassytha filiformis</i> L.	Dodder	Locally abundant
LEGUMINOSAE - Pea Family		
* <i>Abrus pectorius</i> L.	Kolales Halomtano	Uncommon
* <i>Alysicarpus vaginalis</i> (L.) DC		Occasional
* <i>Caesalpinia major</i> Dandy & Excell.	Pakao	Common
* <i>Canavalia rosea</i> (Sw.) DC	Sea bean	Occasional
<i>Entada pursaetha</i> DC	Gayi	Uncommon
<i>Instia bijuga</i> (Colebr.) O. Ktze	Ifil	Uncommon
* <i>Leucaena leucocephala</i> (Lam.) deWit	Tangan-tangan	Common
* <i>Medicago polymorpha</i> Benth		Locally abundant
* <i>Mimosa pudica</i> L.	Sensitive plant	Locally abundant
* <i>Pithecellobium dulce</i> (Roxb.) Benth.	Kamachile	Occasional
MALVACEAE - Hibiscus family		
<i>Hibiscus tiliaceus</i> L.	Pago	Common
* <i>Malvastrum coromandelianum</i> Garcke	False marrow	Common
* <i>Sida acuta</i> Burm. f.	Escobilla papagu	Common
* <i>Sida rhombifolia</i> L.	Escobilla dalili	Common
MELIACEAE - Mahogany Family		
<i>Aglaia mariannensis</i> Merr.	Mapunyao	Uncommon

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE
MORACEAE - Fig Family		
<i>Artocarpus mariannensis</i> Trecul	Dokdok	Occasional
<i>Ficus prolixa</i> Forst. f.	Nunu	Occasional
<i>Ficus tinctoria</i> Forst. f.	Hoda	Occasional
MYRSINACEAE - Myrsine Family		
<i>Discocalyx megacarpa</i> Merr.	Otot	Occasional
MYRTACEAE - Myrtle Family		
<i>Eugenia palumbis</i> Merr.	Agatelang	Uncommon
<i>Eugenia reinwardtiana</i> (Bl.) DC	Aabang	Uncommon
<i>Psidium guajava</i> L.	Guava	Uncommon
NYCTAGINACEAE - Four o'clock Family		
<i>Boerhavia repens</i> L.	Dafao	Common
<i>Pisonia grandis</i> R. Br.	Umumu	Uncommon
OLEACEAE - Olive Family		
<i>Jasminum marianum</i> DC.	Banago	Common
PASSIFLORACEAE - Passion Flower Family		
* <i>Passiflora foetida</i> L.	Love-in-a-mist	Occasional
* <i>Passiflora suberosa</i> L.		Occasional
PIPERACEAE - Pepper Family		
<i>Piper guahamense</i> Dc	Pupulo aniti	Locally abundant
POLYGONACEAE - Buckwheat Family		
* <i>Antigonon leptopus</i> H & A	Candena de Amor	Locally abundant
RHAMNACEAE - Cascara Family		
<i>Colibrina asiatica</i> Brongniart	Gasoso	Occasional
RUBIACEAE - Coffee Family		
<i>Aidia cochinchinensis</i> Lour.		Occasional
<i>Ixora triantha</i> Volkens	Ixora	Uncommon
<i>Morinda citrifolia</i> L.	Lada	Common
<i>Morinda umbellata</i> L.		Uncommon
* <i>Paederia tomentosa</i> ?	Stink vine	Locally abundant
<i>Psychotria mariana</i> Bartl. ex DC	Ajgao	Occasional

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE
RUTACEAE - Citrus Family		
<i>Triphasia trifolia</i> (Burm. f.) P. Wils.	Limon de china	Common
SAPINDACEAE - Soapberry Family		
* <i>Allophyllus timoriensis</i> (DC.) Bl.	Nger	Occasional
SAPOTACEAE - Sapote Family		
<i>Pouteria obovata</i> (R. Br.) Bahni		Occasional
SCROPHYLLARIACEAE - Figwort Family		
* <i>Buchnera floridana</i> Sm.		Locally abundant
SOLANACEAE - Nightshade Family		
* <i>Capsicum frutescens</i> L.	Doni sali	Common
* <i>Cestrum diurnum</i> L.	Tintan-china	Occasional
* <i>Physalis angulata</i> L.	Tomates chaka	Occasional
* <i>Solanum nigrum</i> (L.) Senu lato	Nightshade	Occasional
TILIACEAE - Linden Family		
<i>Elaeocarpus sphaericus</i> K. Schum.	Yoga	Occasional
* <i>Muntingia calabura</i> L.	Panama berry	Occasional
UMBELLIFERAE - Carrot Family		
* <i>Centella asiatica</i> (L.) Urban		Locally abundant
URTICACEAE - Nettle Family		
* <i>Pilea microphylla</i> (L.) Liebmann	Artillary plant	Locally abundant
<i>Pipturus argenteus</i> (Forst. f.) Wedd.	Amajayab	Occasional
VERBENACEAE - Verbena Family		
<i>Callicarpa candicans</i> (Burm. f.) Hochr.	Qualitay	Occasional
* <i>Lantana camara</i> L.	Lantana	Occasional
* <i>Lippia nodiflora</i> (L.) Rich.	Lippia	Locally abundant
<i>Premna obtusifolia</i> R. Br.	Ahgao	Occasional
* <i>Stachytarpheta dichotoma</i> Vahl	False verbena	Common
* <i>Stachytarpheta jamaicensis</i> (L.) Vahl	False verbena	Common

APPENDIX B
Archaeological Inventory Survey (1991)

Archaeological Inventory Survey Gun Beach Hotel Site

Tamuning Municipality
Territory of Guam

PHRI

Paul H. Rosendahl, Ph.D., Inc.

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Archaeological Inventory Survey Gun Beach Hotel Site

Tamuning Municipality
Territory of Guam

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October 1992

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SUMMARY

At the request of Mr. Ron Young of Calvo Enterprises, Paul H. Rosendahl, Ph.D., Inc. (PHRI) recently conducted an archaeological inventory survey and testing in the approximately 21.6 acre Gun Beach Hotel Site project area at Turnon, Tamuning Municipality, Territory of Guam. The basic objective of the survey was to provide information appropriate to and sufficient for compliance with initial development conditions recommended by the Guam Historic Preservation Office (GHPO), and to comply with Executive Orders 89-9 and 89-24 and Public Law No. 20-151.

The field work for the Gun Beach Hotel Site project area consisted of: (a) 100% coverage ground survey of the project area; (b) the excavation of 22 systematically placed backhoe trenches (BTs) and 45 systematically placed shovel tests (STs); (c) the collection of time-sensitive artifacts; and (d) site recordation (including preparation of scaled sketch maps and section drawings, completion of standardized PHRI site and stratigraphy forms, and photography).

It was noted during the survey that a portion of an extensive, previously recorded archaeological site (GHPO Site 66-04-0001) extended into the project area. This site, an extensive subsurface cultural deposit, has been described by numerous researchers and was designated MaGTa-1 by Reinman (1966). During the survey, five prehistoric surface features and four historic features were identified within Site 66-04-0001, including a Japanese gun emplacement and pillbox (Features A and B), an artifact scatter (Feature C), a push pile containing possible *latte* elements (Feature D), a square alcove excavated out of the limestone cliff (Feature E), two rock overhangs (Features F and H), a midden deposit (Feature G) and a small concrete pad (Feature I).

Four additional archaeological sites were encountered outside site 66-04-0001. Site 66-04-0615 is a black, loamy surface and subsurface midden deposit (Feature A), a vertical coral rock (Feature B), and a surrounding subsurface deposit containing small amounts of prehistoric ceramics.

Site 66-04-0616 is an overhang (Feature A), and an associated surface scatter of prehistoric ceramics (Feature B). Site 66-04-0617 is a cave located on the edge of a large depression at the western edge of a raised limestone terrace. On the steep slope at the NE edge of the project area is Site 66-04-0618, consisting of a limestone boulder with a cave on the western side (Feature A) and an overhang on the southern side (Feature B).

Based on federal evaluation criteria, Sites 66-04-0615 and 66-04-0617 are assessed as significant solely for information content. Further work, consisting of archaeological data recovery, is recommended for these sites. Sites 66-04-0616 and 66-04-0618 are assessed as significant for information content, and in addition, are assessed as significant for cultural value, due to the presence of human remains. Further data collection is recommended for these sites, with preservation "as is" recommended for the features where human remains were identified. In the event that preservation is not an acceptable alternative, data recovery is recommended with special treatment of human remains in accordance with applicable Guam statutes and GHPO guidelines. Site 66-04-0001 is also assessed as significant for information value, and in addition, as an excellent example of a site type and for cultural value (based on the presence of human burials). Site 66-04-0001 is recommended for further data collection, for preservation with interpretive development, and for preservation "as is" for the burial components of the site. As for Sites 66-04-0016 and 66-04-0018, if preservation is not an acceptable alternative at these features, data recovery is recommended with special treatment of human remains in accordance with applicable Guam statutes and GHPO guidelines.

Further work in the form of a phased Data Recovery Program (DRP) is recommended for the portion of Site 66-04-0001 within the project area, as well as Sites 66-04-0615, 66-04-0616, 66-04-0617 and 66-04-0168. The DRP should include the formulation of an Archaeological Mitigation Plan (AMP), which would be subject to the approval of the GHPO.

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INTRODUCTION

BACKGROUND

At the request of Mr. Ron Young of Calvo Enterprises, Paul H. Rosendahl, Ph.D., Inc. (PHRI) recently conducted an archaeological inventory survey and testing of the c. 21.6 acre Gun Beach Hotel Site project area at Tumon, Tamuning Municipality, Territory of Guam (Figures 1, 2, and 3). The basic objective of the survey was to provide information appropriate to and sufficient for compliance with initial development conditions recommended by the Guam Historic Preservation Office (GHPO), and to comply with Executive Orders 89-9 and 89-24 and Public Law No. 20-151.

Field work was conducted in January 1992 and involved approximately fifteen labor-days. The field work was conducted by Supervisory Field Archaeologist Jack Dave Henry, B.S., and Field Archaeologists Mark Donham, M.A., Humphrey Calicher, B.A., and William Jurgelski, B.A. Mapping and survey work was conducted by R. Scott Lee, B.A., and Jeff Johnston, B.A. Guam Projects Director Roderick S. Brown, M.A., and Senior Archaeologist Alan E. Haun, Ph.D. provided overall guidance for the project.

This report constitutes the final report for the present project. It includes project objectives, a scope of work, field methods, and findings; and it presents general significance assessments and recommended general treatments for cultural remains in the project area.

SCOPE OF WORK

The basic purpose of an inventory survey is to identify—to discover and locate on available maps—features of potential archaeological significance present within the specified project area. An *inventory survey* is an initial level of archaeological investigation. It is extensive rather than intensive in scope, and is conducted with the primary aim of determining the presence or absence of archaeological resources within a specified project area. A survey of this type indicates both the general nature and the variety of archaeological remains present, and the distribution and density of such remains. It permits a general significance assessment of the archaeological resources, and facilitates formulation of realistic recommendations and estimates for any further work that might be necessary or appropriate. Such work could include *intensive survey*—further data collection involving detailed recording of sites and features, and selected test excavations. It might

also include subsequent *mitigation*—data recovery research excavations, construction monitoring, interpretive planning and development, and/or preservation of sites and features with significant scientific research, interpretive, and/or cultural values.

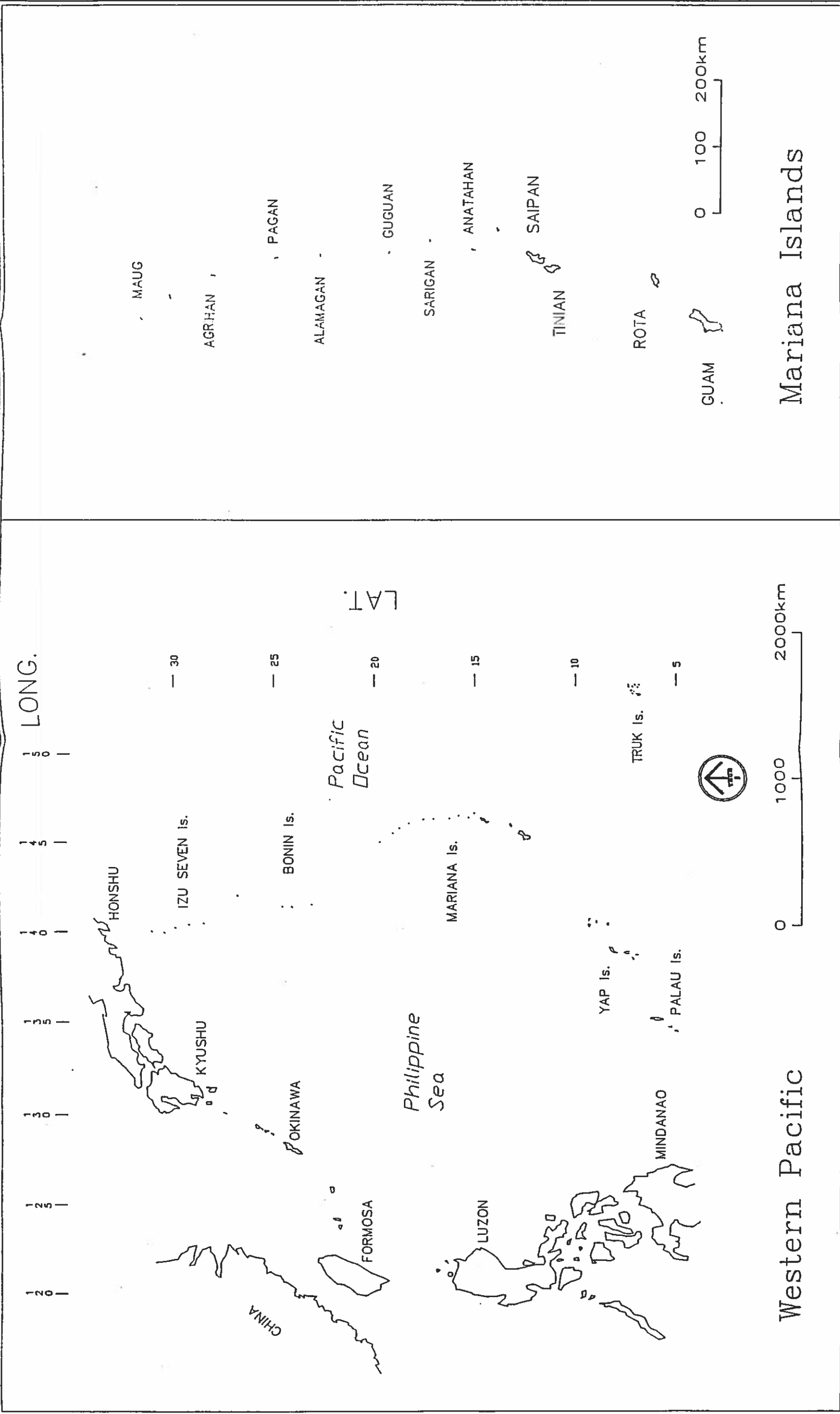
The specific objectives of the present survey were four-fold: (a) to identify (find and locate) all sites and site complexes within the project area, (b) to evaluate the general significance of all identified archaeological remains, and (c) to define the general scope of any subsequent data collection and mitigation work that might be necessary.

The following specific tasks were determined to constitute an appropriate scope of work for the present project:

1. Review available background archaeological and historical literature relevant to the immediate project area;
2. Conduct 100% coverage high-intensity surface survey of the entire project area, with emphasis upon (a) identification and collection of any portable cultural remains (i.e., artifacts, midden, or human bones) and (b) identification and evaluation of any subsurface cultural deposits that might be visible in any existing exposures (e.g., erosional faces, drainage channels);
3. Conduct extensive subsurface testing for buried cultural deposits and features (e.g., firepits, human burials) by means of backhoe trenching and hand excavations, as appropriate; and
4. Analyze background and field data and prepare appropriate reports.

PROJECT AREA DESCRIPTION

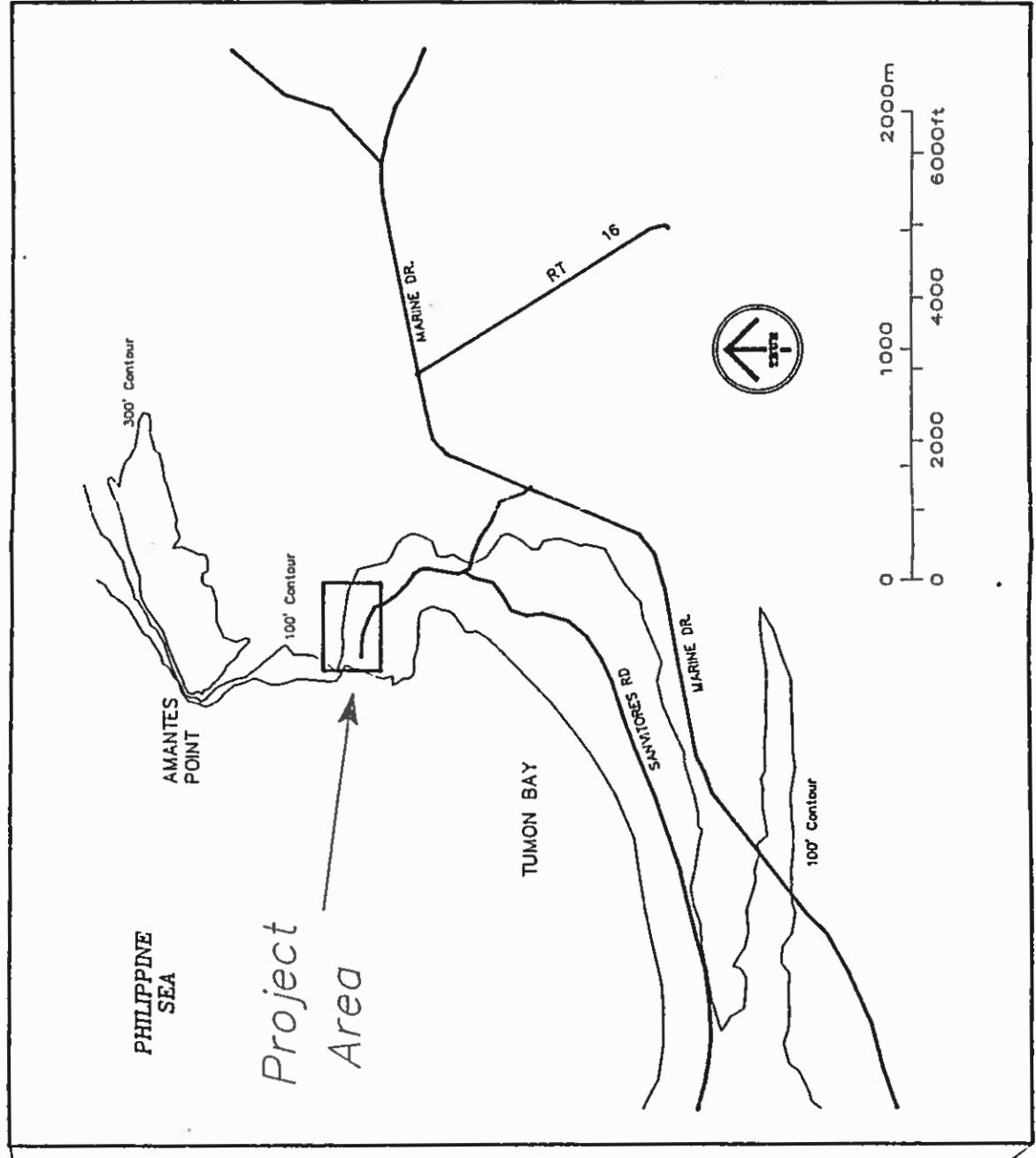
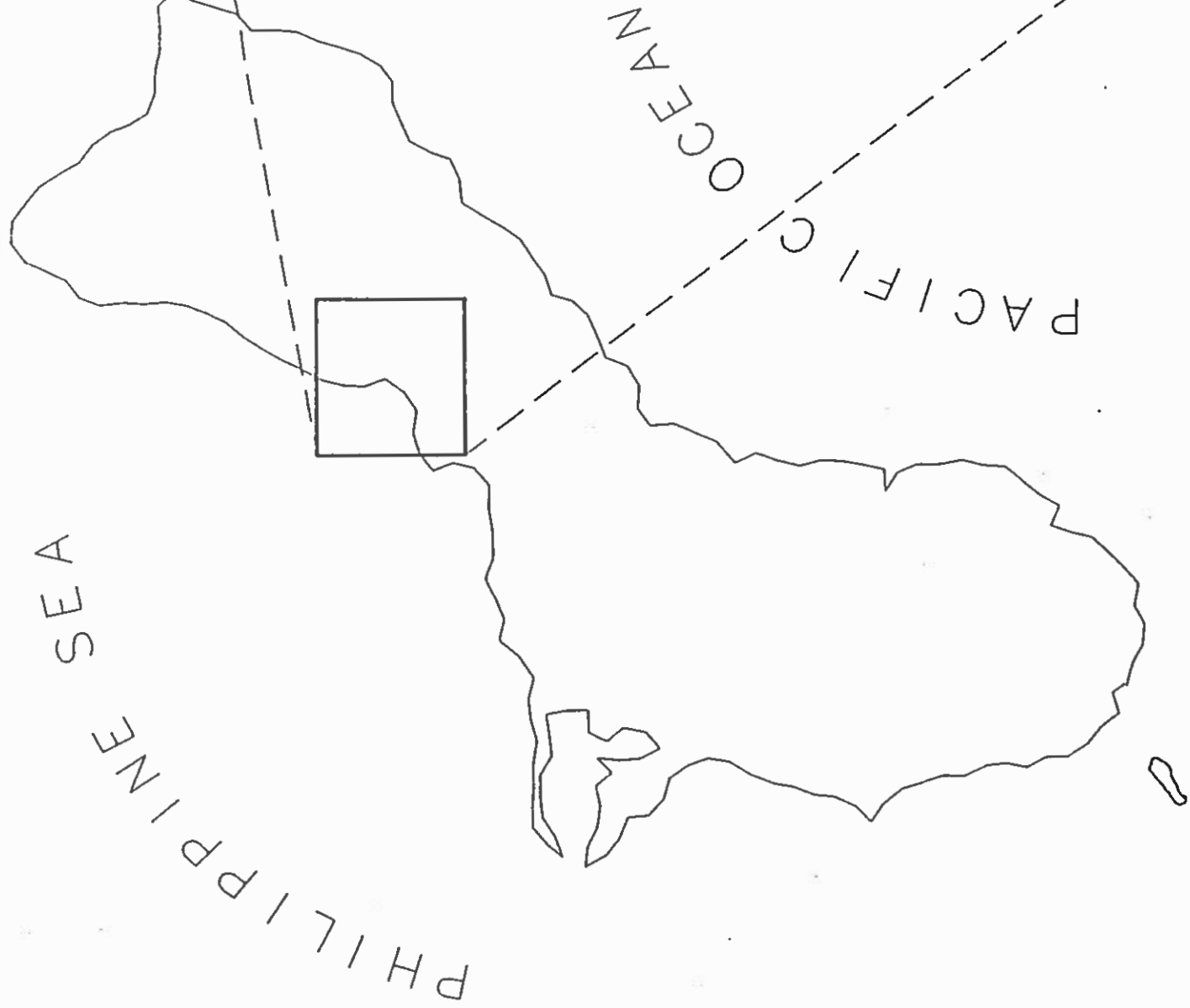
The surface survey of the Gun Beach Hotel Site project area evidenced three geologic zones, consisting of a strand, a raised limestone terrace and a steep sloping area which encircles the valley on the north and east sides. The strand is located in the western portion of the project area, and extends from the shore of Gognga Cove eastward approximately 150 meters. The seaward portion of this area shows significant signs of recent disturbance, evidenced by large mounds of recent gravel fill and modern debris.



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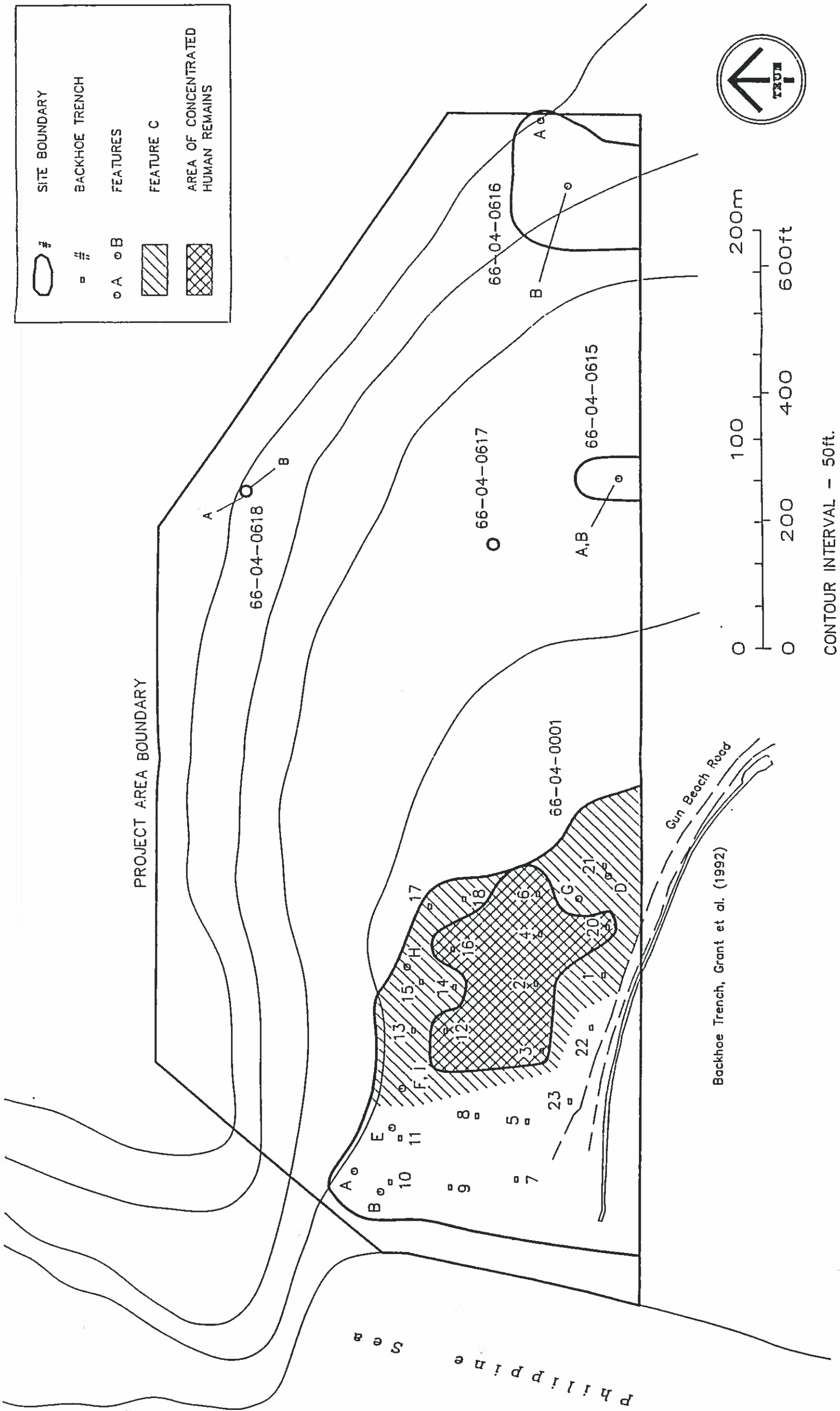
Figure 1.
WESTERN PACIFIC AND MARIANA ISLANDS



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Figure 2.
PROJECT AREA LOCATION



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Figure 3.
PROJECT AREA, SITE, FEATURE,
AND BACKHOE TRENCH LOCATIONS

The strand is relatively flat, ranging in elevation from approximately three to five meters above sea level. Site 66-04-0001 encompasses most of this beach, which has an approximate area of 25,134 m². Vegetation in this area consists of *niyog* (*Cocos nucifera*), *alahai tasi* (*Ipomoea pes-caprae*), *limon-china* (*Triphasia trifolia*), *puting* (*Barringtonia asiatica*), *nonak* (*Hernandia nymphaeifolia*), *kinahulo' usdao* (*Passiflora foetida*), *atmagosa* (*Momordica charantia*), *piga* (*Alocasia macrorrhiza*), *kafu* (*Pandanus fragrans*), and *bejuco halum-tano* (*Flagellaria indica*) (Figure 4). Soils in this area range from dark loamy sand to white, very fine sand.

A raised limestone terrace is located in the eastern portion of the project area, extending from an exposed limestone escarpment in the center of the project area, east to

the base of the steep slope. The terrace is relatively flat and comprises an area of approximately 46,376 m². Sites 66-04-0615, -0616 and -0617 are located on this terrace. Vegetation in this area includes *niyog*, *adang* (*Cycas circinalis*), *limon-china*, *nunu* (*Ficus prolixa*), and *bejuco halum-tano*. Soils consist primarily of red clays.

The steep slope that borders the project area on the north and northeast extends from the valley floor to the top of the cliff. The slope encompasses approximately 37,565 m². Site 66-04-0618 is located approximately three-quarters of the way up this slope, in the northeastern portion of the project area. Vegetation on the slope includes *kafu*, *adang*, *limon-china*, and *bejuco halum-tano*. The soil on the slope consists primarily of yellowish brown, silty loam with limestone gravel inclusions.



Figure 4. Site 66-04-0001, Strand Vegetation (Neg. 2501-15)

BACKGROUND

HISTORICAL OVERVIEW OF GUAM

The Spanish Period

The Chamorros first encountered Europeans when Magellan landed in the Marianas in 1521. Although it is popularly believed that he landed at Umatac, debate has arisen as to whether he might have landed on another island (Saipan, Tinian, or Rota). A recent review of logs maintained by members of Magellan's party suggests that Magellan did land on Guam, and probably put in at Tumon Bay (Rogers and Ballendorf 1989:207). During this first visit, a small boat was reputedly taken by the Chamorros and in response a Spanish reprisal party burned houses and canoes, killed seven locals, and changed the island's name from *Isla de Las Velas Latinas* ("Island of the Lateen Sails") to *Isla de Los Ladrones* ("Island of the Thieves").

During the period 1521-1668 the Spanish focus was on the conquest of the Moluccas (for spices) and the Philippines (for precious metals)—in terms of trade, it appeared that the Marianas had nothing of value. Despite Spain's reluctance to establish a permanent settlement in the islands, Guam became the recipient of regular and increasingly frequent visits from Spanish galleons plying the Acapulco-Manila run. Hence the islands achieved strategic value as a provisioning base that soon became essential to the maintenance and protection of the Spanish galleon trade route in the Pacific. Under orders of the Spanish crown, all galleons sailing from Acapulco to Manila were required to stop at Guam for provisions, water, and repairs. Ships returning to Acapulco from Manila stopped on Guam only if necessary (Corey 1971:1).

Miguel Legazpi was dispatched in 1565 to claim for Spain, among other areas, the Ladrones (de la Corte 1875:2). During his visit to Guam a skirmish broke out resulting in the death of a Spaniard, deaths of several Chamorros, and the burning of numerous houses (Corey 1971:8). As they left Spain's newest possession, Legazpi and his crew were showered with rocks thrown by the local residents (Ballendorf 1974:39).

Despite the lack of formal or permanent settlement, this period (1521-1668) is characterized by sporadic and mostly unintentional residence on Guam by a variety of shipwrecked survivors, ship deserters, and enthusiastic friars. After deserting the *Trinidad* in Maug and finding his way to Guam, Gonzalo de Vigo became the first European

to spend any length of time in the islands (ibid.). He was retrieved four years later by the Spanish navigator, Loaysa (Corey 1971:5).

Those that were shipwrecked in the Marianas showed ingenuity and will in their desire to leave. For instance, 132 survivors of the 1568 wreck of the *San Pablo* sailed on to the Philippines in a boat they crafted locally from bark (ibid. 10). Similarly, when the *Concepcion* was wrecked off Saipan in 1638, the 28 survivors made their way to Guam and enlisted local help to outfit them with a boat in which they eventually made their way to Manila (ibid., 33).

The Spanish were not the sole users of Guam as a Pacific replenishing base. Dutch vessels often called on Guam, usually en route to Manila to attack Spanish colonies. The Dutch Admiral, Oliver Van Noort reprovisioned his fleet in Guam in 1600 before attacking the Spanish in Manila (ibid. 27). Joris Spilbergen, also in command of a fleet, stopped to trade iron for fresh food and water on his way to the Moluccas (ibid., 30). These restocking stops were not always brief; in 1625 the Dutch Nassau Fleet of eleven ships and 1,260 men anchored in Guam for 17 days before continuing westward to blockade the Philippines (ibid.). In 1645, three Dutch ships under the command of Martin Gerritsoon Vries wintered in Umatac (ibid., 35).

The English were also quick to make use of the availability of fresh food and water on Guam and to exploit the islanders' penchant for iron. Thomas Cavendish successfully traded iron for food in 1588, but ended his visit with musket fire from the stern to ward off some Chamorro traders who attempted to follow the ship out to sea (ibid., 17). By 1662 Guam was no longer used as a provisioning base by Dutch or English vessels (ibid., 39).

The first cleric to spend any length of time on Guam was Antonio de los Angeles who worked for a year on Guam (Hezel 1982:117) after leaving the vessel *San Pablo* in 1596 (Corey 1971:19). In 1601, a Franciscan priest, Fray Juan Pobre, jumped ship in order to minister to the needs of 26 Spaniards, survivors of the 1600 wreck of the *Santa Margarita* (Driver 1983:204). Fray Juan and his compadres were retrieved a year later by the *Jesus Maria*, a vessel which spent 40 days in the Marianas recovering from damages sustained during severe storms (Corey 1971:23).

One notable castaway is Choco, a Chinese who was blown off course in his sampan in 1648 (Corey 1971:35). He

came ashore in Saipan and made his way to Guam where he was to become a prominent figure in the Chamorro-missionary conflict two decades later.

Jesuit Father Sanvitores' first contact with the Chamorros occurred in 1662, en route to the Philippines. Thereafter he was unstinting in his efforts to return as a missionary to Guam. Finding a backer for this expedition was difficult since there was little hope of profitable trade developing in the islands. However, Queen Maria Ana of Austria, stricken by the plight of pagan Chamorros, provided Sanvitores with the necessary support to establish a mission in Guam (Sullivan 1957:19). Sanvitores promptly renamed the islands the Marianas in honor of his benefactress (Hezel 1982:117).

Accompanied by four fellow Jesuits and a small garrison, Sanvitores returned to Guam on July 15, 1668 (de la Corte 1875:3). This represented Spain's first attempt to colonize in the Marianas (Driver 1988:22). Given the lack of lucrative resources it has generally been maintained that Spanish motivation in settling this Micronesian foothold was purely pious. It has subsequently been suggested that the Jesuit mission was a front for a permanent presence designed to deter others from upsetting Spanish control of the profitable galleon trade (ibid., 24). The Spanish were not without hope that something might come of this; the Jesuits were instructed to report on any useful produce or minerals that they encountered (Hezel 1982:117).

Initially the Jesuits were well received by the Chamorros but resentment flared quickly, ignited by several factors. The Jesuits insisted the Chamorro's abandon their culture and belief system, which included complex caste and kinship systems. For instance, Sanvitores' immediate alignment with the chief Quipuha, was later revealed as a mistake since Quipuha represented only one of several Chamorro groups (Hezel 1982:120).

The Jesuit insistence that all people were equal in God's eyes was counter to an entrenched caste system that would not permit the baptism of the lower castes before those of higher rank. Furthermore, many chiefs felt that if Christian doctrine was as worthy as Sanvitores described, then it was too good for the lower castes (Garcia 1937, Part X:9).

A Chinese castaway, Choco, sought to prevent further conversions through claims that baptism killed babies as the holy water used by the priests was poisonous (Sullivan 1957:36). The fact that some children did die after baptism did nothing for Sanvitores' cause. The stories quickly gained currency and hostilities escalated (Hezel 1982:120-121).

These factors all fed a rapidly deteriorating situation that saw the deaths of several of the priests and their lay assistants. Attempts to salvage the situation through a policy of *reduccion*—the removal of people from the land into large, centralized settlements, replete with church and priest—only deepened resentment and sparked violent retaliation. Sanvitores began to change his pacifistic tactics in favor of enforcing religious conversion through the garrison (Hezel 1982:122). Several of the Jesuits were killed, culminating in the martyrdom of Sanvitores in 1672 (Hezel 1982:124) when he persisted in the baptism of a child against the wishes of the parents. Violence and bloodshed continued in an episodic fashion fueled by the arrival of Governor Jose Quiroga in 1680, with instructions to end the increasingly expensive rebellions. In this Quiroga was entirely successful and by 1695 he had crushed the last pockets of Chamorro resistance (Hezel 1982:131).

In the midst of this conflict, Governor Antonio de Saravia (1681-1683) attempted to reverse the combative stance of his predecessors and win over the Chamorros through more humane methods. He appointed a Chamorro leader as his lieutenant (Driver 1988:31) and sent Spanish tradesmen around the island to teach various crafts. His approach had some positive impact, but his premature death in 1683 (Hezel 1982:128-129) resulted in a return to the bloodier methods which were preferred by the new governor, Damian Esplana (Hezel 1989:37).

By the turn of the century the Chamorro population had plummeted. Thompson (1932:7) claims that the 23 years of episodic warfare had killed most of the males. Hezel (1982:133) suggests, however, that the total number killed in action should be reckoned in terms of a few hundred rather than tens of thousands. The complete and intentional decimation of the local population would have been quite contrary to the goals of both the Jesuits and the Spanish crown. The Jesuits wanted a large population through which to spread the word, and Spain required a labor base for the production of food and goods with which to reprovision visiting ships.

Large losses in warfare are inconsistent with observations of Chamorro fighting style as noted by Garcia (1937 Part VII:38) "...they are quick to anger and easily calmed, laggards in fighting and quick to flee."

Crozet (1891:83) believes that the Chamorro women were prevailed upon to take abortion-inducing beverages, the alleged belief being that it was preferable not to have children than to have them subjected to the yoke of Christianity. Sanchez (1987:48) suggests that pregnancy preven-

tion was probably practiced in order to spare children wartime death and injuries.

The most plausible reason for the plummeting population was the rampant outbreak of foreign diseases. There are multiple references to devastating epidemics in the islands at this time. For instance, a 1693 outbreak of measles and smallpox (Sanchez 1987:45), a 1688 influenza epidemic, and a 1700 smallpox epidemic (Le Gobien 1700:166).

The idea that warfare was responsible for the shrinking population did not have currency at the time. Quiroga blamed the population reduction on disease (Hezel 1982:135) and de la Corte (1875:38) notes that in 1700 "an awful epidemic broke out among the natives, destroying almost the entire population."

Guam arrived in the eighteenth century subdued, converted to Christianity, at least superficially, and with a population of 3,678. (Sullivan 1957:78). Sullivan suggests that the Chamorros accepted Spanish rule as a preferable alternative to ongoing warfare. However, by this stage they must have been exhausted from conflict and disease; their weariness and reduced numbers cannot have left them any choice but to accept Spanish rule. De la Corte (1875:39) observed "...[the Chamorros] were subjugated rather by force of circumstances than because their minds could grasp the advantages to be derived from a civilization which they could not appreciate."

Population continued to decline, reaching a nadir of 1,654 in 1760. Intermarriage of Chamorro women with Spaniards and Filipinos revived the population count, but signalled the end of a purely Chamorro group genetically (de la Corte 1875:39).

For the Spanish, the early eighteenth century was characterized by administrative concern over the cost of maintaining an expensive, but non-productive colony. Governor Francisco Medrano recommended that the few thousand surviving Chamorros be transported to the Philippines and relocated on Crown land there. This met with staunch opposition from the Jesuits, who would have lost their mission. The plan was abandoned but the question of what to do with the colony lingered (Hezel 1989:54). In 1709, Governor Arquelles proposed that the Spanish withdraw their colonial administration from the islands, leaving a custodial force of only 25 troops and an officer. This plan was also rejected on the grounds that it would leave the galleon route vulnerable and possibly cripple the Spanish empire further west (Hezel 1989:54).

Recognition of Guam's potential importance in protecting the galleon trade precipitated an eighteenth century military buildup on the island. The garrison was increased to 150 soldiers, three companies of fifty each—two Spanish and one Filipino (de la Corte 1875:32). The armed forces were increased further with the establishment by Governor Tobias of the Guam Militia which consisted of 200 Chamorros (Sanchez 1987:50). In 1755, Governor Henrique Olivide y Michelana oversaw the construction of Fort Santo Angel (Pineda 1990:79). By the close of the century, Governor Manuel Muro was orchestrating the construction of Fort San Rafael, Fort Santa Agueda, and Fort Santa Cruz (Sanchez 1987:51).

De la Corte describes the eighteenth century, for the most part, as a period of utter inertia since the missionaries had no one left to convert and the laymen had nothing left to conquer. The Spaniards had little to do but improve their houses and churches (de la Corte 1875:39). Although the benefit to the Chamorro population is arguable this was a period of public works and development, which saw the improvement and construction of roads, churches, schools, and public buildings (ibid., 40). During his 1772 stop in Guam, the French explorer, Crozet (1891:81) observed that the streets were in straight lines and good repair, the public buildings built of brick and tile, and the church in Agana was highly decorated according to Spanish custom. Obviously, the Spanish were becoming well settled and comfortable.

The Jesuit's input extended beyond the ecclesiastical; they taught agriculture, masonry, and other construction skills (Sanchez 1987:49). These early agricultural efforts instigated by the Jesuits paid off. Crozet describes Guam as a terrestrial paradise, noting the abundance of fruit (guavas, bananas, citrons, lemons, oranges, mangoes, pineapples, coconuts, and breadfruit), vegetables (cabbages, gourds, corn), goats, pigs, and poultry (Crozet 1891:82). Crozet goes on to mention Governor Tobias' agricultural innovations: he introduced cultivation of rice, maize, indigo, cotton, cacao, and sugar cane (ibid., 92). Tobias also sought to promote industry in Guam with the establishment of cotton mills, salt pans, and the importation of craftsmen to teach carpentry, masonry, and silversmithing (Sanchez 1987:50).

Tobias was an exceptional governor in his genuine concern for the welfare of the Chamorros (Beardsley 1964:165; Sanchez 1987:50). Earlier in the century, the island had a succession of corrupt administrators who bilked the government treasury, and engaged in profiteering on the galleon trade to the detriment of both the local population and the troops (de la Corte 1875:39; Hezel 1989:41).

The Jesuits were expelled from Guam in 1769 as part of a worldwide attempt to check their power. The news of their expulsion was brought to Guam on the schooner *Nuestra Senora de Guadalupe*, which also brought Augustinian Recollects as missionary replacements (Sullivan 1957:84-85). The Jesuits were fondly regarded and their removal, was a blow to the population of Guam (Sanchez 1987:49).

The eighteenth century closed on a devastating note with the island ravaged by a typhoon, an epidemic, and much of Agana destroyed by fire (ibid., 51). The nineteenth century began with massive rebuilding programs to recover from the typhoon and fire. During this reconstruction the stone bridge at Agana was built (ibid.).

American influence in the Marianas began in the beginning of the nineteenth century. The first American ship to arrive in Guam, the *Lydia* called in 1802, and was followed by the *Maria* in 1804 (Corey 1971:77). Relations with America became less cordial after an 1810 American attempt to establish colonies on Tinian and Saipan. Governor Parreno quashed the attempt in a brief, bloody encounter. A second American settlement attempt was made in 1815. In 1817, when it became clear that the United States needed a base in the Marianas from which to reprovise vessels, the governor permitted them to stay provided they recognize Spanish sovereignty (Sanchez 1987:57).

The early colonial period in the Mariana Islands came to an end in 1815 with cessation of the galleon trade between Acapulco and Manila (Ibanez 1976:xi). Administrative changes were also made at this time; the money provided by the Spanish Crown for the upkeep of the colony was now to come from the Philippines rather than Spain. Since Manila did not have the resources of Spain there was an immediate reduction of financial support for Guam (del Valle 1980:15).

This turn of events set the theme for the remainder of the Spanish occupation of Guam. In the face of diminishing funds from the Crown, the colony experienced economic difficulties. Although galleon visits had ceased, Guam continued to be visited by Russian, British, French, and American vessels (Sanchez 1987:56). In 1832, English and American whaling ships began visiting Guam (Dugan 1956:10). The amount of time and money spent by the whalers in Guam peaked around 1840. De la Corte (1875:44) was critical of the island's failure to take advantage of the economic opportunity. He blamed this on the lassitude of government officials and a perceived Chamorro refusal to look to the future.

The indifference of government officials noted by de la Corte (ibid.) was partly due to the fact that they were already making large profits through the monopolization of all goods arriving on the island. These goods were sold in the only store on island—which was government owned (del Valle 1980:11). This persistent administrative abuse was exemplified by Governors Jose de Medinilla y Pineda (Sanchez 1987:60) and Pablo Perez (Ibanez 1976:3).

De la Corte (1875:46) lamented the lack of an island cash economy with attendant stores and skilled tradesmen. He noted that each Chamorro family grew only what they needed, and that the corrupt practices and trade monopolies of the governors provided little incentive for the Chamorros to move beyond their traditional system of self sufficiency and barter. Various unsuccessful economic and agricultural experiments designed to generate island income, were implemented. Governor Francisco de Villalobos pushed for exportation of dyewood, indigo, cotton, tortoise-shell, mother-of-pearl, arrowroot, and beches-de-mer. He also tried to manufacture wine and brandy from locally grown sugar cane (Sanchez 1987:61). He had the Atatantano Valley and a large swamp east of Agana opened up for rice cultivation (Carano and Sanchez 1964:149). Governor Felipe de la Corte tried to inspire local farmers to produce extra crops for cash by constructing granaries, but to little avail.

The facilitation of these schemes was dependent on a willing and skilled labor force and this was not available on Guam for various reasons. Around the mid-nineteenth century, the colony's population was devastated by a wave of epidemics. An 1849 epidemic claimed over 200 lives, mostly young women, and in 1855 more than 200 children died from an undiagnosed disease. Worse still was the 1856 smallpox epidemic that resulted in 3,463 deaths (Ibanez 1976:1-7). This number was more than half the 1824 population of 5,920 (Carano and Sanchez 1964). Disease outbreaks persisted throughout the remainder of the century: measles in 1861, whooping cough in 1883, measles again in 1888, and influenza in 1890 (Ibanez 1976:12, 56-65). Nevertheless, the population reached 7,983 in an 1880 census (Sanchez 1987:65).

The administration's requirement of a larger labor force provoked a series of importation experiments. Governors Perez and de la Corte both attempted to bring in convict labor from the Philippines. The scheme failed initially under Perez with an abortive revolt among the convicts, but fared better under de la Corte who implemented an incentive program to keep the convicts on the island after they had worked out their sentences (Beardsley 1964:182-184). Governor Moscoso's

plan to use Japanese laborers failed when some of the workers died of overwork, and others, unable to acclimate to the tropics, fell ill (*ibid.* 187).

Despite the best intentions of several governors, the administration failed to turn the colony into an economically viable (in Spanish terms) community. In the mid-1880s Governor Olive y Garcia (Olive 1984:46) described agriculture and industry as in a completely backward state. The advantages offered by proximity to shipping lanes and a favorable climate were offset by entrenched government corruption and a population that was either unable or unwilling to implement the various schemes. Production for profit was not part of the Chamorro tradition, and although the Spanish recognized this they were unwilling to accept it (Carano and Sanchez 1964:155).

