Lorraine R. Inouye
Mayor

Norman K. Hayashi
Director

Tad Nagasako
Deputy Director

Planning Department

25 Aupuni Street, Rm. 109 • Hilo, Hawaii 96720 • (808) 961-8288

December 4, 1990

Office of Environmental Quality Commission
465 South King Street
Kekuanaoa Building, Room 115
Honolulu, HI 96813

Gentlemen:

Final SEIS - Mauna Lani Cove
Determination of Acceptability

We have reviewed the final EIS for the proposed Mauna Lani Cove development. Chapter 343, Hawaii Revised Statutes, requirements were triggered by the filing of a Shoreline Setback Variance petition to allow the proposed development.

We have determined the Final EIS to be acceptable as we find that said document has satisfied the following criteria:

1. Procedures for assessment, consultation, review and revisions required for the EIS have been complied with;

2. Content requirements for a Final EIS have been satisfied; and

3. Comments submitted during the review process have been responded adequately, and revisions have been incorporated or appended to the final document.

As the proposed project is in the process of obtaining the first of many land use approvals, it is still at a conceptual stage of planning. As such, detailed and site specific plans have yet to be prepared. Thus, a supplemental EIS may be required with other permits should site specific and detailed plans indicate a need for additional information, particularly with respect to impacts to the anchialine ponds and their management.

Should you have any questions, please feel free to contact our office.

Sincerely,

NORMAN K. HAYASHI
Planning Director

AK:syw

cc: Ms. Anne Mapes/BCA

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

MAUNA LANI COVE

MAUNA LANI RESORT
SOUTH KOHALA, HAWAII

OCTOBER 1990

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

OCTOBER 1990

MAUNA LANI COVE

MAUNA LANI RESORT
SOUTH KOHALA, HAWAII

PREPARED FOR:
MAUNA LANI RESORT, INC.

PREPARED BY:
BELT COLLINS & ASSOCIATES

FOR SUBMISSION TO:
HAWAII COUNTY PLANNING COMMISSION

THROUGH THE:
HAWAII COUNTY PLANNING DEPARTMENT

SUBMITTED BY:

JAMES R. BELL, CHAIRMAN
BELT COLLINS & ASSOCIATES
HONOLULU, HAWAII

LIST OF FIGURES
(Continued)

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES
(Continued)

CHAPTER ONE

CHAPTER I

INTRODUCTION AND SUMMARY

1. APPLICANT AND BRIEF PROJECT SUMMARY

Mauna Lani Resort, Inc., developer of the master planned Mauna Lani Resort on the Kohala Coast of the island of Hawaii, proposes to develop a water-oriented residential marina on an 88-acre waterfront parcel between the existing Mauna Lani Bay Hotel and Bungalows and Ritz-Carlton, Mauna Lani Hotel. Mauna Lani Cove will include 90 to 140 residential lots or units; a boat basin, to be known as The Landing, containing 110 boat slips, 90 of which will be available to the public on a "first come, first serve" basis and a commercial area with a restaurant and shops; an interpretive center; and related boating facilities as well as other shoreline improvements.

2. PROPOSED GOVERNMENT ACTION

An environmental impact statement (EIS) for the entire Mauna Lani Resort was accepted by the County and State of Hawaii in 1985. Mauna Lani Resort, Inc. is currently seeking government permits to allow development of the Mauna Lani Cove project within the resort. The submittal of a Shoreline Setback Variance (SSV) application to the County of Hawaii subjects the project to Chapter 343, HRS EIS review. Consequently, the Hawaii County Planning Department determined that the project impacts could be significant and that a Supplemental EIS was therefore required.

This Final Supplemental EIS supports the SSV application, as well as other County permit applications, including a Special Management Area (SMA) Use permit and Planned Unit Development (PUD) permit. Mauna Lani Resort, Inc. has submitted a State Conservation District Use Application (CDUA) for work (access channel) in submerged lands in the State Conservation District, and a Corps of Engineers River and Harbor Act of 1899, Section 10 permit application for work in navigable waters. This Supplemental EIS also supports the State application and will support federal permit applications when they are filed/refiled. The access channel will be located in a Resource Subzone and will require about 2 acres of state submerged lands. Other necessary approvals and permits are listed in Section 11.0 of this chapter.

3. PURPOSE OF THIS DOCUMENT

The purpose of this Supplemental EIS is to identify and assess environmental impacts that could result from the development of Mauna Lani Cove. Through this process, as well as the technical studies performed in support of the assessment, the applicant expects to identify weaknesses in the project plan, to propose appropriate mitigation measures for potential negative impacts, and to ultimately create a well-planned, environmentally sound project. To the degree possible, the information contained herein covers both the on- and off-site impacts, infrastructural components and amenities that would serve the project.

10. SUMMARY OF COMPATIBILITY WITH LAND USE PLANS AND POLICIES

The proposed Mauna Lani Cove project site is located within the Urban district boundary as defined by the State Land Use Commission and within Resort lands as designated by the Hawaii County General Plan. Hence, the project is consistent with current State and County land designations. However, to move forward, the project requires several governmental permits which are listed below.