Concurrent with the economic decline of the island was the deterioration of the military fortifications. Villalobos, during his term as governor in the 1830s, had been critically aware of the island's vulnerability and recommended that funds be appropriated to improve the situation (*ibid.*, 150). Nothing came of his request and 50 years later Governor Olive y Garcia noted "the condition of Fort Santa Cruz is deplorable, especially since it is the only one in the Marianas readied for service" (Olive 1984:85).

At the outbreak of the Spanish-American War, in April 1898, Guam was economically weak and militarily vulnerable. News of the war arrived in Guam two months later along with four American warships. The termination of Spanish sovereignty in the Marianas was swift and bloodless. The Americans disarmed the artillery, confiscated weapons, raised the American flag and left, taking with them an assortment of military officials and soldiers as prisoners of war (Ibanez 1976:71).

First American Period

During the early American occupation a conflict arose over who had the right to act as Governor (Carano and Sanchez 1964:177). After two abortive Chamorro attempts at self-rule, the U.S. Navy appointed Richard P. Leary as Governor. Leary took office in 1899 and issued the Leary Proclamation, a formal declaration of American occupation and control of the island (Sanchez 1987).

Leary instituted a battery of reforms, most of which were aimed at ameliorating the effects of long-term Spanish neglect in agriculture, public health and sanitation, education, finance and taxation, land management, and public works. Many of the reforms were accepted, others garnered wide-

spread resentment (Carano and Sanchez 1964:190-195). Leary's decision to expel the Augustinian Recollects was particularly unpopular as the majority of Guamanians were Catholic (Sanchez 1987:91).

The initial attempts to improve agriculture included the outlawing of debt peonage (Apple 1980:5) and the implementation of a homesteading act designed to transfer untitled, fertile land from its owners to farmers willing to put it into production (Beardsley 1964:200). Governor Smith (1916-1918) spearheaded a back-to-the-soil movement and set up incentives for farming. Although these reforms had uneven results, Guam's agricultural output peaked during the Great Depression (Sanchez 1987).

Guam's first general election was held in 1931 but local interest in politics declined rapidly, largely due to dissatisfaction with government policies (Carano and Sanchez 1964:241). Compensation for land annexed for military use and the issue of American citizenship were matters of ongoing concern that were never resolved to the satisfaction of the Guamanians prior to WWII. The 1921 annexation of private land on Orote Peninsula for a new air station precipitated the first protests over federal failure to compensate landowners for annexed land (Sanchez 1987:113). The question of American citizenship for Guamanians was first raised in 1903 (*ibid.*, 97). Several governors supported the citizenship issue, but lacking the support of the naval administration, it was not passed into law during the first American administration.

During the first American administration, Guam's contact with the outside world increased, largely due to the advent of commercial aviation in the Pacific. By 1940, substantial improvements had been made in Guam's economic life, health care, judicial, and education systems (Carano and Sanchez 1964:264). In anticipation of Japanese aggression, the U.S. ordered the evacuation of all American military dependents in October 1941.

Japanese Occupation Period

The Japanese attacked Guam on December 8, 1941 (Sanchez 1979:5). The Japanese Army captured Agaña and established control of the island. On December 10, 1941, Governor McMillin signed a surrender paper (Sanchez 1987:146-181). The Japanese sent captured non-Guamanian U.S. servicemen to POW camps in Japan. Guamanians in U.S. military service were sent to a POW camp in Agaña (Sanchez 1979).

From March 1942 through March 1944, Guam was under the administration of the Japanese Navy. Although the Gua-

manians were at liberty to live where they chose on the island, and move about at will, they were also subject to Japanese acculturation attempts. Guam place names were replaced with Japanese names, and Japanese was taught in the schools. Possession of American items was strictly forbidden under threat of death (ibid., 55). The cessation of commerce along with the scarcity of imported food and work for pay prompted near desertion of the towns. Farming and fishing increased dramatically under the occupation and Guamanians became self-sufficient (ibid. 85).

As the war continued, Japanese hopes of retaining Guam weakened. In anticipation of an American liberation attempt, the Japanese defense force arrived in Guam in March 1944. Chamorro males were mobilized in defense preparations (ibid. 116). The arrival of thousands of Japanese reinforcements strained food production. The worst conditions were experienced by the Chamorros immediately prior to the American invasion (ibid. 122).

As the American forces began air raids, more and more Guamanians were drawn into work gangs, until nearly everyone was ordered into forced labor. There were forced marches as the Guamanians were herded into concentration camps. The only people excluded from these camps were the young men used to carry supplies and build defenses. The locations of the concentration camps placed the Guamanian people outside the battle areas (Carano and Sanchez 1964).

The U.S. forces began their invasion of Guam on July 21, 1944. Three weeks later they had secured the island and the Japanese era on Guam came to a close. The U.S. capture of Guam resulted in the combat deaths of 1,283 Americans and 10,971 Japanese (Carano and Sanchez 1964:308).

Second American Period

A military government was promptly installed on Guam in July 1944. The government had enormous problems providing food, clothing, and shelter for a largely refugee civilian population. Protest arose almost immediately as families were relocated to accommodate the military's land requirements (ibid. 312). Federal land holdings increased dramatically; by 1948 42% of Guam's total land area was held by the government. The resultant controversy over annexation and compensation has yet to be resolved (Sanchez 1987:264-271).

The recovery program was massive and involved the replacement of narrow bullcart roads (Hoyt 1980:272), the provision of temporary schools, attempts to revive the copra, soap, tile, and handcraft industries, the provision of

incentives to return to the land, and the establishment of dispensaries (Carano and Sanchez 1964:314). Two years later, in 1946, the U.S. Naval government was reestablished on Guam (ibid. 316).

In 1950, an Organic Act for Guam was passed by the Congress of the United States. Along with American citizenship, Guamanians acquired a civilian administration and limited self-government (ibid. 319). Governors were appointed until the first election for governor and lieutenant governor in 1970 (Sanchez 1987:308).

HISTORIC LAND USE IN THE PROJECT VICINITY

Little information is available concerning early historic land use in Tumon. In 1668, the first Spanish missionaries led by Father Diego Luis de Sanvitores arrived and established a church at *Hagatna* (Agana), the principal village of the island (Carano and Sanchez 1964) and which is about two miles from *Tomhom* (Tumon). Father Sanvitores was killed in the village of Tomhom four years later. Tumon, because it was near Agana, was probably frequented early on by the Spanish and was perhaps occupied by them.

Evidence of a Japanese military occupation at the northern end of the Gognga Cove area was documented by Graves and Moore (1985) and Kurashina et al. (1987), and confirmed during the current project. Features present include a 200 mm coastal gun emplacement and pillbox, a gun pit and a beehive pillbox.

PREVIOUS ARCHAEOLOGICAL WORK - GENERAL

Under the aegis of B.P. Bishop Museum in Honolulu, Hans G. Hornbostel conducted the first serious archaeological investigations in the Mariana Islands. Hornbostel's work remains largely unpublished, but in 1932 Laura Thompson published an analysis of some of Hornbostel's records and collections (Thompson 1932). Prior to the end of WWII, Hornbostel's work, Thompson's 1932 report, and a work on *latte* sets by Thompson (1940) constituted the entire body of formal archaeological literature concerning the prehistory of Guam.

Immediately after the war, Douglas Osborne (1947) published the results of his efforts to reconstruct *latte* sets in Gognga Cove and the results of his cursory examinations of other portions of the island. Osborne's work was primarily

descriptive, but he did attempt (unsuccessfully) to discern differences between inland and coastal sites and among ceramic materials and characteristics of *latte*. Because he was aware that the data available to him was insufficient, Osborne made no attempt to establish a prehistoric chronology.

The temporal framework within which archaeological interpretations are made today was formulated by Alexander Spoehr (1957). Spoehr's work on Rota, Saipan, and Tinian incorporated the radiocarbon dating method and enabled him to describe two archaeological manifestations of Chamorro prehistory—the Pre-Latte Phase (BC 1500 to AD 800-1000), and the Latte Phase (c. AD 1000-1200 to European colonization). These two phases are distinguished by differences in associated portable remains (particularly ceramics) and by the inclusion, or lack of, monumental architectural features, called *latte* sets, that are associated exclusively with more recent archaeological sites.

Until recently, most archaeological research since Spoehr has focused on the geographic origins of the Chamorro people and on enhancing descriptive Chamorro culture history (Takayama and Egami 1971). More recent research has focused on (a) refining the methods by which temporal variation in the archaeological record can be perceived and quantified (Athens 1986), (b) the discernment of environmental factors (Graves and Moore 1985), and (c) the explanation of diachronic differences in the archaeological record in terms of the evolution of Chamorro culture.

Several researchers have recently attempted to discover patterning in the various features present in archaeological deposits on Guam, with the aim of discerning the areal relationships between the structural and functional entities within prehistoric Chamorro settlements. Bath's 1986 excavations at Matapang during the Sarvitores Road Project and Butler's 1988 work on the north coast of the island of Rota are examples of preliminary attempts to define the basic structural units within prehistoric Chamorro settlements. But with the exception of *latte* sets, not a single complete architectural feature has been exposed.

In recent years, Guam has undergone rapid development. As a result, there has been a substantial increase in archaeological information concerning the island. Archaeological investigations in the coastal regions of Guam as a whole have increased over the last few years, due to commercial development related to the Japanese tourist trade. Hotel construction and the construction of attendant support facilities (utilities, nightclubs, golf courses, shops, and specialty establishments) have resulted in a proliferation of survey and excavation projects. The projects have been mandated by federal and

territorial environmental protection regulations and are funded by the developers of the projects.

As a result of these studies, hypotheses concerning the development of Chamorro culture are being formulated and tested. The emerging picture is one of small Pre-Latte Phase coastal populations adapted to collecting marine resources in the coastal lagoons, and later, Latte Phase populations, adapted to agriculture and making greater use of inland areas. The earliest inhabitants made thin-walled pottery that was tempered with calcareous sand. They also manufactured fishing equipment, shell and stone tools, and shell ornaments. In contrast to later inhabitants, they appear to have made greater use of bivalves than gastropods. Graves and Moore (1985) indicate that in comparison with the upper levels, the lower levels of sites with a Pre-Latte component contain a higher ratio of bivalves to gastropods.

Pre-Latte sites are characterized by deep and ephemeral soil horizons that contain a higher percentage of bivalve remains than is found at Latte Phase sites. They are also characterized by thin and narrow-rimmed pottery, and by the absence of *latte* and mortars (Butler 1988, Bath 1986). Latte deposits are characterized by surface or near-surface organic-rich soils containing abundant, thick-walled, wide-rimmed pottery, and by relatively abundant gastropod remains. Mortars and *latte* stones (sometimes fallen and sometimes erect) are often found on the surfaces of these sites. Human burials are usually found within and near *latte* sets. The association of these burials with the presumed high status architecture suggests that the burials are the remains of high status individuals.

A Transitional Phase between the Pre-Latte and Latte Phases (c. AD 1-AD 1000) has been postulated, but it has not been well defined. During the proposed Transitional Phase, the population increased and expanded seaward and inland. There was an increased dependence on large pelagic fish (Moore 1983), and ceramic vessels increased in size and evolved into "a relatively homogeneous ceramic assemblage" (Graves and Moore 1985).

During the Latte Phase, structures built on compound stone foundation posts (*latte*) became common. *Latte* occur in sets of parallel rows of four, five, six, and seven pairs. These sets are found most frequently in coastal zones, in association with human burials, large and thick wide-rimmed sherds, and midden in which the shellfish *Sitona gibberulus gibbosus* predominates.

Little is known about the Pre-Latte Phase population, and there is no conclusive evidence concerning the origins of

Guam's first inhabitants. Details of their societal organization are not discernible from the limited data available. The earliest recorded archeological site on Guam, at Ypao Beach, in the Tumon Bay area, dates to 3000 BP (Territorial Archaeology Laboratory 1982). A questionable date of BC 4395-3800 was derived from a sample taken by Bath during the Sanvitores Road Project (Bath 1986). From Ypao Beach, population probably expanded towards Gognga Beach and shoreward. In the Latte Phase all the lowland area between the reefs and the inland cliffs appears to have been occupied.

The distribution of recorded and otherwise known Latte Phase habitation sites suggests that these sites occur more frequently and contain more substantial deposits in the coastal plains "in the land sea interface" (Kurashina 1986). Whether these distributions reflect the actual distributions of Latte Phase sites remains to be demonstrated, since there has never been a representative survey of the island. Only a few inland Latte Phase sites have been found. As Reinman has suggested "[l]arge areas of the island remain unsurveyed and there is little doubt that considerably more sites remain..." (Reinman 1977).

Latte Phase sites are much more conspicuous and more likely to be discovered than Pre-Latte sites. They often include the remains of large stone *latte* sets, which are noticeable even in dense jungle. They were also occupied later in time. As a result they are found in higher strata, so that they are more likely to be exposed on the surface. Whether these characteristics explain the preponderance of Latte Phase sites, or whether they are actually more abundant, is open to question. For whatever reason, the fact remains that Pre-Latte sites constitute but a small fraction of the recorded sites on Guam.

Latte sets have been most commonly interpreted as the remains of the foundations of high status residences, or infrequently, as purely ceremonial structural remnants. Archaeological investigations at Latte Phase sites have usually focused on the exposure of the areas within and adjacent to the *latte* sets themselves (Osborne 1947, Reinman 1966, Takayama and Intoh 1976) at the expense of the identification of presumed nearby lower status residences and the portions of the sites that were devoted to other activities. As a result, less is known of the intra-site distribution within Latte Phase sites than of their inter-site variability. Very little is known concerning intra-site variability of Pre-Latte sites. As Graves and Moore (1985) have stated "...we know virtually nothing about early prehistoric organization over a period... that spans at least 2,000 years."

PREVIOUS ARCHAEOLOGICAL WORK - IMMEDIATE VICINITY

There have been several archaeological investigations conducted in the vicinity of the present project area. These include, but are not limited to, work by Hornbostel in the 1920s, Osborne (1947) and Reinman (1966). More contemporary examinations of the area were undertaken by Graves and Moore (1985); Bath (1986); Kurashina et al. (1987); Brown and Haun (1989a, b, c); Brown, Haun, Dilli and Knutsson (1989); and Henry, Brown, and Haun (1991). Hornbostel identified twelve *latte* groups at Gun Beach, though the area was not recorded separately from the Tumon Bay Site (Reed, 1952). Osborne (1947) located and recorded between 12 and 15 *latte* sets in the area of Gognga Cove. Reinman documented ten *latte* sets at the site during his 1965-66 survey of Guam and designated the site as MaGTA-1. The site was subsequently assigned GHPO Site Number 66-04-0001.

Graves and Moore surveyed the present project area during their 1985 survey of Tumon Bay and the surrounding areas. They found scattered *Latte* and Pre-*Latte* Phase ceramics, marine shell tools and artifacts, slingstones, a fire-blackened surface, and fragmentary human remains at several locations.

Bath's 1986 work on the Sanvitores Road Project included extensive excavations at Matapang Park. The excavations, which were aimed at exposing structural features, uncovered 34 probable postmolds, eight pottery concentrations, six firepits, three possible floors, and 13 burials. Six of the postmolds are probable *latte* stone molds. Bath attempted to reconstruct the footprints of several pole and thatch structures, but her excavations did not expose contiguous areas large enough to make her reconstructions convincing.

Previous archaeological work by Kurashina et al. (1987) resulted in the identification of six "localities" within Site 66-04-0001. Four of these localities (A, B, AA and BB), were noted during the present project, and redesignated as features A, B, D and G respectively. The remaining two localities, G (midden area), and H (borrow area), have apparently been destroyed or buried by the introduction of recent fill materials.

Excavations at the Continental Boutique Project Area (Brown and Haun (1989a), resulted in the collection of prehistoric ceramics, marine shell, and human bone from a

disturbed context. Brown and Haun speculate that there may have been a prehistoric deposit in the area, but indicate the possibility that the prehistoric cultural materials found were brought in as fill.

At the nearby Fujita Hotel Expansion Project area (Brown et al. 1989), Tumon Bay 20-Unit Condominium Project Area (Brown and Haun 1989b), and Teraza Hotel Expansion Project Area (Brown and Haun 1989c), intact portions of stratified prehistoric deposits were documented. These deposits are not horizontally contiguous—gaps in all of them are

the result of recent mechanical disturbance. The contents, stratigraphy, and dates associated with the deposits suggest they resulted from spatially and temporally extensive occupation of the central Tumon area.

Investigations conducted at the LSI Plaza Site Project Area, evidence significant mechanical disturbance (Henry, Brown, and Haun 1991). Mechanically excavated trenches showed evidence of the mining of sand, and the subsequent introduction of gravel fill. No intact archaeological deposits were noted.

METHODS

FIELD METHODS

Methods employed during field work included surface survey, shovel testing, backhoe trenching, and site recordation. The surface survey involved walking E-W transects spaced at 10 m intervals. The beginning and end of each transect was flagged and labeled, as were all surface features encountered. All surface features were photographed, shovel tested, and recorded using standardize PHRI forms. Scaled plan and cross section maps were prepared when appropriate. Wherever possible the approximate locations of identified sites were plotted on available topographic maps with the aid of a Topcon GTS-3B total station.

Several geologic zones are present within the project area, each requiring separate subsurface testing techniques. The southwest portion of the project area is a coastal beach strand measuring approximately 25,134 m². A 30-meter grid system was superimposed over this area with the aid of a Topcon GTS 3-B total station. Grid north-south was situated parallel to Tumon Bay with Grid north oriented at magnetic north. Twenty-two backhoe trenches (BTs) were excavated in the coastal strand to test for the presence/absence and general distribution of buried cultural deposits. Trenches were excavated either to the emergence of human remains, to limestone bedrock, or to a known culturally sterile soil. The southwest corner of each BT was positioned as close as possible to each grid intersection.

The BTs averaged 2.5 m in length, 1.4 m wide and approximately 1.8 m deep. Scaled section drawings were completed of representative sidewalls of all BTs which exhibited intact cultural strata. Bulk soil samples were collected from subsurface features. All samples and portable remains were bagged, accessioned and transported to the PHRI laboratory for analysis. Photographs were taken of all BTs and cultural features. Strata were described in writing using standard procedures and terminology as set forth in the *Soil Survey Manual* (Soil Survey Staff 1962).

The eastern portion of the project area is a raised limestone terrace. In this area, 45 shovel tests were excavated 20 m apart to test for the presence/absence and general distribution of buried cultural deposits. Portable remains collected were bagged, accessioned and transported to PHRI laboratories for analysis.

No systematic excavations were conducted in the sloping area in the north and northeastern portion of the project area. All surface features that possessed the potential to yield subsurface cultural deposits were examined.

Strata were described in writing using standard procedures and terminology as set forth in the *Soil Survey Manual* (Soil Survey Staff 1962). Stratum, as used here, is a soil unit classed by reference to the era within which the soils were deposited. Strata often include substrata referenced by lower case letters beginning (at the highest elevation within a stratum) with "a". Strata are assigned Roman numeral designations based on the criteria listed below. Strata devoid of cultural materials ("sterile" strata) but underlain by a stratum containing cultural materials are assumed to have been deposited after the underlying stratum. Such strata are classified as substrata of the next-highest stratum.

Stratum I (Recent, <50 years old)

Stratum I is typically composed of recent imported fill but may include historic and prehistoric cultural materials; however, these materials must be present as the demonstrable result of secondary deposition caused by recent earthmoving activities;

Stratum II (Historic, >50 years old)

Stratum II must include historic cultural materials. Stratum II may include secondarily deposited, recent and prehistoric cultural materials but may not include, or be underlain by, primarily deposited recent cultural materials (Stratum I);

Stratum III (Prehistoric, older than AD 1521)

Stratum III must either include prehistoric cultural materials, or be underlain and overlain by a stratum or strata containing prehistoric cultural materials. No primarily deposited historic or recent materials may be present;

Stratum IV (Pre-Cultural or Sterile)

Stratum IV may contain no cultural materials and may not be underlain by strata containing cultural materials.

FINDINGS

SURFACE FINDINGS

Portions of the Gun Beach Hotel Site project area show evidence of mechanical modification. The area which extends from Tumon Bay eastward approximately 60 m, contains large surface piles of recently deposited limestone gravel and surface and subsurface trash deposits. In the eastern portion of the strand, there are signs of surface bulldozing, including, push piles, and the mottled soil of the upper subsurface deposits.

Large amounts of modern trash are present beneath the top of the steep slope along the northern edge of the project area. This debris includes aluminum cans, glass bottles, plastic, tires, tin roofing and major appliances. It is probable that these materials were discarded from the top of the cliff, because this area is not readily accessible from below.

During the surface survey, five archaeological sites were identified, including the previously recorded, multi-component, historic and prehistoric complex (66-04-0001), a midden area (Site 66-04-0615), a rock overhang and associated ceramic scatter (Site 66-04-0616), a cave (66-04-0617), and a cave and overhang complex (Site 66-04-0618) (Table A-1, Figure A-3).

A surface examination of Site 66-04-0001 revealed five prehistoric and four historic surface features. These include a Japanese gun emplacement and pillbox (Features A and B) (Figures 5 and 6), an artifact scatter (Feature C), a push pile containing possible *late* elements (Feature D), an alcove carved out of the limestone cliff (Feature E), two rock overhangs (Features F and H), a midden deposit (Feature G), and a concrete pad (Feature I) (Table A-1, Figure A-3).

Site 66-04-0615 consists of a black loamy surface deposit (Feature A), and an upright coral rock (Feature B). The site is located on a raised limestone terrace in the eastern portion of the project area. Within the project area, Feature A measures approximately 2.00 m N-S, 3.00 m E-W and extends to approximately 0.25 m below surface (mbs). Portable remains recovered include prehistoric ceramics, marine shell and thermally altered rock. Feature B is a large piece of coral rock located on the eastern edge of Feature A. The base is firmly buried in the black soil with approximately 0.50 m extending above ground surface (Figure 7).

Site 66-04-0616 is an overhang (Feature A), and an

associated surface scatter of prehistoric ceramics (Feature B), located at the eastern end of the raised limestone terrace. The overhang, which measures approximately 0.75 m deep, 2.00 m wide, and 1.50 m high, is situated on the eastern face of a large, surface limestone boulder. Another overhang was noted on the western end of the boulder, but no portable remains were found in association with this feature. An examination of the areas surrounding Feature A evidenced a surface scatter of prehistoric ceramics in an area of approximately 3,414 m², which continues south out of the project area an unknown distance (Figure 8).

Site Number 66-04-0617 is a cave located on the edge of a large depression at the western edge of the raised limestone terrace. The entrance to the cave is small (0.5 m high by 0.5 m wide), and is located beneath a large banyan tree which grows on the eastern edge of the depression. The interior of the cave measures approximately 6.0 m deep, 5.0 m wide and 0.85 m high. A sparse scatter of prehistoric ceramics, land and marine shell, and nonhuman bone was noted within the cave and on the surface in the surrounding vicinity (Figure 9).

On the steep slope at the NE edge of the project area is Site 66-04-0618. This site consists of a large surface boulder with a cave on the western side (Feature A) and an overhang on the southern side (Feature B). Human skeletal remains were noted on the surface of both features. The approximate area of the site is 20 m² (Figure 10).

SUBSURFACE FINDINGS

The excavation of 22 BTs and six STs in the beach evidences subsurface manifestations of Site 66-04-0001 within the project area. BT excavations illustrated a partially disturbed, stratified prehistoric deposit encompassing approximately 24,838 m² and extending to a depth of 1.1 m bs. Portable remains recovered include prehistoric ceramics, marine shell, thermally altered rock, lithic flakes and shell and stone tools. Three BTs evidenced fire-related, basin shaped pits (BTs -2, -7 and -9). A concentration of human remains was noted in the eastern portion of the strand, with *in situ* burials present in five BTs (BTs -2, -3, -6, -16 and -20). Disturbed human remains were noted in BTs -4, -7 and -12. This burial concentration has an approximate area of 4,993 m² and is illustrated in Figure 3.

The excavation of 17 STs at Site 66-04-0615 revealed a subsurface deposit consisting of a strong brown silty clay and

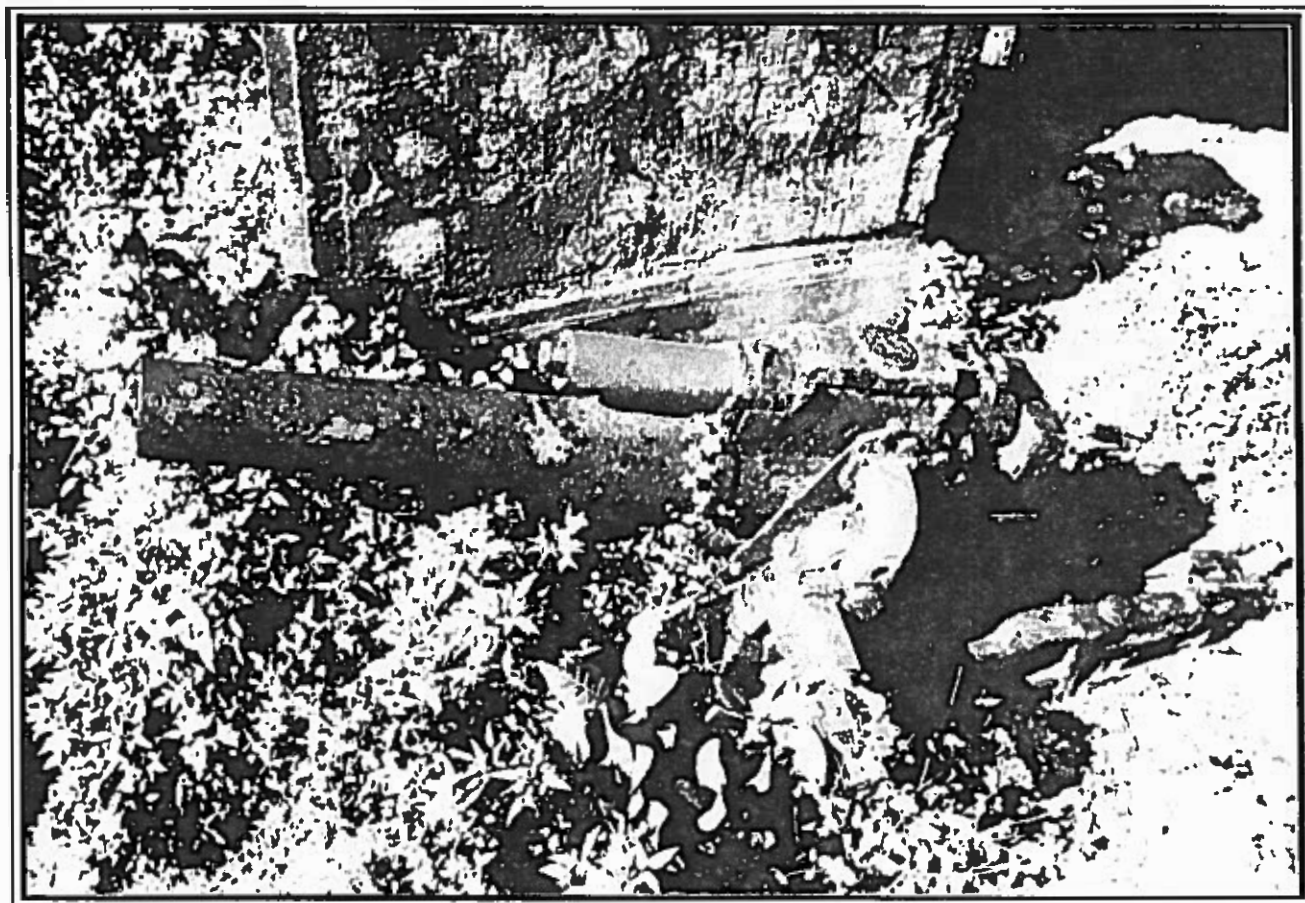


Figure 5. Site 66-04-001, Japanese Gun (Neg. 2497-28)

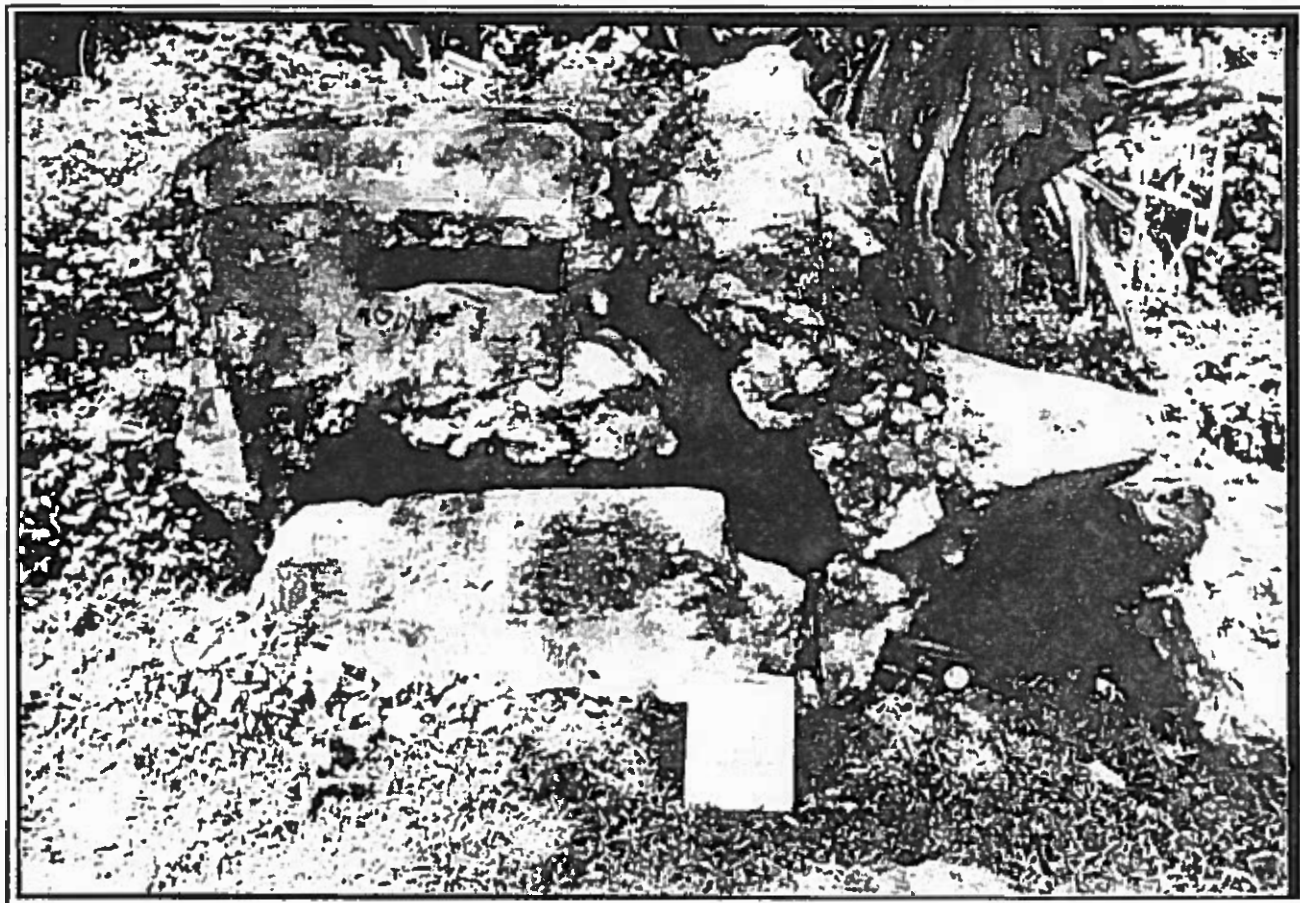


Figure 6. Site 66-04-001, Japanese Pillbox (Neg. 2497-24)

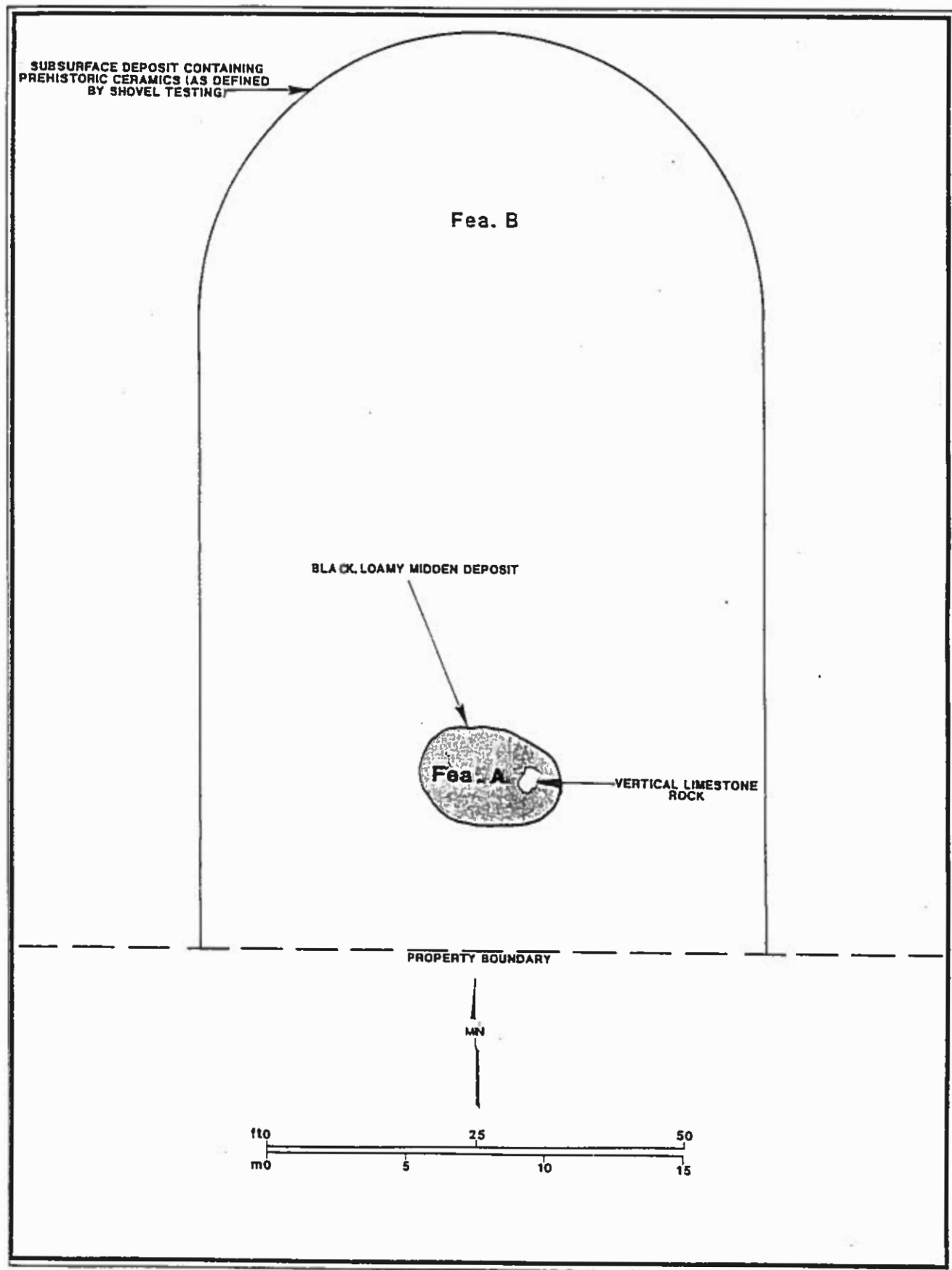


Figure 7. Site 66-04-0615

defined a site area of approximately 585 m², which extends south out of the project area an unknown distance.

The excavation of two STs at 66-04-0616 evidenced 0.25 m of a dark brown clay loam containing prehistoric ceramics and marine shell, overlying 0.1 m of a reddish yellow clay loam containing human remains. The excavation of 24 STs in Feature B yielded between 0.1 and 0.3 m of strong brown, culturally sterile silty clay. These findings indicate that the ceramics noted within Feature B are confined solely to the surface.

A subsurface examination of Site 66-04-0617 evidenced approximately 0.30 m of a reddish brown clay loam with 50% limestone gravel and rock inclusions. Three STs excavated in the area resulted in the recovery of small amounts of prehistoric ceramics, land and marine shell and nonhuman bone. The approximate area of the site is 55 m².

The excavation of three STs at Site 66-04-0618 evidenced between 0.1 and 0.2 m of a brown silty clay with 50% limestone gravel inclusions. No subsurface prehistoric cultural materials were noted.

STRATIGRAPHIC DESCRIPTIONS

Stratum I (RECENT)

Recently deposited strata were found in 13 of the 22 BTs excavated at Site 66-04-0001, (BTs -3, -5, 7-14, and 21-23). The composition of Stratum I in six BTs (BTs -7, 9-11, -13 and -14), consists of a mottled gray and white very fine sand, containing varying degrees of modern trash and redeposited prehistoric cultural materials. These deposits were located in the eastern two-thirds of the coastal beach strand, and were probably the result of bulldozing. Push piles in the south eastern portion of the beach, in conjunction with the mottled nature of the soil, supports the theory of mechanical disturbance.

Stratum I in the remaining eight BTs, (BTs -3, -5, -8, -12, and 21-23) consists of a white to pinkish white, coarse limestone gravel fill (Figure 11). These deposits are located in the western one-third of the strand, and are probably the result of efforts to replace the soil removed in sand mining activities. Kurashina et al. (1987), recorded a large borrow pit (Locality H), in the vicinity of these recent fill deposits. The current survey failed to locate this borrow pit, and it is likely that it was filled in with the limestone material. Sites 66-04-0615 through -0618 yielded no recent deposits.

Stratum II (HISTORIC)

Materials dating to the Historic period were recorded in several BTs, at Site 66-04-0001. However, as these deposits also included modern debris, no Stratum II designation could be assigned. Sites 66-04-0615 through -0618 yielded no historic deposits.

Stratum III (PREHISTORIC)

Deposits dating to the prehistoric period were evident at Sites 66-04-0001, 0615, 0616, and 0617. No deposits dating to the prehistoric period were noted at Site 66-04-0618.

Substratum IIIa at Site 66-04-0001 is present in 17 of the 22 BTs excavated (BTs 1-7, 12-18, 20-21 and -23). This deposit is a partially truncated, very dark grayish brown to black, loamy sand with prehistoric ceramics, marine shell, burned botanical remains, nonhuman bone, thermally altered rock, stone and shell tools, a basin-shaped pit feature and human remains.

Substratum IIIb at Site 66-04-0001 is present in 12 of the 22 BTs excavated (BTs 1-3, -6, -12, 15-18, -20, -21 and -23). This deposit ranges from a white to a brown fine sand with prehistoric ceramics, nonhuman bone, marine shell, a basin shaped-pit feature and human remains.

Substratum IIIc at Site 66-04-0001 is present in five of the 22 BTs excavated (BTs -1, -2, -15 -16 and -20). This deposit ranges from a white to gray fine sand and contains prehistoric ceramics, marine shell, and human remains.

Substratum IIIa at Site 66-04-0615 is evident in two STs excavated within Feature A (Midden). This deposit is a black loamy sand containing prehistoric ceramics, marine shell, and thermally altered rock.

Substratum IIId at Site 66-04-0001 is present only in BT-1, and consists of a black loamy sand containing prehistoric ceramics, marine shell, thermally altered rock and a basin shaped pit feature. An excellent example of the stratified prehistoric cultural deposits is illustrated in Figure 12.

Substratum IIIa at Site 66-04-0615 is evident in three of the 17 STs excavated. This deposit is a strong brown silty clay containing small amounts of prehistoric ceramics.

Substratum IIIa at Site 66-04-0616 is evident in two of the 25 STs excavated. This deposit is a dark brown clay loam with prehistoric ceramics and marine shell.

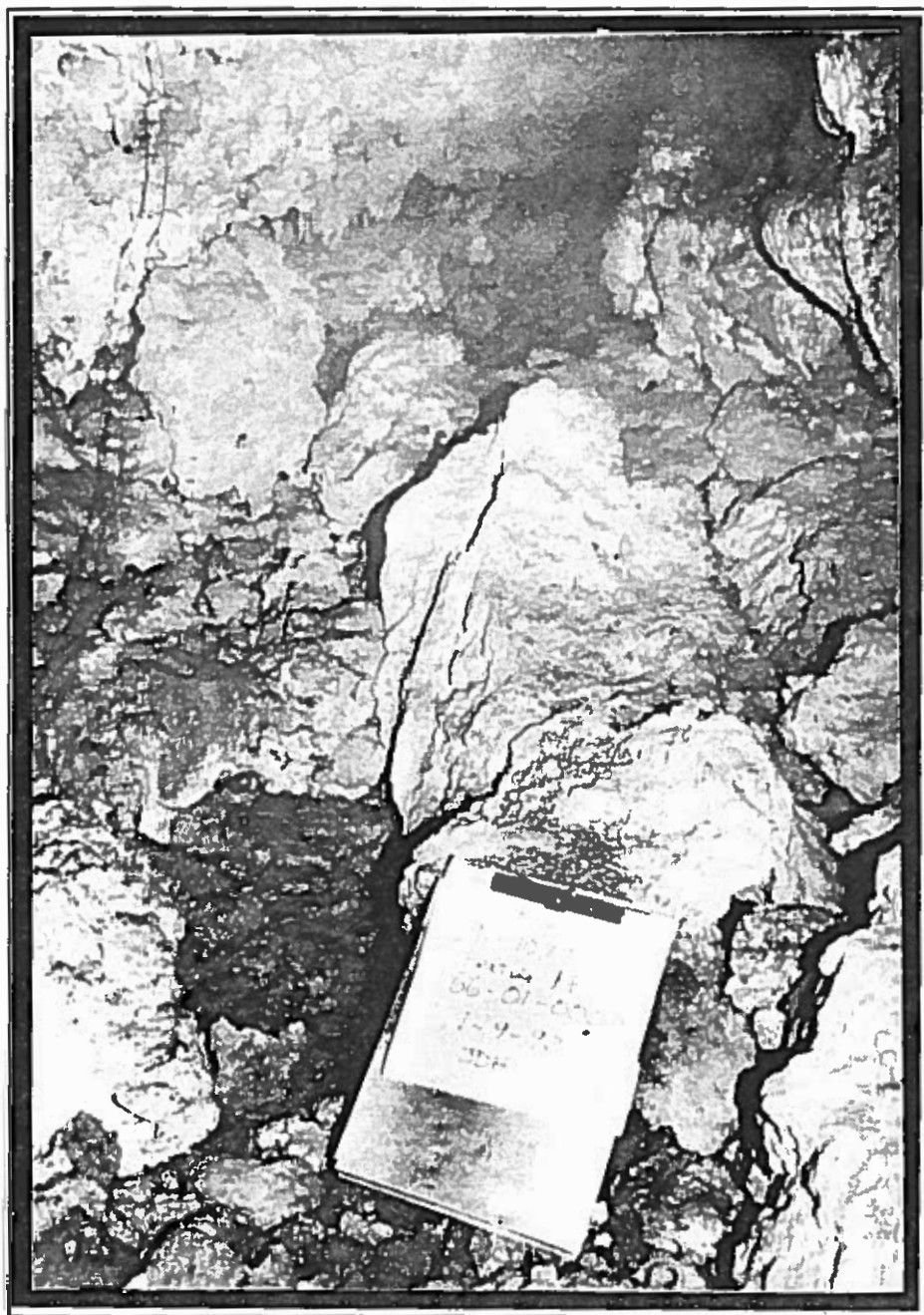


Figure 9. Site 66-04-0617, Cave Entrance (Neg. 2497-20)



Figure 10. Site 66-04-0618, Cave Entrance (Neg. 2497-8)



Figure 11. Site 66-04-0001, Limestone Gravel Fill (Neg. 2499-28)

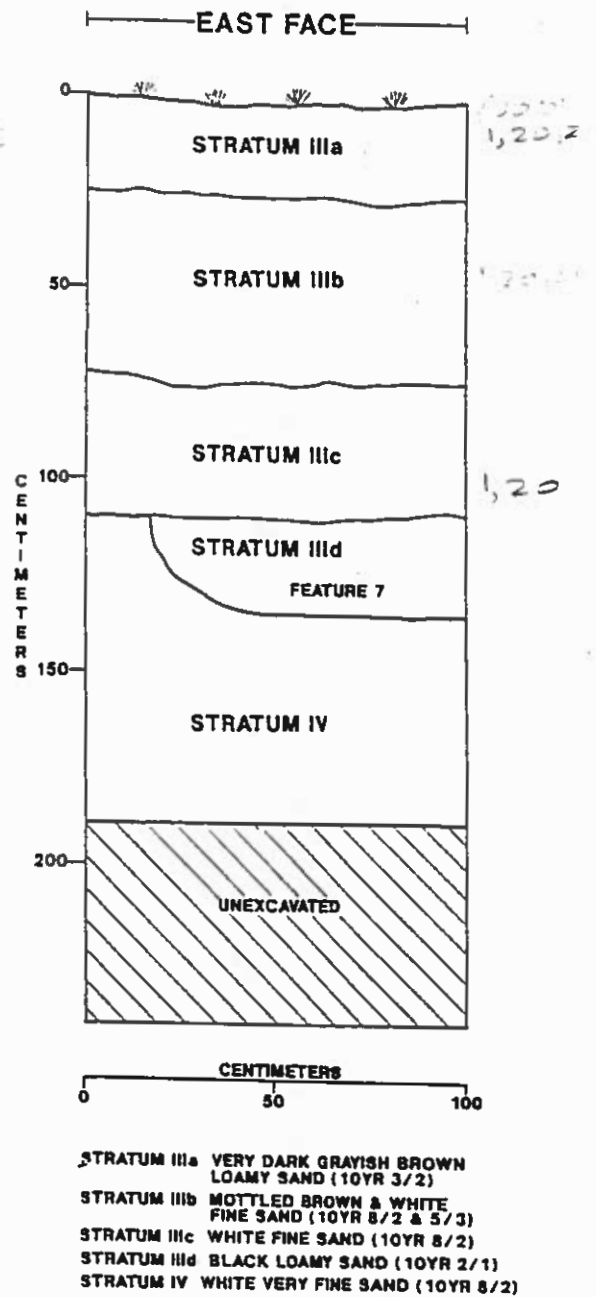


Figure 12. Site 66-04-0001, East Wall of BT-1

Substratum IIb at Site 66-04-0616 is evident in two of the 25 STs excavated. This deposit is a reddish yellow clay loam with 20% limestone gravel inclusions, containing small amounts of prehistoric ceramics and human remains.

Substratum IIIa at Site 66-04-0617 is a reddish brown clay loam with 50% limestone gravel inclusions, prehistoric ceramics, marine shell and nonhuman bone.

Stratum IV (PRE-CULTURAL)

Deposits dating to the pre-cultural period were noted in 16 of the 22 BTs excavated at Site 66-04-0001. This deposit consists of a culturally sterile fine white sand, over bedrock. The remaining eight BTs (BTs 2-4, -6, -7, -12, -16 and -20), encountered human remains and were terminated before culturally sterile soil could be reached. A summary of Backhoe Trench Stratigraphy is presented in Table A-2.

SOIL FEATURE DESCRIPTIONS

Several soil features were noted during the subsurface examination of Site 66-04-0001. These include 11 dating to the prehistoric period and one to the historic. A summary of soil features, including formal and functional interpretations, is presented in Table A-3.

Feature 1

Feature 1 is an *in situ* human burial located in the south wall and floor of BT-16. The soil within the feature is an orange-yellow, fine sand. The feature measures 0.10 m N-S (extending south out of the trench an unknown distance), and 0.60 m E-W. Trenching was terminated upon discovery of human remains.

Feature 2

Feature 2 is a basin-shaped pit located in the northwest corner of BT-16. The soil within the feature consists of a very dark grayish brown, sandy loam with prehistoric ceramics, and marine shell. The feature measures 0.80 m in width (extending west out of the unit an unknown distance), and 0.70 m in depth.

Feature 3

Feature 3 is an *in situ* human burial located in the south wall and floor of BT-2. Soil within the feature is a gray, sandy loam. The feature measures 0.60 m N-S (extending south out

of the trench an unknown distance), and 0.45 m E-W. Trenching was terminated upon discovery of human remains.

Feature 4

Feature 4 is a disturbed human burial located in the south wall of BT-4. Soil within the feature is a very dark grayish brown, sandy loam. The feature measures 0.4 m E-W and extends west out of the trench an unknown distance. Trenching was terminated upon discovery of human remains.

Feature 5

Feature 5 is an *in situ* human burial located in the south wall and floor of BT-3. Soil within the feature is a gray, sandy loam. The feature measures 0.15 m N-S (extending south out of the trench an unknown distance) and 0.38 m E-W. Trenching was terminated upon discovery of human remains.

Feature 6

Feature 6 is an *in situ* human burial located in the north wall and floor of BT-6. Soil within the feature is a very dark grayish brown, sandy loam. The feature measures 0.25 m N-S, (extending north out of the trench an unknown distance), and 0.45 m E-W. Trenching was terminated upon discovery of human remains.

Feature 7

Feature 7 is a basin-shaped pit located in the east wall of BT-1. Soil within the feature is a black, sandy loam and contains prehistoric ceramics, marine shell and thermally altered rock. The feature measures 0.85 m N-S, (extending south out of the trench an unknown distance), and is 0.25 m deep.

Feature 8

Feature 8 is an *in situ* human burial located in the north wall and floor of BT-20. Soil within the feature is an orange-brown, sandy loam. The feature measures 0.25 m N-S, (extending north out of the trench an unknown distance), and 1.5 m E-W. Trenching was terminated upon discovery of human remains.

Feature 9

Feature 9 is a basin-shaped pit located in the east wall of BT-21. Soil within the feature is a light brown, sandy loam with small amounts of charcoal present. The features mea-

measures 0.80 m N-S, (extending south out of the unit an unknown distance), and 0.70 m deep.

Feature 10

Feature 10 is a basin-shaped pit located in the north wall of BT-11. Soil within the feature is a very dark grayish brown, sandy loam, containing large quantities of glass, aluminum cans, plastic and butchered nonhuman bone. The feature measures 0.90 m E-W and 0.35 m deep.

Feature 11

Feature 11 is a human-bone scatter located in the north and east walls and floor of BT-12. Soil within the feature is

a brown, sandy loam. The feature measures 0.45 m N-S (extending north out of the trench an unknown distance), and 0.95 m E-W, (extending east out of the unit an unknown distance). Trenching was terminated upon discovery of human remains.

Feature 12

Feature 12 is a human-bone scatter located in the north wall and floor of BT-7. Soil within the feature is a very pale brown, very fine sand. The feature measures 0.20 m N-S, (extending out of the trench an unknown distance) and 0.40 m E-W, (extending east out of the trench an unknown distance). Trenching was terminated upon discovery of human remains.

DATA ANALYSES

All field-accessioned bags, except bags of human bone, are checked into the main lab, and the provenience information written on the bags is compared to that recorded on the field-accession records. Completed accession records are entered on the main lab computer using a relational database program (Paradox 3). Bulk soil samples are placed in an enclosed, air-conditioned area to await floatation or other processing. Bags sorted in the field are placed in boxes with materials of the same category to await analysis. Bags of unsorted materials are stored until lab technicians can sort them. Material from "dirty" (i.e., loamy soil) areas is waterscreened and dried prior to sorting. Material from "clean" (i.e., sandy) areas is not waterscreened.

Materials are sorted by lab technicians into specific bags, and the proper provenience information is written on each bag in permanent ink. Items are sorted into the following categories: shell (not worked), pottery, human bone, nonhuman bone, non-ceramic artifacts, and botanical. Human bone is immediately transferred to the osteology lab. Carbonized botanical material is sealed in either foil or plastic to prevent contamination. Items of each category are placed in boxes to await analysis; non-ceramic artifacts are separated by material type within the storage box.

Ceramics and non-ceramic artifacts are washed in water with a soft brush, except for items such as metal, fabric, leather, lime-impressed ceramics, fragile or decorated ceramics, fragile shell artifacts (e.g., fishhooks, *Isognomon* shell), or fragile bone artifacts. Rim sherds greater than 2.0 cm in size and all non-ceramic artifacts are given catalog numbers, starting with "1" for each project or site. PHRI project number, GHPO site number (if available) and catalog number are written on the artifact in permanent black ink. If the item is too small to hold the information, it is placed within a sealable plastic bag or vial on which the catalog number and provenience information is inscribed in permanent ink. Sorting and cataloguing data are entered in a database program (Paradox 3), and data tables are generated from this database.

FINDINGS

Investigations in the project area resulted in the identification of five prehistoric and two historic sites. Materials were collected from all five prehistoric sites. Although this portion of prehistoric Site 66-04-0001 has been impacted by recent human activities, the artifactual data show

patterning which is congruent with earlier researchers' observations concerning the site.

RADIOMETRIC DATING

Five samples of charcoal and low-carbon bulk soil were chosen from discrete cultural deposits at 66-04-0001 for radiocarbon age determination analysis. Three samples were sent to the Geochron Laboratories Division of Krueger Enterprises, Inc., of Cambridge, Massachusetts. Two samples were submitted to Beta Analytic Inc. of Miami, Florida. Standard procedures were employed in the processing and analysis of all samples. The isotope values obtained during the counting process were then used to calculate the carbon-13/carbon-12 ratio for each sample, with the final result being determined relative to international standards in order to reduce errors produced by carbon isotope fractionation. The results of the radiocarbon age determinations are presented in Table A-4. The age for each sample is reported as a two standard deviation range. After adjustment based on carbon isotope ratios, the ages were calibrated using the tables provided in Stuiver and Pearson (1986), which correct variations in atmospheric carbon over time.

Samples were selected from two soil features (Features 2 and 7) and general level fill in Features C and H. Two samples were selected from different depths in Feature 2 in order to determine the nature of this feature. The deposits in the project area were practically devoid of datable carbon, and these samples represent the only suitable dating samples available.

Radiometric determinations showed two distinct groupings, centered around Transitional Pre-Latte and early-to-middle Latte Phase dates. The Transitional Pre-Latte dates were associated with Features 2 and 7, both of which were located in the surface of Feature C, a large artifact scatter.

Feature 2 is a fire pit which contained charcoal and other portable remains, including ceramics. Charcoal sample 2154 (sample numbers are preceded by 1077-), taken from 0.75 mbs, yielded an adjusted date of 1670 ± 150 BP. Sample 2155, a bulk low-carbon soil sample taken from only 5.0 cm above the previous sample yielded an adjusted date of 370 ± 110 BP.

Feature 7, also a fire pit, yielded an early date as well. Soil sample 2156, taken from 1.10-1.35 mbs, was dated to 1915 ± 115

BP, a Transitional Pre-Latte Phase date. There were no artifacts associated with this feature.

General level fill from Feature H, an overhang, and from Feature C yielded early to middle Latte Phase dates. Sample 2158, a charcoal sample from 0.35 m bs in Feature H, yielded an adjusted date of 530 ± 60 BP. The only artifacts associated with Feature H consisted of five small (unanalyzable) ceramic sherds and several historic items. Examination of stratigraphic data for the area surrounding Feature H showed what may originally have been a midden area outside the overhang, corresponding to substrata IIIb and IIIc in BT-14, BT-15, BT-16, and perhaps BT-18. Sample 2157, a bulk low-carbon soil sample taken from 0.35-0.55 m bs in BT-14 within Feature C, yielded a date of 690 ± 105 BP. No non-ceramic artifacts were recovered from this provenience, although a small number of prehistoric ceramics were.

Discussion

The range of dates obtained indicate a length of occupation spanning the Transitional Pre-Latte Phase through the Latte Phase. Subsurface features yielded the earliest determinations. The remaining three dates, from general level fill and the upper levels of Feature 2, indicate an early to middle Latte Phase context for these levels. These determinations are substantiated by the artifactual data, primarily the prehistoric ceramics.

The majority of ceramics contained volcanic sand inclusions, and had thickened rims and textured-to-smooth finishes. These attributes are most commonly associated with the Latte Phase. Variation in thickness within the collection of Type B rims themselves suggests that the ceramics were produced at different times during the Latte Phase. A small number of sherds with polished surfaces and calcareous sand inclusions were also noted in BT-20 and BT-21, indicating a possible Pre-Latte Phase component. Unfortunately, no radiocarbon samples were available from these BTs.

This pattern of dates and associated artifactual materials was also found in PHRI Project 91-1040, the AT&T Communications Cable Project, located to the south across Gun Beach Road (Grant et al. 1992). Site 66-04-0001, a large prehistoric village site, spans Gun Beach Road and thus encompasses both the current project area as well as the 91-1040 project area. Both Pre-Latte and Latte Phase dates were obtained during by Grant et al., two of which ranged from approximately 1670-1800 BP (Transitional Pre-Latte). Three additional determinations were Latte Phase, and ranged from 625-1045 BP. Again, the earlier dates were associated with subsurface features from which few diagnostic artifacts were

retrieved. Ceramics data obtained by Grant et al. indicated a Latte Phase context, with volcanic sand inclusions and thickened rims predominating.

Summary

Radiometric determinations were obtained for five samples from discrete proveniences in the project area. Results indicated an occupation span ranging from the Transitional Pre-Latte to the early and middle Latte Phase dates and were partially supported by the limited artifactual data.

NON-CERAMIC ARTIFACTS

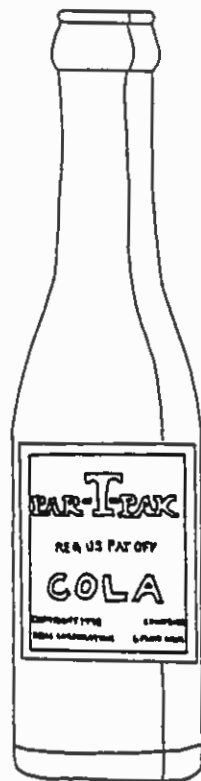
A total of 92 artifacts were recovered from Site 66-04-0001 (Table A-5: Summary of Non-ceramic Artifacts). The artifacts were recovered from three surface features (Features C, F, and H) and one soil feature (Feature 10). No non-ceramic artifacts were collected from the remaining four prehistoric sites.

Findings

Feature 10. Feature 10 is a recent trash pit encountered in BT-11, substratum Ib (0.25-1.10 mbs). Four historic artifacts, three complete bottles and an amber glass sherd, were recovered from this feature. The glass fragment (Cat. No. 4) was from a machine-made bottle, though no maker's marks or embossing was present.

The three intact bottles were soft drink containers. Cat. No. 1 was a clear, seven ounce, dot-impressed bottle. The shoulder of the bottle was embossed with the molded phrases, "NOT TO BE REFILLED" and "NO DEPOSIT NO RETURN." The base of the bottle displayed a maker's mark: an encircled "I" within a diamond flanked by "20" on the left and "52" on the right with the word "Duraglas" below, as well as the bottlers' identification, "I WAY BEVERAGES."

Cat. No. 2 was a light-green tinted, machine-made bottle with a six-ounce capacity (Figure 13). The painted label on the front of the bottle was still intact. Painted in red and white, it read, "PAR-T-PAK / REG U.S. PAT. OFF. / COPYRIGHT 1945 / NEHI CORPORATION." The back read, "BOTTLE STERILIZED BEFORE FILLING * CONTAINS CARBONATED WATER / SUGAR, AN ACIDULANT, / COLA NUT EXTRACTIVES, / NATURAL FLAVORS, / CARAMEL COLOR / PROPERTY OF STANDARD BEVERAGES / OAKLAND - SAN FRANCISCO." The base was embossed with a similar maker's mark as Cat. No. 1, an encircled "I"



ACC. NO. 37 / CAT. NO. 2

SCALE 2:1

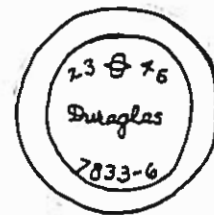


Figure 13. Par-T-Pak Cola Bottle

within a diamond flanked by "23" on the left and "46" on the right with the word "Duraglas" below.

The third intact bottle (Cat. No. 4) was a clear, machine-made Pepsi bottle. The neck of the bottle was molded with alternating ribbons, some reading "PEPSI COLA" and others with a crosshatched pattern (Figure 14). The front of the bottle was painted in red and white, though only a portion of the label remained. The base was embossed with a maker's mark reading, "DES PAT 120-277 / 14-B-50 / an encircled 'B' / TEMPERGLAS / 1333."

Feature C. A total of 47 non-ceramic artifacts was recovered from 14 BTs excavated in Feature C, a large artifact scatter. Only four of these were historic. Historic items included a 4.5-inch iron nail and a six-inch spike (Cat. No. 9) recovered from BT-5 substratum Ic (0.90-1.10 m bs), a clear glass body sherd (Cat. No. 15) recovered from BT-22 substratum Ic and a small, teal, glass bottle (Cat. No. 18).

The teal bottle was machine-made and did not exhibit maker's or bottler's marks. The bottle was decorated with four 11 mm-wide panels made up of five small ribs. In between each of the ribbed panels a portion of the glass had been partially cut away, adding another component to the design. The bottle measured 62 mm in diameter, with a 65 mm tall body and was 99 mm tall when the neck and screw top lip were included. Decorative bottles such as these usually held perfume or similar cosmetic contents.

Thirty-six shell artifacts were recovered from Feature C, most of which were *Tridacna* shell fragments or tool fragments. A total of 716.41 g of whole and fragmentary *Tridacna* shells was recovered from depths ranging between 0.0 and 1.10 mbs. These fragmentary shells may represent debitage from *Tridacna* adze manufacture.

Tridacna adzes were represented by a complete adze, a broken adze and an adze fragment. The complete adze (Cat. No. 19) was trapezoidal in frontal profile and lenticular in cross-section. The bit was straight and the poll was rounded. Bevel angle for the bit measured 66 degrees. The surface of the adze was natural but slightly waterworn. The adze was manufactured from the dorsal portion of a left valve. It should be noted at this point that the anatomy of the *Tridacnidae* is different than that of many other bivalves. According to Rosewater (1965:350-353 IN Kirch and Yen 1982:210), in *Tridacna* the hinge area is ventral, and the thinner portion of the valve is in fact dorsal.

The broken adze (Cat. No. 5) was rectangular in frontal profile and lenticular in cross-section. The bit was convex, 27

mm long by 10 mm wide and had a bevel angle of 48 degrees. The poll was missing. This adze was also manufactured from the dorsal portion of a left valve.

The fragment (Cat. No. 7) was the bit portion of an adze. The frontal profile was rectangular and the cross-section was lenticular. The bit was concave, 24 mm long by 10 mm wide and had a bevel angle of 76 degrees. The adze was manufactured from the posterior dorsal section of a right valve.

Twenty-three pieces of *Isognomon* were also recovered. Twenty-two of these were recovered from the same provenience (BT-2, 0.0 to 0.20 mbs; Cat. No. 24). These fragments may represent only a few individual shells. Two pieces were large, and may represent raw material stored for fishhook manufacture. The remaining pieces may be debitage from fishhook manufacture. Although no finished fishhooks or gorges were recovered, one possible fishhook tab (Cat. No. 34) was recovered from BT-20, substratum IIc, 0.73-1.10 m bs. One of the edges appeared drilled, although the shell was too waterworn to be certain. All the *Isognomon* recovered was associated with proveniences in which there was also a human burial.

Two *Terebra* artifacts were recovered, a complete adze (Cat. No. 12) and a possible adze blank (Cat. No. 29). The anterior portion of Cat. No. 12 was ground to a convex bit. The bit was approximately 33 mm long, 12 mm wide and had a bevel angle of 64 degrees. The apex of the shell was chipped. Cat. No. 29 was identified as an adze blank, as the apex of the shell displayed slight grinding. The anterior end of the shell was broken.

Six lithic artifacts were recovered, most of which were groundstone items. A single secondary chert flake (Cat. No. 8) was collected from the surface of Feature C. The bit portion of a basalt adze or chisel (Cat. No. 11) was recovered from the surface. The fragment had an almost circular cross-section; between 32 and 38 mm in diameter. The bit edge itself had a length of 33 mm. The bevel, with a slightly convex edge, was ground to a 73-degree angle.

The poll portion of a basalt tool was collected from BT-6, substratum IIIa (Cat. No. 6). Manufactured from a fine-grained basalt, this tool may be the poll portion of a pestle.

Two pestle or pounder fragments were recovered, one (Cat. No. 10) from BT-21, substratum IIIb and one (Cat. No. 14) from BT-22, substratum III. Cat. No. 10 was the utilized end of an andesite pounder. Pecking was evident on the use surface. The fragment had a circular cross-section with a



ACC. NO. 37 / CAT. NO. 4

SCALE 2:1



Figure 14. Pepsi Cola Bottle

diameter of 88 mm. Cat. No. 14 was ovoid in cross section, and was quite battered and weathered.

A modified andesite cobble (Cat. No. 13) was recovered from BT-1, substratum IIIa. A small portion of the surface was broken but not abraded. The function of this modified stone is unknown, although it may have been a hammerstone.

Several radiometric determinations were available from Feature C, ranging from Transitional Pre-Latte Phase (1670-1915 BP) to the Latte Phase (370-690 BP). Three dates were derived from soil features. One came from general level fill in BT-14, the other two from BT-1 and BT-16. None of the non-ceramic artifacts was directly associated with the radiometric dating samples.

Feature F. A total of 39 non-ceramic artifacts was recovered from Feature F, an overhang. All were historic or recent in origin and consisted of 12 pieces of metal and 27 pieces of glass. The metal fragments (Cat. No. 16) were small and unidentifiable, weighing a total of 10.59 g. The glass fragments (Cat. No. 17) were from a variety of machine-made bottles. Eighteen of the fragments were amber; four of these were dot-impressed body sherds, 13 were plain body sherds and one was a plain base. Eight body/shoulder sherds were clear glass; one displayed the crosshatching found on Pepsi bottles, two were ribbed, three were plain, one was dot-impressed and one displayed the molded characters "ANA". One glass sherd was green and dot-impressed. Makers' marks or bottler information could not be determined from these small sherds. No radiometric samples were taken from this feature.

Feature H. Only two artifacts were recovered from ST-5 in Feature H, also an overhang. They were the metal backing of a lapel pin (Cat. No. 22) and a glass fragment (Cat. No. 23). Cat. No. 23 was a plain, clear, body sherd with no distinguishing marks. Although only historic artifacts were recovered from Feature H, charcoal recovered from 0.35 mbs was radiocarbon dated to 530 ± 60 BP. These historic items, then, are intrusive into prehistoric strata.

Discussion

A total of 92 artifacts was recovered from the four distinct features (10, C, J, and L) within the project area. A majority of the items, including the entire prehistoric assemblage, was recovered from Feature C. When considering the artifacts from each feature individually, the assemblages were either too small or the artifacts within those assemblages too fragmentary to supply much information. In addition, none of

the artifacts were directly associated with the radiometric determinations. Looking upon the artifacts from across the project area as two inclusive assemblages, historic and prehistoric, a general view of the material culture of the area may be revealed.

Historic Artifacts. The recovered historic assemblage included 49 items. Of these, only bottle glass had diagnostic potential. A total of 31 pieces of bottle glass was recovered. Only three intact bottles (recovered from Feature 10, a recent trash pit) yielded information as to their origin. Cat. No. 1 was a clear, dot-impressed soft drink bottle with a bottle maker's mark of an encircled "I" within a diamond with the word "Duraglas" below. This was the mark of the Owens-Illinois Glass Co. The Owens-Illinois Glass Co. was formed in 1929 when two large glass companies merged, the Illinois Glass Co. group and the Owens Bottle Machine Co. Many additional companies were added through the years, to make Owens-Illinois Glass Co. one of the country's the largest bottle producers (Toulouse 1971:403). A total of twenty six plants were recorded in 1971. A plant designation number was molded to the left of the company symbol on each bottle allowing identification of the manufacture location of the specific bottle. The number to the right of the symbol refers to the year in which it was made. The symbol on Cat. No. 1 was flanked by "20" on the left and "52" on the right designating a manufacture in the Oakland, California plant in the year 1952. The Oakland plant was opened sometime around 1944 and is still in operation (Toulouse 1971:407).

The Owens-Illinois Glass Co. mark was accompanied by the scripted word "Duraglas". Owens-Illinois often used the mark on their wares. Beginning on September 4, 1940, the word was embossed in script, but the style of writing was changed to capital block letters on October 18, 1963 (Toulouse 1971:170). No reference for "I WAY BEVERAGES" bottlers was found.

Cat. No. 2 was a light-green tinted cola bottle (Figure 13). The painted label on the front referred to the "NEHI CORPORATION." Nehi was first introduced as a new beverage line of the Chero Cola organization. The Chero Cola Company was created by Claude A. Hatcher in Columbus, Ohio in 1912. Soon after the introduction of the Nehi line in 1924, the Nehi Corporation was organized (Riley 1958:261,264). In 1933 Nehi's Par-T-Pak brand was introduced. By the middle of the century, over 400 bottlers were franchised to distribute Nehi (Riley 1958:156). The Gun Beach example exhibited the words "PROPERTY OF STANDARD BEVERAGES / OAKLAND - SAN FRANCISCO." The base was also embossed with the Owens-Illinois maker's mark with the word

"Duraglas." The symbol was flanked by "23" on the left and "46" on the right, representing manufacture in 1946 at the Los Angeles, California plant (Toulouse 1971:407).

The third intact bottle (Cat. No. 4, Figure 14) was a Pepsi bottle with the patented (DES PAT 120-277) crosshatched pattern. Pepsi was first made as "Brad's Drink" in 1896 by Caleb D. Bradham in New Bern, North Carolina. By 1901 the beverage was known as "Pepsi-Cola" and in 1903 the Pepsi-Cola Company was organized (Riley 1958:258). The base of the Cat. No. 4 possessed a maker's mark of an encircled 'B'. This was the mark used by the Brockway Glass Co. of Brockway, Pennsylvania. The symbol of the letter "B" within a circle was copyrighted by Brockway in 1928, though it was used as early as 1925. The company was established in 1907 as the Brockway Machine Bottle Co. at the site of a closed glass factory. The company experimented with various types of glass machines and soon expanded its bottle-making capabilities. In 1933 Brockway Machine Bottle Co. merged with Brockway Sales Co., a subsidiary, to form the Brockway Glass Co. By 1941 Brockway's second plant in Crenshaw, Pennsylvania was in operation and in 1946 a plant in Muskogee, Oklahoma, formerly the De Camp Consolidated Glass Casket Co., became Plant 3. By 1964 the Brockway Glass Co. obtained eight bottle plants operated by the Continental Can Co., more than doubling its size. Brockway is still in operation today (Toulouse 1971:59-62). The "14-B-50" molded on the base of the bottle may represent a manufacture in Plant No. 14 in 1950, though no reference to the positioning of the numbers was found.

Prehistoric Artifacts. A total of 36 shell items was recovered, 11 of these (30.6%) were of *Tridacna* shell. One complete adze and two adze bit fragments were present. The adzes had straight or slightly convex bit edges and straight parallel sides conforming to established descriptive typologies: Type 2 in Spoeher's system (1957) and in Reinman's system, (1977) (which was based on Spoeher's system). It also conformed to Kirch and Yen's (1982) Type 3, Craib's (1977) Type 1b and Ray's (1981) Type 6b. All were of these types were manufactured from the dorsal region of the parent *Tridacna* shells. This area of the shell was more commonly utilized than the opposing ventral hinge region. As Kirch and Yen (1982:230) stated in their attribute study "functional lines may have crosscut the dorsal/hinge distinction" because there was "no significant difference between dorsal- and hinge-region adzes with respect to their cutting edge." Adzes of this type were not only common but were widely distributed through time (Kirch and Yen 1982:231). Spoeher (1957:152) concurs, stating "no stratigraphic difference can be ascribed to the types set forth here."

The remaining eight *Tridacna* shell items, weighing a total of 716.41 g, were predominantly large fragments or whole shell. Six of the large pieces had an average measurement of 69 mm by 103 mm by 10 mm and could represent a supply of raw material for future use in adze or other artifact manufacture, or breakage from procurement of *Tridacna* meat for consumption. The smaller fragments were too small to have been used as raw material in adze manufacture and may have been debitage. In a study done on Rota, McNamara and Butler (1988) examined a collection of *Tridacna* debris (N=108) in order to see if there was patterning which might shed light on the reduction sequence and manufacturing strategy for shell adzes. Accordingly, fragments were identified and counted by the categories hinge, nonhinge, angular fragment, and flake. Few distinct trends were noted, although this mode of analysis may have merit for larger collections. As only eight fragments were collected from the current project, the kind of analysis outlined by McNamara and Butler would not be meaningful.

In conjunction with siding information done on complete adzes, a closer examination of *Tridacna* debris may allow researchers to distinguish between shells broken for meat procurement versus broken shell from tool manufacture. Of course, these two categories undoubtedly overlap, as larger fragments broken during food preparation could have been saved for tool manufacture. If one valve side versus another was consistently broken for meat removal, with the unbroken half saved for tool manufacture, one might expect to see patterning not only in the side used for adzes, but in the proportion of sides represented in manufacturing debris. This assumes that manufacturing debris tends to be discarded in areas separate from areas of food preparation and discard. Excavations at Fafai Beach (Haun et al. 1990), located approximately 50 m from 66-04-0001, showed that *Tridacna* debitage tended to be strongly associated with finished adzes and adze fragments (Haun et al. 1990:17). Further, the majority of *Tridacna* adzes at Fafai Beach were manufactured from the left valve of the parent shell, as were the three *Tridacna* adzes from the Gun Beach Hotel Project. The information gathered so far, while incomplete, suggests that this line of inquiry may be fruitful for larger assemblages of *Tridacna* artifacts.

Two *Terebra* artifacts were recovered, one a complete adze, the other a possible adze blank. The adze (Cat. No. 12) conformed to Craib's Type 6 and as he states, *Terebra* adzes "demonstrate exceedingly little variation, due to the limitations imposed by the general shell morphology" (Craib 1977:79). The *Terebra* adze manufacturing process, as described by Craib (1977:78), begins by pecking one side of the

shell "producing an ever widening aperture". The adze blank (Cat. No. 29) was missing the aperture portion of the shell and may have broken during this early stage of manufacture. The apex of the shell was slightly ground, the possible beginnings of a bevel. Similar "adzes", those with beveled polishes and unmodified apertures, have been recorded from the Marianas (Craib 1977:81).

Twenty-three (63.9%) pieces of *Isognomon* were recovered. *Isognomon* shell was the primary material used in fishhook and gorge manufacture. Only one of the fragments (Cat. No. 34) was noticeably worked and may be a fishhook tab. The fragment had a drilled area 6.0 mm in diameter on one side. The remaining 22 pieces of *Isognomon*, weighing a total of 28.13 g, may have been debitage. Because of the fragility of the *Isognomon* shell, it was difficult to differentiate naturally broken pieces of shell from culturally produced debitage. Whole shells and large pieces of shell may represent raw material for hook manufacture.

The six lithic artifacts recovered from the project area were either from early stages of manufacture or were fragmentary and lacked diagnostic features. The presence of a single basalt adze fragment (Cat. No. 11) reinforces Reinman's (1977:109) observation that on Guam, shell adzes are twice as numerous as stone adzes, perhaps because shell was more abundant and more easily worked. Spoehr postulated that "stone adzes were used for heavy work and shell tools for lighter work and for finishing" (1957:151).

Summary

A small number of artifacts were recovered from various surface and subsurface features at Site 66-04-0001. Although the collection was nearly evenly divided between historic and prehistoric artifacts, all the prehistoric artifacts were recovered from Feature C, a large artifact scatter. Radiocarbon samples taken from feature and general level fill within Feature C yielded dates which spanned the Transitional Pre-Latte through Latte Phases. Shovel tests in two overhangs on the periphery of Feature C yielded only small bits of glass and metal, although charcoal from one of the overhangs dated to approximately 530±60 BP. The diagnostic historic artifacts date from the late 1940s to the early 1950s, and were primarily derived from a large trash pit (Feature 10), located on the western edge of the project area.

Unlike other more extensive investigations in the same general area (e.g., Fafai Beach [Haun et al. 1990] in another portion of 66-04-0001 [Grant et al. 1992], excavations at the Gun Beach Hotel Project Area did not yield a large variety of non-ceramic artifacts. Rather than finding a variety of domes-

tic, manufacturing, warfare, and fishing implements, a small range of artifact types are represented.

Domestic activities are implied by the presence of pounders or pestles, as well as the ceramic artifacts, while manufacturing activities such as woodworking are indicated by the variety of adzes and adze-making debris. A possible fishhook tab was identified, but no finished fishhooks, gorges, or sinkers were found. Likewise, no mortars, abraders, slingstones or other kinds of artifacts typically associated with a large Latte village are represented in the assemblage. The primary activities represented appear to be domestic and manufacturing activities. This distribution suggests several possible explanations. One, that the Gun Beach area in general has been impacted by bulldozing and other historic activities, thus resulting in disturbance of intact cultural deposits. It is also possible that the limited area tested was on the periphery of the original village site, or that it was an area in which only a few activities were carried out. A combination of these two factors may well be the reason for the patterning observed in the non-ceramic artifact assemblage.

The relationship of the overhang features to the main portion of the site represented by Feature C is difficult to surmise from existing evidence. Though part of the overall site, these may have been used in a limited manner which is not reflected in the archaeological record. It also seems likely that recent human activities, indicated by the presence of historic and recent trash in the overhangs, has obliterated whatever prehistoric remains originally existed.

CERAMIC ANALYSIS

A total of 249 sherds was collected from the Gun Beach project area. Of the total number of sherds, 97 sherds (36 rims, four transitional and 57 body sherds) were analyzable. The first step in analysis was to size-sort the sherds into "analyzable" and "unanalyzable" categories. Analyzable sherds consisted of rim or transitional sherds measuring over 2.0 cm along any dimension except thickness, and body sherds measuring over 4.0 cm along any dimension except thickness. Transitional sherds are defined as those sherds exhibiting a point of inflection and representing a transition point between two sections of the vessel's morphology, e.g., shoulder, base or neck sherds. Unanalyzable sherds were simply counted and bagged. Analyzable sherds were subjected to full attribute analysis.

Methods

The following attributes were recorded for all body and rim sherds: color, hardness, nonplastic inclusions, thickness

and surface treatment. In addition, the following attributes were recorded for all rim sherds: stance, rim form, rim edge form and orifice diameter. The coding format used is provided in Appendix B.

Color. Color was recorded for the exterior, interior and core of each sherd using Munsell Soil Color Charts. Color was not recorded for eroded surfaces.

Hardness. Hardness of each sherd was based on criteria outlined in the coding format, which is included in Appendix B.

Inclusions. Each sherd was examined along a fresh break for amount, size, sorting and type of nonplastic inclusions. Recent investigators (cf. Moore 1983, Sant and Lebetzki 1988) have questioned whether all nonplastic inclusions present in Marianas pottery represent deliberate tempering, suggesting instead that some inclusions may be naturally present in the clay sources. Some inclusions, such as grog, and possibly crushed shell, are undoubtedly temper. However, since this issue is still unresolved, the word "temper" is not used to describe nonplastic inclusions.

Inclusions are classed on the basis of color, angularity, size and reactivity to dilute hydrochloric acid. White, rounded-to-angular clasts with a positive reaction to acid correspond to previous identifications of "calcareous sand temper" or CST; a mixture of white (calcareous) and nonwhite inclusions roughly corresponds to the previous classification of "mixed sand temper" or MST, and white (noncalcareous) and nonwhite inclusions correspond to "volcanic sand temper" or VST. Additional categories such as shell, grog, "no inclusions" as well as mixtures of all of the above are also recognized.

Sherd Thickness. Rim thickness was measured at the widest point of the rim on a line intersecting the center of the vessel. All body sherds were measured for maximum and minimum thickness. No thickness measurements were taken on severely eroded sherds.

Finish. Surface finish was noted for the interior and exterior of all rim and body sherds.

"Smooth" surfaces were classified on the basis of a general absence of surface treatment; they consisted of a featureless, nonglossy surface except for occasional incompletely smoothed coil marks, or occasional faint striations or ridges resulting from the smoothing process.

Surfaces were classified as "textured" if they had been finished in such a way as to leave a distinctive pattern of striations (such as "brushed", "scraped", "combed") or im-

pressions (such as cordmarked, mat-impressed, net-impressed or fabric-impressed). Decoration such as punctations or finger trailing is also coded under "impressions."

The "rough" category corresponds to Sant and Lebetzki's (1988:191) "plain rough" and includes sherds which exhibit traces of striations or impressions which had subsequently been partially smoothed over to produce a roughened texture. Thus, "rough" sherds are often observed to be intermediate in a continuum between "plain" and "textured."

"Polished/burnished" sherds were identified on the basis of a regular, glossy surface which felt soapy or waxy to the touch.

"Slipped" refers to the application of a thin coating of fine clay particles suspended in water. Often this results in a color contrast with the paste which aids in identification (Shepard 1985:191). Most of the so-called "red slipped" ware, characteristic of early pre-Latte ceramic assemblages, is actually floated rather than slipped (Sant and Lebetzki 1988:192). According to Rice (1987:151):

The terms self-slip and floated surface are sometimes used for finely textured surfaces that appear to be slipped with the same material that constitutes the clay body. The presence of a distinct slip is difficult to determine, and in some cases this effect could result simply from carefully wiping the surface with a wet hand, which brings the finest particles to the surface and orients them.

"Eroded" refers to sherds whose surface finish has been obliterated by extensive weathering or breakage.

Finish was coded as "indeterminate" if interior and exterior could not be distinguished, or if the presence of calcareous buildup obscured surface characteristics.

Orifice Diameter. Orifice diameter was estimated using a chart of concentric circles. At least 10% of the original diameter must be intact for this measurement to be performed. As oval vessels were also manufactured in the Marianas, diameters are merely estimates and may be incorrect if a sherd from an oval vessel is encountered.

Rim Form. Rim form was classified as either non-thickened or thickened, which correspond to Types A and B, respectively, according to Spoehr's (1957) typology. Examples are provided in Appendix B.

Rim Stance. Rim stance was classified as inverted, vertical, incurving, everted, excurved, flared, horizontal, pendant or indeterminate (see Appendix B for examples).

Rim Edge Form. Rim edge form was classified as round, convex, concave, pointed (including beveled) and flattened (see Appendix B for examples).

Other Attributes. The presence or absence of carbon residues, surface applications and sherd modification was recorded for each sherd.

Findings

Color. Color is generally regarded as a relatively insignificant attribute in Marianas pottery studies (Moore 1983:76). Therefore, color was not systematically analyzed for this report. General observations indicate that interior and exterior surfaces are generally of hue 5YR, while core colors are usually included in hue 2.5YR. Core colors tend to have a higher chroma and a lower value, while the reverse is true for the interior and exterior surfaces. Thus the interior and exterior surface colors are significantly lighter and less brilliant than the core colors. This may be due at least in part to the post-depositional calcareous residue which was noted to some extent on nearly every sherd. Although sherds with their surfaces completely obscured by this residue were excluded from the color analysis, it is probable that the residue influenced color observations on other sherds even when the surface was only partially obscured. The color transition noted, from the better-fired exterior portions of the sherd to the less well-fired core, is not unusual.

Hardness. Nearly all sherds (95%, N=37) could be scratched with a fingernail, giving them a Moh's hardness value of approximately 2.5 (which is between 2 and 3 on the modified Moh's scale used by PHRI), generally consistent with values from most non-kiln-fired pottery, which "...commonly ranges between 3 and 5 in hardness, but values of 2 and 7 are not unknown" (Rice 1987:356). Spoehr's (1957) hardness measurements, also based on the Moh's scale, ranged between 2.5 and 5.5 for Marianas Plainware.

Inclusions. Sherds which tested positive to muriatic acid all contained shell inclusions. Occasionally, trace inclusions of rounded white clasts (calcareous sand) were also noted. These sherds correspond to what other investigators have termed "calcareous sand temper" (CST).

Sherds containing both white and nonwhite inclusions were divided into two categories depending upon their reaction to muriatic acid. Those testing positive were considered equivalent to what other investigators have called "mixed sand temper" (MST). Those testing negative were combined with the nonwhite category, which corresponds to "volcanic sand temper" (VST).

Several sherds were encountered which were contaminated by calcareous deposition, in the form of a whitish powder which had permeated the interior of the sherd. In this case care was taken to make a fresh break far enough into the sherd's interior to minimize the possibility of a false positive in the acid test. Also, care was taken to apply the acid to an area observed to be free from calcareous deposits. In one sherd (Acc. No. 22) the calcareous deposit was so pervasive that the sherd was disqualified from the acid test.

In two cases the sherds were observed to have shell inclusions but tested negative with muriatic acid, presumably because the calcareous elements had leached out. These two were excluded from the analysis.

Sherds with nonwhite (VST) inclusions dominate the Gun Beach ceramic assemblage, with 84.04% (n=79) of the total. Sherds with shell and white inclusions accounted for 8.51% (n=8); white and nonwhite (with positive reaction to muriatic acid), 1.06% (n=1); and no inclusions, 6.38% (n=6).

Most of these sherds with nonwhite inclusions (62%, n=49) were observed to have very few inclusions evident in the area of the fresh break (i.e., with very poorly-sorted inclusions). Often only a single fragment was visible in a given sherd. Therefore a certain degree of overlap exists between the two categories of "nonwhite" and "no inclusions." The sherds classified as "no inclusions" may have had a low quantity of inclusions, of which none were visible in the vicinity of the fresh break.

Body Sherd Thickness. Body-herd thickness measurements were taken on a total of 53 sherds. The mean was calculated at 10.53 mm; the standard deviation was 2.34; and the range was 4.5 to 17.2 mm. The mean thickness of 5.0 mm of sherds with calcareous inclusions (n=5) is slightly greater than for the total number of sherds.

Surface Finish. The dominant surface finish was smooth, which accounted for 40.21% (n=39) of the sherds. Other surface finishes noted include rough (24.74%; n=24), textured (14.43%, n=14), polished/burnished (3.09 %, n=3), eroded (7.22%, n=7) and indeterminate (10.31%, n=10).

This assemblage contained a fairly large proportion of sherds exhibiting a certain degree of surface roughening (cf. Sant and Lebetzki 1988:250). Rough and textured surfaces accounted for 39.17% (n=38) of all sherds.

As noted earlier, a continuum was observed between smooth, rough and textured sherds regarding the degree of smoothing over of striations. Textured surfaces exhibited

striations with no evidence of smoothing over. Rough surfaces often exhibited clear evidence of striations, some of which have been partially or completely obliterated. Often even "smooth" sherds had very faint traces of smoothed over striations. For the textured sherds, a fair degree of variation was observed relative to the kinds of striations present. Two sherds were striated in a "combed" (cf. Moore 1983:103) pattern of regular, fine (<3 mm crest to crest), mostly parallel grooves. Four sherds were more irregularly combed, with medium (3-6 mm crest to crest), mostly parallel striations. One rim sherd (Cer. No. 15) was combed with very coarse (>6 mm crest to crest), vertical, parallel striations, in a pattern very similar to what Spoehr (1957:Figure 52) called "Marianas Trilled". Three sherds had very irregular, shallow striations, which look like they may have been created by scraping the wet clay with a handful of grass. Finally, four sherds had very fine, mostly parallel striations which were not long grooves but rather very short and overlapping, creating a very rough texture. One rim sherd of this latter type (Cer. No. 28) had a smooth zone immediately below the rim edge, and a zone of oblique striations zone below.

Polished/burnished sherds are rare ($n=3$) in the Gun Beach assemblage. All of these contained shell inclusions. One of these (Cer. No. 14) was a shoulder fragment. None of the polished/burnished sherds exhibit striations.

Rim Attributes. Of the 36 rims analyzed, the most common rim type is thickened (Type B; 83.33%; $n=30$), with an incurving (75%; $n=27$) stance with nonwhite (100%; $n=36$) inclusions. Only three non-thickened (Type A) rims were observed, while rim form was indeterminate on three specimens. No stance besides incurving was noted; however, stance could not be determined on 25% ($n=9$) of the rims analyzed. Rim-edge form was almost equally divided between rounded (36.11%; $n=13$) and convex (47.22%; $n=17$), with six (16.66%) indeterminate.

Average rim thickness (based on 31 measurements) is 20.69 mm, with a range of 8.3-35.0 mm and a standard deviation of 6.34. Average orifice diameter (based on nine measurements) is 35.33 cm, with a range of 24.00-42.00 cm.

Of the 30 thickened rims, 53.33% ($n=16$) exhibit internal thickening; 26.66% ($n=8$) are symmetrically thickened; 3.33% ($n=1$) are thickened on the exterior only; and thickening could not be determined for 16.66% ($n=5$). Complex thickening, associated with massive Type B rims, was not observed.

Finish was smooth on 13 sherds (36.11%); rough on 11 sherds (30.56%); textured on three sherds (8.33%); eroded on three sherds (8.33%); and indeterminate on six sherds

(16.66%). The proportions of surface treatments observed on rims were similar to those of the total assemblage. Rim profiles are illustrated in Figures 15-17.

Discussion

The ceramic assemblage primarily contains sherds from large, globular vessels with internally or symmetrically thickened rims and wholly or partially striated or roughened surfaces. This combination of attributes is typical of the late prehistoric Latte Phase (c. A.D. 1000-1600).

As noted earlier, there was a fairly wide variation noted in the rim thickness measurements of the thickened rims, ranging from 9.6-35.0 mm. Thickness variations in thickened rims may have temporal significance. This variation has been addressed by few researchers. For example, Sant and Lebetzki (1988:236-240), noted a stratigraphic trend in thickened rims in sites on Rota. They proposed a transitional category of slightly thickened rims between the nonthickened Type A and the robustly thickened Type B. They term this form "incipient" or "transitional" Type B, noting that rims of this type tended to be found in deeper contexts than "classic" Type B rims. If this trend holds true for Guam as well, then ceramics with slightly thickened (incipient Type B) rims may be characteristic of the early Latte Phase. Other researchers (Wickler 1990, Swift *et al.* 1991) have since made use of this refinement of Type B rims to better understand and explain temporal change in ceramic manufacture on the Marianas.

The variation observed in rim thickness measurements from the current project results from the presence of both subtypes of thickened rims. Wickler (1990:104) proposes a limit of 15 mm for the less robustly thickened "transitional" Type B rims. However, his report does not specify the way that rim thickness was determined. Using the method outlined in the Methods section (above), it seems that 20 mm may be a more appropriate figure. Using this criterion, the thickened rims from Gun Beach are divided between "transitional" ($n=14$) and "robust" ($n=16$). Representative rim profiles of "transitional" and "classic" thickened rims from the assemblage are provided in Figure 15.

Thus, the major cultural component present at the Gun Beach Project appears to date to the early to middle Latte Phase (c. A.D. 1000-1600). The presence of a large number of robust, Type B rims further narrows the possible date of occupation to the middle to late Latte Phase (c. A.D. 1300-1600). Five sherds of a thick, shell-tempered ware with polished surfaces were recovered from BT-20 and BT-21. Although no radiocarbon dates were associated with these BTs, these sherds may represent a Pre-Latte component at

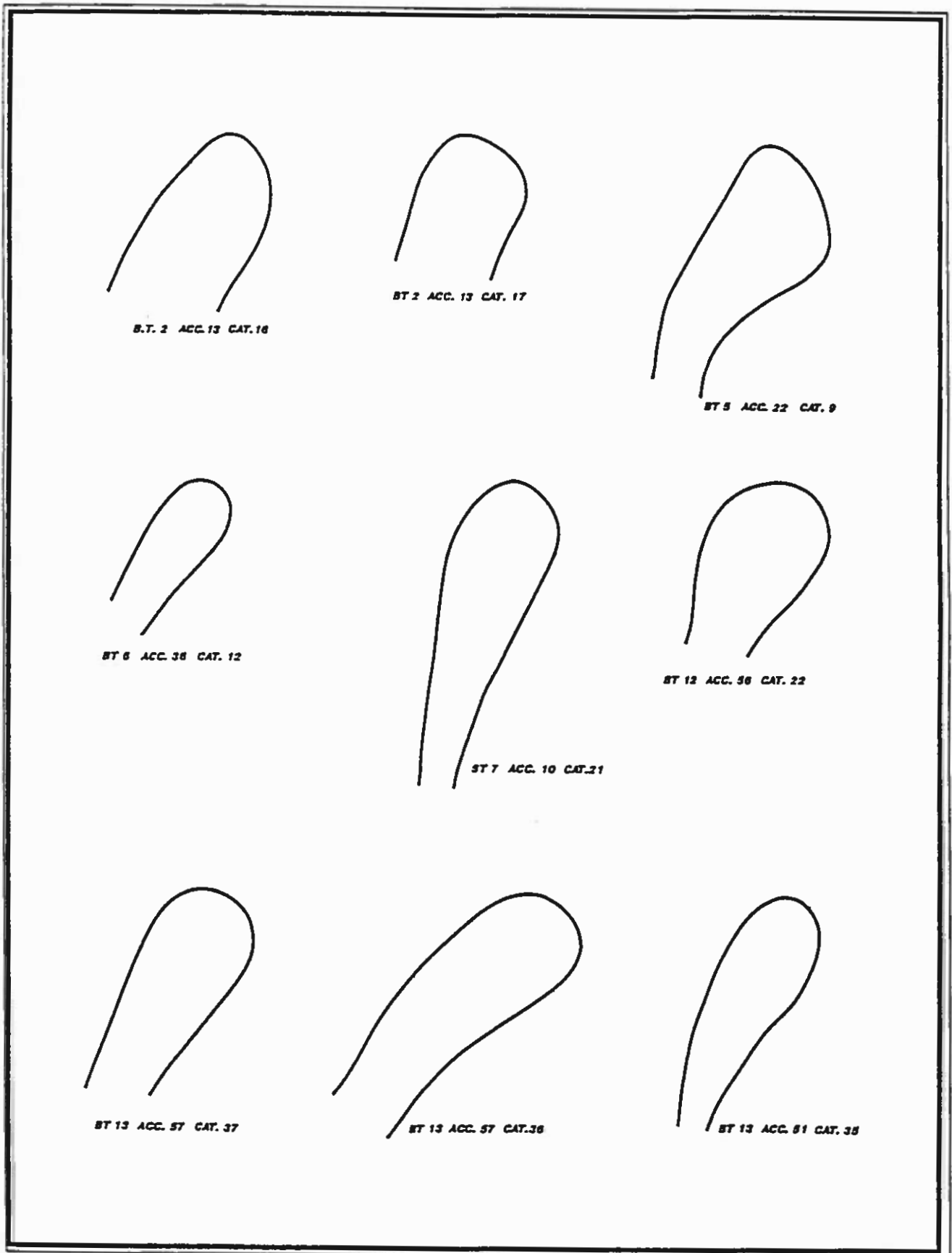


Figure 15. Rim Profiles

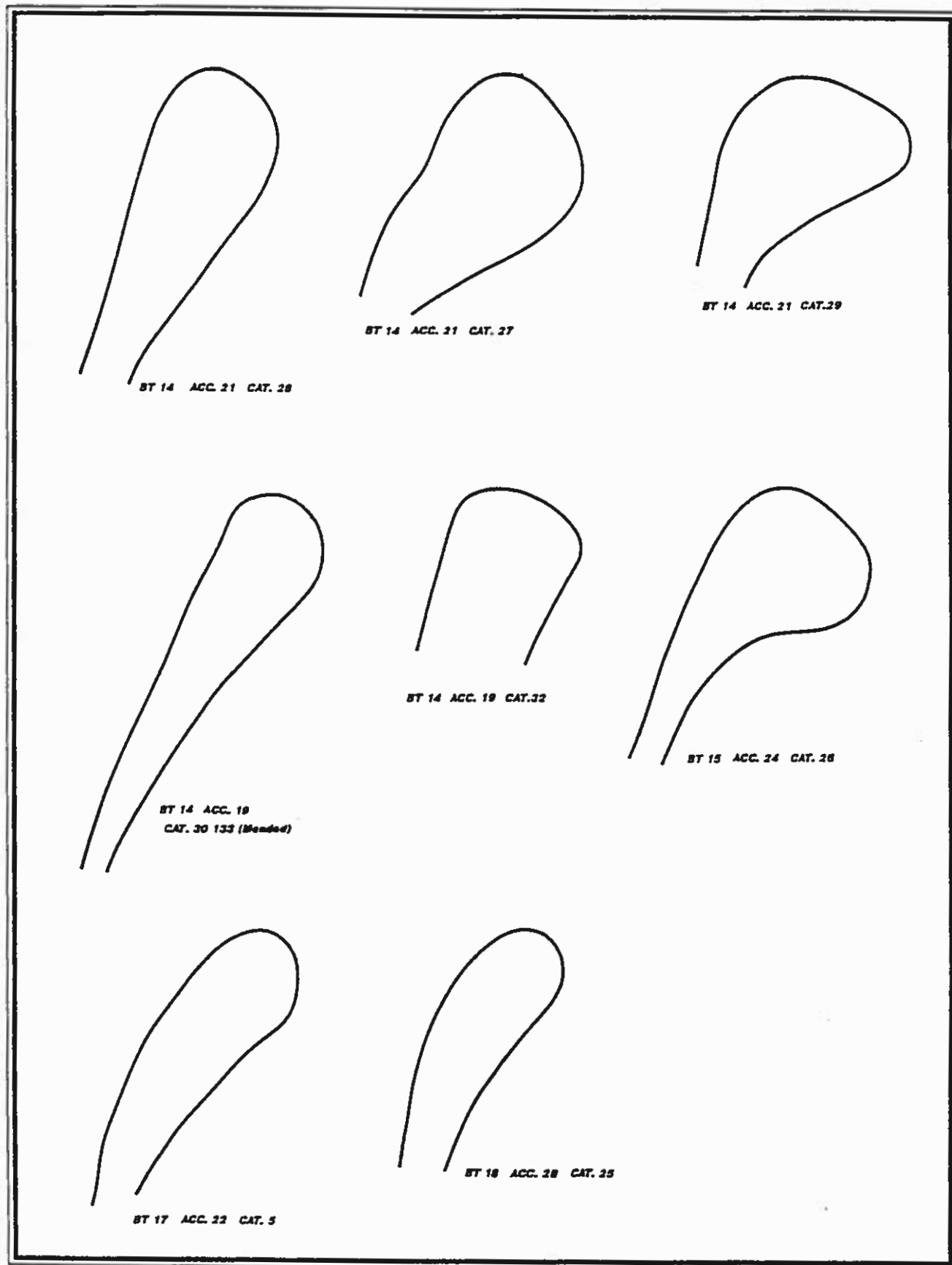


Figure 16. Rim Profiles

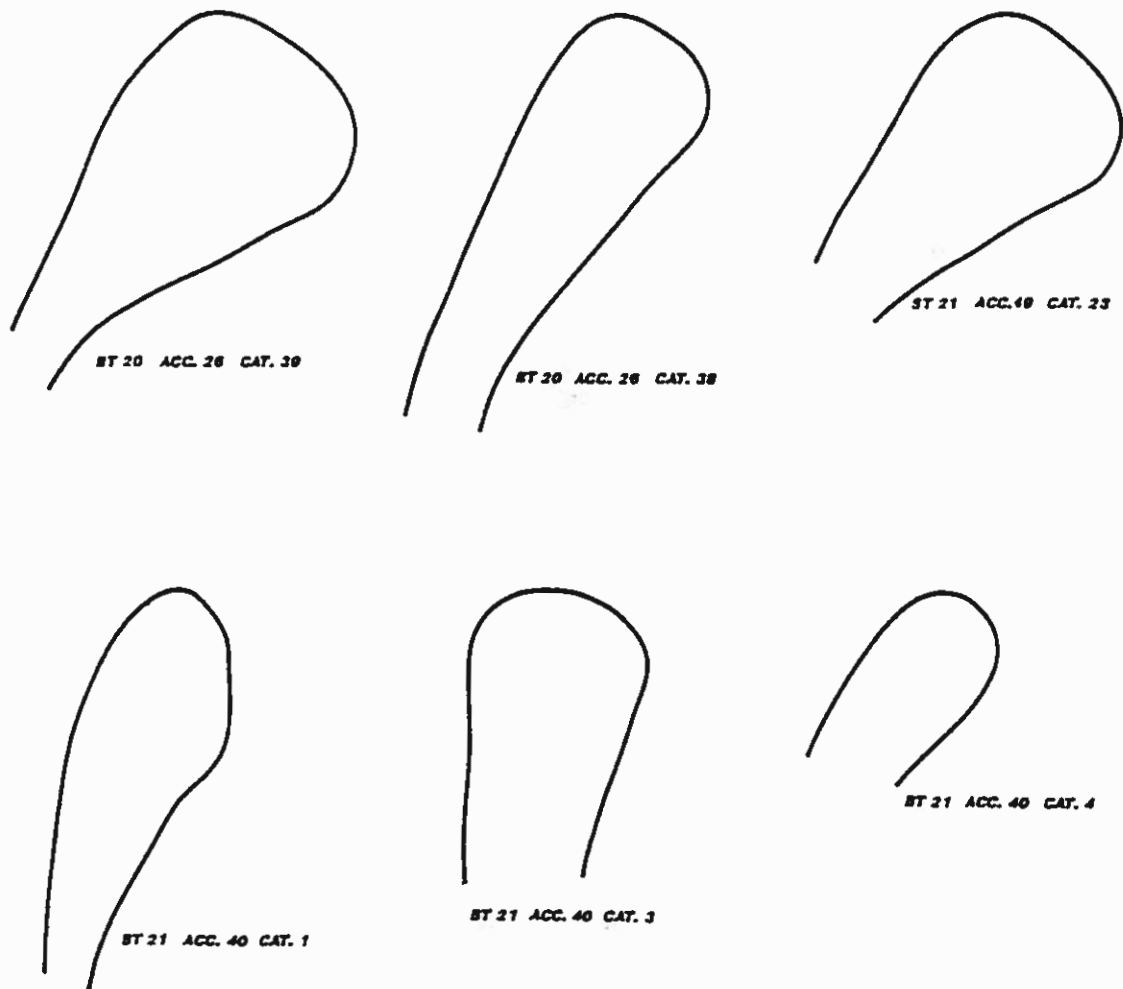


Figure 17. Rim Profiles

Site 66-04-0001. BT-20 and BT-21 were located in an area of the site which had some of the deepest and most varied deposits. The remnants of Latte Set 12 (Osborne 1947) and an associated midden area (Feature G), as well as several human burials, were also located in the vicinity of these two BT's.

Five radiocarbon dates were obtained in this project (Table B-4). None are directly associated with analyzable pottery, but the dates coincide quite well with the two cultural occupations implied by most of the ceramic assemblage.

INVERTEBRATE REMAINS

Methods

Analyzed shell came from 1/4" dry-screened general level and 1/8" dry-screened feature fill. All molluscan remains were identified to the Family level, or to the genus/species level if possible. PHRI/Guam's comparative collection, housed at the main laboratory, was used to aid identifications, as were the following sources: Abbott and Dance (1986), Eisenberg (1981), Hinton (1975), and Roth (1989). Shells were also assigned a five-digit computer code number, using a shell coding format devised by PHRI/Guam personnel (Appendix C).

Small shell fragments were placed in one of several categories: unknown bivalve, or unknown gastropod—if the fragment was sufficiently large to determine biological class—or unidentified shell, if the fragments were extremely small or lacked distinguishing characteristics. Additional categories identified in the course of shell analysis included operculum (a plate which serves to close the aperture of some gastropod species), Echinoidea (sea urchin parts, usually the hard spines), chiton (chiton shell, Class Polyplacophora), and Crustacea, (i.e., crab shell). Obvious shell tools or debitage were removed from the unmodified shell and analyzed separately with artifacts. Utilized sea urchin spines were removed to be analyzed with other artifacts from the site.

Each category of identified shell was bagged and individually weighed. Relative percentages of shell types were calculated for each provenience, as well as for the site as a whole. Shell was not counted, nor was a minimum number of individuals (MNI) calculated for the shell remains from this project area. However, ubiquity values were calculated in order to correct for possible skewing of the data which can occur when weights alone are used to characterize importance of individual taxa in a site. Using weight calculations only, for example, a single large *Turbo* shell would be accorded more importance than many smaller shells which weigh less, but

which may also have been important food resources. Further, differential preservation of archaeological remains results in the over-representation of more durable materials (like the larger, heavier shells) in sites. As Hastorf and Popper state:

In sum, ubiquity analysis is useful, within limitations, for showing general trends when one has little control over the sources of patterning in one's data. By measuring the frequency of occurrence instead of abundance, it reduces but does not eliminate the effects of differences in preservation and sampling (Hastorf and Popper 1988:64).

Findings

A total of 2404.44 g of shell was identified from dry-screened samples from levels in fifteen units placed within features located in five sites (Site 66-04-0001 Features C, F, G, H, and 10; Site 66-04-0615 Feature B; Site 66-04-0616 Feature A; Site 66-04-0617 Feature A; and Site 66-04-0618 Feature A). All but Feature C in Site 66-04-0001 was represented by a single sample. Fifteen species were identified: seven gastropod (marine, littoral, and terrestrial) and nine bivalve families (Table A-6). Marine gastropod remains constituted the largest percentage of identified shell by weight (53.26%), followed by bivalves (45.88%), and littoral/terrestrial gastropods, or unidentified shell remains (0.86%). Approximately 97% of shell by weight was recovered from Feature C. A relatively small amount of shell was recovered from the remaining eight features.

Marine gastropods and bivalves were the predominant classes identified. Marine gastropod taxa most frequently identified included *Strombus gibberulus gibbosus* and *Turbo setosus*. These taxa were present in over 25% of all samples (see Table A-7). Bivalve taxa most frequently identified included *Gafrarium pectinatum* and members of the Tridacnidae family, each present in at least 20% of all samples (see Table A-7). The littoral/terrestrial gastropod most commonly identified was *Pythia scarabaeus* (ubiquity value of 13.9%). Unidentified shell represented 1.2% of all remains by weight and was found in five of the 36 samples.

The Strombidae, or true conchs, were represented in the assemblage by the species *S. gibberulus gibbosus*. *S. gibberulus gibbosus* comprised 1% of all shell remains by weight, and 1.9% of all identified gastropod remains. This species was found in 25% of the samples from the project area.

The Turbinidae family was represented by the species *Turbo setosus*, which was a relatively consistent component in the assemblage. With a total weight of 955.44 g, this taxon

comprised 40% of the total shell by weight. As noted above, *Turbo* shells are usually large and heavy, so this percentage by weight does not reflect the true importance of this taxon. Ubiquity values indicate that *Turbo* is not as important as weights alone indicate: *Turbo setosus* had a ubiquity value of 30.6%, being present in 11 of the 36 samples.

Members of the Tridacnidae family comprised 30% of all shells by weight and 65% of identified bivalve remains by weight. Again, the large, heavy shells of this taxon account for such figures. *Tridacna* was identified in eight of the 36 samples (ubiquity value 22.2%).

Members of the Veneridae family, primarily *Gafrarium pectinatum*, constituted 4.8% of the total shell by weight and 10.4% of identified bivalve remains. *Gafrarium pectinatum* was present in 10 of the 36 samples (ubiquity value 27.8%). Note that the ubiquity value for *Gafrarium* is almost as high as that for *Turbo*, although its percentage by weight is much lower, an indication of this shell's smaller size.

Littoral and/or terrestrial gastropods comprised a small percentage (0.8% by weight) of total shell at the site. *Pythia scarabaeus* and *Achatina fulica* represented over 93% of the littoral terrestrial gastropods by weight. *P. scarabaeus* was identified in five of 36 samples. *Pythia scarabaeus*, a small snail of the family Melampidae (Ellobiidae), comprised a negligible percentage of total shell remains at the site. Members of the genus *Pythia* are "...inhabitants of the areas between land and sea, in salt marshes, mangrove swamps, estuaries, mud flats, and even on land where they hide under wet palm fronds, leaves, and coconut husks" (Roth 1989:136). *Achatina fulica*, the Giant African land snail, was found in only two of 36 samples.

The categories "unidentifiable gastropods", "unidentifiable bivalves" and "unidentifiable shell" totaled 1.2% of all shell by weight. For the most part, these categories contained small fragments of shell that lacked distinguishing characteristics.

The most deeply stratified deposits in Site 66-04-0001 were located in BTs -1, -3, -5, -21 and -22, located just north of Gun Beach Road, and near Feature H in BT-15 and BT-16. These are the same areas with the greatest variety of all classes of material remains, including shell. The majority of shell came from substrata IIIa and IIIb. Although the largest amount of shell by weight (over one kilogram) was recovered from substratum IIIa, this is also the substratum with the largest areal coverage. In addition, IIIa was partially truncated and may contain materials from different areas and depths. Substratum IIIb encompassed a smaller area, roughly follow-

ing the outline of the area of concentrated human remains. Nevertheless, the total weight for shell from IIIb was over 800 g, comparable to the amount of shell from substratum IIIa. Substratum IIIc encompasses an even smaller area of this portion of Site 66-04-0001 and very few portable remains were associated with this substratum. Substratum IIId, found only in BT-1, also contained very few associated remains. A firepit feature, Feature 7, was intrusive into substratum IIId and dated to approximately 1900 BP. This date corresponds well with an 1870 BP radiocarbon date obtained from the deepest level at Gognga Rockshelter (Graves and Moore 1985).

Discussion

Only five taxa were consistent components of the shell assemblage, indicated by their presence in at least 15% of all samples. These taxa were *S. gibberulus gibbosus*, *Turbo setosus*, *Gafrarium pectinatum*, and members of the Tellinidae, including *T. palatum*. All of these taxa are economically important taxa, and most likely represent prehistoric food debris.

The lack of variety in the shell assemblage is most noticeable when the invertebrate remains identified at the Gun Beach Hotel area are compared to the assemblage described by Grant et al. (1992), in the western portion of Gun Beach (across Gun Beach Road). While the most commonly identified taxa remained *Strombus* and *Tellina*, many other taxa, such as the Cardiidae, Psammobiidae, and Arcidae were also identified from by Grant et al. Although their excavations were more extensive, and despite the fact that a number of disturbance factors may be at work in the eastern portion of Site 66-04-0001, this lack of variety in the shell assemblage for the current project is notable.

Although few ethnographic reference sources are available concerning the use of shell resources in Micronesia, Smith (1986:73) lists a number of mollusks currently harvested for food on Guam. Many of these species are also represented in the shell remains at the Gun Beach Hotel Project area (Table A-8). These include gastropods such as *Trochus niloticus*, *Tectus pyramis*, *Turbo setosus*, and *Strombus gibberulus*; and bivalves such as *Modiolus auriculatus*, *Tellina palatum*, *Tellina scobinata*, *Gafrarium pectinatum*, and members of the Tridacnidae family. Some of the most frequently identified taxa are discussed below.

Family Strombidae. The Strombidae, or true conchs, is a large family numbering approximately 65 species of marine gastropods, distributed mainly in the tropical waters of the Indo-Pacific. *Strombus* spp. usually inhabit sandy or muddy areas near coral reefs, in intertidal to

shallow waters (Eisenberg 1981:182). *Strombus* shell is a common component of archeological sites in Guam (cf. Carucci 1988, Moore 1983, Reinman 1977). Smith (1986:73) notes that *S. gibberulus gibbosus*, called *do'gas* in Chamorro, is still harvested for food on Guam.

Families Tellinidae and Turbinidae. Shell analyses from sites on Guam indicate that these two families "appear to be major food sources" (Carucci 1988:324). Smith (1986:73) lists several species of *Tellina* and *Turbo*, which are still used as food on Guam (Table A-8: Shells Harvested on Guam). *Tellina palatum* was present in six of 36 screened samples. Six additional samples of tellin shells were identified only to the family level. *Turbo setosus* was encountered in 11 of 36 samples, all from Features C and H in Site 66-04-0001. *Turbo* was not identified in any of the other sites tested.

Turbinid shells usually inhabit the edges of reefs near deeper water, while tellinid shells are most frequently found in shallow lagoon flats. Carucci observed that the presence of tellinid and turbinid remains may be indicative of the age and sexual division of labor. Ethnographic data from Australia indicated that tellinid shells were usually collected by women and children on reef flats at low tide. In contrast, turbinid shells, which usually inhabit the edges of reefs near deeper water, were collected by men during the course of spearing and netting fish. This patterning was also noted on Rota, where it is the Chamorro men who usually collect turbinid shells (Carucci 1988:327).

Family Veneridae. *Gafrarium pectinatum*, listed as an edible species by Smith (1986), was recovered from 10 of 36 samples. Commonly known as venus clams, members of the genus *Gafrarium* are common, small bivalves that inhabit shallow water areas in the Indo-Pacific.

Ethnographic data from Moen, Chuuk, indicate that *Gafrarium pectinatum* is currently used there for food. The shells of these clams are also used as scrapers for peeling breadfruit (King and Parker 1984:214-215).

Summary

Over two kilograms of shell were sorted and identified from five prehistoric sites in the project area. Most of this shell came from Feature C, located in the eastern portion of Site 66-04-0001 (The entire site encompasses a much larger area than the current project area). Over half of the shell recovered came from substratum IIIa, a partially disturbed substratum whose area roughly equals the extent of Feature C. The remainder came from substratum IIb, which covers a smaller portion of the site and has probably

not been disturbed by recent human activities (although storm deposits and bioturbation were noted).

A midden area was associated with Feature H, an overhang feature. Feature H contained a small amount of shell, although it appears that shell and other refuse was disposed of outside the overhang. A firepit feature (Feature 2) and a human burial (Feature 1) were also encountered in the vicinity of the overhang.

Very few shell taxa were consistent components of the assemblage. Only five taxa occurred in at least 15% of all samples: *S. gibberulus gibbosus*, *Turbo setosus*, *Gafrarium pectinatum*, and members of the Tellinidae, including *T. palatum*. All of these taxa are economically important taxa, and most likely represent prehistoric food debris.

The small size of the shell assemblage, as well as the lack of variety in the remains as compared to shell collected from the western and central parts of Site 66-04-0001, is consistent with the observations made by other archaeologists concerning the eastern portion of the Gognga Cove site (cf. Osborne 1947 and Graves and Moore 1985). Although the western and central portions of the site contained numerous *latte* sets, the eastern portion contained only the ruined remains of several *latte* sets. The eastern portion of Site 66-04-0001 may have been differentially affected by recent human activities, particularly WWII. At the same time, it also seems likely that this portion of the site was indeed less utilized prehistorically than the remainder of the settlement, primarily the central and western portions of Site 66-04-0001.

NONHUMAN VERTEBRATE REMAINS

Nonhuman vertebrate remains were recovered from three sites: 66-04-0001, 66-04-0617, and 66-04-0618. It is doubtful that any of this bone is of prehistoric cultural origin, as all was collected from either the surface or from disturbed/recent contexts.

At Site 66-04-0001, bone was collected from the surface of Feature F (an overhang), from Feature 10 (an historic trash pit), and from substratum Ic at BT-10. The bone from Feature F was identified as the femur of a rat or mouse (family Muridae). Feature 10 contained a variety of bone from pig (*Sus scrofa*), cow (*Bos taurus*), unidentifiable large bird (class Aves), and a number of fragments of large mammal bone, probably a mixture of cow and pig. Many of the bones exhibited butcher marks, though none were burned. BT-10 also contained several fragments of pig and cattle bone, also exhibiting butcher marks.

One fragment of large mammal bone, possibly deer (*Cervus* sp.), was collected from the surface of Feature A (a cave) in Site 66-04-0617. At Site 66-04-0618, also a cave, two fragments of unidentified large mammal bone were identified. These fragments may have come from a cow.

Based on contextual information, it seems clear that none of the nonhuman vertebrate bone is from prehistoric cultural contexts. Feature 10, the historic trash pit, contained several non-native species of mammals as well as the bones of at least two large birds. None of the bone was burned. BT-10 is located nearby, and the butchered cattle and pig bone from this trench may be associated with the same episode of disposal as the materials from Feature 10. Soda bottles found in Feature 10 dated to the late 1940's (post-WWII). The rat/mouse bone found in Feature F probably reflects the presence of this animal in the natural fauna of the area. Although rats and mice were not part of the pristine fauna of Guam, they probably arrived with the first human inhabitants as stowaways among the cargo in canoes. The bone in the two cave features in Sites 66-04-0617 and 66-04-0618 may have been dragged into the caves by scavenging animals.

The dearth of nonhuman vertebrate remains in the deposits in the Gun Beach Hotel project is reflective of the overall poor recovery of all classes of remains. Much of the project area has been disturbed, which may account in part for the paucity of nonhuman bone. The use of 1/4" mesh screen is probably also a major factor; small fishbones, for example, frequently pass through 1/4" mesh and are not collected.

BOTANICAL REMAINS

A small collection of charred botanical remains was recovered from screen fill in only one site, Site 66-04-0001. All botanical materials were associated with features and primarily consisted of small, unidentifiable wood charcoal fragments and coconut endocarp fragments.

Less than one gram of coconut endocarp was recovered from Feature G, a midden feature located in the southeast portion of the project area. Approximately 3.5 g of wood charcoal and coconut endocarp fragments were collected from Feature H, an overhang. These materials were submitted for radiometric dating and yielded an adjusted date of 530 ± 60 BP. Feature F, also an overhang, yielded 0.45 g (three fragments) of coconut endocarp. Subsurface Feature 2, a firepit, yielded less than 10.0 g of wood charcoal, which was mixed with a charcoal-rich matrix. This material was also sent for radiometric dating and yielded an adjusted date of 167 ± 150 BP.

As with the nonhuman bone, the low recovery of charred botanical remains may be attributed in part to the use of 1/4" mesh screen, which catches only the largest and least fragile materials (typically coconut shell and larger wood fragments). However, several bulk soil samples were taken from subsurface features (Features 7 and 9, for example) or from areas that appeared charcoal-rich and these samples also contained little identifiable charcoal. With charred botanical remains as with several other classes of materials, this eastern portion of Site 66-04-0001 appears to contain smaller concentrations of archaeological remains than western areas of the site, where latte sets were once located.

SUMMARY OF LABORATORY FINDINGS

Examination of the archaeological materials from five prehistoric sites within the project area revealed a small and at least partially disturbed assemblage that spans the Transitional Pre-Latte Phase through Latte Phase. Historic and recent disturbance was evident from the presence of WWII defensive structures (Features A and B), as well as glass bottles, metal items and non-native animal bone. Small amounts of prehistoric pottery, shell, and historic animal bone, were recovered from Sites 66-04-0615, -0616, -0617, and -0618. The largest site investigated was Site 66-04-0001, from which most of the materials were recovered. Known as Gognga Cove or Gun Beach, this site actually spans a much larger area than the current project area, encompassing the entire cove. The current project area includes only the eastern portion of the original site. Previous investigations at Gognga Cove (cf. Osborne 1947, Reinman 1967, Graves and Moore 1985, Kurashina et al. 1987) indicated that at least 12, and possibly 15, latte sets were originally located on the beach and back by the cliff line. No latte were located inland, although a number of midden mounds were found in the upland areas surrounding the site. Osborne's maps show that latte sets were not evenly distributed at Gognga Cove, but tended to cluster in the western side of the cove. According to Graves and Moore (1985:68):

Virtually all of the stone structures were located in the central and western portion of the cove, close to the cliffline. The eastern side of the cove, which contains land area suitable for building latte sets is nearly devoid of such structures, with the possible exception of Latte 12a and 12b. If residential debris is scattered across the beach zone, especially back by the cliffline, this arrangement would suggest a division of the settlement into at least two sections.

Graves and Moore also observed that the latte sets themselves appeared to be arranged into several distinct groups. The

earliest occupation of the site was estimated to have occurred during the late Pre-Latte Phase, (c. 1800 BP) based on radiocarbon and ceramic data (Graves and Moore 1985:135).

The findings of the current investigation confirm the observations of previous researchers concerning the spatial organization of the Site 66-04-0001 as well as its temporal association. The remains of only one *latte* set were identified (Feature D), and correspond to the location of Osborne's Latte Set 12. A midden area (Feature G) was located adjacent to this *latte* set. No other remains of *latte* sets were identified in the course of excavations in the project area. Less-concentrated midden materials were spread across Feature C (large artifact scatter) to depths of over a meter below surface, with invertebrate remains and ceramics as the primary components. Charcoal, animal bone and nonceramic artifacts were infrequently encountered. Examination of stratigraphic data for the area surrounding Feature H showed a midden area outside the overhang, corresponding to substrata IIIb and IIIc in BT-14, BT-15 and BT-16, and perhaps BT-18. Subsurface features encountered included several firepits and numerous human burials. The human burials were not excavated; because of this, the area where concentrated human remains were located is not well-represented by material remains.

Radiometric determinations showed two distinct groupings, centered around Transitional Pre-Latte and early to middle Latte Phase dates. The Transitional Pre-Latte dates were associated with two features, -2 and -7. Both of these soil features were located in surface Feature C, a large artifact scatter. The range of dates obtained indicates a length of occupation spanning the Transitional Pre-Latte Phase through the Latte Phase. Subsurface features yielded the earliest determinations. The remaining three dates, from general level fill and the upper levels of Feature 2, indicate an early to middle Latte Phase context for these levels. These determinations are substantiated by the artifactual data, primarily the prehistoric ceramics.

The majority of ceramics contained volcanic sand inclusions and had thickened rims and textured-to-smooth finishes. These attributes are most commonly associated with the Latte Phase. Variation in thickness within the collection of Type B rims themselves suggests that the ceramics were produced at different times during the Latte Phase. A small number of sherds with polished surfaces and calcareous sand inclusions were also noted in BT-20 and BT-21, indicating a possible Pre-Latte Phase component. Unfortunately, no radiocarbon samples were available from these BTs.

Unlike other, more extensive investigations in the same general area (e.g., Haun et al. [1990] at Fafai Beach and Grant

et al. [1992] in another portion of 66-04-0001), excavations at the Gun Beach Hotel Project Area did not yield a large variety of nonceramic artifacts. Only a small range of artifact types are represented, rather than a variety of domestic, manufacturing, warfare, and fishing implements. Domestic activities are implied by the presence of pounders or pestles, as well as the ceramic artifacts, while manufacturing activities such as woodworking are indicated by the variety of adzes and adze-making debris. A possible fishhook tab was identified, but no finished fishhooks, gorges, or sinkers were found. Likewise, no mortars, abraders, slingstones or other kinds of artifacts typically associated with a large Latte Phase village are represented in the assemblage. The primary activities represented appear to be domestic and manufacturing activities. This patterning may be due to recent disturbance, or it may reflect differential use of the site, as the spatial distribution of the *latte* sets seems to indicate.

Molluscan remains were the largest class of ecofactual remains represented. Despite the fact that over two kilograms of shell were collected and identified, the remains differed substantially from shell collections identified from other parts of the site. For example, the lack of variety in the shell assemblage is most noticeable when the invertebrate remains identified at current project area are compared to the assemblage identified by Grant et al. (1992) in the western portion of Gun Beach (across Gun Beach Road). While the most commonly identified taxa remained *Strombus* and *Tellina*, many other taxa, such as the Cardiidae, Psammobiidae, and Arcidae (all bivalves) were also identified by Grant et al. Although these excavations were more extensive, and despite the fact that a number of disturbance factors may have been at work in the eastern portion of Site 66-04-0001, the lack of variety in the shell assemblage is notable.

Graves and Moore have suggested that exploitation of bivalve taxa is most characteristic of the Pre-Latte Phase, with gastropods such as *Strombus* becoming more important food resources in the Latte Phase (Graves and Moore 1985:38). Although the evidence is limited, it may be that the Grant et al. project area had a better representation of early materials, as evidenced by the greater variety of shell, especially the greater proportion of bivalve taxa. In contrast, the eastern portion of the site may have been occupied not only less intensively, but later in the sequence as well, as evidenced by the high proportion of gastropod to bivalve taxa.

The dearth of nonhuman vertebrate remains in the deposits in the Gun Beach Hotel project is a reflection of the overall poor recovery of all classes of remains. Much of the project area has been disturbed, which may account in part for

the paucity of nonhuman bone. The use of 1/4" mesh screen is probably also a major factor; small fishbones, for example, frequently pass through 1/4" mesh and are not collected.

As with the nonhuman bone, the low recovery of charred botanical remains may be attributed in part to the use of 1/4" mesh screen, which catches only the largest and least fragile materials (typically coconut shell and larger wood fragments). However, several bulk soil samples were taken from subsurface features (Features 7 and 9, for example) or from areas that appeared charcoal-rich, and these samples also contained little identifiable charcoal. With charred botanical remains as with several other classes of materials, this eastern portion of Site 66-04-0001 appears to contain smaller concentrations of archaeological remains than western areas of the site, where latte sets were once located.

This pattern of dates and associated artifactual materials was also found in PHRI Project 91-1040, the AT&T Communications Cable Project, located to the south, across Gun Beach Road (Grant et al. 1992). Site 66-04-0001, a large prehistoric village site, spans Gun Beach Road and thus encompasses both the current project area as well as the project area of Grant et al. Both Pre-Latte and Latte Phase dates were obtained there, two of which ranged from approximately 1670-1800 BP (Transitional Pre-Latte). Three additional determinations were Latte Phase, and ranged from 625-1045 BP. Again, the earlier dates were associated with subsurface features from which few diagnostic artifacts were retrieved. Ceramics data from by Grant et al. indicated a Latte Phase context, with volcanic sand inclusions and thickened rims predominating.

Based on stratigraphic, artifactual, and radiocarbon information from the current project, as well as from the observations of other researchers, it seems likely that the earliest occupation of the area occurred approximately 1900 years ago (Graves and Moore 1985:163), and that the area was occupied through the Latte Phase up to historic times. The current excavations by PHRI represent the first systematic subsurface investigations in the eastern portion of Site 66-04-0001, and tentatively confirm Graves and Moore's hypothesis concerning intrasite variation at Gognga Cove.

HUMAN REMAINS

Site 66-04-0001

A small assemblage of adult human remains, consisting of cranial fragments (possibly occipital), and a long bone

fragment, was recovered from Stratum IIIc (0.10-0.25 cm below surface) in Backhoe Trench 12. Due to the small number of fragmentary elements, it cannot be assessed whether these remains belong to the same individual.

A small assemblage of adult human remains was recovered from Stratum IIIa in Backhoe Trench 15. The assemblage consisted of the lamina and spinous process portion of a cervical vertebra fragment and a midshaft portion of a femur fragment. As in the case above, because of the small number of fragmentary elements, it cannot be determined whether these remains belong to the same individual. The vertebra fragment did not exhibit any arthritis on the facets.

A single ulna shaft fragment was recovered from Stratum IIIc (0.6-1.0 cm below surface) in Backhoe Trench 15. This fragment appears gracile and therefore, could belong to either an adult female or an adolescent.

Site 66-04-0616

A small assemblage of adult long bone fragments was recovered from Feature A, ST-10, Stratum IIb (0.25-0.30 cm below surface). The assemblage consisted of two midshaft portions of a right ulna, a midshaft portion of a right radius fragment, and long bone fragments. These appear to be the remains of a single adult individual, but further age and sex assessment is not possible.

One of the eight long bone fragments appears to have been charred. It is blackened over three-quarters of the surface but does not exhibit any transverse or diagonal fractures or warping. This is characteristic of dry bone burning (Baby 1954:4).

Site 66-04-0618

A small assemblage of adult long bone shafts was recovered from the surface of Feature A, a cave. These included a midshaft tibia fragment, and several long bone fragments, possibly upper limb. Due to the fragmentary nature of these remains, it cannot be assessed as to whether they belong to the same individual.

The remains are in very poor condition (i.e., very weathered) and have a "chalky" appearance. The possible upper limb long bone fragments also exhibit a green stain characteristic of algae, possibly due to being recovered from the cave.

CONCLUSION

DISCUSSION

The present project area includes two sites and portions of those prehistoric archaeological sites. One is a previously recorded site (GHPO Site Number 66-04-0001) that contains a historic component, and four previously undocumented sites, which have been subsequently assigned GHPO Site Numbers 66-04-0615 through 0618. The overall extents of Sites 66-04-0001, 66-04-0615 and 66-04-0616 were not ascertainable but all extend beyond the southern boundary of the project area.

The portion of Site 66-04-0001 within the boundaries of the current project area has an approximate area of 22,639 m². It is a partially disturbed, stratified prehistoric cultural deposit containing prehistoric ceramics, marine shell, thermally altered rock, flaked lithics, shell and stone tools, *in situ* and disturbed human remains, and the possible remnants of a disturbed *latte* set. Radiometric analysis of carbon samples recovered from the site evidence two distinct occupational groupings, centered around Transitional Pre-Latte and early to middle Latte Phase. The site is functionally interpreted as a permanent habitation site. This is based on the abundance and variety of portable remains present, and on the presence of human remains and *latte* elements.

The remainder of the sites include surface and subsurface scatters of prehistoric ceramics, rock overhangs, and a cave. These sites are isolated and comparatively small, ranging in size from 20 m² to 3,414 m². No datable samples were obtained from any of these sites, but the ceramic attributes, particularly the presence of ceramics with thickened rims suggests a Latte Phase occupation. The proximity of the five sites within the current project area, the similarities of their ceramic assemblages, and their apparent contemporaneous ages suggest that they are components of an extensive and complex Latte Phase coastal settlement system. Site 66-04-0001 appears to be the remains of a permanent coastal settlement (village), while the remainder of the sites represent temporary, intermittent, or less intensively utilized habitation areas, associated with, but peripheral to Site 66-04-0001. This site distribution pattern is characteristic of coastal and near-coastal settlements on Guam, and reflects a concentration of a full range of activities on the coast and a less-intensive and more specialized use of near-coastal areas.

A portion of Site 66-04-0001 has been disturbed by road construction and the recent introduction of fill. Nevertheless,

this site retains sufficient integrity to contribute substantially to an understanding of the spatial relationships within and between sites. Questions concerning the intrasite distribution of features, the associated activities, and the relationships between these sites and sites with differing feature constellations, artifact assemblages, and environmental associations can be addressed by systematic archaeological investigations in the project area before the sites described above sustain additional damage.

GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

General significance assessments and recommended general treatments for identified sites were formulated upon completion of the field work. Significance categories used in the site evaluation process are based on the National Register criteria for evaluation, as outlined in the Code of Federal Regulations (36 CFR Part 60). Guam Historic Preservation Office, GHPO, uses these criteria for evaluating cultural resources. The purpose of the National Register is to list properties that are "...significant in American history, architecture, archaeology and culture..." (NHPA Sec 101 [a][1]). A property has significance if it satisfies each of two categories comprising the National Register criteria for evaluation (36 CFR Part 60.4): (1) the site must possess integrity of location, design, setting, materials, workmanship, feeling, and association; and (2) it must be characterized by at least one of the following:

- (a) It must be associated with events that made significant contributions to broad patterns of history;
- (b) It must be associated with the lives of persons significant in the past;
- (c) It must embody distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic value or represent a significant and distinguishable entity whose components may lack individual distinction (representative examples of site types); or
- (d) It must have yielded, or may be likely to yield, information important in prehistory or history (information content)

Sites are also assessed for cultural significance using guidelines prepared by the Advisory Council on Historic Preservation (ACHP) entitled "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (ACHP 1985). The guidelines define cultural value as "...the contribution made by an historic property to an ongoing society or cultural system. A traditional cultural value is a cultural value that has historical depth" (1985:1). The guidelines further specify that "[a] property need not have been in consistent use since antiquity by a cultural system in order to have traditional cultural value" (1985:7). Table A-9 contains general significance assessments and recommended general treatments.

Based on the above Federal criteria, two sites (Sites 66-04-0615 and 66-04-0617) are assessed as significant solely for information content. Further work, consisting of archaeological data recovery, is recommended for these sites. Two sites (Site 66-04-0616 and 66-04-0618) are assessed as significant for information content, and in addition, are assessed as significant for cultural value due, to the presence of human remains. Further data collection is recommended for these sites, with preservation "as is" recommended for the portions of the site where human remains were identified. In the event that preservation is not an acceptable alternative at these features, data recovery is recommended with special treatment of human remains in accordance with applicable Guam statutes and GHPO guidelines.

Site 66-04-0001 is also assessed as significant for information value, and in addition, as an excellent example of a site type and for cultural value (based on the presence of human burials). Site 66-04-0001 is recommended for further data collection, for preservation with interpretive development, and for preservation "as is" for the burial components of the site. As for Sites 0016 and 0018, if preservation is not an acceptable alternative at these features, data recovery is recommended with special treatment of human remains in accordance with applicable Guam statutes and GHPO guidelines.

These recommendations are based on the assumption that all features would be adversely affected by the proposed project. Adverse effects include both direct and indirect effects. Direct effects include actions that would prohibit future study of a feature, or preclude its preservation as an interpretive exhibit. Indirect effects include actions such as increasing the potential for vandalism, or destruction of the setting by modification of the immediately surrounding terrain.

Subject to approval by the GHPO, the recommended treatments would not be necessary if all adverse effects could be avoided. This would require preserving the features and their immediate surroundings, and ensuring that the features would be protected from inadvertent, construction-related activities, vandalism, etc. Such measures could include accurate locational plotting, fencing, periodic monitoring, deed covenants, and/or the posting of signs.

To facilitate management decisions regarding the subsequent treatment of resources, the general significance of all archaeological remains identified during the survey was also evaluated in terms of potential scientific research, interpretive, and/or cultural values (PHRI Cultural Resource Management [CRM] value modes). *Scientific research value* refers to the potential of archaeological resources for producing information useful in the understanding of culture history, past lifeways, and cultural processes at the local, regional, and interregional levels of organization. *Interpretive value* refers to the potential of archaeological resources for public education and recreation. *Cultural value*, within the framework for significance evaluation used here, refers to the potential of archaeological resources to contribute to the preservation and promotion of cultural and ethnic identity and values (See Table A-1 for value mode assessments for individual features).

As an important initial step, it is recommended that all identified sites and features be accurately located and plotted by professional surveyors, with the aid of an archaeologist, on an appropriately scaled, accurate topographic map of the project area. This would greatly aid development planning and would allow future archaeological investigations (data collection, data recovery and/or preservation) to be more accurately evaluated on a site by site basis.

Further work in the form of a phased Data Recovery Program (DRP) is recommended for the portion of Site 66-04-0001 within the project area, as well as Sites 66-04-0615, 66-04-0616, 66-04-0617 and 66-04-0618. The DRP should include the formulation of an Archaeological Mitigation Plan (AMP), which would be subject to the approval of the GHPO. The AMP would be based on the findings of the ongoing analyses of data recovered during the present survey. Mitigation recommendations should involve further archaeological data collection, including some combination of detailed recording, systematic excavations and monitoring. Excavations should be concentrated in areas where intact cultural materials were located. Project redesign (avoidance) may be

appropriate if localized concentrations of human burials are encountered.

It should be noted that the findings and recommendations presented within this Final Report have been based on an archaeological inventory survey involving surface and subsurface examination of the Gun Beach Hotel Site project

area and are subject to the limitations of such surveys. There is always the possibility, however remote, that potentially significant, unidentified cultural remains will be encountered in the course of future archaeological investigations or subsequent development activities. In such situations, archaeological consultation should be sought immediately.

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APPENDIX A

TABLES

Table A-1.

SUMMARY OF IDENTIFIED SITES AND FEATURES

Site Number	Feature	Formal Type	Tentative Functional Interpretation	CRM Value Mode Assess.			Field Work Tasks		
				R	I	C	DR	SC	EX
66-04-0001	A	Gun	Defensive	L	H	L	-	-	-
66-04-0001	B	Pillbox	Defensive	L	H	L	-	-	-
66-04-0001	C	Artifact Scatter	Habitation	H	L	H	-	+	+
66-04-0001	D	Disturbed Latte	Habitation	H	L	L	-	-	+
66-04-0001	E	Limestone Alcove	Undetermined	L	L	L	-	-	-
66-04-0001	F	Rock Overhang	Habitation	H	L	L	-	-	+
66-04-0001	G	Midden	Habitation	H	L	*	-	+	+
66-04-0001	H	Rock Overhang	Habitation	H	L	L	-	+	+
66-04-0001	I	Concrete Pad	Undetermined	L	L	L	-	-	-
66-04-0615	A	Midden	Habitation	H	L	L	-	+	+
66-04-0615	B	Coral Monument	Undetermined	H	L	L	-	-	-
66-04-0616	A	Rock Overhang	Habitation	H	L	H	-	+	+
66-04-0616	B	Ceramic Scatter	Habitation	H	L	L	-	+	+
66-04-0617	-	Cave	Habitation	H	L	L	-	+	+
66-04-0618	A	Cave	Habitation	M	L	H	-	+	+
66-04-0618	B	Rock Overhang	Habitation	M	L	H	-	+	+

* Pending further data collection

Cultural Resource Management

Value Mode Assessment—Nature: R = scientific research, I = interpretive, C = cultural
—Degree: H = high, M = moderate, L = low

Field Work Tasks: DR = detailed recording (scaled drawings, photographs, and written descriptions), SC = surface collections, EX = limited excavations.

Table A-2.

SUMMARY OF BACKHOE TRENCH STRATIGRAPHY - Site 66-04-0001

BT No.	Strat	Depth(bs)	Comments
BT-1	IIIa	0.25	Very dark grayish brown sandy loam with prehistoric ceramics and marine shell. Evidence of bioturbation and possible mechanical truncation on surface.
	IIIb	0.73	Mottled white and brown fine sand with prehistoric ceramics and marine shell. Evidence of bioturbation.
	IIIc	1.10	White fine sand with marine shell.
	IIId	1.35	Black sandy loam with prehistoric ceramics, thermally altered rock and a basin-shaped pit feature (Feature 7).
	IV	1.90	White very fine, culturally sterile sand. BT terminated at known sterile depth.
BT-2	IIIa	0.20	Very dark grayish brown sandy loam with prehistoric ceramics and marine shell. Evidence of bioturbation and possible mechanical truncation on surface.
	IIIb	0.40	Grayish brown fine sand with prehistoric ceramics. Evidence of bioturbation.
	IIIc	0.50	Dark gray very fine sandy loam with a human burial feature (Feature 3). BT terminated at emergence of burial.
BT-3	Ia	0.25	White coarse gravel fill. Recently deposited.
	Ib	0.70	Yellow coarse gravel fill. Recently deposited.
	IIIa	0.90	Very dark grayish brown sandy loam with prehistoric ceramics and marine shell. Evidence of bioturbation.
	IIIb	1.00	Dark gray sandy loam with a human burial feature (Feature 5). BT terminated at emergence of burial.
BT-4	III	0.25	Very dark grayish brown sandy loam with prehistoric ceramics, marine shell and a human burial feature (Feature 4). Evidence of bioturbation and possible mechanical truncation on surface. BT terminated at emergence of burial.
BT-5	Ia	0.20	Yellow coarse gravel fill. Recently deposited.
	Ib	0.90	Pinkish white coarse gravel fill. Recently deposited.
	Ic	1.10	Very dark grayish brown sandy loam with prehistoric ceramics, marine shell and metal fragments. Probable mechanical disturbance.
	III	1.60	Grayish brown fine sand with prehistoric ceramics. Evidence of bioturbation.
	IV	1.90	White very fine, culturally sterile sand. BT terminated at known sterile depth.
BT-6	IIIa	0.15	Very dark grayish brown sandy loam with prehistoric ceramics, marine shell and a basalt adze. Evidence of bioturbation.
	IIIb	0.22	Grayish brown fine sand with marine shell and a human burial feature (Feature 6). Evidence of bioturbation. BT terminated at emergence of burial.
BT-7	Ia	0.15	Dark gray very fine sand with glass, aluminum cans and metal fragments. Evidence of bioturbation and probable mechanical disturbance.
	Ib	0.20	White very fine sand with glass and aluminum cans. Evidence of bioturbation and possible mechanical disturbance.
	III	0.30	Very pale brown very fine sand with a human bone scatter feature (Feature 12). Evidence of bioturbation, mechanical and/or storm disturbance. BT terminated at emergence of bone scatter.
BT-8	I	1.50	Pinkish white, culturally sterile, coarse gravel and limestone fill. Recently deposited. BT terminated on collapse of trench.
BT-9	I	0.25	Grayish brown very fine sand with marine shell, glass, metal fragments, tin and aluminum cans and butchered nonhuman bone.
	IV	1.50	White, culturally sterile very fine sand. BT terminated in known sterile soil.

Table A-2. (cont.)

BT No.	Strat	Depth(bs)	Comments
BT-10	Ia	0.15	Very pale brown very fine sand with marine shell, glass, plastic, metal fragments and tin and aluminum cans. Evidence of modern disturbance.
	Ib	0.30	White very fine sand with marine shell and glass fragments. Probable storm deposit.
	Ic	0.39	Black very fine sandy loam with marine shell and butchered nonhuman bone. Possible historic "A" horizon.
	IV	1.80	White, culturally sterile very fine sand. BT terminated in known sterile soil.
BT-11	Ia	0.23	Very dark grayish brown sandy loam with glass and metal fragments. Probable modern disturbance.
	Ib	1.10	Dark brown sandy loam with prehistoric ceramics, nonhuman bone, glass bottles tin and aluminum cans, and a historic trash pit (Feature 10). Evidence of bioturbation and probable mechanical disturbance.
	IV	1.60	White, culturally sterile very fine sand. BT terminated in known sterile soil.
BT-12	I	0.80	Pinkish white coarse gravel fill. Recently deposited.
	IIIa	1.00	Very dark grayish brown sandy loam with prehistoric ceramics and marine shell. Evidence of bioturbation and probable mechanical truncation.
	IIIb	1.15	Grayish brown sandy loam with a human bone scatter feature (Feature 11). Evidence of bioturbation and probable mechanical disturbance. BT terminated at emergence of bone scatter.
BT-13	Ia	0.20	Very dark grayish brown sandy loam with prehistoric ceramics, marine shell and glass fragments. Evidence of bioturbation and probable mechanical truncation on surface.
	Ib	0.30	White medium sand with marine shell and plastic. Evidence of bioturbation and storm disturbance.
	III	0.45	Black sandy loam with prehistoric ceramics and marine shell. Evidence of bioturbation.
	IVa	0.75	White, culturally sterile coarse sand and gravel.
	IVb	1.80	Very pale brown, culturally sterile very fine sand. BT terminated in known sterile soil.
BT-14	I	0.50	Mottled white and very dark grayish brown sandy loam with prehistoric ceramics, marine shell and thermally altered rock. Evidence of bioturbation and probable mechanical disturbance.
BT-15	IIIa	0.25	Black sandy loam with prehistoric ceramics, marine shell, thermally altered rock and human bone fragments. Evidence of bioturbation.
	IIIb	0.65	Very pale brown fine sand with prehistoric ceramics and marine shell. Evidence of bioturbation.
	IIIc	1.00	Dark yellowish brown fine sand with prehistoric ceramics, marine shell and human bone fragments. Evidence of bioturbation.
	IV	2.225	White, culturally sterile very fine sand. Evidence of bioturbation. BT terminated on bedrock.
BT-16	IIIa	0.40	Very dark grayish brown with prehistoric ceramics, marine shell and a large basin-shaped pit feature (Feature 2). Evidence of bioturbation.
	IIIb	0.90	Dark yellowish brown fine sand with marine shell and a tridacna adze. Evidence of bioturbation.
	IIIc	0.75	Reddish yellow fine sand with a human burial feature (Feature 1). Evidence of bioturbation. BT terminated at emergence of burial.
BT-17	IIIa	0.30	Very dark grayish brown sandy loam with prehistoric ceramics and marine shell. Evidence of bioturbation.
	IIIb	0.70	Brown fine sand with marine shell. Evidence of bioturbation.
	IV	1.70	White, culturally sterile very fine sand. Evidence of bioturbation. BT terminated in known sterile soil.
BT-18	IIIa	0.25	Very dark grayish brown sandy loam with prehistoric ceramics and marine shell. Evidence of massive bioturbation.
	IIIb	0.65	Very pale brown fine sand with marine shell. Evidence of bioturbation.
	IV	1.80	White, culturally sterile fine sand. Evidence of bioturbation. BT terminated in known sterile soil.
BT-19	Void		

Table A-2. (cont.)

BT No.	Strat	Depth(bs)	Comments
BT-20	IIIa	0.15	Very dark grayish brown sandy loam with prehistoric ceramics and marine shell. Evidence of bioturbation.
	IIIb	0.37	Very pale brown fine sand with prehistoric ceramics and marine shell. Evidence of bioturbation.
	IIIc	0.40	Reddish yellow fine sand with dense human bone scatter feature (Feature 8). BT terminated at emergence of bone scatter.
BT-21	I	0.50	Very pale brown coarse sand and gravel with modern glass fragments. Evidence of mechanical disturbance by earthmoving activities in vicinity of Feature D.
	IIIa	0.70	Very dark grayish brown sandy loam with prehistoric ceramics, marine shell, thermally altered rock and stone tools. Evidence of bioturbation.
	IIIb	1.00	Grayish brown fine sand with prehistoric ceramics, marine shell, stone tools and basin-shaped pit feature (Feature 9). Evidence of bioturbation.
	IV	2.05	White, culturally sterile very fine sand. BT terminated in known sterile soil.
BT-22	Ia	0.30	Pinkish white coarse gravel fill. Recently deposited.
	Ib	0.50	Gray fine silt. Possible drainage sediment.
	Ic	0.60	Very dark grayish brown sandy loam with prehistoric ceramics and glass fragments. Probable mechanical disturbance.
	Id	0.70	White fine sand. Probable storm deposit.
	III	1.15	Very dark grayish brown sandy loam with prehistoric ceramics, marine shell and stone tools. Evidence of bioturbation.
	IV	1.65	White, culturally sterile very fine sand. BT terminated in known sterile soil.
BT-23	I	0.60	Pinkish white coarse gravel fill. Recently deposited.
	IIIa	0.75	Very dark grayish brown sandy loam with prehistoric ceramics and thermally altered rock. Evidence of bioturbation and possible mechanical disturbance.
	IIIb	1.0	Grayish brown fine sand with prehistoric ceramics. Evidence of bioturbation.
	IV	1.80	White culturally sterile very fine sand. BT terminated in known sterile soil.

Table A-3.

SUMMARY OF SOIL FEATURES - SITE 66-04-0001

Fea.	BT	Stratum	Formal Type	Function
1	16	IIIc	Pit	Human Burial
2	16	IIIa	Basin-Shaped Pit	Fire-Pit
3	2	IIIc	Pit	Human Burial
4	4	III	Scattered Human Remains	Human Bone Scatter
5	3	IIIb	Pit	Human Burial
6	6	IIIb	Pit	Human Burial
7	1	IIIc	Basin-Shaped Pit	Fire-Pit
8	20	IIIc	Pit	Human Burial
9	21	IIIb	Basin-Shaped Pit	Unknown Function
10	11	Ib	Basin-Shaped Pit	Historic Trash Pit
11	12	IIIb	Scattered Human Remains	Human Bone Scatter
12	7	III	Scattered Human Remains	Human Bone Scatter

Table A-4.

SUMMARY OF RADIOCARBON AGE DETERMINATIONS - Site 66-04-0001

PHRI Lab No. RC-	Beta Lab No. BETA-	Provenience	C-14 Age Yrs. B.P. (one Sigma)	C-13/ C-12 Ratio	C-13 Adj. C-14 Age Yrs. B.P.	*Calendric Range Yrs.A.D.
2154	51348	BT-16, Fea. C-2, Stratum IIIa, 0.75 mbs, Acc. No. 20	1700±150	-26.7	1670±150	20-660
2158	51349	ST-5, Fea. H, Stratum IIIa, 0.35 mbs, Acc. No. 6	530±60	-25.3	530±60	1290-1450
PHRI Lab No. RC-	Geocron Lab No. GX-	Provenience	C-14 Age Yrs. B.P. (one Sigma)	C-13/ C-12 Ratio	C-13 Adj. C-14 Age Yrs. B.P.	*Calendric Range Yrs.A.D.
2155	17666	Feature C-2, Stratum IIIa, 0.70 mbs, Acc. No. 44	370±110	-25.2	370±110	1322-1341 1390-1680 1739-1805 1933-1954
2156	17667	BT-1, Fea. C-7, Stratum IIIc, 1.10-1.35 mbs, Acc. No. 45	1925±115	-25.2	1915±115	190BC-380
2157	17668	BT-14, Fea. C, Stratum IIIa, 0.35-0.55 mbs, Acc. No. 58	700±105	-25.8	690±105	1160-1430

* Calibrated according to Stuiver and Pearson (1986). Range at two sigmas.

TABLE A-5.
SUMMARY OF NONCERAMIC ARTIFACTS

Cat	Acc.	HIF	SF	Cu	Unit	Strat	X	Y	mls1	mls2	Specimen	Material	N	Length	Width	Thick	Weight
Feature 10 (Firepit in Fea C)																	
1	37	-	10	BT	11	Ib	-	-	0.25	1.10	Bottle	Glass	1	-	-	-	-
2	37	-	10	BT	11	Ib	-	-	0.25	1.10	Bottle	Glass	1	-	-	-	-
3	37	-	10	BT	11	Ib	-	-	0.25	1.10	Fragment	Glass	1	-	-	-	-
4	37	-	10	BT	11	Ib	-	-	0.25	1.10	Bottle	Glass	1	-	-	-	-
Subtotal Feature 10																	
Feature C (Amifact Scatter)																	
13	30	C	-	BT	1	IIa	-	-	0.00	0.25	Pebble	Andesite	1	-	36	31	-
34	32	C	-	BT	1	IIc	-	-	0.73	1.10	Poss. Tab	Isognomon	1	25	20	3	3.47
24	13	C	-	BT	2	IIa	-	-	0.00	0.20	Fragments	Isognomon	22	-	-	-	28.13
19	14	C	-	BT	3	IIa	-	-	0.65	0.90	Adze	Tridacna	1	88	39	8	60.05
32	15	C	-	BT	4	IIa	-	-	0.00	0.25	Fragment	Tridacna	1	75	98	8	104.95
9	42	C	-	BT	5	Ic	-	-	0.90	1.10	Spikes	Iron	2	-	-	-	-
30	42	C	-	BT	5	Ic	-	-	0.90	1.10	Fragment	Tridacna	1	58	76	11	53.75
6	35	C	-	BT	6	IIa	-	-	0.00	0.07	Pesile Frag	Basalt	1	89	46	-	-
18	51	C	-	BT	13	Ia/III	-	-	0.00	0.20	Bottle	Glass	1	-	-	-	-
31	57	C	-	BT	13	III	-	-	0.25	0.45	Whole Shell	Tridacna	1	86	114	13	138.87
25	21	C	-	BT	14	I/III	-	-	0.00	0.50	Fragment	Tridacna	1	35	50	11	18.94
28	24	C	-	BT	15	IIc	-	-	0.60	1.00	Whole Shell	Tridacna	1	79	124	7	127.46
33	16	C	-	BT	16	IIb	-	-	0.35	0.90	Fragment	Tridacna	1	67	87	8	91.42
5	23	C	-	BT	16	IIb	-	-	0.00	0.55	Adze (broken)	Tridacna	1	52	32	7	23.31
27	28	C	-	BT	18	IIa	-	-	0.00	0.25	Fragment	Tridacna	1	51	93	10	75.44
29	27	C	-	BT	20	IIb	-	-	0.15	0.37	Poss Adze Blank	Terebra	1	77	26	-	28.33
26	27	C	-	BT	20	IIb	-	-	0.50	0.70	Fragment	Tridacna	1	53	99	11	105.58
21	40	C	-	BT	21	IIa	-	-	0.70	1.00	Pesile/Pounder	Coral	1	58	47	27	-
10	43	C	-	BT	21	IIb	-	-	0.50	0.60	Fragments	Andesite	1	-	88	-	-
15	38	C	-	BT	22	Ic	-	-	0.70	1.15	Poss Pounder	Glass	1	-	-	-	-
14	41	C	-	BT	22	III	-	-	0.00	-	Adze Frag	Basalt	1	88	52	29	-
11	60	C	-	SC	-	-	437.15	571.62	•	-	Adze Frag	Basalt	1	73	38	32	-
12	61	C	-	SC	-	-	437.99	607.62	•	-	Adze Frag	Terebra	1	86	34	11	48.43
7	59	C	-	SC	-	-	446.04	572.74	•	-	Adze Frag	Tridacna	1	47	33	8	20.56
8	59	C	-	SC	-	-	446.04	572.74	•	-	Secondary Flake	Chert	1	24	21	7	2.33
Subtotal Feature C																	
Feature F (Overhang)																	
16	5	F	-	ST	4	I/III	-	-	0.00	0.55	Fragments	Metal	12	-	-	-	10.59
17	5	F	-	ST	4	I/III	-	-	0.00	0.55	Fragments	Glass	27	-	-	-	-
Subtotal Feature F																	
Feature H (Overhang)																	
23	6	H	-	ST	5	IIa	-	-	0.00	0.35	Fragments	Glass	1	-	-	-	-
22	6	H	-	ST	5	IIa	-	-	0.00	0.35	Lapel Pin Back	Metal	1	-	-	-	-
Subtotal Feature H																	
TOTAL																	
92																	

Measurements in mm, weights in grams

• = surface

brk = broken

TABLE A-6
SUMMARY OF INVERTEBRATE REMAINS

Category	Code	Size	Area	Feet	Unit	MBSI
GASTROPODS						
Bivalves						
Strombidae	11100.00	-	-	-	-	-
Strombus g. gibbosus	11111.00	4.61	2.10	2.93	4.14	0.30
Cerithiidae	11200.00	-	-	-	-	-
Cerithium nodulosum	11211.00	-	-	-	-	-
Chrysomorus bailliarisferalis	11222.00	-	-	-	-	-
Conidae	11400.00	-	-	-	-	-
Cynatidae	11600.00	-	-	-	-	-
Charonia tritonis	11621.00	-	-	-	-	-
Cypriacidae	11900.00	-	-	-	-	-
Tubinidae	12200.00	-	-	-	-	-
Turbo scarius	12211.00	161.69	75.55	-	64.39	0.47
Trochidae	13200.00	-	-	-	-	-
Tectus pyramis	13231.00	-	-	-	-	-
Trochus niloticus	13242.00	-	-	-	-	-
Unknown Gastropods	13500.00	-	-	-	-	-
SUBTOTAL GASTROPODS		314.34	119.18	2.93	4.14	0.30
BIVALVES						
Terebridae	13900.00	-	-	-	-	-
Mytilidae	21100.00	-	-	-	-	-
Modiolus auriculatus	21121.00	-	-	-	-	-
Tellinidae	21300.00	-	-	-	-	-
Tellina scabinata	21313.00	-	-	-	-	-
Tellina psalanum	21315.00	-	-	-	-	-
Vesendae	21400.00	-	-	-	-	-
Gyfarum pectinatum	21411.00	2.52	11.63	5.60	7.43	0.30
Pannobididae	21600.00	-	-	-	-	-
Alephia sp.	21610.00	-	-	-	-	-
Isoptomidae	21700.00	-	-	-	-	-
Spondylidae	22000.00	-	-	-	-	-
Tridacidae	22100.00	-	-	-	-	-
Mactridae	22800.00	-	-	-	-	-
Atactodes spiralis	22810.00	-	-	-	-	-
Unknown Bivalve	23500.00	-	-	-	-	-
SUBTOTAL BIVALVES		2.52	11.63	5.60	7.43	0.30
LITTORAL / TERRESTRIAL						
Unidentifiable Shell	30000.00	-	-	-	-	-
Melampidae	60100.00	-	-	-	-	-
Pythia scaberrima	60111.00	-	-	-	-	-
Actinidae	60500.00	-	-	-	-	-
Acteocina fulica	60510.00	-	-	-	-	-
SUBTOTAL LIT & OCEANIC		-	-	-	-	-
GRAND TOTAL		316.86	130.78	3.93	4.14	0.30

Table A-7.

UBIQUITY VALUES FOR INVERTEBRATE REMAINS

Identification	n*	Ubiquity**
Gastropods		
Strombidae	-	-
Strombus g. gibbosus	9	25.0 %
Cerithiidae	-	-
Cerithium nodulosum	1	2.8 %
Clypeomorus bitillariaeformis	1	2.8 %
Conidae	3	8.3 %
Cymatidae	-	-
Charonia tritonis	1	2.8 %
Cypraeidae	1	2.8 %
Turbinidae	-	-
Turbo setosus	11	30.6 %
Trochidae	1	2.8 %
Tectus pyramis	1	2.8 %
Trochus niloticus	1	2.8 %
Unknown Gastropod	2	5.6 %
Bivalves	-	-
Terebridae	2	5.6 %
Mytilidae	-	-
Modiolus auriculatus	2	5.6 %
Tellinidae	6	16.6 %
Tellina scobinata	2	5.6 %
Tellina palatum	6	16.6 %
Veneridae	2	5.6 %
Gafrarium pectinatum	10	27.8 %
Psammodiidae	-	-
Asaphis sp.	2	5.6 %
Isognomonidae	2	5.6 %
Spondylidae	1	2.8 %
Tridacnidae	1	2.8 %
Mactridae	-	-
Atactodea striata	1	2.8 %
Unknown Bivalve	3	8.3 %
Unidentifiable Shell	2	5.6 %
Melampidae	-	-
Pythia scarabaeus	2	5.6 %
Achatinidae	-	-
Achatina fulica	1	2.8 %

* Total number of samples = 36;

** Ubiquity is calculated by dividing the number of samples in which a given taxon is identified by the total number of samples from the project area. Minimum ubiquity value = 36/1, or 2.8.

Table A-8.

SHELLS HARVESTED ON GUAM

Scientific Name (Common Name)	Chamorro Name	Habitat**
Polyplacophora (Chitons)		
Family Chitonidae		
<i>Acanthopleura gemmata</i>	tagula	IT (Rk)
Gastropoda (snails)		
Family Trochidae (topshells)		
<i>Trochus niloticus</i>	alileng	ORF, RM, RFS
<i>Tectus pyramis</i>		RM, RFS
Family Turbinidae (turban shells)		
<i>Turbo argyrostomus</i>	alileng	RM
<i>Turbo setosus</i>	alileng	RM
Family Neritidae (nerites)		
<i>Nerita plicata</i>		IT (Rk)
<i>Nerita polita</i>		IT (Rk)
Family Strombidae (conchs)		
<i>Strombus gibberulus</i>	do'gas	RF(Sn)
<i>Strombus luhuanus</i>	do'gas dankolo	RF, LG (Sn)
<i>Lambis chiragra</i>		RF, RFS
<i>Lambis lambis</i>	toru	RF (Sn/Rb)
<i>Lambis truncata</i>		RFS (Sn)
Family Vasidae (vase shells)		
<i>Vasum turbinellus</i>		RF (Sn/Rb)
Bivalvia (clams and mussels)		
Family Mytilidae (mussels)		
<i>Modiolus auriculatus</i>		LG (Sg)
Family Chamidae		
<i>Chama</i> spp.		RF/LG (Rk)
Family Lucinidae		
<i>Ctena bella</i>		LG (sg), RF (Sn)
<i>Codakia punctata</i>		RF(Sn/Rb)
Family Cardiidae (cockles)		
<i>Fragum fragum</i>		RF (Sn), LG (Sg)
Family Tridacnidae (giant clams)		
<i>Tridacna maxima</i>	hima	RM, RFS
<i>Tridacna squamosa</i>	hima	RM, RFS
Family Tellinidae		
<i>Quidnipagus (Tellina) palatum</i>		RF/LG (Sg)
<i>Scutarcopagia scobinata</i>		LG (Sg), RF (Sn)
Family Psamobiidae		
<i>Asaphis violascens</i>	pa'gang	IT (Sn/ Rb)
Family Veneridae		
<i>Gafrarium pectinatum</i>		LG (Sg), RF (Sn)
<i>Gafrarium tumidum</i>		MG (Md)

* From Smith, Barry

1986 Reef invertebrate harvesting. Pp. 22-67. (Table on p. 73) IN Fishing on Guam, by S. Amesbury, F. Cushing, and R. Sakamoto. Guide to the Coastal Resources of Guam Vol. 3. University of Guam Marine Lab Contribution No. 225.

** ORF= outer reef flat; RM= reef margin; RFS= reef front slope; IT= intertidal; RF= reef flat; LG= lagoon; MG= mangrove flats; Rk= rock; Sn= sand; Sn/ Rb= sand and rubble; Sg= seagrass meadows; Md= mud.

Table A-9.

**SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS
AND RECOMMENDED GENERAL TREATMENTS**

Site Number	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
66-04-0615	+	-	-	-	+	-	-	-
66-04-0617	+	-	-	-	+	-	-	-
Subtotal	2	0	0	0	2	0	0	0
66-04-0616	+	-	-	+	+	-	-	+
66-04-0618	+	-	-	+	+	-	-	+
Subtotal	2	0	0	2	2	0	0	2
66-04-0001	+	-	+	+	+	-	+	+
Subtotal	1	0	1	1	1	0	0	2
Total	5	0	1	3	5	0	0	2

General Significance Categories:

A = Important for information content, further data collection necessary (CRM value mode assessment = scientific research value);

X = Important for information content, no further data collection necessary (CRM value mode assessment = scientific research value);

B = Excellent example of site type at local, region, island, State, or National level (CRM value mode assessment = interpretive value);

C = Culturally significant (CRM value mode assessment = cultural value).

Recommended General Treatments:

FDC = Further data collection necessary (further survey and testing, and possibly subsequent data recovery/mitigation excavations);

NFW = No further work of any kind necessary, sufficient data collected, archaeological clearance recommended, no preservation potential (possible inclusion into landscaping suggested for consideration);

PID = Preservation with some level of interpretive development recommended (including appropriate related data recovery work); and

PAI = Preservation "as is," with no further work (and possible inclusion into landscaping), or minimal further data collection necessary.

APPENDIX B

CERAMIC CODING FORMAT INDIGENOUS (PREHISTORIC) ARTIFACTS PREHISTORIC CERAMIC CODING KEY

Variable Name	Code	Variable	Variable Name	Code	Variable
24. SHERD TYPE:	100	Indeterminate	44. HCL	T/F	Pos. or neg. reaction with dilute HCL
	101	Body sherd	45. —	170	—
	102	Transitional sherd		171	—
	102	Rim sherd		172	—
	.			173	—
	109	Other		174	—
25. —	110-119	—	46. THICKENING	175	Rim too eroded to determine
26. INCLUSIONS:	120	None		176	Rim thickened
	121	Non-white inclusions		177	Rim not thickened
	122	Shell fragments		178	—
	123	Rounded white clasts		179	—
	124	Sherd fragments (grog)	48. RIM STANCE: *	180	Undetermined
	125	121 & 122		181	Inverted
	126	121 & 123		182	Everted
	127	121 & 124		183	Vertical
	128	122 & 123		184	Flared/ outcurving
	129	122 & 124		185	Horizontal
	130	123 & 124		186	Pendant
	.			187	—
	139	Other		188	Incurving
27. SIZE SORTING:†	140	No clasts present		189	Other
	141	Well-sorted, coarse	49-50 RIM SHAPES	200	Undetermined
	142	Well-sorted, medium		201	Simple (not thickened)
	143	Well-sorted, fine		202	Thickened
	144	Poorly-sorted, coarse	(Recorded for	203	—
	145	Poorly-sorted, medium	interior and	204	Complex thickening
	146	Poorly-sorted, fine	exterior of rim)	205	—
	.			206	—
	149	—		207	—
	Other			209	Other
28. %INCLUSIONS -	150	Absent	210-249	—	
	151	Low (1-10%)	51 RIM EDGE FORM *	250	Undetermined
	152	Moderate (11-30%)		251	Round
	153	Abundant (>30%)		252	—
	.			253	Convex
	159	Other		254	Concave
38. HARDNESS	160	Indeterminate		255	Pointed
	161	Scratched by a fingernail		256	Flattened
	162	Scratched by an iron nail		.	
	163	Scratched by glass		259	Other
	164	Scratched by a steel nail			
	165	Scratched by carbon steel			
	.				
	169	Other			

- See Figure C-1

† See Figure C-2

* Codes may be added as unforeseen characteristics are observed. (For prehistoric ceramics, material type= 1078, condition classification=not applicable at this time, description type= 1217 [informal])

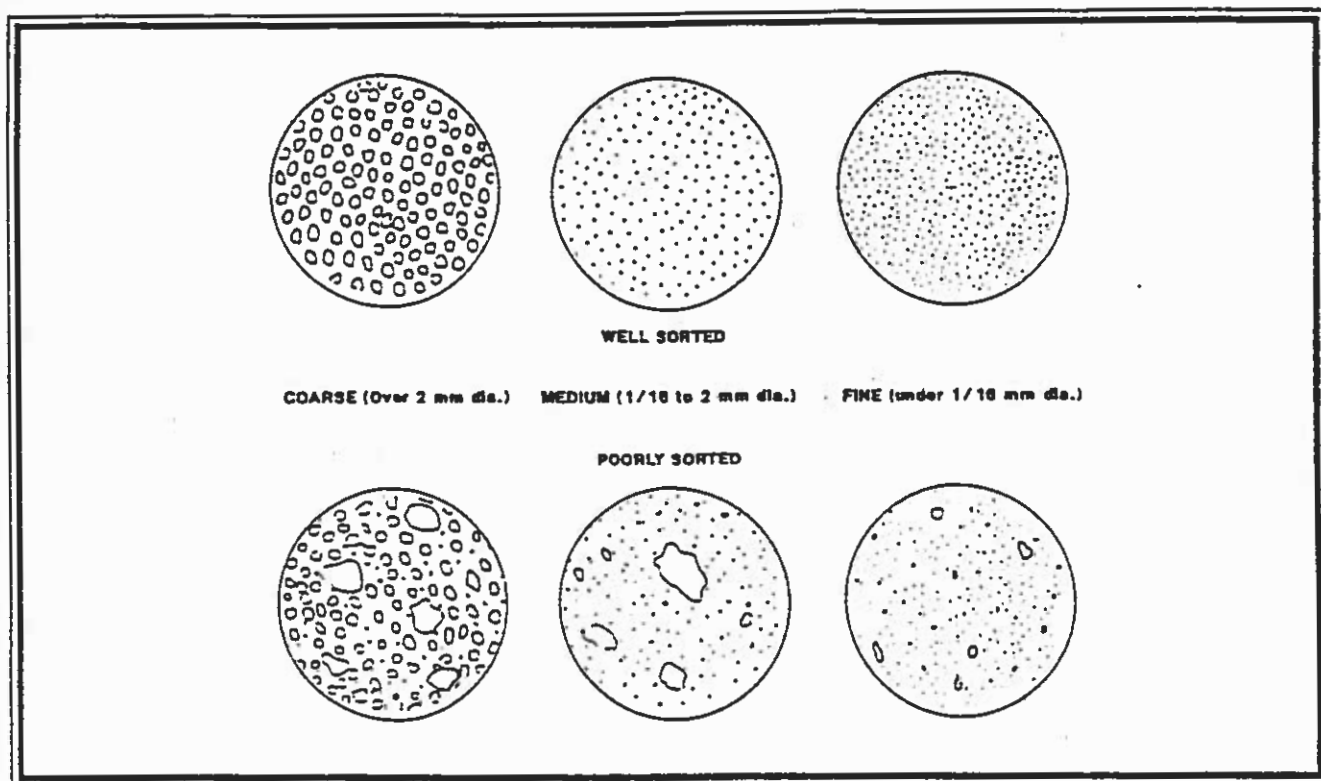


Figure B-1. CLAST SIZE SORTING DIAGRAM

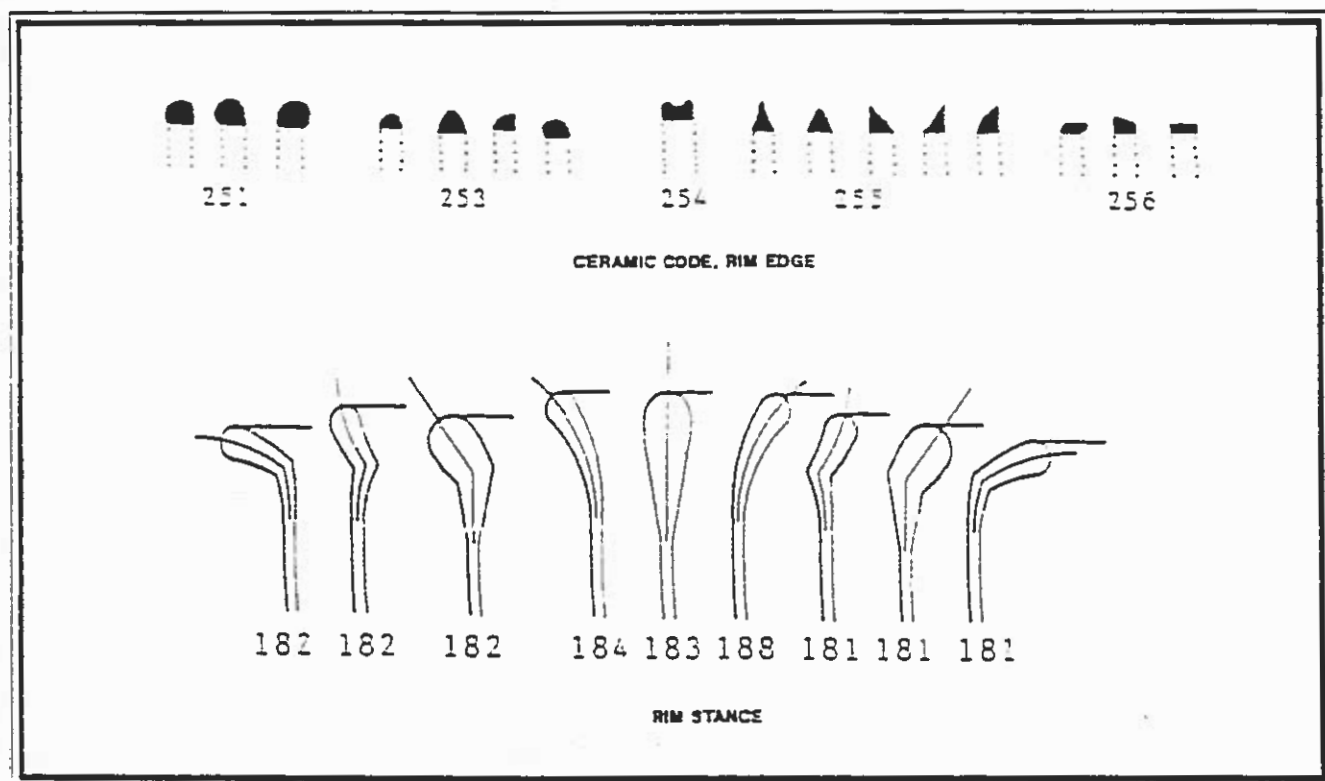


Figure B-2. RIM EDGE AND RIM STANCE DIAGRAM

Variable Name	Code	Variable	Variable Name	Code	Variable
53-54. FINISH:	260	Undetermined	62-64. APPLICATION:	370	None
	261	Eroded		371	Lime plaster
	262	Rough		372	Limonite coating
	263	Smooth		373	Lime-filled striations or impressions
	264	Textured		374	Painted
	265	Polished		399	Other
	266	Clay slip			
	267	Lime slip			
	279	Other	65-66. CARBON:	400	None
280-299	—			401	Thin film
				402	<1 mm
55-58. STRIATIONS:	300	None		403	1 mm or thicker
	301	Single line		409	Other
	302	Multiple lines	67-77. LOCATION:	450	Body interior
	303	Fine (<3mm crest to crest)		451	Body exterior
	304	Medium (>3mm - 6mm crest to crest)		452	Body interior and exterior
	305	Coarse (>6mm crest to crest)		453	Portion of sherd
	306	Regularly spaced		454	Entire sherd
	307	Irregularly spaced		455	Transition
	308	Uniform (refers to line size and shape)		456	Rim interior
	309	Non-uniform (refers to line size & shape)		457	Rim exterior
	310	Parallel		458	Rim edge
	311	Non-parallel		470	Other
	312	Continuous pattern (all lines are parallel)			
	313	Non-continuous (lines at angles)	78. MODIFICATION:	See Universal Modification Codes	
	329	Other	79. LOCATION:	See 67-77	
59-61. IMPRESSION:	330	None			
	331	Arcuate			
	332	Semicircular			
	333	Circular			
	334	Conical			
	335	Hemispherical			
	336	Cylindrical			
	337	Pinched			
59-61. IMPRESSION:	338	Mat impressed			
	339	Cord marked			
	340	Net impressed			
	341	Floral imp. (leaves, twigs, seeds, etc.)			
	342	Punctate			
	343	Stamped			
	344	Finger impressions			
	345	Fingernail impressions			
	346	Textile impressions			
	369	Other			

APPENDIX C

SHELL CODING FORMAT

MARINE GASTROPODS

ORDER: GASTROPODA 10000 GAS

FAMILY:

Strombidae	11100	STR
<i>Strombus</i> sp.	11110	SGS
<i>Strombus gibberulus gibbosus</i>	11111	SGG
<i>Strombus mutabilis</i>	11121	SSM
<i>Strombus lubuanus</i>	11122	SSL
<i>Strombus urceus</i>	11123	SSU
<i>Strombus labianus</i>	11124	SSA
<i>Strombus canarium</i>	11125	SSC
<i>Strombus leniginosus</i>	11126	SSN
<i>Lambis</i> sp.	11130	SLS
<i>Lambis chiragra</i>	11131	SLC
<i>Lambis lambis</i>	11132	SLL
Cerithiidae	11200	CER
<i>Cerithium</i> sp.	11210	CCS
<i>Cerithium nodulosum</i>	11211	CCN
<i>Cerithium rostratum</i>	11213	CCR
<i>Clypeomorus</i> sp.	11220	CCY
<i>Clypeomorus bifasciatus</i>	11221	CCB
<i>Rhinoclavis</i> sp.	11230	CRS
<i>Rhinoclavis fasciata</i>	11231	CRF
<i>Rhinoclavis sinensis</i>	11232	CHS
<i>Rhinoclavis aspera</i>	11233	CCA
<i>Rhinoclavis vertagus</i>	11234	CCV
Buccinidae	11300	BUC
<i>Cantharus</i> sp.	11310	BUS
<i>Cantharus undosus</i>	11311	BCU
Conidae	11400	CON
<i>Conus</i> sp.	11410	CSP
<i>Conus ebraeus</i>	11411	CCE
<i>Conus eburneus</i>	11412	COE
<i>Conus sponsalis</i>	11413	COS
<i>Conus miles</i>	11414	COM
<i>Conus testularius</i>	11415	COT
<i>Conus chalcidius</i>	11416	COC
<i>Conus pulicarius</i>	11417	COP
<i>Conus ingidus</i>	11418	COF
<i>Conus viridulus</i>	11419	COV
Naticidae	11500	NAT
<i>Polinices</i> sp.	11510	NPS
<i>Polinices melanostomus</i>	11511	NPM
<i>Polinices flemingianus</i>	11512	NPF
<i>Polinices tumidus</i>	11513	NPT
<i>Natica</i> sp.	11520	NNS
<i>Natica gualtierana</i>	11521	NNG
Cymatidae	11600	CYM
<i>Cymatium</i> sp.	11610	CYS
<i>Cymatium nicobanicum</i>	11611	CYN
<i>Cymatium muncionum</i>	11612	CYM
<i>Charonia</i> sp.	11620	CAS
<i>Charonia tritonis</i>	11621	CCT
Neritidae	11700	NER
<i>Nerita</i> sp.	11710	NES
<i>Nerita albigilla</i>	11711	NNA
<i>Nerita plicata</i>	11712	NCP
<i>Nerita planospira</i>	11713	NPL
<i>Nerita signata</i>	11714	NTS
<i>Nerita undata</i>	11715	NTU
<i>Clithon</i> sp.	11720	NCS
<i>Clithon ovalaniensis</i>	11721	NCO
<i>Neritina</i> sp.	11730	NET
<i>Neritina turrita</i>	11731	NTT

Acteonidae	11800	ACT
<i>Acteon</i> sp.	11810	AAS
<i>Pupa</i> sp.	11820	APS
<i>Pupa solidula</i>	11821	APU
Cypraeidae	11900	CYP
<i>Cypraea</i> sp.	11910	CYS
<i>Cypraea moneta</i>	11911	CCM
<i>Cypraea crosa</i>	11912	CCC
<i>Cypraea caputserpentis</i>	11913	CCA
<i>Cypraea isabella</i>	11914	CCI
<i>Cypraea annulus</i>	11915	CCU
<i>Cypraea lynx</i>	11916	CCL
Muricidae	12100	MUR
<i>Drupa</i> sp.	12110	MDS
<i>Drupa ricinus</i>	12111	MDR
<i>Drupa grossularia</i>	12112	MDG
<i>Drupa morum</i>	12113	MDM
<i>Murex</i> sp.	12120	MMS
<i>Chicoreus brunneus</i>	12121	MMB
<i>Thais</i> sp.	12130	MTS
<i>Thais bufo</i>	12131	MTB
<i>Morula</i> sp.	12140	TMS
<i>Morula margariticoia</i>	12141	TMM
<i>Nassa</i> sp.	12150	NAS
<i>Nassa sarta</i>	12151	NSS
Turbinidae	12200	TUR
<i>Turbo</i> sp.	12210	TTS
<i>Turbo setosus</i>	12211	TTV
<i>Astraea stellata</i>	12213	TAS
Turbinellidae	12300	TUB
<i>Vasum</i> sp.	12310	VVS
<i>Vasum turbinellus</i>	12311	VVT
Fasciolaridae	12400	FAS
<i>Lautus</i> sp.	12410	FLS
<i>Lautus polygonus</i>	12411	FLP
Atyidae	12500	ATY
<i>Atya</i> sp.	12510	AYS
<i>Atya cornuta</i>	12511	AAC
Planaxidae	12600	PLA
<i>Planaxis</i> sp.	12610	PPS
<i>Planaxis sulcatus</i>	12611	PPU
Pyramidellidae	12700	PYR
<i>Pyramidella</i> sp.	12710	PYS
<i>Pyramidella sulcata</i>	12711	PYU
<i>Otopleura nodicincta</i>	12721	PON
Patellidae	12800	PAT
<i>Celiana</i> sp.	12810	PCS
<i>Celiana radiata</i>	12811	PCR
<i>Patella flexuosa</i>	12820	PAF
Melampidae	12900	MEL
<i>Melampus flavus</i>	12910	MEF
Mitridae	13000	MIT
<i>Mitra succuca</i>	13010	MIS
<i>Mitra eremitarum</i>	13011	MIC
<i>Mitra paupercula</i>	13013	MIP
<i>Nebulaea</i> sp.	13020	NEB
Siphonariidae	13000	SIP
<i>Siphonaria</i> sp.	13110	SIS
Trochidae	13200	TRO
<i>Umbonium</i> sp.	13210	TUM
<i>Umbonium vestiarum</i>	13211	TUV
<i>Umbonium costatum</i>	13212	TUC
<i>Basilissa</i> sp.	13220	TBS
<i>Tectus pyramis</i>	13231	TBP
<i>Trochus</i> sp.	13240	TRO
<i>Trochus maculatus</i>	13241	TRM
<i>Trochus niloticus</i>	13242	TRN

Tectus fenestratus	13243	TRF
Trochus tubiferus	13244	TRT
Trochus ochroleucas	13245	TRH
Tonnidae	13300	TON
Tonna perdis	13310	TOP
Malea pommum	13320	TOM
Vermetidae	13400	VER
Unknown Gastropods	13500	UNG
Operculum	13600	OPC
Turretellidae	13700	TUR
Bullidae	13800	BUL
Bulla sp.	13810	BBS
Bulla vernicosa	13811	BBV
Terebridae	13900	TER
Terebra sp.	13910	TBR
Terebra subulata	13911	TBS
Terebra gouldi	13912	TEG
Terebra maculata	13913	TEM
Architectonicidae	14000	ARC
Philippia radiata	14010	ARP
Bursidae	14100	BUL
Bursa sp.	14110	BUS
Bursa granularis	14111	BUG
Angaridae	14200	ANG
Angaria sp.	14210	AAN
Angaria delphinus	14211	AAD
Crepidulidae	14300	CRE
Hipponicidae	14400	HIP
Nassaridae	14500	NAS
Nassarius suffianus	14510	NSS
Potamididae	14600	POD
Terebra sulcata	14610	PTS
Vanikoridae	14700	VAN
Vanukoro canaliculata	14710	VAC
Coralliophilidae	14800	COR
Coralliophila nentioidea	14810	CON
Cassidae	14900	CSS
Casmaria enniaceus	14910	CSE
Olividae	15000	OLV
Costellariidae	15100	CTL
Vexillum sp.	15110	CTV
Modiolidae	15200	MOD
Haliotidae	15300	HAL
Haliotis glabra	15310	HAG
Haliotis varia	15311	HAV

BIVALVES

ORDER BIVALVIA	20000	BIV
Mytilidae	21100	MYT
Ischadium sp.	21110	ISC
Ischadium recurvum	21111	ISR
Modiolus sp.	21120	MMS
Modiolus aciculatus	21121	MMA
Brachidontes sp.	21130	BRC
Septifer sp.	21140	SEP
Septifer bifurcatus	21141	SEB
Lucinidae	21200	LUC
Cocakia sp.	21210	LCS
Cocakia punctata	21212	LC P
Ctena sp.	21220	LTS
Ctena bella	21221	LCB
Anodon sp.	21240	LNS
Tellinidae	21300	TEL
Tellina sp.	21310	TTS
Tellina robusta	21311	TTR
Tellina perna	21312	TTP
Tellina scobinata	21313	TTB
Tellina palatum	21314	TTM
Tellina stauriella	21315	TTL
Tellina disculus	21316	TTD

Veneridae	21400	VGS
Gafrarium sp.	21410	VGS
Gafrarium pectinatum	21411	VGP
Gafrarium tumidum	21412	VGT
Dosinia sp.	21420	VDS
Dosinia japonica	21421	VDJ
Lioconcha sp.	21440	VLI
Lioconcha castrensis	21441	VLC
Periglypta sp.	21450	VPY
Periglypta reticulata	21451	VPR
Cardiidae	21500	CAR
Fragum sp.	21510	CFS
Fragum fragum	21511	CTA
Fragum unedo	21512	CTU
Trachycardium sp.	21520	CTS
Trachycardium mindanense	21521	CTM
Psammobiidae	21600	PSA
Asaphus sp.	21610	PSP
Asaphus violascens	21611	PSD
Isognomonidae	21700	ISO
Isognomon sp.	21710	IIS
Isognomon legumen	21711	IIL
Isognomon perna	21712	IIP
Arcidae	21800	ARC
Anadara sp.	21810	AAS
Anadara antiquata	21811	ATS
Barbatia sp.	21820	ACS
Barbatia decussata	21821	ASI
Barbatia foliata	21822	ASF
Arca sp.	21830	ARS
Arca navicularis	21831	AAN
Chamidae	21900	CHA
Chama sp.	21910	CCS
Chama dunken	21911	CCD
Chama reflexa	21912	CCR
Chama brassica	21913	CCB
Spondyliidae	22000	SPO
Tridacnidae	22100	TRJ
Cardidae	22200	GAR
Macridae	22300	MAC
Ostreidae	22400	OST
Carditidae	22500	CRD
Cardita sp.	22510	CRS
Cardita vanegata	22511	CCV
Pectinidae	22700	PEC
Mesodesmatidae	22800	MES
Atactodea striata	22810	MEA
Unknown Bivalve	22900	UBV

LITTORAL/ TERRESTRIAL GASTROPODS

Littoral/Terrestrial Gastropods	60000	NMG
Melampidae	60100	EL
Pythia sp.	60110	EB
Pythia scabra eul	60111	EYS
Oliacinae	60200	BLE
Englandina sp.	60210	BES
Englandina rosea	60211	BYB
Bradybaenidae	60300	BYB
Helicostylus sp.	60310	HEL
Lanc snail	60400	LNS
Achatinidae	60500	LAA
Achatina fulica	60510	LAF
Littorinidae	60600	LIT
Lymnaeidae	60700	LYM
Amphineura [hite]	70000	CHI

MISCELLANEOUS

Unidentifiable Shell	30000	UDS
Echinoidea	40000	CRU
Crustacea	50000	CRU

APPROVAL PAGE

Archaeological Inventory Survey Gun Beach Hotel Site

Submitted: Holland K. Statter
for Paul H. Rosendahl, Ph. D.

Position: President and Principal Archaeologist

Date: October 13, 1992

Approved: _____

Representing: _____

Position: _____

Date: _____

Approved: _____

Representing: _____

Position: _____

Date: _____

APPENDIX C
Environmental Baseline Survey

DRAFT

**ENVIRONMENTAL BASELINE SURVEY
GUN BEACH
TUMON, GUAM**

**Prepared for
GMP ASSOCIATES, Inc.**

**Prepared by
PACIFIC BASIN ENVIRONMENTAL CONSULTANTS, INC.**

OCTOBER 1992

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I. PURPOSE

The purpose of this report is to provide a current survey of the environmental conditions on the reef flat fronting the proposed Gun Beach Hotel in Tumon. An Environmental Baseline Survey (EBS) includes data on existing water quality, currents and flora and fauna observed in the area. Projects planned for coastal areas generally require an Environmental Impact Assessment once project designs are available. At that time expected impacts and mitigation measures become an integral part of the report.

II. LOCATION

Gun Beach is located on the west coast of Guam in the northern tip of Tumon Bay (Figure 1). The reef surveyed for this report is bounded on the west by the reef front and the Pacific Ocean, on the east by Gun Beach, on the south by the Australian telecommunications cable and on the north by Bijia Point.

III. USES OF THE AREA

Gun Beach is a popular area for local residents as well as visitors. Beachgoers use the beach for picnics and occasional campouts. The waters are used by fishermen, reef walkers, swimmers and snorkelers during high tides and by divers who may use the cable channel for easy entry into the deeper waters past the reef margin. Many people traverse the area to reach Fafai Beach which is immediately north of Gun Beach.

IV. PHYSICAL DESCRIPTION

A. General Description

Potential development along the coast is most likely to impact the shallow reef areas nearby. The reef flat is generally surveyed in detail because of its proximity to shoreline development and because of the diversity and quantity of reef organisms in the area. Zones further offshore (from the reef margin seaward) tend to be impacted only when development is uncontrolled or extends into the reef zone. This report therefore describes in detail conditions existing only on the reef flat.

The area fronting Gun Beach in Tumon includes a sandy beach, a narrow intertidal zone, reef flat, reef margin, reef front and slope (Figure 1). The beach is approximately 45 feet (ft.) wide from vegetation to MLLW, with a fairly steep slope of 20 percent (Sea Engineering Services, 1980). It is composed of well sorted medium to coarse calcareous sand with coral rubble, gravel and foraminiferan tests. Running along the beach is a narrow (approximately 20 ft. wide) intertidal zone primarily composed of beach sand with small amounts of rubble. No corals and few organisms of any kind exist in this zone.

The reef flat is approximately 350 ft. wide from MLLW to the reef margin. It contains two physiographic zones, the inner reef flat and outer reef flat. The inner reef flat is subtidal and has few corals or other organisms. The outer reef flat is mostly emergent during low tides and is primarily an algal zone. Corals are generally limited to depressions in the reef rock pavement. These depressions and the corresponding abundance of corals increase in quantity, size and diversity as the outer reef flat approaches the reef margin.

A shallow man-made cable channel runs along the southern boundary of the project site. A second naturally formed channel runs along the northern boundary of the site along Bijia Point. Both of these channels are similar in depth and substrate to the inner reef flat and are therefore included in the description of that physiographic zone. The areas past the reef flat (reef margin and seaward) are not included in this survey.

B. Zonation

1. Inner Reef Flat and Channels

The inner reef flat (Figure 1) is approximately 100 ft. wide and runs along the beach turning seaward as it approaches Bijia Point. It then becomes a wide, shallow channel that exits the reef front. The inner reef flat is subtidal even during low-low tides. Its bottom surface is composed of hard reef rock pavement with a thick layer of sand. Moving seaward towards the outer reef flat, the sand progressively thins to a veneer (less than $\frac{1}{4}$ inch) of sand overlying the reef rock pavement. Depressions filled with small rubble, gravel and sand are scattered throughout the area. Topography is irregular with numerous small boulders that have detached from deeper waters and washed into this area during large storms. Most corals occurring in this zone live on these boulders.

Two channels begin in the inner reef flat and extend across the outer reef flat past the reef margin. The cable channel is a narrow (approximately six feet wide) channel that runs straight out to the reef margin and down the reef slope. The depth of the substrate is the same as throughout the inner reef flat, that is, it is approximately three feet deep during MLLW and submerged even during low tides. The substrate is also similar to that throughout the nearshore portion of the inner reef flat with thick sand and small rubble or gravel overlying hard reef rock pavement. The sides of the channel are irregular vertical rock walls with small concavities.

The wider channel near Bijia Point seems to be an extension of the inner reef flat as it rounds Bijia Point. It has similar depth and bottom substrate as the rest of the nearshore portion of the inner reef flat. This channel is 15 to 30 ft. wide and approximately three feet deep. The seaward portion of the channel has large numbers of corals and other reef organisms. In addition, numerous small boulders sit on the substrate.

The inner reef flat grades into the shallower outer reef flat with irregular cuts (Figure 1) in some areas while in other areas a more gradual merging is typical. These cuts give these areas the appearance of a ragged edge between the inner and outer reef flats. Where these cuts occur they have deeper inner reef flat substrate (deep sand and gravel), surrounded on three sides by the shallower hard reef rock pavement of the outer reef flat.

2. Outer Reef Flat

The outer reef flat is approximately 250 ft. wide and is distinguished by its thick mats of algae and generally emergent nature during low tides. Topography is irregular because of the presence of numerous large and small depressions in the reef pavement. These depressions become larger and more numerous in the seaward portion of the outer reef flat and are typically one to two feet deeper than the surrounding substrate. Because of the position of these depressions near the reef margin, they are wave-washed even during the lowest tides. No boulders exist in the area because the strong currents and large waves tend to move them into the deeper inner reef flat during storms.

The substrate in areas that are emergent during low tides is hard reef rock pavement mostly covered with thick mats of algae. The substrate in depressions is primarily sand, gravel and small rubble overlying pavement. The mats of algae do not extend into these depressions but are present in the shallower areas between them.

C. Water Quality

1. Survey Method

Four stations (Stations 1-4) were surveyed for water quality (Figure 2). Parameters tested were turbidity (NTU) and suspended solids (mg/l). Water was collected from just below the surface and analyzed in the laboratory. Samples were taken during a low incoming tide on September 24, 1992 and a high outgoing tide on September 29, 1992.

2. Results

Water in the vicinity of Gun Beach is rated as M-2 (Good) by the Guam Environmental Protection Agency. Water quality results from two field trips are compiled in Table 1 in the Appendix. Turbidity ranged from a low of 1.14 NTU at Station 3 to a high of 12.50 NTU at the same station. Suspended solids ranged from a low of 2.4 mg/l at Station 1 to 18.5 mg/l at Station 4.

D. Currents

1. Survey Method

Current velocity and direction were measured at four stations on the reef flat (Figure 2). A small drift drogue was placed in the water and allowed to drift with the current. The amount of time it took the drogue to drift a prescribed distance (generally five meters) and the direction were noted. Velocity was calculated using the distance and time data.

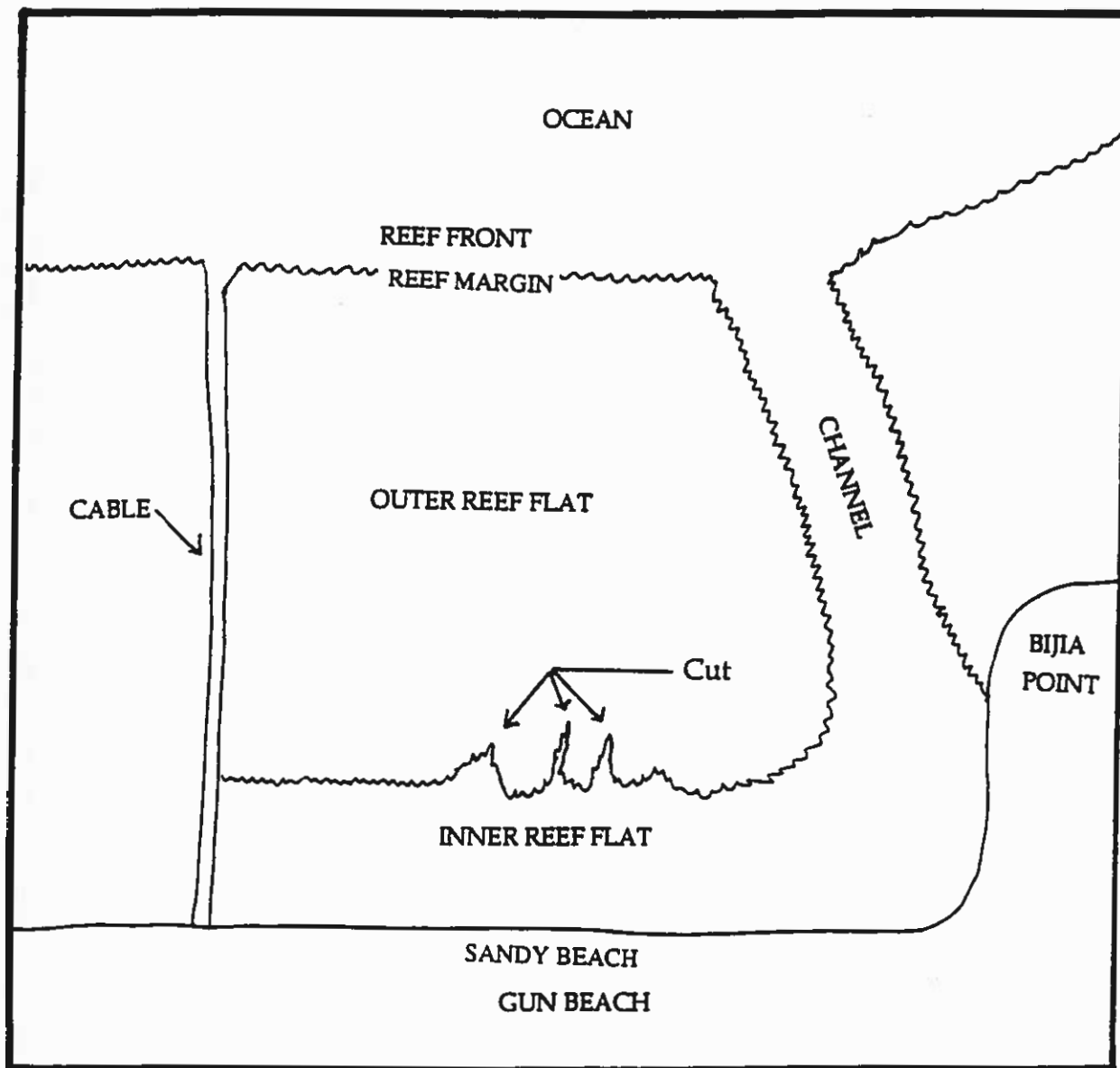


Figure 1. Diagram of project area showing physiographic reef zones, the cable, channel exiting the reef near Bijia Point and Gun Beach.

2. Results

Currents were generally slow and direction was extremely variable during both tides surveyed (Table 2 in Appendix). The average velocity was 7 cm/s, with Station 3 (the seaward part of the channel during an outgoing tide) having the highest average velocity (17 cm/s). Current direction was extremely variable at all stations on both days (the only exception was Station 3 on 9/29/92, the same station with the highest velocity).

Because of the meandering currents, a number of measurements were not included either because velocity was too low or the direction changed so radically that there was no discernible current. For instance, current direction at the same station taken only minutes apart varied by as much as 120 degrees (Table 2 in Appendix).

These results indicate that currents in the general area are not strong during most days. The only distinct current on the days when sampling occurred was during an outgoing tide at Station 3 which is located in the seaward portion of the channel before it exits the reef flat. It is important to note, however, that currents in the area are known to be extremely dangerous at unpredictable times of year and during high storm wave assault. Large quantities of water enter and exit the reef through the two channels causing strong currents. Although these results did not show this, more intense sampling would eventually give more definitive results.

V. BIOLOGICAL DESCRIPTION

A. General Description

1. Inner Reef Flat and Channels

In general, the inner reef flat contains a lower diversity and quantity of corals, macroinvertebrates and algae than on the outer reef flat. Diversity and quantity of each group increases substantially in the seaward portion of the channel near Bijia Point and to a lesser extent in the seaward portion of the cable channel. The sea cucumber Holothuria leucospilota is the only abundant organism throughout this zone.

Corals were, in general, rare and small throughout the zone. Most coral colonies were observed growing on the sides of small boulders. This is particularly true in the nearshore portion where the substrate consists of thick sand. However, corals were comparatively quite diverse and abundant in the seaward portion of the channel near Bijia Point. This area also supports the largest colonies in the zone as a whole.

Fish diversity is higher in the inner reef flat because this area is deep enough to support fish even during low tides. The greatest abundance and diversity of fish in this zone were observed in the seaward portion of the channel near Bijia Point.

2. Outer Reef Flat

Most of the shoreward portion of the outer reef flat is emergent during low tides, limiting the types of organisms living in the area. In general, the emergent area is an algal zone. This emergent portion of the outer reef flat is covered with thick mats of algae (Boodlea composita, Gelidiella acerosis and Gelidiopsis intricata interspersed with other species) and numerous brittle stars which make up the bulk of macroinvertebrates.

Numerous depressions pit the outer reef flat and are filled with sand, gravel and rubble. These depressions contain most of the corals and other organisms that were observed throughout the outer reef flat zone. The abundance and size of these depressions increases substantially on the seaward portion of the outer reef flat as it merges with the reef margin.

Most marine organisms require submergence for survival and growth. The increased abundance of depressions supplies habitat for marine organisms not able to tolerate conditions on the emergent portions of the reef flat. Corals in particular increase substantially in abundance, size of colony and diversity of species in these depressions in the seaward portion of the outer reef flat. In fact, although some small encrusting corals may be present, no corals were actually observed growing on the emergent portion of the outer reef flat during either of the two field trips to the area. In addition, although fish were scattered throughout the zone during high tide, they were limited to the depressions during low tide.

B. Survey Method

Two half-day field trips were made to the project site. All coral, fish, algae and macroinvertebrate species were identified and relative abundance noted on an underwater notepad. Algae species that could not be identified in the field were brought back to the laboratory and identified. Difficult species were identified with the help of Roy Tsuda, PhD.

C. Results

1. Algae

Sixteen species of algae were observed on the reef flat fronting Gun Beach (Table 3 in Appendix). Twelve species were observed on the inner reef flat and sixteen were observed on the outer reef flat. The most abundant species in both areas were unidentified diatoms and foraminiferans (which also make up a portion of the beach sand). Cladophora fascicularis, Hydrolithon reinboldii, Jania capillaceae and Peysonellia rubra were also common in both areas. Valonia aegagropila, a fleshy green algae, was abundant in some of the larger depressions on the outer reef flat.

Both surveys were conducted during the wet season in September 1992. Because the abundance and diversity of algae changes seasonally, a more complete baseline relative to algae would include surveys spanning different seasons.

2. Corals

A total of 18 coral species were observed at the project site (Table 4 in Appendix). Because coral abundance and diversity were appreciably higher in the seaward portion of the channel near Bijia Point (Figure 2) as well as in the seaward portion of the outer reef flat, the two physiographic zones (inner and outer reef flat) were subdivided into four coral subzones. For the purposes of this report, the inner reef flat is divided into: Subzone A - the inner reef flat which includes the cable channel and the nearshore portions of the channel near Bijia Point; and Subzone B - the seaward portion of the channel near Bijia Point. The outer reef flat is divided into: Subzone C - the nearshore portion of the outer reef flat; and Subzone D - the seaward portion of the outer reef flat.

Subzones B and D contain the highest diversity of corals at the project site. These two subzones each contain 12 coral species, while Subzones A and C contain 7 and 10 coral species, respectively. Subzones B and D also contained the largest colonies as well as the greatest overall quantity of corals. Both of these subzones are located close to the reef margin where coral diversity and quantity typically increase. Even during low tides, waves wash across this area which keeps corals submerged in cool water and increases the availability of oxygen and food.

Psammocora obtusangulata is the most abundant coral throughout the inner and outer reef flat zones. It also forms some of the largest colonies, particularly in Subzones A, B and C. Porites lutea also forms large colonies in subzones B and D. Leptastrea purpurea is a small (generally less than two inches in diameter) encrusting species observed in all subzones and common in Subzones A and B.

3. Macroinvertebrates

A list of macroinvertebrate species is compiled in Table 5 in the Appendix. Six species of sea cucumbers were observed on the inner reef flat while five species were observed on the outer reef flat. The most common species on the inner reef flat was Holothuria leucospilota and, in localized areas, Stichopus chloronotus. On the outer reef flat, Actinopyga echinites was the most common species though A. mauritiana was common on the seaward portion of the outer reef flat (Subzone D).

Sea urchins were generally uncommon in both reef zones as was the only starfish species observed, Linckia laevigata. During low tide, two unidentified brittle star species were abundant throughout the emergent portions of the outer reef flat. Cyprea moneta (money cowry) and an unidentified small mussel were also common throughout the outer reef flat.

4. Fish

A total of 42 species were observed on the reef flat (Table 6 in Appendix). Thirty nine were observed in the inner reef flat and 27 in the outer reef flat. Two species were

abundant in schools, Mulloides flavolineatus (goatfish) and Siganus spinus (rabbitfish). Three other species were abundant primarily on the outer reef flat during high tide: Chrysiptera glauca; Halichoeres trimaculatus; and Rhinecanthus triostegus. The most abundant species overall were wrasses (at least ten species) and damselfish (seven species).

In general, fish are abundant throughout the reef flat during high tide but are limited to the depressions in the outer reef flat and the inner reef flat zone during low tide. The greatest abundance of fish were observed in the channel near Bijia point during low as well as high tide.

D. Endangered Species

No threatened or endangered species were observed on the reef flat fronting Gun Beach. In the past, sea turtles (Chelonia mydas and Eretmochelys imbricata) have been known to swim outside the reef just north of Tumon Bay; however, no turtle nests have been observed in the vicinity (Gerald Davis, unpublished report).

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APPENDIX

TABLES

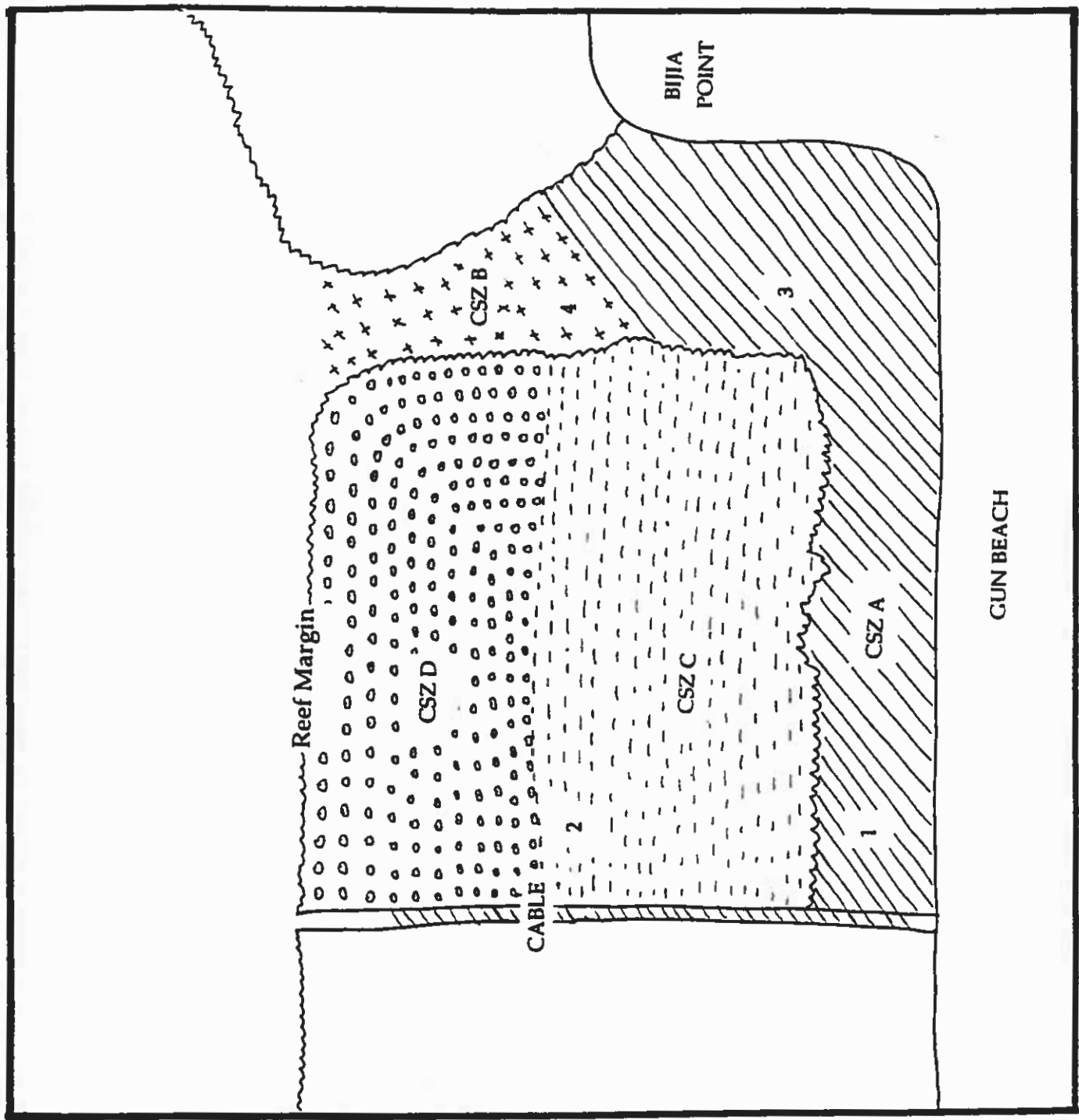


Figure 2. Diagram of project area showing coral subzones and water monitoring stations. CSZ refers to coral subzones. Water monitoring stations are labeled 1, 2, 3 and 4.

Table 1. Water quality measurements on the reef flat fronting Gun Beach. Samples were taken from four stations on two dates in September, 1992. Samples were tested for turbidity (NTU) and suspended solids (mg/l). See Figure 2 for location of stations.

STATION	TIDE	TURBIDITY (NTU)	SUSPENDED SOLIDS (mg/l)
9/24/92			
1	Low incoming	1.90	2.4
2	Low incoming	1.62	8.5
3	Low incoming	12.50	18.5
4	Low incoming	4.25	8.6
9/29/92			
1	High outgoing	1.39	5.4
2	High outgoing	1.56	8.6
3	High outgoing	1.14	8.4
4	High outgoing	1.31	18.2

Table 2. Current velocity and direction on the reef flat fronting Gun Beach. See Figure 2 for location of stations. The tide was low incoming on 9/24/92 and high outgoing on 9/29/92.

STATION	DATE/TIME	DIRECTION (Degrees)	VELOCITY (m/s)
1	9/24/92 3:21	220	.07
1	9/24/92 3:26	200	.13
1	9/24/92 3:28	190	.07
2	9/24/92 3:32	270	.07
2	9/24/92 3:35	120	.07
2	9/24/92 3:37	190	.10
3	9/24/92 3:50	070	.03
3	9/24/92 3:53	120	.03
3	9/24/92 3:59	*	*
3	9/24/92 4:04	130	.04
4	9/24/92 3:42	170	.05
4	9/24/92 3:45	150	.04
4	9/24/92 3:48	230	.05
1	9/29/92 11:45	*	*
1	9/29/92 11:50	330	.04
1	9/29/92 11:55	210	.02
2	9/29/92 12:00	060	.04
2	9/29/92 12:04	*	*
2	9/29/92 12:07	280	.10
3	9/29/92 12:13	090	.17
3	9/29/92 12:14	090	.19
3	9/29/92 12:15	090	.14
4	9/29/92 12:20	270	.08
4	9/29/92 12:22	*	*
4	9/29/92 12:24	290	.03

* current too slow or meandering for accurate measurement.

Table 3. Relative abundance of algae on the reef flat fronting Gun Beach. See Figure 1 for location of physiographic reef zones 1 and 2.

ZONE 1 = Inner reef flat

ZONE 2 = Outer reef flat

RELATIVE ABUNDANCE

A = Abundant

C = Common

U = Uncommon

R = Rare

SPECIES	ZONE 1	ZONE 2
<u>Boodlea composita</u>	U	A
<u>Chlorodesmis fastigiata</u>	R	R
<u>Cladophora fascicularis</u>	A	C
Foraminiferan tests	A	A
<u>Galaxaura marginata</u>		U
<u>Gelidiella acerosis</u>	U	C
<u>Gelidiopsis intricata</u>	U	C
<u>Hydrolithon reinboldii</u>	C	C
<u>Jania capillacea</u>	C	A
<u>Mastophora</u> sp.		C
<u>Neogonidithon frutescens</u>		U
<u>Peysonellia rubra</u>	C	C
<u>Porolithon onkodes</u>	U	C
<u>Valonia aegagropila</u>	R	C
Unidentified blue-green algae		A

Table 4. Relative abundance of corals on the reef flat fronting Gun Beach. See Figure 1 for location of physiographic reef Zones 1 and 2 and Figure 2 for coral Subzones A, B, C, and D.

ZONE 1 = INNER REEF FLAT

A = Inner reef flat including the cable and nearshore channel areas.

B = Outer portion of the channel.

ZONE 2 = OUTER REEF FLAT

C = Emergent (nearshore portion) of outer reef flat.

D = Seaward portion of the outer reef flat.

RELATIVE ABUNDANCE

A = Abundant

C = Common

U = Uncommon

R = Rare

CORAL SPECIES	CORAL ZONES			
	A	B	C	D
<u>Acropora nasuta</u>		R		U
<u>A. surculosa</u>				U
<u>A. tenuis</u>				C
<u>A. species (purple)</u>	R		R	
<u>Goniastrea retiformis</u>	R	R	R	R
<u>Heliopora coerulea</u>				R
<u>Leptastrea purpurea</u>	C	C	R	R
<u>Pavona decussata</u>		R	R	
<u>P. divaricata</u>		R		
<u>Pocillopora damicornis</u>	R	C		
<u>P. danae</u>		R	R	C
<u>P. verrucosa</u>			R	C
<u>Porites anae</u>	R			
<u>P. australiensis</u>		U	U	
<u>P. cylindrica</u>		R		R

Table 4 continued.

CORAL SPECIES	CORAL ZONES			
	A	B	C	D
<u>P. lutea</u>		C	U	C
<u>P. rus</u>	C	U	R	R
<u>Psammocora obtusangulata</u>	C	C	U	A

Total Species per coral subzone

7

12

10

12

Total Species per reef zone

14

15

Total Species overall

18

Table 5. Relative abundance of macroinvertebrates on the reef flat fronting Gun Beach.
See Figure 1 for location of physiographic reef zones.

ZONE 1 = Inner reef flat
ZONE 2 = Outer reef flat

RELATIVE ABUNDANCE

A = Abundant
C = Common
U = Uncommon
R = Rare

SPECIES	ZONE 1	ZONE 2
SEA CUCUMBERS <u>Actinopyga echinites</u> <u>A. mauritiana</u> <u>Bohadschia argus</u> <u>Holothuria atra</u> <u>H. leucospilota</u> <u>Stichopus chloronotus</u> <u>Synapta maculata</u>	U R* U A C R	C C** R U R
SEA URCHINS <u>Echinothrix diadema</u> <u>Echinothrix mathaei</u> SEA STARS <u>Linckia laevigata</u> BRITTLE STARS Unidentified brown species Unidentified striped species	R* U* R*	U U A C
MISCELLANEOUS Yellow sponge Gray sponge <u>Palythoa tuberculosa</u> <u>Cyprea moneta</u> Unidentified small mussel	U	U U** C C

Note: * Species observed in channel only.
** Species observed only in seaward portion of outer reef flat.

Table 6. Relative abundance of fish observed on the reef flat fronting Gun Beach. See Figure 1 for location of physiographic reef zones.

Relative Abundance

A = Abundant
A/S = Abundant in School
C = Common
U = Uncommon

SCIENTIFIC NAME	INNER REEF FLAT ZONE	OUTER REEF FLAT ZONE
SYNODONTIDAE (Lizardfishes) <u>Synodus</u> sp.	U	
BELONIDAE (Needlefishes) <u>Strongylura incisa</u>	U	
FISTULARIIDAE (Cornetfishes) <u>Fistularia commersonii</u>	U	
SERRANIDAE (Groupers) <u>Epinephelus merra</u>	U	U
APOGONIDAE (Cardinalfishes) <u>Apogon novemfasciatus</u>	C	U
NEMIPTERIDAE (Breams) <u>Scolopsis lineatus</u>	C	C
MULLIDAE (Goatfishes) <u>Mulloides flavolineatus</u>	A/S	U
<u>Parupeneus barberinus</u>	C	
<u>P. multifasciatus</u>	U	C

Table 6 continued.

SCIENTIFIC NAME	INNER REEF FLAT ZONE	OUTER REEF FLAT ZONE
CHAETODONTIDAE (Butterflyfishes)		
<u>Chaetodon auriga</u>	U	C
<u>C. citrinellus</u>	C	U
<u>C. lunula</u>	C	
POMACENTRIDAE (Damselfishes)		
<u>Abudefduf septemfasciatus</u>	C	U
<u>Chrysiptera leucopoma</u>	U	
<u>C. glauca</u>	C	A
<u>Dascyllus aruanus</u>	U	
<u>Pomacentrus pavo</u>		U
<u>Stegastes albifasciatus</u>	C	C
<u>Stegastes sp.</u>	C	C
LABRIDAE (Wrasses)		
<u>Cheilinus undulatus</u>	U	
<u>Cheilio inermis</u>	U	
<u>Coris variegata</u>	U	U
<u>Halichoeres hortulans</u>	U	U
<u>H. trimaculatus</u>	A	A
<u>Hemigymnus melapterus</u>	U	U
<u>Macropharyngodon meleagris</u>	U	
<u>Stethojulis bandanensis</u>	U	U
<u>Thalassoma hardwickii</u>	U	U
Unidentified wrasse	U	
SCARIDAE (Parrotfishes)		
<u>Scarus sordidus</u>	U	C
<u>Scarus sp.</u>	U	U
BLENNEIDAE (Blennies)		
<u>Istiblennius sp.</u>		C

Table 6 continued.

SCIENTIFIC NAME	INNER REEF FLAT ZONE	OUTER REEF FLAT ZONE
<u>Salarias fasciatus</u>	C	U
GOBIIDAE (Gobies) Unidentified goby		U
ACANTHURIDAE (Surgeonfishes)		
<u>Acanthurus triostegus</u>	C	A
<u>Naso literatus</u>	U	
ZACLIDAE (Moorish Idol) <u>Zanclus cornutus</u>	C	C
SIGNAIDAE (Rabbitfish) <u>Siganus spinus</u>	A/S	A/S
BALISTIDAE (Triggerfishes) <u>Rhinecanthus aculeatus</u>	C	U
TETRAODONTIDAE (Puffers)		
<u>Arothron hispidus</u>	U	
<u>A. nigropunctatus</u>	U	
<u>Canthigaster solandri</u>	U	
Total Species per Zone	39	27
Total Species Overall		42

APPENDIX D
Coral Communities, Macroinvertebrates,
and Bottom Cover on
Fore Reef At Gun Beach

CORAL COMMUNITIES, MACROINVERTEBRATES AND BOTTOM COVER ON THE FORE REEF AT GUN BEACH

by

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INTRODUCTION

The coastal area at Gun Beach is comprised of a sandy beach front and a 100m+ wide, low intertidal to shallow subtidal reef flat that is dominated by a lightly dissected reef pavement, and is largely devoid of loose sediments. The reef flat lacks a well developed reef crest and gives way to the fore reef in a zone with poorly developed spur and groove. On the basis of geomorphology and coral communities, the fore reef can be divided into 3 major zones: 1) a shallow reef front, to a depth of 2-4 m, 2) a relatively flat, even reef terrace between 3-15m, and 3) a steeper deep reef slope starting around 15 m depth and continuing to considerably greater depths. These three zones were surveyed in the vicinity of the AT&T cable, to provide baseline data on the reef and marine communities of the area.

METHODS

The coral community of the Gun Beach fore reef varies both across as well as along isobaths. The most significant patchiness along isobaths is the occurrence of locally high coral cover in areas dominated by *Porites rus*. The location and extent of these *Porites rus* communities were mapped by towing an observer behind the boat along the 4m, 8m, 12m, and 16m isobaths, with the margins of these communities marked by buoys, and mapped by triangulation.

Quantitative surveys of the reef communities were made at three sites. At each site, surveys were carried out along single 50 m long transect lines laid along each of three depth contours: 2m, 8m, and 16m. The resulting 9 areas sampled are identified as "locations" below. The three sites were located as follows: Site 1) near field: transect extending 20-70 m north of the AT & T cable path; Site 2) far field: transect extending 50-100 m south of the AT & T cable path; and Site 3) control: transect extending ca. 375-425 m south of the AT & T cable path (Figure 1).

Along each transect, coral cover, species composition, diversity and colony size distribution were measured using the point-quarter method, by determining the identity and size of the coral colonies encountered at each of 64 (16X4) points (cf. Birkeland & Lucas, 1990). Bottom cover was measured using 10 replicate 0.25 m² stringed quadrats, placed along the transect line at 5 m intervals, by recording cover under each of the 16 string intercepts. Macroinvertebrate abundance was measured along a 50 X 2 m belt transect, by counting all larger (> 5 cm) invertebrates (mostly echinoderms) encountered in the open as well as in crevices and under overhangs (cf. Amesbury et al. 1993 for methods). These surveys, with the exception of fish diversity count reported separately, were designed to evaluate community structure and composition by quantitatively determining the abundance of dominant species; they were not designed for enumerating the total diversity of the fauna.

RESULTS

Bottom cover and corals

The whole of the fore reef is dominated by hard substrata, with sand and rubble constituting < 5% cover at all but one location (Site 2, 16m: 9%) (Figure 2). Turf algae, coralline algae, corals, and sponges (mostly the "coral killer sponge", *Terpios hoshinota*) dominate cover, their relative abundance apparently dependent mostly on 1) depth and 2) location of extensive *Porites rus* stands.

As revealed by the tow surveys, *Porites rus* is generally common along the seaward edge of the terrace, at least for several hundred meters both north and south of the AT & T cable path. All three 16 m locations fell in zones of moderate to great *P. rus* abundance (Figure 3). *Porites rus* dominated reefs extend onto the terrace in a large patch starting ca. 20 m to the south of the cable path and continuing for considerable distance to the south (Figure 1). The 8 m transects at sites 2 and 3 were in these communities, and the shallowest transect at Site 3 also had moderate *P. rus* cover (Figure 3). The boundaries of this *P. rus* community (Figure 1) are abrupt at some locations, but more gradual and thus subjective at others.

The three shallow locations are similarly dominated by turf algae, with coralline algae abundant (28-34%), coral cover moderate (6-17%), and sponges rare (<2%). The dominant coral species vary somewhat among the three sites (Figure 3, 4, Table 1), although *Galaxea fascicularis*, *Goniastrea retiformis*, *Leptoria phrygia*, and *Stylocoeniella armata* are common at all. *Acropora* was rare even at this depth, although several *Acropora* species are abundant on the shallowest reef front (< 1m). Coral colony size is generally small at 2 m (Figure 5).

At 8 m there is considerably variation among sites, due mainly to the presence of extensive *Porites rus* stands at site 3, and, especially, at site 2. In these stands, corals (largely *Porites rus*, Figure 3) (33-51%), and sponges (largely *Terpios hoshinota*, Table 2) (24-30%) dominate cover. At Site 1, turf algae dominate and two species, *Leptastrea purpurea* and *Porites lobata*, contribute over two thirds of the 15% coral cover (Figures 2, 3, 4). The considerable abundance of large corals at sites 2 and 3, but not 1 (Figure 5) is due to the abundance of large (0.5-2.5 m) *P. rus* colonies.

The deepest (16 m) locations were all situated at the start of the deep reef slope, past the seaward margin of the terrace. *Porites rus* is common in this area along the entire shoreline towed, but does not usually reach as high cover as it does in the areas of the reef terrace that it dominates. Bottom cover is dominated by algae (36-71%), with corals forming moderate cover (13-20%). At sites 1 and 2 *Porites rus* dominated (96-97% of total coral cover) (Figure 3), and sponges (mostly *Terpios hoshinota*, Table 2) were also abundant (31-33% bottom cover) (Figure 2). There is a strong correlation between the abundance of *P. rus* and sponges among the nine locations (Figure 6). *Leptastrea purpurea* and several *Porites* species were among the most common other corals at all three deep sites (Figures 3, 4, Table 1). The abundance of large *P. rus* is quite evident in the colony size data from sites 1 and 2 (Figure 5).

Between 9 and 22 species of coral were encountered per transect (64 points), yielding a total of 49 species among the 576 points surveyed (Tables 1, 3). The shallowest locations tended to have

the greatest species richness (Figure 7), although this may be due in part to the relative rarity of *P. rus* there, a coral which dominated many of the deeper sites.

Macroinvertebrate abundance

A total of 26 macroinvertebrate (> 5 cm) species were encountered within the 900 m² surveyed. Of these, the holothurians *Actinopyga mauritiana*, *Stichopus chloronotus*, and the echinoids *Echinometra mathaei* (species complex), *Echinostrephus aciculatus* *Echinothrix diadema* occurred most commonly (> 0.1 m⁻² population densities at least at one location; Table 4, Figures 8-13).

Actinopyga mauritiana is a characteristic inhabitants of reef fronts and occurred at a population density of 0.22-0.34 m⁻² at the three shallowest locations; it was absent in the transects at all deeper locations (Figure 8). All the other common species preferred the shallowest locations also (Figures 9-12). In contrast the economically important holothurian *Holothuria nobilis* was encountered only within the deepest transects (Figure 13).

DISCUSSION AND CONCLUSIONS

Much of the outer reef at Gun Beach is fairly typical for Guam, with low to moderate coral cover, typical depth related coral zonation, and common echinoids and holothurians. The presence of extensive stands of *Porites rus* in such a fore reef setting, with correspondingly high coral cover is less widespread. On Guam, such dense *P. rus* stands are usually encountered in more protected, inner reef environments, such as Apra Harbor and the Piti Bombholes, although they also occur at some fore reef sites. In contrast to surrounding coral communities, *P. rus* stands are less diverse in their coral fauna, perhaps because 1) this coral excludes others by its high cover, and 2) because of the correlated high abundance of the sponge *Terpios hoshinota*, which can rapidly overgrow and kill corals (Figure 6, Plucer-Rosario, 1988; Rützler & Muzik, 1993). *Porites rus* however contributes considerably to the topographic relief of the reef, as it makes colonies several meters high with abundant crevices. This allows for the development of a rich invertebrate cryptofauna observable on night dives in this area. Fish abundance also may be correlated with this topographic complexity, and the highest fish abundance was observed at Site 2, also the area of the most extensive *P. rus* stands (see Amesbury, below).

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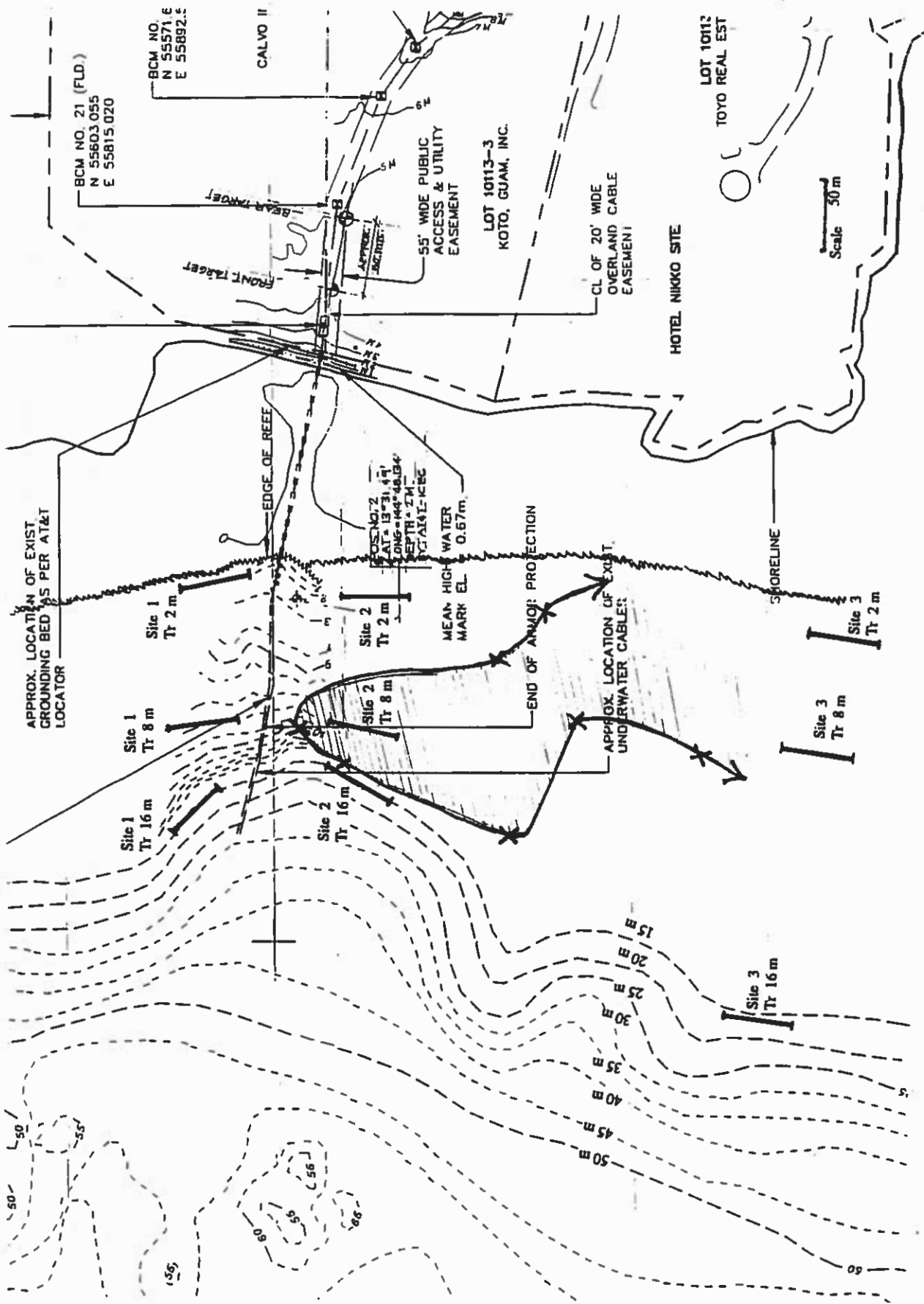


Figure 1 - Map of Gun Beach fore reef, locations of 9 transects and approximate extent of large reef terrace *Porites rus* stand hatched. Additional *Porites rus* communities line the reef slope along the entire area.

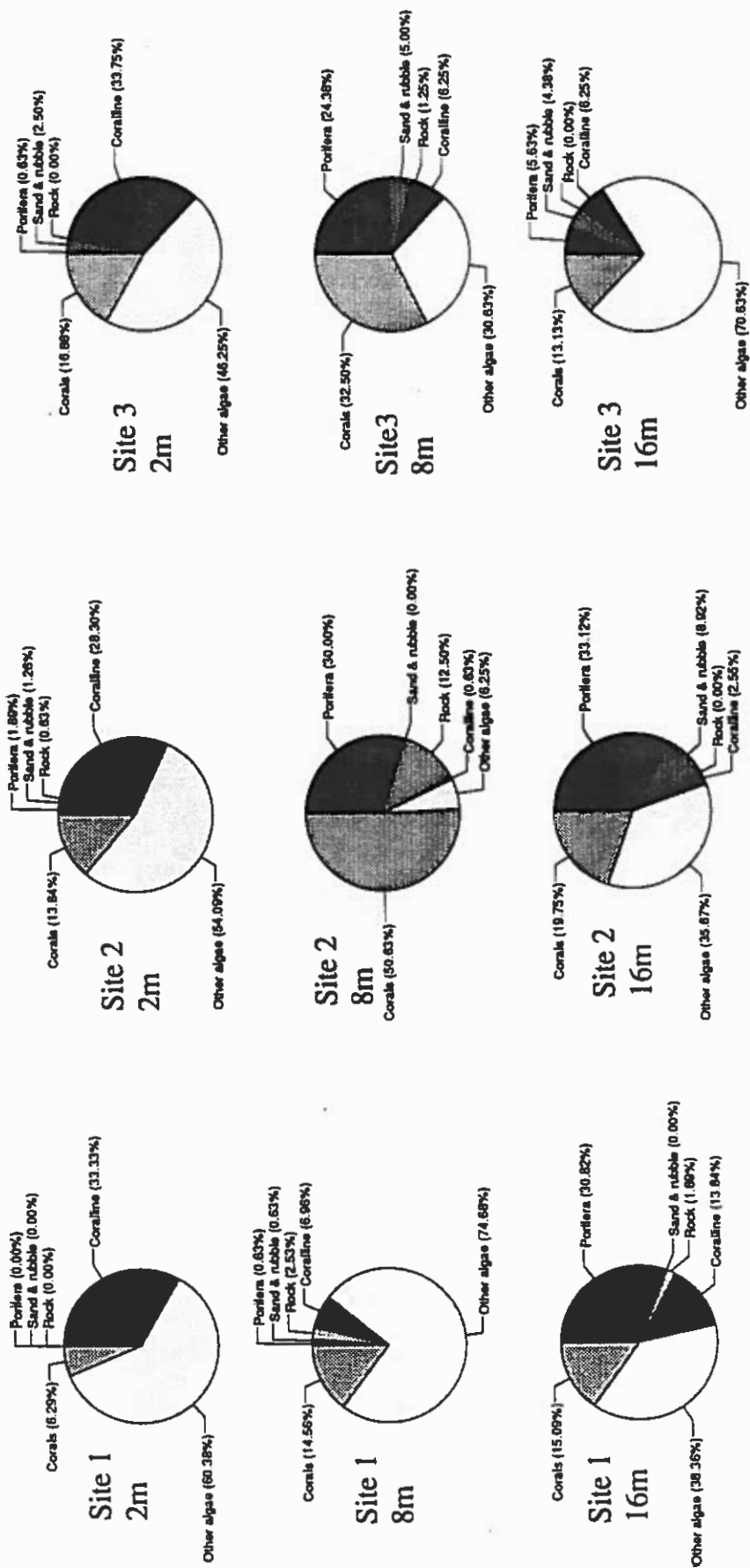


Figure 2 - Bottom cover at 9 locations based on quadrat surveys. "Other algae" include all but corallines; Porifera (sponges), mostly of *Terpios hoshinota*. See Table 2 for detailed data.

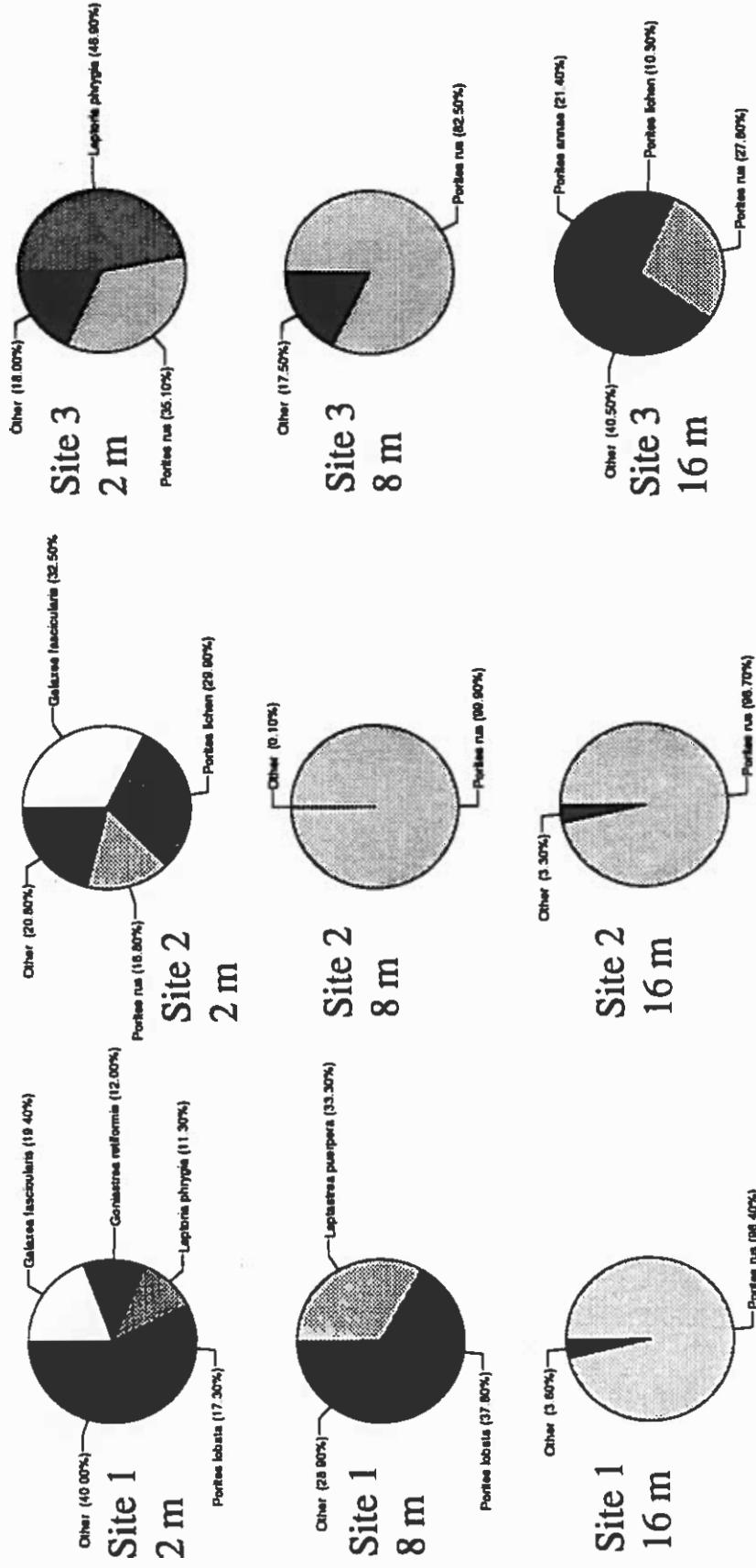


Figure 3 - Species specific coral cover based on point quarter survey. Only species that contribute > 10 % to the total coral cover identified. See Table 1 for detailed data.

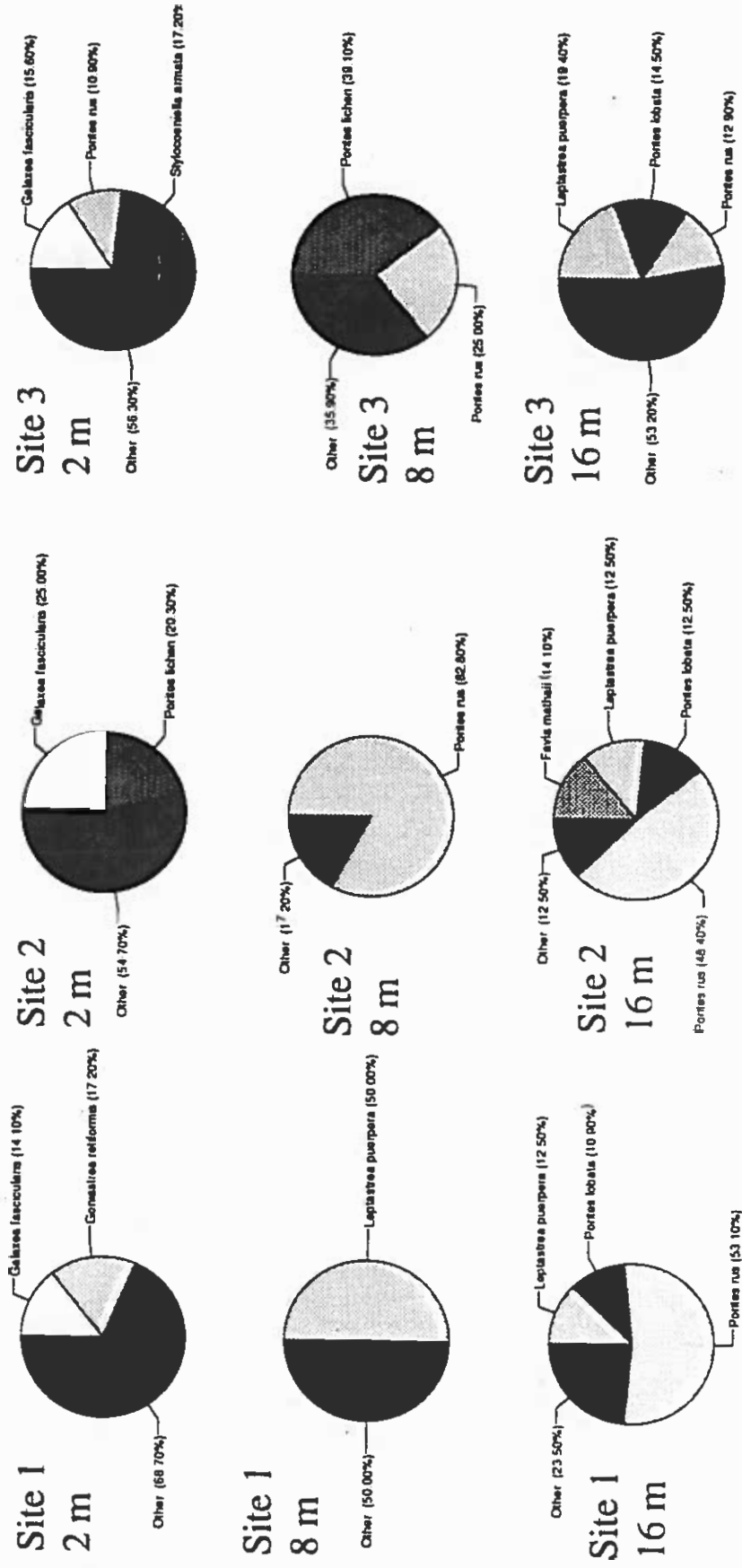


Figure 4 - Species specific coral abundance based on point quarter survey. Only species that contribute > 10 % of colonies surveys identified. See Table 1 for detailed data.

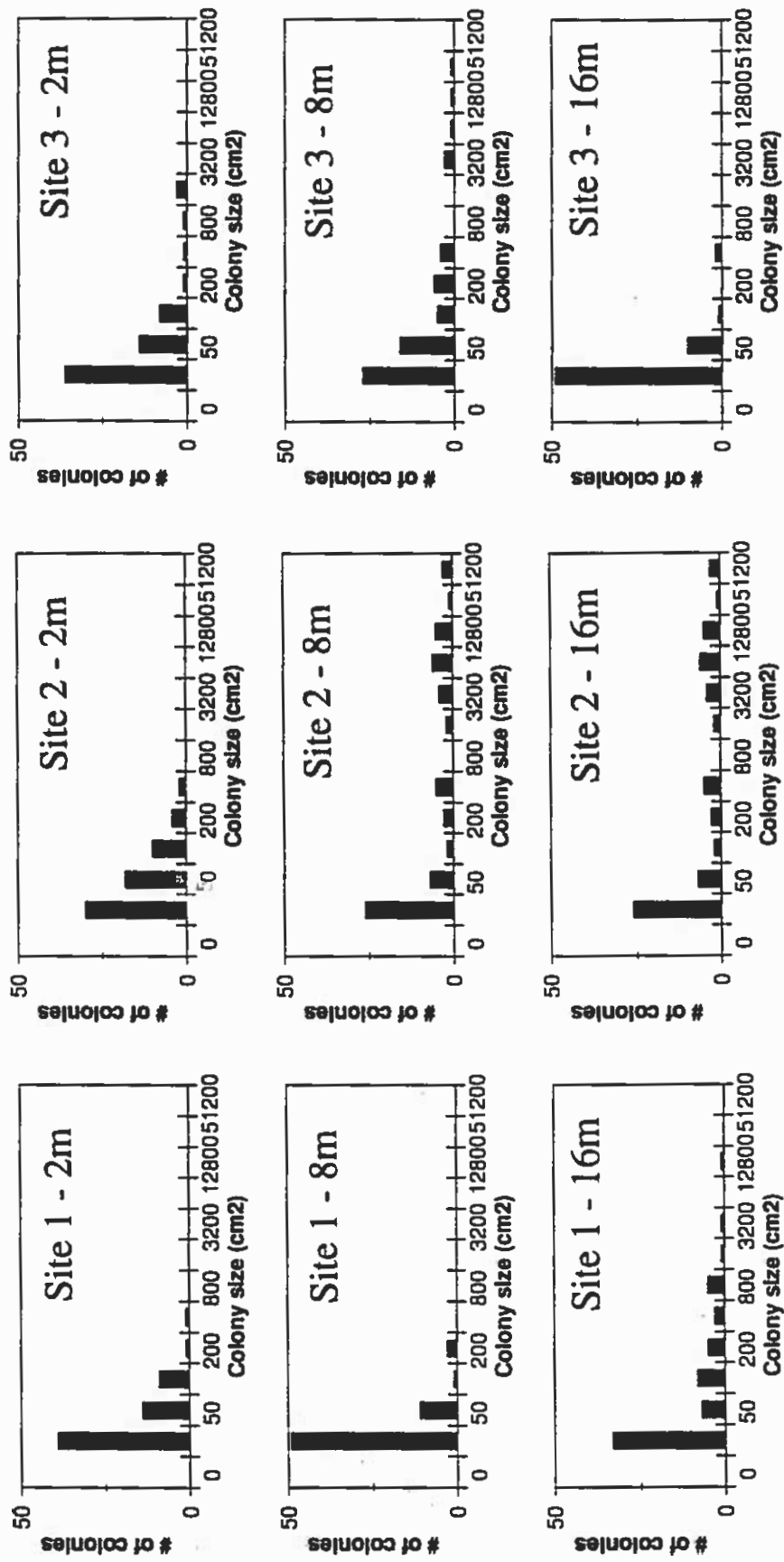


Figure 5 - Size distribution of coral colonies based on point quarter survey.

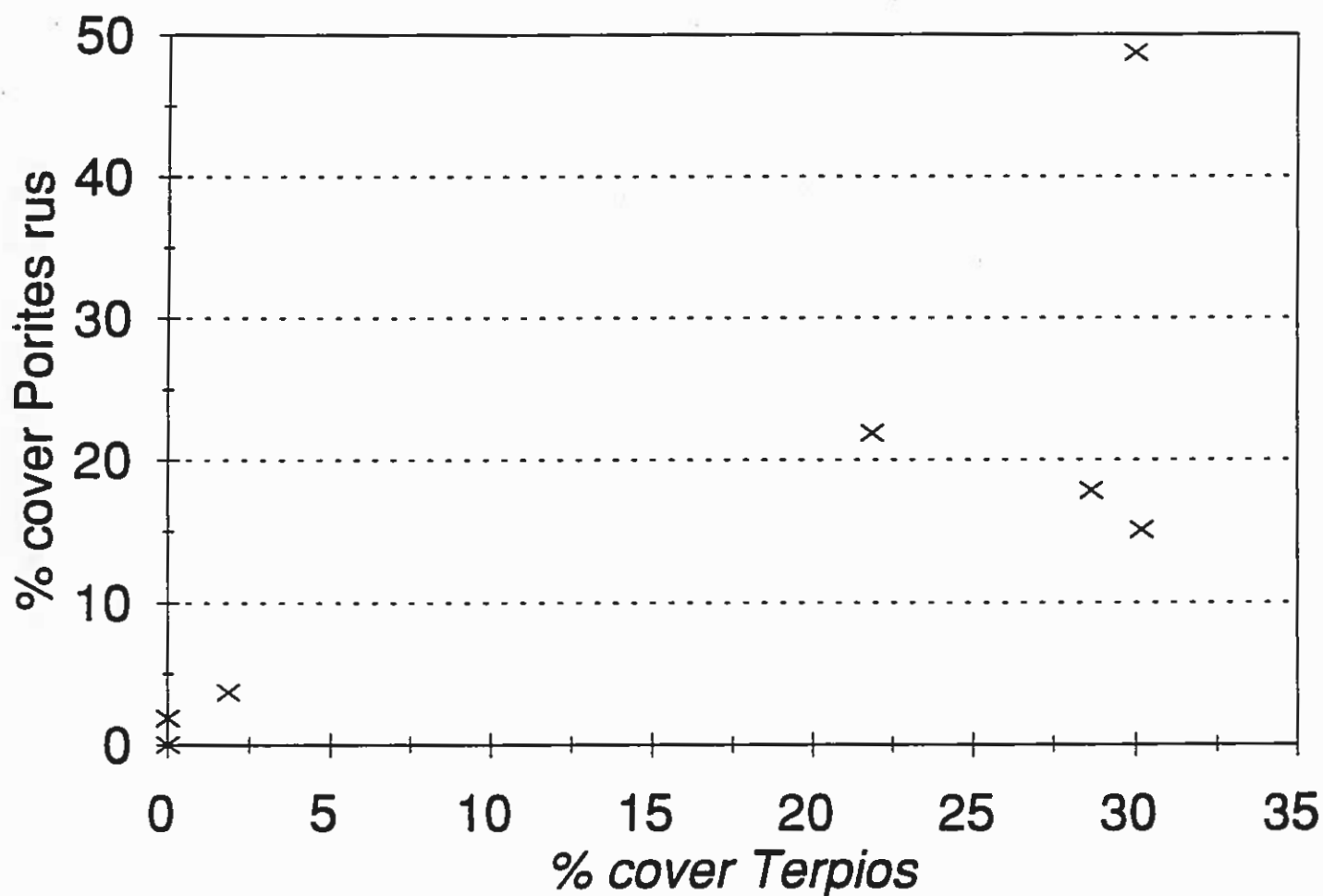


Figure 6 - Regression between the abundance of *Porites rus* and *Terpios hoshinota* based on quadrat data for the 9 transects. The left-most two points include two transects each.

Coral species richness among 64 points surveyed

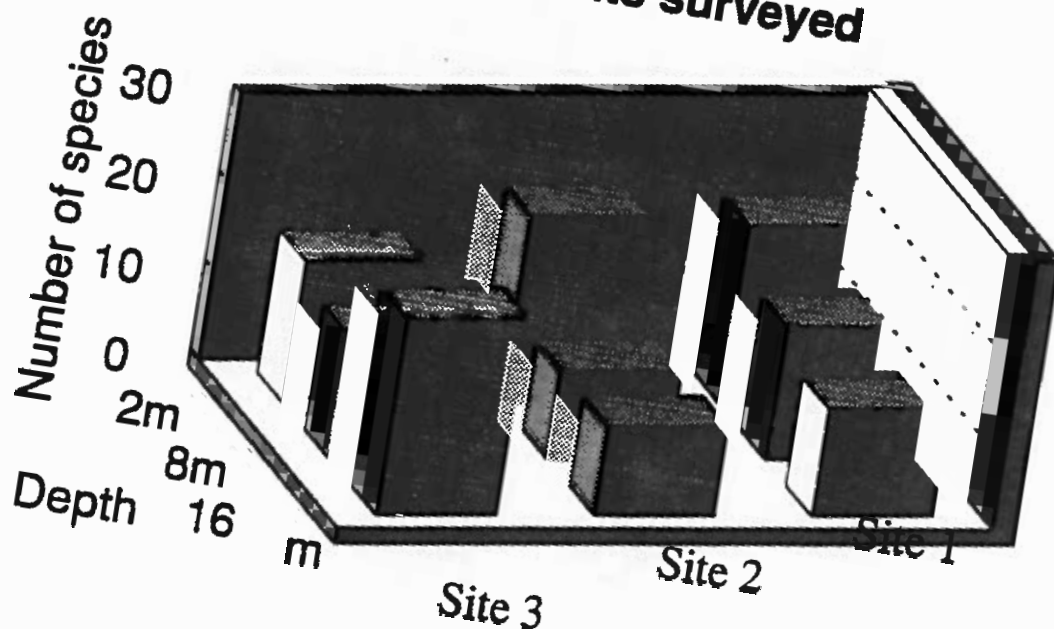


Figure 7 - Coral species richness based on point quarter survey.

Density of *Actinopyga mauritiana*

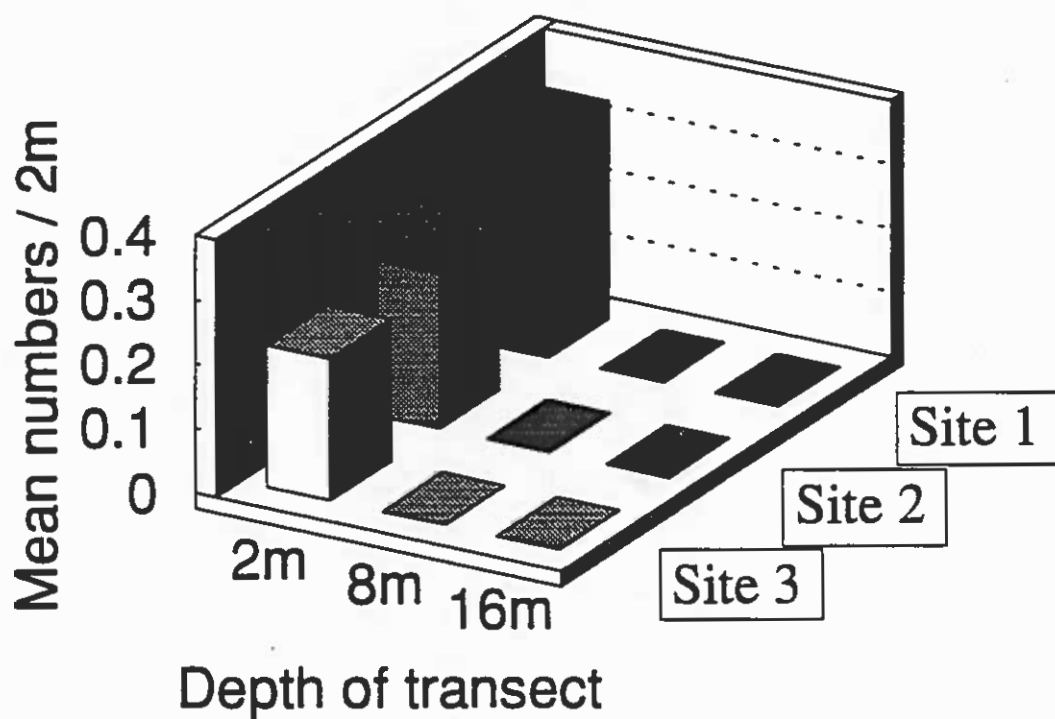


Figure - 8 - Population density of holothurian *Actinopyga mauritiana* based on 100 m² area surveyed.

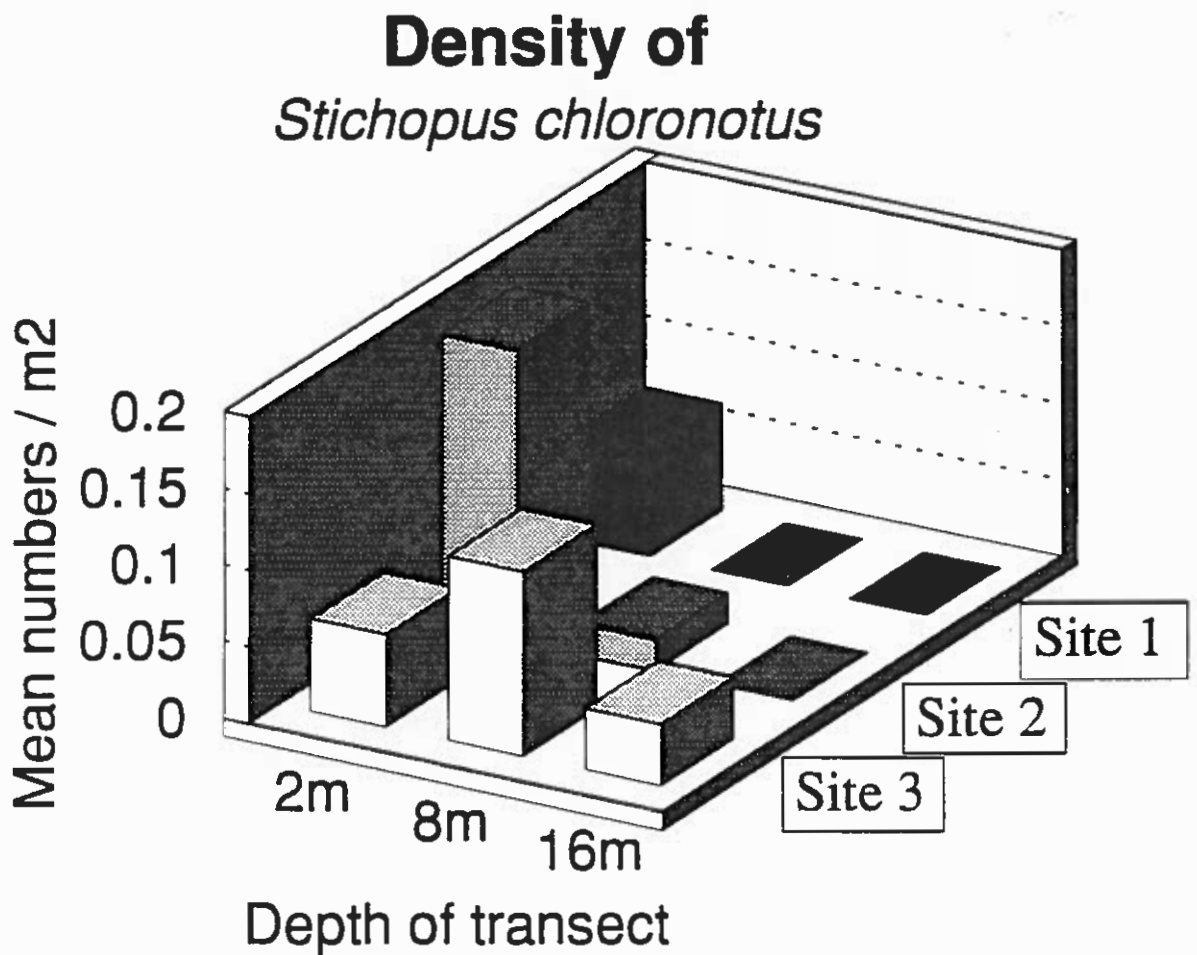


Figure - 9 - Population density of holothurian *Stichopus chloronotus* based on 100 m² area surveyed.

Density of *Echinometra mathaei*

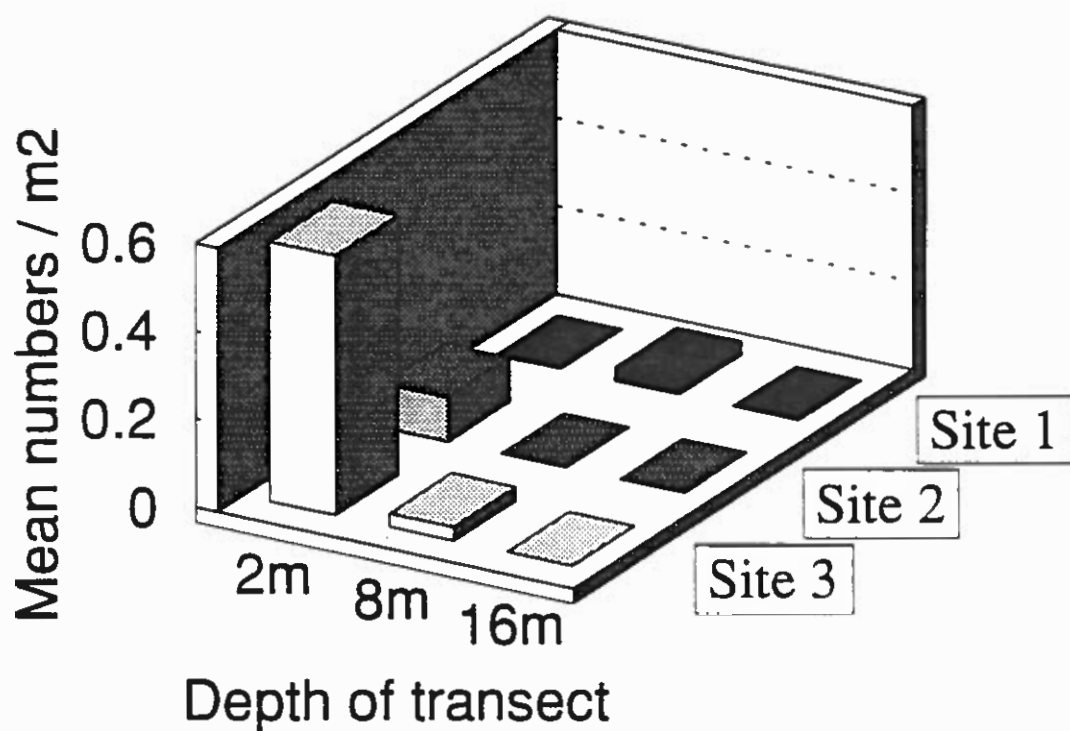


Figure - 10 - Population density of echinoid *Echinometra mathaei* (species complex) based on 100 m² area surveyed.

Density of *Echinothrix diadema*

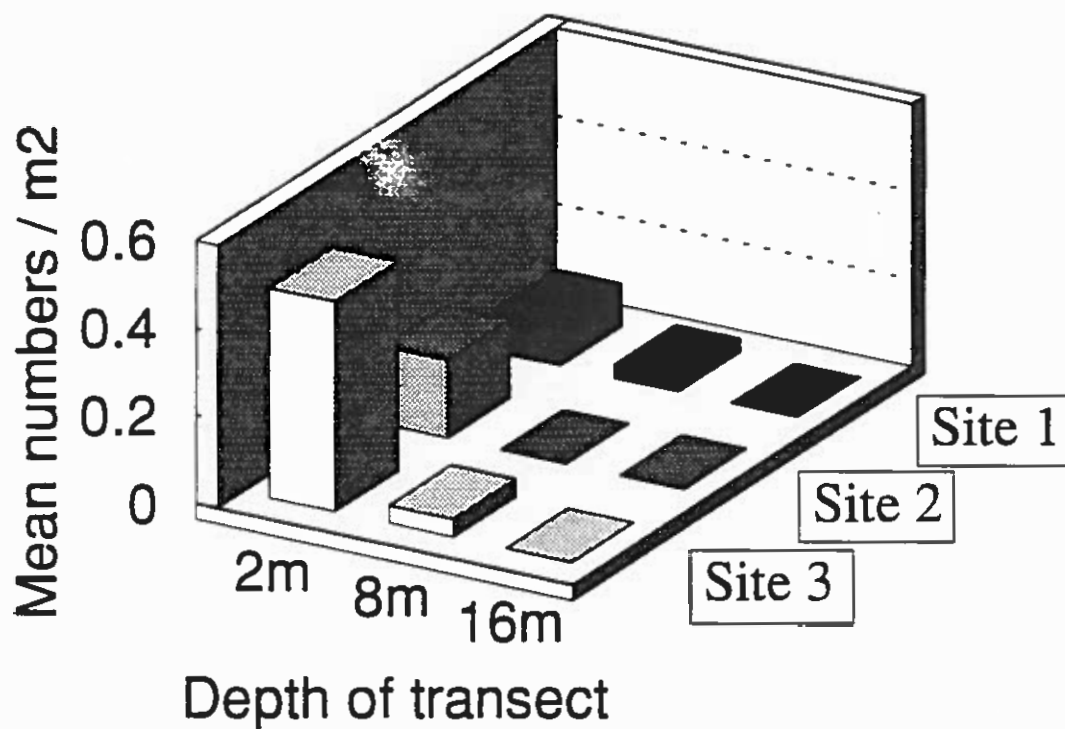


Figure - 11 - Population density of echinoid *Echinothrix diadema* based on 100 m² area surveyed.

Density of *Echinostrephus aciculatus*

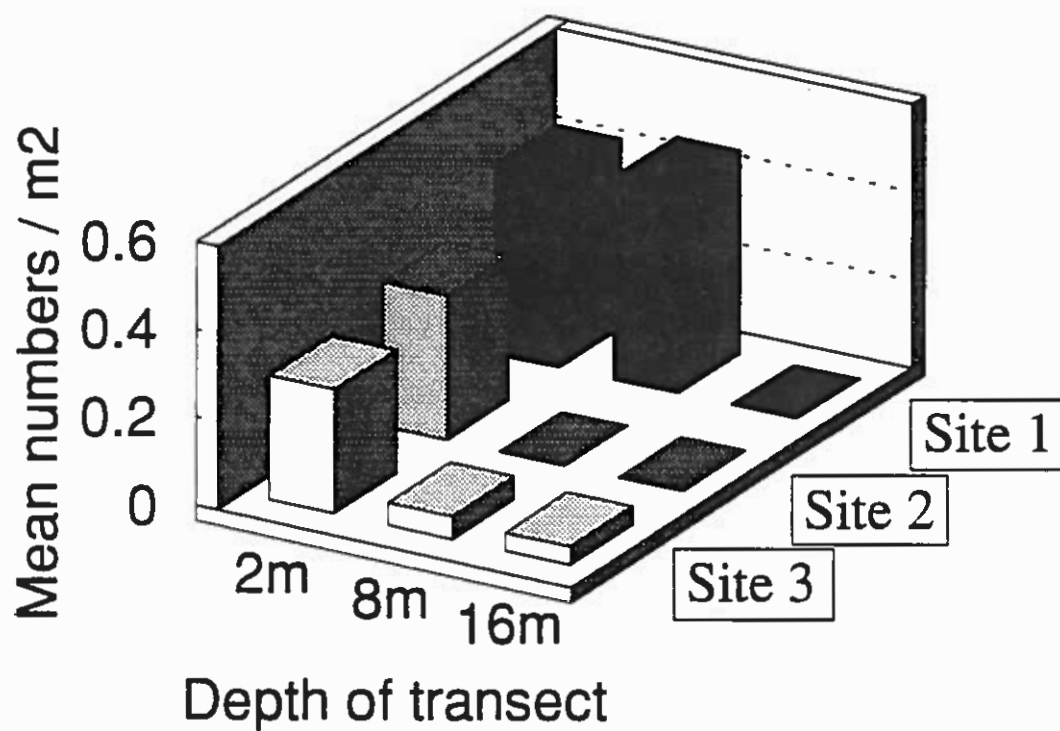


Figure - 12 - Population density of echinoid *Echinostrephus aciculatus* based on 100 m² area surveyed.

Density of *Holothuria nobilis*

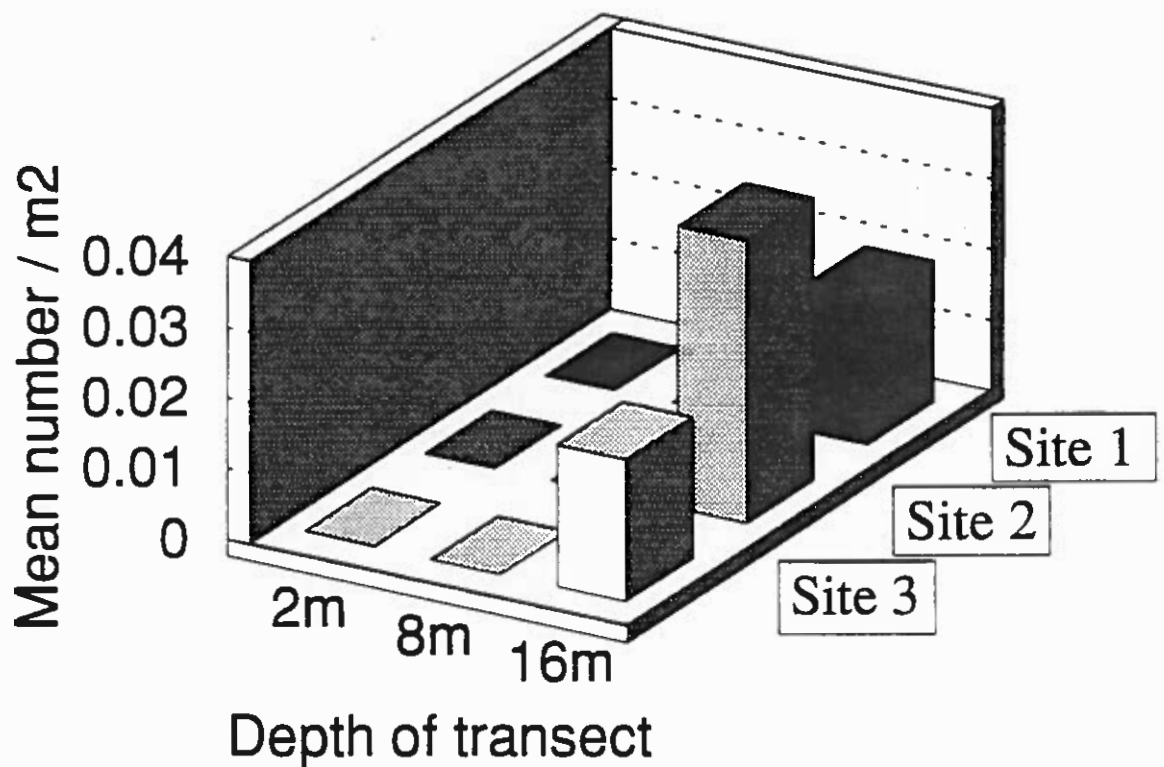


Figure - 13 - Population density of holothurian *Holothuria nobilis* based on 100 m² area surveyed.

Table 1 - Species specific coral colony size, cover, and abundance based on point quarter survey.

Date	Site	Depth	Species	Total area occupied (cm ²)	Number of colonies	Mean colony area (cm ²)
11.14.94	1	2m	<i>Acanthastrea echinata</i>	22	1	22
11.14.94	1	2m	<i>Acropora humilis</i>	8.2	1	8.2
11.14.94	1	2m	<i>Favia mathail</i>	31.0223125	3	10.341
11.14.94	1	2m	<i>Favia stelligera</i>	124.874625	4	31.219
11.14.94	1	2m	<i>Galaxea fascicularis</i>	323.9671875	9	35.996
11.14.94	1	2m	<i>Goniastrea retiformis</i>	200.6633125	11	18.242
11.14.94	1	2m	<i>Leptastrea puerpera</i>	17.47459375	2	8.7373
11.14.94	1	2m	<i>Leptastrea transversa</i>	3.9	1	3.9
11.14.94	1	2m	<i>Leptoria phrygia</i>	188.0973125	5	37.619
11.14.94	1	2m	<i>Millepora platyphylla</i>	15.7	1	15.7
11.14.94	1	2m	<i>Pavona duerdeni</i>	92.67425	4	23.169
11.14.94	1	2m	<i>Platygyra pini</i>	51	1	51
11.14.94	1	2m	<i>Pocillopora sp(p).</i>	9.0318125	3	3.0106
11.14.94	1	2m	<i>Pocillopora meandrina</i>	6.3	1	6.3
11.14.94	1	2m	<i>Pocillopora verrucosa</i>	37.7	1	37.7
11.14.94	1	2m	<i>Porites lichen</i>	29.84425	3	9.9481
11.14.94	1	2m	<i>Porites lobata</i>	289.803375	2	144.9
11.14.94	1	2m	<i>Porites rus</i>	106	1	106
11.14.94	1	2m	<i>Psammocora contigua</i>	89.9254375	4	22.481
11.14.94	1	2m	<i>Stylocoeniella armata</i>	23.56125	6	3.9269
11.25.94	1	8 m	<i>Astreopora listeri</i>	40.8395	5	8.1679
11.25.94	1	8 m	<i>Astreopora sp.</i>	0.4	1	0.4
11.25.94	1	8 m	<i>Favia mathail</i>	21.205125	3	7.0684
11.25.94	1	8 m	<i>Goniastrea edwardsi</i>	48.10421875	2	24.052
11.25.94	1	8 m	<i>Leptastrea puerpera</i>	379.53246875	32	11.86
11.25.94	1	8 m	<i>Millepora tuberosa</i>	9.4	1	9.4
11.25.94	1	8 m	<i>Montipora grisea</i>	69.898375	3	23.299
11.25.94	1	8 m	<i>Montipora venosa</i>	12.6	1	12.6
11.25.94	1	8 m	<i>Pavona varians</i>	32.98575	2	16.493
11.25.94	1	8 m	<i>Pocillopora sp(p).</i>	1.2	1	1.2
11.25.94	1	8 m	<i>Porites lobata</i>	431.5635625	6	71.927
11.25.94	1	8 m	<i>Porites lutea</i>	75.396	3	25.132
11.25.94	1	8 m	<i>Porites rus</i>	9.4	1	9.4
11.25.94	1	8 m	<i>Porites sp(p).</i>	2.55246875	2	1.2762
11.25.94	1	8 m	<i>Psammocora contigua</i>	6.3	1	6.3
11.14.94	1	16m	<i>Acanthastrea echinata</i>	70.7	1	70.7
11.14.94	1	16m	<i>Favia mathail</i>	40.8395	3	13.613
11.14.94	1	16m	<i>Galaxea fascicularis</i>	40.8395	2	20.42
11.14.94	1	16m	<i>Goniastrea pectinata</i>	43.981	2	21.991
11.14.94	1	16m	<i>Heliopora coerulesa</i>	148.4	1	148.4
11.14.94	1	16m	<i>Leptastrea puerpera</i>	61.25925	8	7.6574
11.14.94	1	16m	<i>Pavona varians</i>	2.4	1	2.4
11.14.94	1	16m	<i>Pocillopora sp(p).</i>	7.1	1	7.1
11.14.94	1	16m	<i>Porites lobata</i>	236.397875	7	33.771
11.14.94	1	16m	<i>Porites rus</i>	20596.459375	34	605.78
11.14.94	1	16m	<i>Porites sp(p).</i>	120.94775	3	40.316
11.14.94	1	16m	<i>Stylocoeniella armata</i>	4.1	1	4.1

11.16.94	2 2m	<i>Favia matthaii</i>	7.1	1	7.1
11.16.94	2 2m	<i>Favia stelligera</i>	38.8760625	2	19.438
11.16.94	2 2m	<i>Favites russelli</i>	28.3	1	28.3
11.16.94	2 2m	<i>Galaxea fascicularis</i>	795.584875	16	49.724
11.16.94	2 2m	<i>Goniastrea retiformis</i>	21.40146875	2	10.701
11.16.94	2 2m	<i>Goniopora fruticosa</i>	44.766375	2	22.383
11.16.94	2 2m	<i>Leptastrea puerpera</i>	37.698	2	18.849
11.16.94	2 2m	<i>Leptastrea transversa</i>	3.9	1	3.9
11.16.94	2 2m	<i>Leptoria phrygia</i>	4.7	1	4.7
11.16.94	2 2m	<i>Montastrea curta</i>	6.3	1	6.3
11.16.94	2 2m	<i>Montipora sp(p).</i>	12.566	2	6.283
11.16.94	2 2m	<i>Pavona duerdeni</i>	36.912625	2	18.456
11.16.94	2 2m	<i>Pavona varians</i>	67.54225	3	22.514
11.16.94	2 2m	<i>Platygyra pini</i>	27.5	1	27.5
11.16.94	2 2m	<i>Pocillopora verrucosa</i>	27.5	1	27.5
11.16.94	2 2m	<i>Porites annae</i>	23.6	1	23.6
11.16.94	2 2m	<i>Porites lichen</i>	730.98778125	13	56.23
11.16.94	2 2m	<i>Porites rus</i>	410.751125	6	68.459
11.16.94	2 2m	<i>Psammocora contigua</i>	48.69325	2	24.347
11.16.94	2 2m	<i>Stylocoeniella armata</i>	17.27825	3	5.7594
11.16.94	2 2m	<i>Stylophora mordax</i>	56.6	1	56.6
11.25.94	2 8 m	<i>Alveopora sp.</i>	23.6	1	23.6
11.25.94	2 8 m	<i>Echinopora lamellosa</i>	18.8	1	18.8
11.25.94	2 8 m	<i>Favia matthaii</i>	4.7	1	4.7
11.25.94	2 8 m	<i>Galaxea fascicularis</i>	4.7	1	4.7
11.25.94	2 8 m	<i>Goniopora fruticosa</i>	6.3	1	6.3
11.25.94	2 8 m	<i>Leptastrea puerpera</i>	23.6	1	23.6
11.25.94	2 8 m	<i>Pocillopora verrucosa</i>	67.54225	2	33.771
11.25.94	2 8 m	<i>Porites lobata</i>	4.7	1	4.7
11.25.94	2 8 m	<i>Porites rus</i>	207920.1775	53	3923
11.25.94	2 8 m	<i>Stylocoeniella armata</i>	3.1415	2	1.5708
11.16.94	2 16m	<i>Favia matthaii</i>	151.577375	9	16.842
11.16.94	2 16m	<i>Galaxea fascicularis</i>	15.7	1	15.7
11.16.94	2 16m	<i>Leptastrea puerpera</i>	153.148125	8	19.144
11.16.94	2 16m	<i>Leptastrea transversa</i>	14.1	1	14.1
11.16.94	2 16m	<i>Pocillopora sp(p).</i>	3.926875	2	1.9634
11.16.94	2 16m	<i>Porites lobata</i>	471.6176875	8	58.952
11.16.94	2 16m	<i>Porites rus</i>	24526.475875	31	791.18
11.16.94	2 16m	<i>Porites (Synaraea) sp. 1</i>	4.7	1	4.7
11.16.94	2 16m	<i>Stylocoeniella armata</i>	3.5341875	2	1.7671
11.29.94	3 2 m	<i>Acropora surculosa</i>	150.006625	4	37.502
11.29.94	3 2 m	<i>Favia stelligera</i>	47.907875	2	23.954
11.29.94	3 2 m	<i>Galaxea fascicularis</i>	393.472875	10	39.347
11.29.94	3 2 m	<i>Goniastrea retiformis</i>	100.528	5	20.106
11.29.94	3 2 m	<i>Leptastrea puerpera</i>	6.3	1	6.3
11.29.94	3 2 m	<i>Leptoria phrygia</i>	2996.991	6	499.5
11.29.94	3 2 m	<i>Montipora grisea</i>	94.245	2	47.123
11.29.94	3 2 m	<i>Montipora sp(p).</i>	51.049375	4	12.762
11.29.94	3 2 m	<i>Pavona varians</i>	14.1	1	14.1
11.29.94	3 2 m	<i>Platygyra daedalea</i>	44	1	44

11.29.94	3 2 m	<i>Platygyra pini</i>	113.094	2	56.547
11.29.94	3 2 m	<i>Pocillopora sp(p).</i>	5.9	1	5.9
11.29.94	3 2 m	<i>Porites rus</i>	2245.387125	7	320.77
11.29.94	3 2 m	<i>Porites superfusa</i>	27.68446875	6	4.6141
11.29.94	3 2 m	<i>Psammocora contigua</i>	69	1	69
11.29.94	3 2 m	<i>Stylocoeniella armata</i>	27.0954375	11	2.4632
11.28.94	3 8 m	<i>Favia matthali</i>	3.926875	3	1.309
11.28.94	3 8 m	<i>Favites russelli</i>	28.2735	2	14.137
11.28.94	3 8 m	<i>Goniopora fruticosa</i>	6.283	2	3.1415
11.28.94	3 8 m	<i>Heliopora coerulea</i>	4.7	1	4.7
11.28.94	3 8 m	<i>Leptastrea puerpera</i>	9.4	1	9.4
11.28.94	3 8 m	<i>Montipora sp(p).</i>	4.7	1	4.7
11.28.94	3 8 m	<i>Platygyra pini</i>	25.132	2	12.566
11.28.94	3 8 m	<i>Porites annae</i>	2605.088875	3	868.36
11.28.94	3 8 m	<i>Porites australiensis</i>	2039.6	1	2039.6
11.28.94	3 8 m	<i>Porites lichen</i>	2018.8064375	25	80.752
11.28.94	3 8 m	<i>Porites lobata</i>	73.039875	5	14.608
11.28.94	3 8 m	<i>Porites rus</i>	32235.716875	16	2014.7
11.28.94	3 8 m	<i>Porites sp(p).</i>	1.6	1	1.6
11.28.94	3 16 m	<i>Astreopora listeri</i>	34.5565	2	17.278
11.28.94	3 16 m	<i>Astreopora myriophthalma</i>	34.5565	2	17.278
11.28.94	3 16 m	<i>Astropora listeri</i>	11.8	1	11.8
11.28.94	3 16 m	<i>Cyphastrea serailia</i>	3.9	1	3.9
11.28.94	3 16 m	<i>Favia matthali</i>	29.84425	3	9.9481
11.28.94	3 16 m	<i>Favia stelligera</i>	0.8	1	0.8
11.28.94	3 16 m	<i>Favites russelli</i>	11.8	1	11.8
11.28.94	3 16 m	<i>Fungia granulosa</i>	5.9	1	5.9
11.28.94	3 16 m	<i>Leptastrea puerpera</i>	122.1258125	12	10.177
11.28.94	3 16 m	<i>Montipora verrucosa</i>	4.7	1	4.7
11.28.94	3 16 m	<i>Pocillopora sp(p).</i>	4.7	1	4.7
11.28.94	3 16 m	<i>Pocillopora verrucosa</i>	4.7	1	4.7
11.28.94	3 16 m	<i>Pocillopora verrucosa</i>	14.13675	2	7.0684
11.28.94	3 16 m	<i>Porites annae</i>	265.45675	2	132.73
11.28.94	3 16 m	<i>Porites australiensis</i>	47.907875	2	23.954
11.28.94	3 16 m	<i>Porites lichen</i>	128.016125	4	32.004
11.28.94	3 16 m	<i>Porites lobata</i>	119.7696875	9	13.308
11.28.94	3 16 m	<i>Porites rus</i>	344.779625	8	43.097
11.28.94	3 16 m	<i>Porites sp(p).</i>	29.058875	3	9.6863
11.28.94	3 16 m	<i>Psammocora profundacella</i>	2.4	1	2.4
11.28.94	3 16 m	<i>Stylocoeniella armata</i>	10.209875	3	3.4033
11.28.94	3 16 m	<i>Fungia (Verrillifungia) sp.</i>	7.1	1	7.1

Table 2 - Percent bottom cover at 9 locations based on quadrat surveys.

Date		11.13.94	11.25.94	11.13.94	11.16.94	11.25.94	11.16.94	11.29.94	11.28.94	11.28.94
Site		1	1	1	2	2	2	3	3	3
Depth		2m	8m	16m	2m	8m	16m	2m	8m	16m
Porifera	Total	0	0.632911	30.81761	1.886792		30 33.12102	0.625	24.375	5.625
<i>Terpios</i>	<i>hoshinota</i>	0	0	30.18868	0	30	28.66242	0	21.875	1.875
blue encrust	sponge	0	0	0.628931	0	0	0	0	0	0
encrusting	sponge	0	0.632911	0	1.886792	0	4.458599	0.625	2.5	3.75
Sand		0	0.632911	0	0.628931	0	8.280255	1.25	5	4.375
Rubble		0	0	0	0.628931	0	0.636943	1.25	0	0
Rock		0	2.531646	1.886792	0.628931	12.5	0	0	1.25	0
Coralline	Total	33.33333	6.962025	13.83648	28.30189	0.625	2.547771	33.75	6.25	6.25
Coralline	encrusting	29.55975	5.696203	8.805031	21.38365	0.625	2.547771	27.5	5	6.25
Coralline	branch	3.773585	1.265823	5.031447	6.918239	0	0	6.25	1.25	0
Other algae	Total	60.37736	74.68354	38.36478	54.08805	6.25	35.66879	46.25	30.625	70.625
Turf		59.74843	74.68354	34.59119	53.45912	6.25	30.57325	43.75	27.5	65.625
<i>Halimeda</i>		0	0	3.144654	0	0	5.095541	0.625	1.875	5
<i>Dictyota</i>		0.628931	0	0.628931	0.628931	0	0	0	0	0
<i>Padina</i>		0	0	0	0	0	0	0	1.25	0
<i>Mastophora</i>		0	0	0	0	0	0	1.875	0	0
Corals	Total	6.289308	14.55696	15.09434	13.83648	50.625	19.74522	16.875	32.5	13.125
<i>Pocillopora</i>	sp(p).	0	0	0	0.628931	0	0.636943	0	0	0
<i>Montipora</i>	sp(p).	1.257862	0	0	0.628931	0	0	0	0	0
<i>Astreopora</i>	sp(p).	0	0.632911	0	0	0	0	0.625	0	0
<i>Porites</i>	<i>rus</i>	0	1.898734	15.09434	1.886792	48.75	17.83439	0	21.875	3.75
<i>Porites</i>	<i>massive</i>	0	0.632911	0	0	1.875	1.273885	0	3.75	3.75
<i>Porites</i>	<i>lichen</i>	0	1.265823	0	3.773585	0	0	0	5	3.75
<i>Psammocora</i>	sp(p).	0	0	0	0.628931	0	0	0	0	0
<i>Psammocora</i>	<i>contigua</i>	0	0	0	0	0	0	1.25	0	0
<i>Psammocora</i>	<i>superficialis</i>	0	0	0	0	0	0	4.375	0	0
<i>Galaxea</i>	<i>fascicularis</i>	0.628931	0	0	2.515723	0	0	5.625	1.25	0
<i>Favia</i>	<i>matthaii</i>	0.628931	0.632911	0	0	0	0	1.25	0	0
<i>Goniastrea</i>	<i>retiformis</i>	1.257862	0	0	0.628931	0	0	0	0	0
<i>Goniastrea</i>	<i>edwardsi</i>	0	0	0	0	0	0	0	0	0
<i>Leptoria</i>	<i>phrygia</i>	0	0	0	1.886792	0	0	0.625	0	0
<i>Leptastrea</i>	<i>purpurea</i>	0	8.860759	0	0.628931	0	0	0	0.625	1.875
<i>Cyphastrea</i>	<i>serailia</i>	0	0.632911	0	0.628931	0	0	1.25	0	0
<i>Heliopora</i>	<i>coerulea</i>	0	0	0	0	0	0	1.875	0	0
<i>Millepora</i>	<i>platyphylla</i>	2.515723	0	0	0	0	0	0	0	0

**Table 3 - Coral species encountered in point quarter surveys,
with number of transects in which they occurred noted.**

Species	# of transects
<i>Acanthastrea echinata</i>	2
<i>Acropora humilis</i>	1
<i>Acropora surculosa</i>	1
<i>Alveopora</i> sp.	1
<i>Astreopora listeri</i>	4
<i>Astreopora myriophthalma</i>	1
<i>Cyphastrea serailia</i>	1
<i>Echinopora lamellosa</i>	1
<i>Favia mathall</i>	8
<i>Favia stelligera</i>	4
<i>Favites russelli</i>	3
<i>Fungia (Verrillifungia) sp.</i>	1
<i>Fungia granulosa</i>	1
<i>Galaxea fascicularis</i>	6
<i>Goniastrea edwardsi</i>	1
<i>Goniastrea pectinata</i>	1
<i>Goniastrea retiformis</i>	3
<i>Goniopora fruticosa</i>	3
<i>Helopora coerulea</i>	2
<i>Leptastrea puerpera</i>	9
<i>Leptastrea transversa</i>	3
<i>Leptoria phrygia</i>	3
<i>Millepora platyphylla</i>	1
<i>Millepora tuberosa</i>	1
<i>Montastrea curta</i>	1
<i>Montipora grisea</i>	2
<i>Montipora</i> sp(p).	3
<i>Montipora venosa</i>	1
<i>Montipora verrucosa</i>	1
<i>Pavona duerdeni</i>	2
<i>Pavona varians</i>	4
<i>Platygyra daedalea</i>	1
<i>Platygyra pini</i>	4
<i>Pocillopora meandrina</i>	1
<i>Pocillopora</i> sp(p).	6
<i>Pocillopora verrucosa</i>	5
<i>Porites (Synaraea) sp. 1</i>	1
<i>Porites annae</i>	3
<i>Porites australiensis</i>	2
<i>Porites lichen</i>	4
<i>Porites lobata</i>	6
<i>Porites lutea</i>	2
<i>Porites rus</i>	9
<i>Porites</i> sp(p).	4
<i>Porites superfusa</i>	1
<i>Psammocora contigua</i>	4
<i>Psammocora profundacella</i>	1
<i>Stylocoeniella armata</i>	7
<i>Stylophora mordax</i>	1

Table 4 - Macroinvertebrate population densities (per m²).

Date		11.14.94	11.25.94	11.14.94	11.16.94	11.25.94	11.16.94	11.29.94	11.28.94	11.28.94
Site		1	1	1	2	2	2	3	3	3
Depth		2m	8m	16m	2m	8m	16m	2m	8m	16m
Holothuroidea										
<i>Actinopyga</i>	<i>mauritiana</i>	0.34	0	0	0.24	0	0	0.22	0	0
<i>Bohadschia</i>	<i>argus</i>	0	0	0	0	0	0	0	0.03	0.03
<i>Holothuria</i>	<i>nobilis</i>	0	0	0.02	0	0	0.04	0	0	0.02
<i>Stichopus</i>	<i>chloronotus</i>	0.07	0	0	0.19	0.02	0	0.06	0.12	0.04
Echinoidea										
<i>Echinometra</i>	<i>matthei</i>	0	0.03	0	0.1	0	0	0.59	0.03	0
<i>Echinostrephus</i>	<i>aciculatus</i>	0.43	0.46	0	0.33	0	0	0.28	0.05	0.04
<i>Echinothrix</i>	<i>diadema</i>	0.1	0.03	0	0.18	0	0	0.48	0.04	0
Asteroides										
<i>Acanthaster</i>	<i>planci</i>	0	0	0	0	0	0	0	0	0.01
<i>Culcita</i>	<i>novaeaguineae</i>	0	0	0.01	0	0	0	0	0	0
<i>Fromia</i>	<i>milleporina</i>	0	0.01	0	0	0	0	0	0	0
<i>Linckia</i>	<i>guidingi</i>	0	0	0.01	0	0	0	0	0.01	0.01
<i>Linckia</i>	<i>laevigata</i>	0	0	0	0	0	0	0	0	0
<i>Linckia</i>	<i>multifora</i>	0	0	0	0	0	0	0	0.02	0
Ophiuroidea										
<i>Ophiocoma</i>		0	0	0	0.02	0	0	0.04	0	0
<i>Ophiomastix</i>	<i>caryophyllata</i>	0	0	0	0	0	0.01	0	0	0
Crinoidea										
<i>sp.</i>		0	0	0	0	0	0.02	0	0	0
Bivalvia										
<i>Tidacna</i>	<i>maudana</i>	0	0.02	0	0.02	0	0	0.04	0.03	0.01
Gastropoda										
<i>Canthium</i>	<i>columna</i>	0	0.01	0	0	0	0	0	0	0
<i>Conus</i>	<i>sp.</i>	0	0.01	0	0	0	0	0	0	0
<i>Conus</i>	<i>miles</i>	0	0.02	0	0	0	0	0	0	0
<i>Drupa</i>	<i>rubusidaeus</i>	0	0.03	0	0	0	0	0	0	0
<i>Mancinella</i>	<i>tuberosa</i>	0	0	0	0	0	0	0.06	0	0
<i>Nudibranch</i>	<i>sp.</i>	0	0.02	0	0	0	0.01	0	0	0.01
<i>Trochus</i>	<i>niloticus</i>	0.03	0	0	0	0.01	0	0.02	0.01	0
<i>Vasum</i>	<i>?turbineolum</i>	0	0.01	0.01	0	0	0	0	0	0
Crustacea										
<i>Stenopus</i>	<i>hispidus</i>	0	0	0	0	0.01	0	0	0	0

APPENDIX E
Fore Reef Fishes

FORE REEF FISHES AT GUN BEACH

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INTRODUCTION

The fish surveys were carried out to assess fish abundance, species richness, and species composition in fore reef habitats off Gun Beach and in comparable habitats some 400 m to the south. Fish surveys were carried out in conjunction with surveys of reef corals and macroinvertebrates to provide baseline information on marine animal communities in this area.

MATERIALS AND METHODS

Fifty-meter long transect lines were placed in each of three depth zones (2 m, 8 m, and 16 m) at three sites (20 m north of submarine cable [Site 1], 50 m south of cable [Site 2], and 400 m south of cable [Site 3]; see Figure 1 in Paulay et al. report). Transect lines ran along the appropriate isobaths and were oriented more or less parallel to the reef front. The surveys were performed by a scuba-equipped diver who swam along each transect line recording the identity and number of all fishes observed within 1 m of either side of the line (a total of 100 m² per transect). Following the enumeration, a list was made of additional fish species observed in the immediate vicinity of the transect line but which had not been included in the transect counts.

RESULTS AND DISCUSSION

The areas surveyed had a diverse fish fauna; a total of 142 species were observed during the surveys (Table 1). In general fewer species were found at the 2-m transects than at the deeper depths (Figure 1). Overall there was little difference in species richness among the three sites.

Fish abundance averaged approximately 1.5 fish/m², but there was considerable variability from transect to transect (Figure 2). Site 2 exhibited higher fish densities at all depths than did the other sites. Perhaps more important than depth or location in influencing fish abundance was topographic relief: flatter, more featureless areas harbored fewer fishes than did more irregular areas.

The damselfishes, family Pomacentridae, were the numerically dominant fish group. Five damselfish species, Plectroglyphidodon lacrymatus, Stegastes fasciolatus, Pomacentrus vaiuli, Chrysiptera traceyi, and C. leucopoma, accounted for 75% of all the fishes counted along the transects. These are all small, site-attached species which feed primarily on algae. Some fairly large, harvestable species were also seen, including various species of surgeonfishes (family Acanthuridae), the jack Caranx melampygus, the emperor Lethrinus xanthurus, various species of goatfishes (family Mullidae), and various species of parrotfishes (family Scaridae). Large, transitory species tend to be underestimated by the survey methods used here. One marine turtle was also seen near Site 3.

The fish communities appear to be thriving at all three sites.

GUN BEACH SURVEY

FISH SPECIES RICHNESS

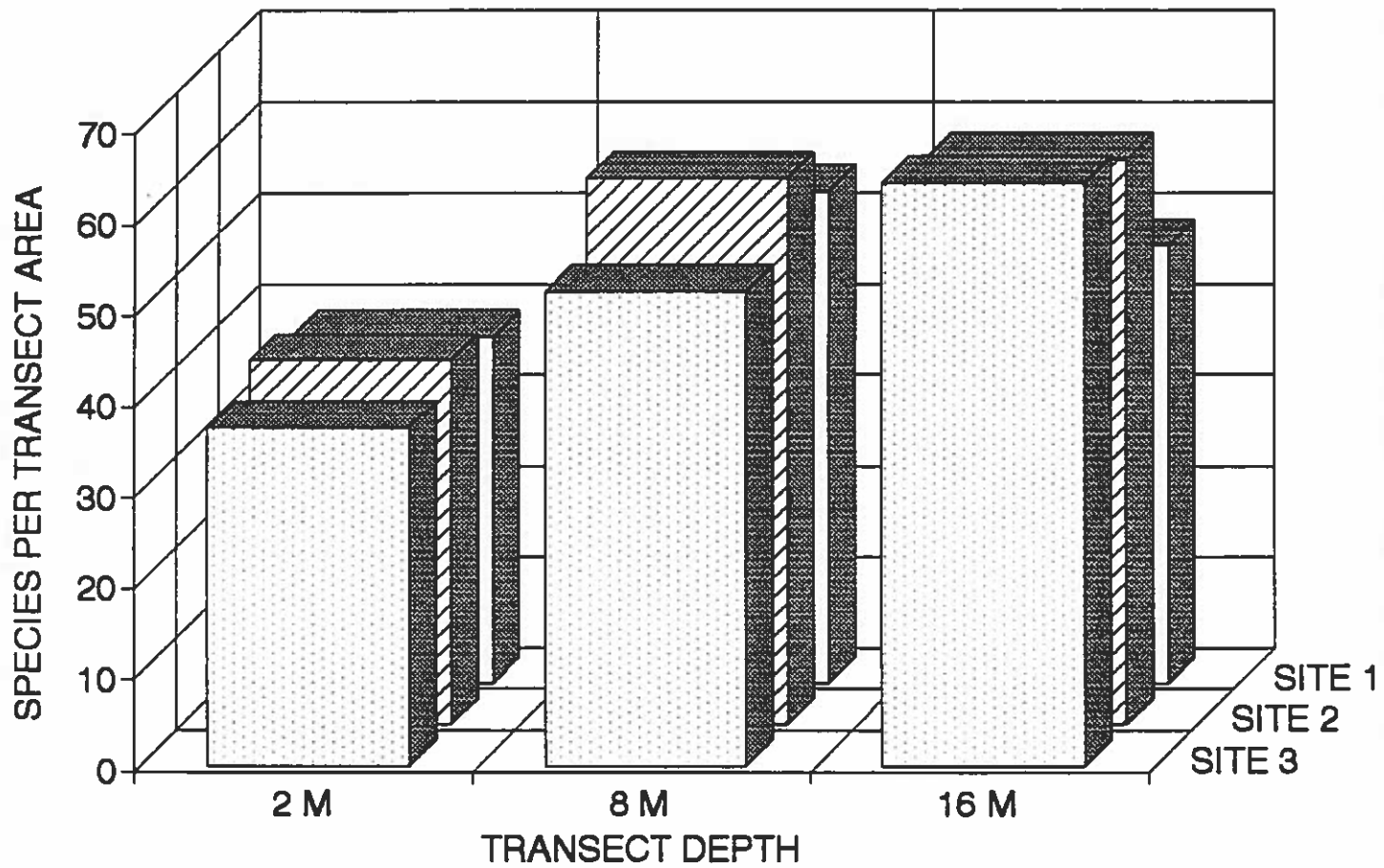


Figure 1

GUN BEACH SURVEY

FISH ABUNDANCE

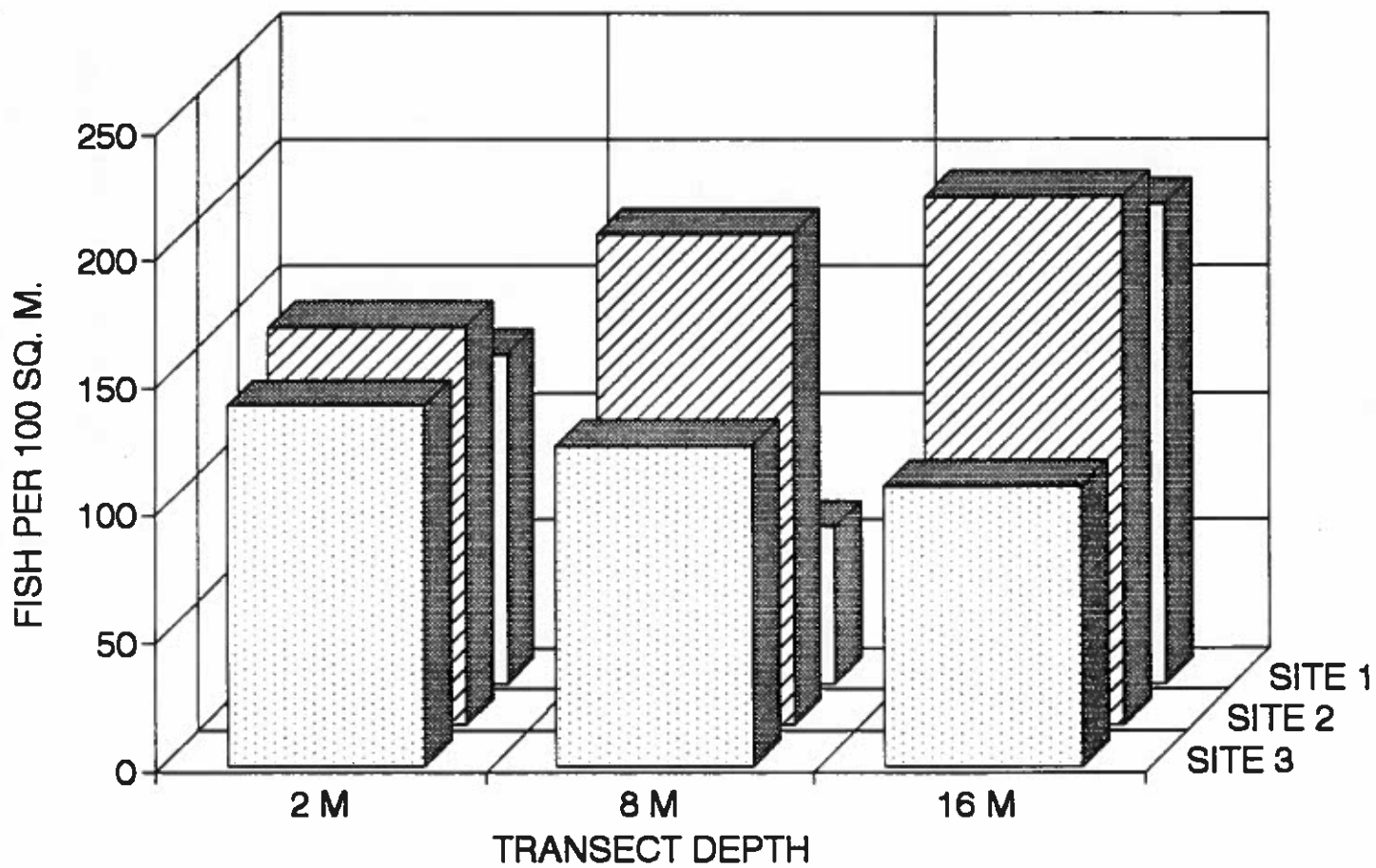


Figure 2

Table 1

GUN BEACH SURVEY 50X2-M TRANSECTS

	TR1 2M	TR1 8M	TR1 16M	TR2 2M	TR2 8M	TR2 16M	TR3 2M	TR3 8M	TR3 16M
ACANTHURIDAE	5			1			1		
ACANTHURIDAE	obs	obs	obs		1		obs	2	obs
ACANTHURIDAE	3	3	2	10	5	4	16	8	1
ACANTHURIDAE			obs	obs					
ACANTHURIDAE						obs			
ACANTHURIDAE		obs			obs				
ACANTHURIDAE		obs		4		obs			1
ACANTHURIDAE	obs	1	7	3	10	7	1	18	obs
ACANTHURIDAE	obs	1	4	2	2	6		2	4
ACANTHURIDAE						1			
ACANTHURIDAE			obs		obs	obs			
ACANTHURIDAE						1		obs	
AULOSTOMIDAE					obs				
BALISTIDAE	obs	obs	obs	obs	3	obs		obs	obs
BALISTIDAE							obs		
BALISTIDAE		obs	obs		obs	obs			obs
BALISTIDAE	obs					obs			obs
BALISTIDAE		obs	obs						
BLENNIIDAE									
BLENNIIDAE									
BLENNIIDAE			4			3	obs	obs	1
BLENNIIDAE				1			obs		
CAESIONIDAE									obs
CARANGIDAE		obs							

GUN BEACH SURVEY
50X2-M TRANSECTS

		TR1	TR1	TR1	TR2	TR2	TR2	TR2	TR2	TR3	TR3	TR3
		2M	8M	16M	2M	8M	16M	2M	8M	16M	obs	obs
CARANGIDAE	Decapterus sp.		obs								obs	obs
CHAETODONTID	Chaetodon auriga	obs	obs								obs	obs
CHAETODONTID	Chaetodon bennetti				obs			obs	1			
CHAETODONTID	Chaetodon citrinellus	obs	obs						2			
CHAETODONTID	Chaetodon ephippium	obs	obs					obs				
CHAETODONTID	Chaetodon lunula	1										
CHAETODONTID	Chaetodon mertensii							obs				
CHAETODONTID	Chaetodon ornatissimus	obs										
CHAETODONTID	Chaetodon punctatofasciatus		obs	obs	obs			obs	2			
CHAETODONTID	Chaetodon reticulatus	obs		obs	obs			obs	1	1	2	obs
CHAETODONTID	Chaetodon trifasciatus	obs	obs							obs	obs	
CHAETODONTID	Chaetodon ulletensis							1	obs		obs	
CHAETODONTID	Forcipiger flavissimus	obs	obs	obs					1		obs	obs
CHAETODONTID	Forcipiger longirostris							obs	obs			
CHAETODONTID	Hemitaenichthys polylepis			5								obs
CHAETODONTID	Heniochus chrysostomus			1				obs		1		
CHAETODONTID	Heniochus monoceros											obs
CIRRHITIDAE	Cirrhitichthys falco											2
CIRRHITIDAE	Paracirrhites forsteri							obs				
HEMIRHAMPHIDA	unidentified	obs			obs							
HOLOCENTRIDAE	Myripristis kuntee			2					3	2		obs
HOLOCENTRIDAE	Sargocentron caudimaculatus			2				obs	obs			
HOLOCENTRIDAE	Sargocentron diadema			1								1
HOLOCENTRIDAE	Sargocentron spiniferum			obs				obs				
LABRIDAE	Anampses caeruleopunctata	obs	obs							obs	obs	

	TR1	TR1	TR1	TR2	TR2	TR2	TR2	TR2	TR3	TR3	TR3	
	2M	8M	16M	2M	8M	16M	2M	8M	16M	2M	8M	16M
LABRIDAE	Anampses twisti	obs	obs		1	1		1				
LABRIDAE	Bodianus axillaris				1	obs						obs
LABRIDAE	Cheilinus chlorourus		4									
LABRIDAE	Cheilinus diagrammus											
LABRIDAE	Cheilinus oxycephalus											
LABRIDAE	Cheilinus trilobatus	obs										
LABRIDAE	Cheilinus unifasciatus		2	obs		1						2
LABRIDAE	Cheilio inermis	obs										
LABRIDAE	Coris aygula		obs			obs						obs
LABRIDAE	Coris gaimard					obs						
LABRIDAE	Gomphosus varius	obs	obs	obs	1	3	obs	obs	obs	obs	obs	obs
LABRIDAE	Epibulus insidiator		obs	obs	1							
LABRIDAE	Halichoeres biocellatus					obs					obs	4
LABRIDAE	Halichoeres hortulanus		obs	obs		obs	obs			obs	obs	obs
LABRIDAE	Halichoeres margaritaceus		obs									
LABRIDAE	Halichoeres marginatus									obs		
LABRIDAE	Halichoeres melanurus					1	obs					2
LABRIDAE	Hemigymnus fasciatus	obs	obs	obs	1	obs	obs	1	obs	obs	1	obs
LABRIDAE	Hemigymnus melapterus	obs	obs									
LABRIDAE	Hologymnosus dollatus		obs			1						
LABRIDAE	Labroides bicolor				obs							
LABRIDAE	Labroides dimidiatus	1	obs	3		4	3				1	obs
LABRIDAE	Labropsis xanthonotus				1							
LABRIDAE	Macropharyngodon meleagris		1	2	obs	1	obs	1	1	obs	obs	obs
LABRIDAE	Stethojulis bandanensis	obs			1	obs				obs	obs	

	TR1	TR1	TR1	TR2	TR2	TR2	TR2	TR2	TR3	TR3	TR3	
	2M	8M	16M	2M	8M	16M	2M	8M	16M	2M	8M	16M
LABRIDAE	Anampses twisti	obs	obs		1	1		1				
LABRIDAE	Bodianus axillaris				1	obs						obs
LABRIDAE	Cheilinus chlorourus		4									
LABRIDAE	Cheilinus diagrammus											
LABRIDAE	Cheilinus oxycephalus											
LABRIDAE	Cheilinus trilobatus	obs		obs								
LABRIDAE	Cheilinus unifasciatus		2			1						2
LABRIDAE	Cheilio inermis	obs										
LABRIDAE	Coris aygula		obs			obs						obs
LABRIDAE	Coris gaimard					obs						
LABRIDAE	Gomphosus varius	obs	obs	obs	1	3	obs	obs	obs	obs	obs	obs
LABRIDAE	Epibulus insidiator		obs	obs	1							
LABRIDAE	Halichoeres biocellatus					obs					obs	4
LABRIDAE	Halichoeres hortulanus		obs	obs		obs	obs			obs	obs	obs
LABRIDAE	Halichoeres margaritaceus		obs									
LABRIDAE	Halichoeres marginatus									obs		
LABRIDAE	Halichoeres melanurus					1	obs					2
LABRIDAE	Hemigymnus fasciatus	obs	obs	obs	1	obs	obs	1	obs	obs	1	obs
LABRIDAE	Hemigymnus melapterus	obs	obs									
LABRIDAE	Hologymnosus dollatus		obs			1						
LABRIDAE	Labroides bicolor				obs							
LABRIDAE	Labroides dimidiatus	1	obs	3		4	3				1	obs
LABRIDAE	Labropsis xanthonotus				1							
LABRIDAE	Macropharyngodon meleagris		1	2	1	1	obs	1	1	1	obs	obs
LABRIDAE	Stethojulis bandanensis	obs			1	obs	1	obs	obs	obs	obs	

**GUN BEACH SURVEY
50X2-M TRANSECTS**

	TR1	TR1	TR1	TR2	TR2	TR2	TR2	TR2	TR3	TR3	TR3
	2M	8M	16M		2M	8M	16M		2M	8M	16M
LABRIDAE				Thalassoma hardwickii	obs						
LABRIDAE				Thalassoma lutescens	obs	3	7				
LABRIDAE				Thalassoma quinquevittatum	8	1		6	2	obs	obs
LABRIDAE				juvenile		1		1			1
LETHRINIDAE				Gnathodentex aurolineatus			obs				4
LETHRINIDAE				Lethrinus harak		obs				obs	4
LETHRINIDAE				Lethrinus xanthurus							obs
LETHRINIDAE				Monotaxis grandoculis						obs	obs
LUTJANIDAE				Aphareus furca							obs
LUTJANIDAE				Lutjanus bohar		obs					obs
LUTJANIDAE				Lutjanus kasmira							obs
LUTJANIDAE				Lutjanus monostigmus						obs	
MICRODESMIDAE				Nemateleotris magnifica		obs					obs
MICRODESMIDAE				Ptereleotris evides		obs	9				obs
MICRODESMIDAE				Ptereleotris zebra		obs					obs
MONACANTHIDA				Cantherhines pardalis							
MONACANTHIDA				Paraluteres prionurus							
MONACANTHIDA				Pervagor janthinosoma		1	1	obs	2	obs	1
MULLIDAE				Mulloidichthys flavolineatus							
MULLIDAE				Mulloidichthys vanicolensis			obs		1		obs
MULLIDAE				Parupeneus barberinus				obs			
MULLIDAE				Parupeneus ciliatus							obs
MULLIDAE				Parupeneus cyclostomus							
MULLIDAE				Parupeneus multifasciatus		obs	obs				obs
NEMIPTERIDAE				Scolopsis lineatus		1		obs			obs

	TR1	TR1 8M	TR1 16M	TR2 2M	TR2 8M	TR2 16M	TR3 2M	TR3 8M	TR3 16M
OSTRACIIDAE	Ostracion meleagris		obs						
PEMPHERIDAE	Pempheris oualensis								
PINGUIPEDIDAE	Parapercis clathrata				obs			obs	
PINGUIPEDIDAE	Parapercis sp.				1			obs	
POMACANTHIDA	Centropyge flavissimus		obs			obs			obs
POMACANTHIDA	Centropyge heraldi		obs			obs		obs	obs
POMACANTHIDA	Centropyge shepardii		obs			obs			obs
POMACANTHIDA	Pomacanthus imperator					obs			
POMACANTHIDA	Pygoplites diacanthus					obs	4		
POMACENTRIDA	Abudefduf sexfasciatus		obs						
POMACENTRIDA	Abudefduf vaigiensis		obs				obs		
POMACENTRIDA	Amphiprion chrysoptera						3		obs
POMACENTRIDA	Chromis acares					obs		1	
POMACENTRIDA	Chromis agilis		1		9		2		
POMACENTRIDA	Chromis alpha		1				3		1
POMACENTRIDA	Chromis amboinensis						8		
POMACENTRIDA	Chromis margaritifer				3				
POMACENTRIDA	Chrysiptera leucopoma	27	8			41	47		
POMACENTRIDA	Chrysiptera traceyi		1	31		51	42	6	6
POMACENTRIDA	Dascyllus reticulatus			1		obs			
POMACENTRIDA	Dascyllus trimaculatus						obs		obs
POMACENTRIDA	Plectroglyphidodon dickii	obs					obs	1	
POMACENTRIDA	Plectroglyphidodon johnstonianus							obs	
POMACENTRIDA	Plectroglyphidodon lacrymatus	16	44		8	47	37	38	31
POMACENTRIDA	Pomacentrus vaiuli	12	48		4	23	4	26	39

	TR1	TR1 8M	TR1 16M	TR2	TR2 2M	TR2 8M	TR2 16M	TR3	TR3 2M	TR3 8M	TR3 16M
OSTRACIIDAE	Ostracion meleagris		obs		obs	obs				obs	obs
PEMPHERIDAE	Pempheris oualensis										
PINGUIPEDIDAE	Parapercis clathrata										
PINGUIPEDIDAE	Parapercis sp.					1			obs	obs	
POMACANTHIDA	Centropyge flavissimus		obs			obs	obs			obs	obs
POMACANTHIDA	Centropyge heraldi		obs				obs			obs	obs
POMACANTHIDA	Centropyge shepardii		obs				obs				obs
POMACANTHIDA	Pomacanthus imperator						obs				
POMACANTHIDA	Pygoplites diacanthus										
POMACENTRIDA	Abudefduf sexfasciatus	obs									
POMACENTRIDA	Abudefduf vaigiensis	obs			obs	obs			obs		
POMACENTRIDA	Amphiprion chrysoptera										obs
POMACENTRIDA	Chromis acares					obs				1	
POMACENTRIDA	Chromis agilis		1			9	2				
POMACENTRIDA	Chromis alpha		1				3				1
POMACENTRIDA	Chromis amboinensis						8				
POMACENTRIDA	Chromis margaritifer					3					
POMACENTRIDA	Chrysiptera leucopoma	27	8		41				47		
POMACENTRIDA	Chrysiptera traceyi		1	31		51	42			6	6
POMACENTRIDA	Dascyllus reticulatus			1		obs					
POMACENTRIDA	Dascyllus trimaculatus						obs		obs		obs
POMACENTRIDA	Plectroglyphidodon dickii	obs							obs	1	
POMACENTRIDA	Plectroglyphidodon johnstonianus									obs	
POMACENTRIDA	Plectroglyphidodon lacrymatus		16	44	8	47	37		13	38	31
POMACENTRIDA	Pomacentrus vaiuli		12	48	4	23	54		4	26	39

GUN BEACH SURVEY
50X2-M TRANSECTS

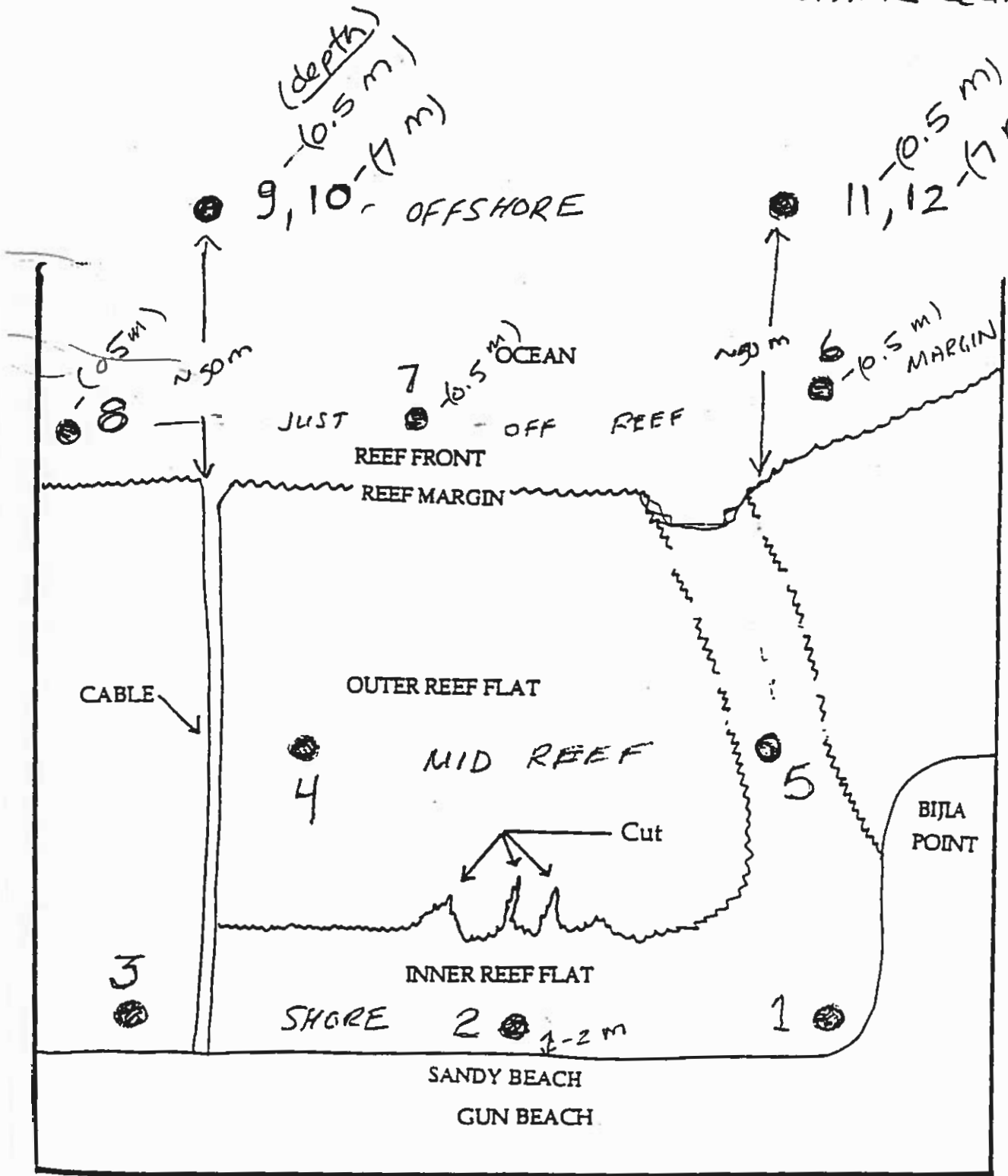
	TR1	TR1	TR1	TR2	TR2	TR2	TR3	TR3	TR3
	2M	8M	16M	2M	8M	16M	2M	8M	16M
POMACENTRIDA <i>Pomachromis guamensis</i>									
POMACENTRIDA <i>Stegastes fasciolatus</i>	82	11		68			51	9	
POMACENTRIDA juvenile				1					
SCARIDAE <i>Calotomus spinidens</i>				obs		1			
SCARIDAE <i>Scarus forsteni</i>					1				
SCARIDAE <i>Scarus schlegeli</i>						obs			obs
SCARIDAE <i>Scarus sordidus</i>	obs	obs	2	obs	4	1	obs	obs	2
SCARIDAE juvenile		obs				obs	3		2
SCORPAENIDAE <i>Pterois voltans</i>	obs								
SERRANIDAE <i>Cephalopholis urodeta</i>		1	1		3	1		obs	
SERRANIDAE <i>Epinephelus merra</i>				obs		1	1	obs	
SIGANIDAE <i>Siganus argenteus</i>	obs	obs		obs	obs				obs
SIGANIDAE <i>Siganus sp.</i>						obs			
SYNODONTIDAE <i>Synodus variegatus</i>	1								
TETRAODONTIDA <i>Canthigaster amboinensis</i>				2					
TETRAODONTIDA <i>Canthigaster solandri</i>	obs	obs	obs	3	2	2	obs	obs	1
ZANCLIDAE <i>Zanclus cornutus</i>	obs	obs	obs	obs	obs	obs	obs	obs	obs
NO. FISH PER 100 SQ. M.	129	61	188	156	192	207	141	125	109
NO. SPECIES PER TRANSECT	38	54	48	40	60	62	37	52	64

University of Guam

Seawater Samples from 11/29/94

SAMPLE NO.	TIME	TEMP (°C)	SAL. (ppt)	D.O. (% sat)	D.O. (mg/l)	pH	TURB. (ntu)	TSS (mg/l)	NO ₃ +NO ₂ (mg N/l)	NH ₃ (mg N/l)	TOTAL N (mg N/l)	Ortho-P (mg P/l)	TOTAL P (mg P/l)	CHL α (µg/l)
1	1520	29.7	33.77	89	5.2	8.39	2.22	10.3	0.044	0.003	0.211	0.004	0.013	0.32
2	1535	29.1	34.31	82	5.1	8.42	0.84	10.2	0.021	0.002	0.198	0.009	0.010	0.17
3	1530	29.4	34.30	82	5.2	8.46	2.58	9.1	0.012	0.002	0.140	0.008	0.014	0.41
4	1600	28.4	34.57	77	5.6	8.35	0.44	4.1	0.003	0.001	0.105	0.007	0.010	0.22
5	1542	29.5	33.87	63	5.5	8.48	1.78	3.9	0.014	0.002	0.132	0.006	0.010	0.19
6	1129	28.0	33.17	79	6.8	8.29	0.22	3.1	0.022	0.002	0.116	0.007	0.010	0.10
7	1117	28.0	34.56	80	6.9	8.27	0.46	1.1	0.007	0.002	0.137	0.006	0.009	0.10
8	1102	28.0	34.55	95	7.1	8.27	0.31	1.3	0.005	0.002	0.131	0.005	0.010	0.19
9	1232	28.0	34.51	69	5.3	8.25	0.23	0.5	0.004	< 0.001	0.126	0.005	0.009	0.17
10	1242	27.7	34.58	57	5.5	8.24	0.36	2.3	< 0.001	< 0.001	0.133	0.004	0.009	0.13
11	1140	27.9	34.45	80	6.2	8.26	0.31	4.5	0.005	< 0.001	0.128	0.004	0.011	0.15
12	1155	27.8	34.58	81	6.3	8.23	0.24	3.7	< 0.001	< 0.001	0.129	0.004	0.010	0.16

12 SAMPLE LOCATIONS FOR WATER QUALITY



APPENDIX F
Birds and Terrestrial Fauna

BIRDS AND TERRESTRIAL FAUNA

<u>SCIENTIFIC NAME</u>	<u>COMMON NAME</u>	<u>STATUS</u>
BIRDS		
<i>Arenaria i. interpres</i>	Ruddy Turnstone	E
<i>Dicrurus macrocercus harterti</i>	Black Drongo	X
<i>Egretta s. sacra</i>	Reef Heron	E
<i>Gygis alba candida</i>	White Tern	X
<i>Ixobrychus sinensis</i>	Yellow Bittern	E
<i>Passer montanus saturatus</i>	Eurasian Tree Sparrow	X
<i>Pluvialis dominica fulva</i>	Golden Plover	X
<i>Streptopelia bitorquata dusumieri</i>	P.T. Dove	E
REPTILES		
<i>Anolis caroliniensis</i>	Chameleon	X
<i>Emoia caeruleocauda</i>	Blue-tailed Skink	X
<i>Emoia sp.</i>	Skink	X
<i>Gehyra sp.</i>	Gecko	X
<i>Hemidactylus frenatus</i>	Gecko	X
MAMMALS		
<i>Canis familiaris</i>	Feral Dog	X
<i>Felis catus</i>	Feral Cat	E
<i>Rattus exulans</i>	Polynesian Rat	E
<i>Rattus rattus</i>	Roof Rat	E
<i>Suncus murinus</i>	Musk Shrew	E

Note: E = not observed but expected to occur
X = observed

Ref: Draft Environmental Impact Statement Microdredging of Tumon Bay, Barrett Consulting Group, Inc. July 1988.

APPENDIX G

Parking Calculations



ASSOCIATES, INC.

3177/10
1.2
Engineers/Architects

April 3, 1995

Mr. John T. Anderson
Territorial Planner/Chief Planner
Government of Guam
Department of Land Management
P.O. Box 2950
Agana, Guam 96910

RE: CASE NO. 95-06, TENTATIVE DEVELOPMENT PLAN
ENTER OCEAN GUAM PROJECT
LOT 10113-R3, TUMON, MUNICIPALITY OF DEDEDO, GUAM

Dear Mr. Anderson:

This is a follow up to the DRC meeting on March 16, 1995. We fully agree with your comment that parking requirement must be met. Indeed, it is the owner intention to ensure that we do not deter any customer because of inadequate parking.

Attached is a copy of parking calculation and proposed parking plan. In summary, the following is our parking analysis:

- ▣ Total parking required: 182 spaces
- ▣ Total parking provided:
 - 210 standard, 8-1/2 feet x 19 feet, parking spaces
 - 8 disabled parking spaces
 - 3 bus parking spaces
 - 4 loading/unloading areas



ASSOCIATES, INC.

Engineers/Architects

Mr. John T. Anderson

April 3, 1995

Page 2

In addition to the private parking spaces provided, the facility will operate a shuttle service utilizing six, 25 passenger jitneys. Five will make pick ups at all large hotels in Tumon Bay areas, and the sixth jitney will service the Tamuning hotels.

Thank you for your attention on the subject matter. Should you require additional information or clarification, we will be happy to comply and assist you.

Sincerely,

GMP ASSOCIATES, INC.

Djoni Setiadi, A.I.A.

Director of Architecture

cc: Mr. Frank Taitano
Planner IV, DLM

Attachment:

1. Parking Calculation (2 pages)
2. Parking Plan
3. Staffing Plan (2 pages)

PARKING CALCULATION

A. CUSTOMER PARKING				
ACTIVITY		GROSS AREA	NET AREA	CUSTOMER PARKING
1. <u>Upper Level</u>				
a. Admission Counter		300 SF	N/A - Employee Area	0 *1
b. Open Circulation Area		5,000 SF	N/A - Accessory Area	0 *2
c. Gift Shop/Dive Shop		1,500 SF	1,005 SF	10
d. Administrative Offices		2,200 SF	N/A - Employee Area	0 *1
e. Memory/Video Sales		300 SF	201 SF	2
f. Changing Rooms and Restrooms				
- Men		800 SF	N/A - Accessory Area	0 *2
- Women		800 SF	N/A - Accessory Area	0 *2
g. Snack Bar		1,100 SF	737 SF	7
h. Open Lanai Seating		1,500 SF	1,005 SF	10
i. Operations Shop		1,200 SF	N/A - Employee Area	0 *1
2. <u>Lower Level</u>				
a. Aquarium Gallery		10,750 SF	7,203 SF	72
b. Cocktail Lounge		3,750 SF	2,513 SF	25
c. Main Kitchen		3,400 SF	N/A - Employee Area	0 *1
d. Maintenance Shop		2,000 SF	N/A - Employee Area	0 *1
e. Biological Maintenance		2,000 SF	N/A - Employee Area	0 *1
f. Restrooms		300 SF	N/A - Accessory Area	0 *2
3. <u>Bodies of Seawater</u>				
a. Dive Trail		25,000 SF	N/A	N/A
b. Submarines Trail		25,000 SF	N/A	N/A
c. Lagoon		3,500 SF	N/A	N/A
d. Shark Tank		2,500 SF	N/A	N/A
4. <u>Others</u>				
a. Landscaped Island		11,000 SF	N/A - Accessory Area	0 *2
b. Vehicle Maintenance Shop		2,000 SF	N/A - Employee Area	0 *1
Customer Parking Required = 126 Spaces				

Notes

*1. Employee parking is calculated in Part B.

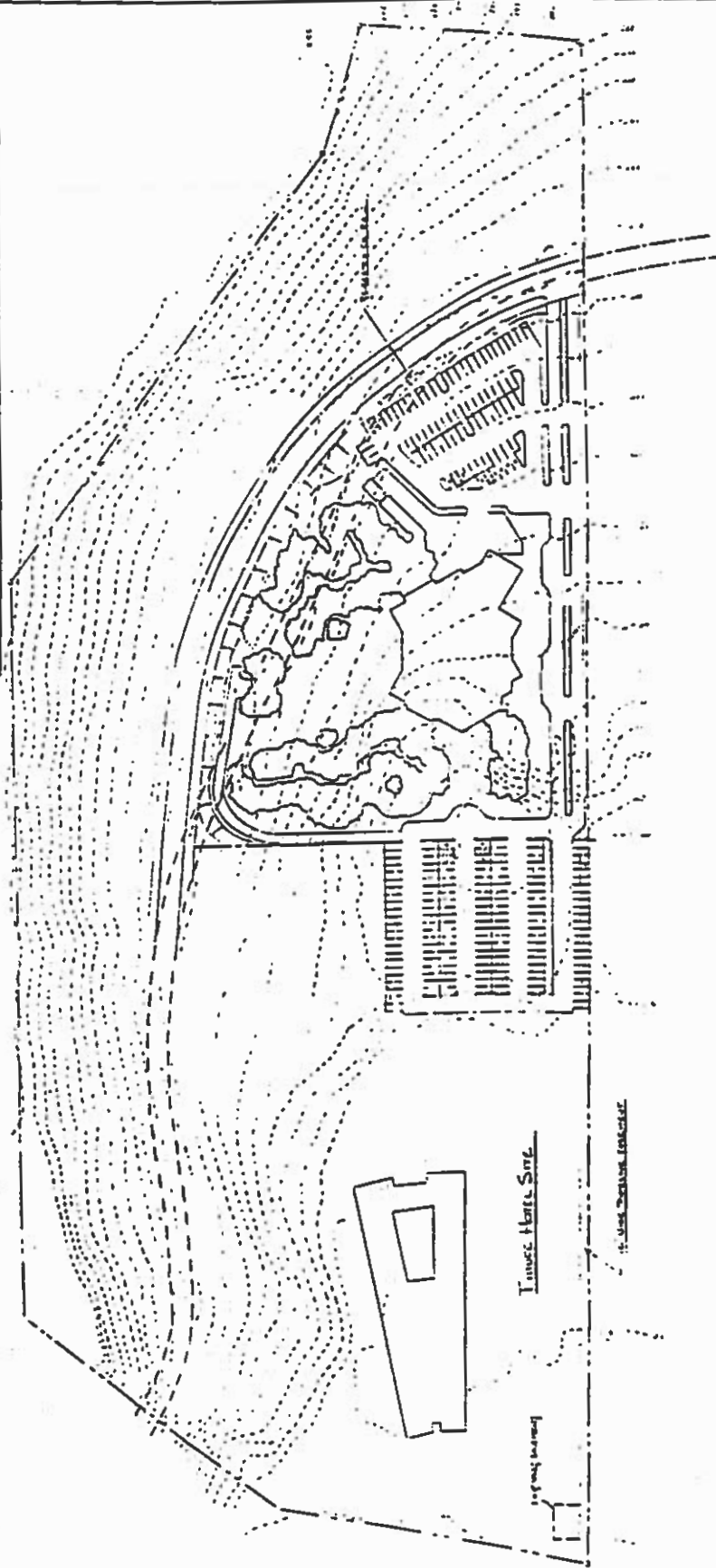
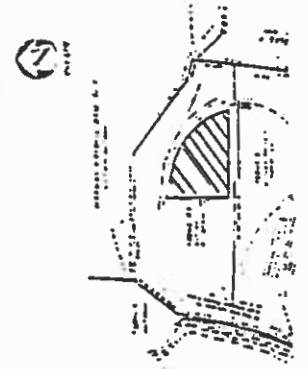
*2. Accessory areas include storage, restrooms and circulation areas. Accessory areas are ordinarily used only by persons who already occupy the main areas of an occupancy. Therefore, there is no additional occupant load in the accessory areas.

B. EMPLOYEE PARKING

Staffing plan calls for a total of 184 employees. (See attached staffing plan). Total employees must cover a 15 hour day, 7 day per week operation. It is equivalent of, 2.5, 5 day, 8 hour shifts. So, total number of employees onsite at any given time = $184/2.5 = 74$ persons. Therefore, total employee parking required = $74 \times 3/4 = 56$ Spaces

C. SUMMARY

- ☐ Total parking required for the facility = $126 + 56 = 182$ Spaces
- ☐ Total parking provided:
 - 210 Standard spaces (8-1/2' x 19'), (145 unpaved and 65 paved)
 - 3 Bus parking spaces (9' x 40')
 - 8 Disabled parking spaces
 - 4 Loading/Unloading areas



6.00000 5.99 6.99 = 18.99

**NOTE: FOR GENERAL SITE
ARRANGEMENT ONLY**
Arrangement of Lanes and Curbstone
Roadway May Vary From That Shown



Hawaii

systems engineering and associated
aspects and of providing such
services as, development and
equipment utilization, and maintenance
of electronic systems.

ENTEROCEAN
Intestine. Stomach. Proctum.

PROPOSED ENTEROCEAN
FACILITY
GUN BEACH
AGANA, GUAM

[illegible]

Hardscapes
Hawaii

Figure 10. The effect of the amount of water on the rate of water uptake by the roots of the plant. The rate of water uptake was measured by the change in weight of the roots over a period of 10 minutes. The results are shown in the graph below.

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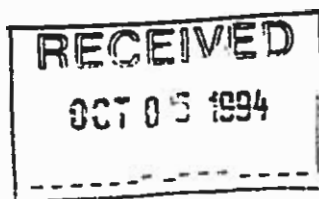
PARKING PLAN

ENTEROCEAN GUAM

Staffing Plan

(Opening)

Position	Background/ Experience	Class (Adm./ Direct)	Number of People
Executive			
VP/Gen. Manager	Management	A	1
Admin. Asst.	Management	A	1
Accounting/Personnel			
Controller	Accounting	A	1
Chief Accountant	Accounting	A	1
Personnel Manager	Human Resources	A	1
Adm. Asst.	Business	A	1
Accounting Clerks	Accounting	A	6
Sales/Marketing			
Manager-Sales/Marketing	Marketing Mgt.	A	1
Supervisor-Receptionists	Management	A	1
Asst. Supervisor-Reception.	Management	A	1
Manager - Retail Sales	Sales Management	A	1
Asst. Mgr. - Retail	Sales Management	A	1
Manager - Club Sales	Sales Management	A	1
Asst. Mgr. - Club Sales	Sales Management	A	1
Receptionists	General	D	14
Retail Sales Personnel	General	D	12
Tour Operations			
Manager - Tour Operations	Ocean Sci./Management	A	1
Manager - Dive Tour Ops.	Ocean Sciences	A	1
Asst. Mgr. - Dive Tour Ops.	Ocean Sciences	A	1
Manager - Semi-Sub Ops.	Ocean Sciences	A	1
Asst. Mgr. - Semi-Sub Ops.	Ocean Sciences	A	1
Dive Tour Leaders	Ocean Sciences	D	13
Dive Tour Attendants	Ocean Sciences	D	8
Semi-Sub Operators	Ocean Sciences	D	8
Semi-Sub Attendants	Ocean Sciences	D	8
Entertainment			
Entertainment Director	Entertainment Mgt.	A	1
Entertainers	Entertainment	A	6



ing Plan (Continued)
ence and Education

Director - Science/Education	Marine Biology	A	1
Curator	Marine Biology	A	1
Asst. Curator	Marine Biology	A	1
Biologist	Marine Biology	A	1
Bio-Technician	Marine Biology	A	1
Fish Collector	Marine Biology	A	2
Manager - Education	Marine Biology	A	1
Chief Docent	Marine Biology	A	1
Docents	Marine Biology	A	5

Food and Beverage Operations

Manager - Food & Beverage	F & B Management	A	1
Manager - Sea Cave Lounge	F & B Management	A	1
Asst. Mgr. - Sea Cave	F & B Management	A	1
Manager - Snack Shop	F & B Management	A	1
Asst. Mgr. - Snack Shop	F & B Management	A	1
Manager - Catering	F & B Management	A	1
Food and Beverage Personnel	General	D	44

Maintenance

Maintenance Manager	Engineering	A	1
Mechanics	Maintenance Engr.	A	1
Electrician	Electrician	A	1
Electronics Tech.	Electronics	A	1
Grounds Maint. Personnel	Landscape Maint.	A	2

Transportation

Transportation Manager	General	A	1
Drivers	General	A	18

Total	184
Total Admin.	77
Total Direct	107

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