11. NECESSARY APPROVALS AND PERMITS

This Supplemental EIS supports various Hawaii County permit applications and a State Conservation District Use Application for work in submerged lands. Table I-1 is a listing of *major* approvals and permits required for the Mauna Lani Cove project. Other approvals and permits are also required for development to go forth after the following have been obtained.

It is apparent from the above noted figures that there is a definite need for additional small boat moorings in West Hawaii, as well as the entire state. While the proposed project will not satisfy the entire demand for moorings, it will provide some assistance in that regard as well as alleviate future demands on state provided facilities.

5. STATEMENT OF OBJECTIVES

Mauna Lani Resort is one of three major destination resorts on the Kohala coast that were planned and established many years ago. Based on an updated master plan, the resort is being developed in an orderly manner, responding to market demand within the context of the important objective of creating and maintaining an attractive world-class visitor and residential complex with strong ties to the local community. An important overall goal is to continue the operation and expansion of a successful venture which supports the developer's ability to make meaningful community contributions.

Community Contributions

Included in Mauna Lani Resort's community contributions to date are:

- Current on-site employment force of approximately 1,500 persons (including construction forces) with an estimated annual payroll of about $40 million.
- Annual support of numerous youth and adult education/activity programs including high school scholarship and trust funds, canoe and equestrian clubs, arts and dancing programs, Boys/Girls Clubs and mental illness and crisis programs.
- Support of environmental groups and programs such as Sierra Club, Kona Outdoor Circle, Pacific Game Fish Research Foundation, Pacific Ocean Research Foundation, Puako Petroglyph Archaeological District, Green Turtle Restoration Program, Hawaii International Billfish Tournament, West Coast Whale Research Foundation, Hawaii Nature Center, Kona Historical Society and the state endangered species propagation program.
- Annual support of community medical and health programs including Lucy Henriques Hospital, North Hawaii Community Hospital, American Cancer Society, American Lung Association, suicide prevention programs, DARE Program and child and family service programs.
- Manpower and financial support for various community functions such as North Kohala Country Fair, Earth Day, Ironman Triathalon, Merrie Monarch Festival and various rodeos, art fairs and other community functions.
- Mauna Lani School - a child care center on-site for Mauna Lani Resort employees (the only company sponsored facility of this type in West Hawaii).

Project Objectives

Mauna Lani Cove plays a specific role in the ordered development of the master planned resort. With the residential marina, Mauna Lani Resort, Inc. hopes to attain several major objectives:

- Balance private and public benefits derived from the project.
- Further the mission of the Kohala Coast as set forth in the 1958 State Plan for Tourist Destinations and the 1967 Olohana Corporation land development plan, "The Kohala Coast Resort Region."
- Add an amenity which will be an integral part of Mauna Lani Resort, compatible with the resort's established character: low density and designed for maintenance of environmental integrity.
- Add a new water-related dimension which will enhance the resort's competitive market position and add to the character of the Kohala Coast.
- Avoid building another hotel, for which the land is zoned, and instead add a distinct, low density residential product to those currently offered by the resort.
- Maximize the number of waterfront residential lots at Mauna Lani Resort (some residences will have frontage onto navigable waters and direct access to a private dock) and community water-related opportunities.
- Create an attractive project that is accessible to the public as a park/community center, including use of the boat basin and channels by community water sport clubs and use of the commercial center. This will be a community center where people will come to enjoy waterfront or water-oriented activities such as walking, running, paddling, boating, sailing, fishing, dining, shopping, and visiting the interpretive center.
- Assist in satisfying the demand for small boat docking facilities among existing Mauna Lani homeowners and the general public.
- Provide the impetus for expanding the pleasure boat service industry in Hawaii.
- Create a state-of-the-art, high-service marina with fuel dock, sewage pump station and strict operation and maintenance plans that can serve as a model for other public and private marinas.
- Provide transient moorings to discourage and minimize proliferation of "open roadstead" moorings.

Public Benefits

Of the above objectives, continuing to balance the private and public benefits to be derived from the project is of utmost importance to Mauna Lani Resort, Inc. The direct public benefits to be derived specifically from the proposed project include the following:

- Additional small boat mooring and launch facilities in West Hawaii.
- Additional and improved public access to the shoreline.
- Additional and improved public shoreline park facilities.
- Improved anchialine pond, coastal pond and nearshore marine conditions.
- Increased state and county tax revenues.
- Increased employment opportunities in a variety of positions and industries.
- Increased small boat, canoe and kayak recreational opportunities.
- Additional small boat dry storage facilities in West Hawaii.
- Additional safe, protected small boat anchorage facilities along the West Hawaii coastline for all boaters during emergency and storm condition situations.

These direct public benefits would be in addition to those already provided by Mauna Lani Resort and they would be provided at essentially no cost to the public. These benefits have been developed and planned in consultation and cooperation with the County Planning Department and private groups such as Public Access Shoreline Hawaii (PASH). Mauna Lani Resort, Inc. is also discussing, with the state and county, additional off-site public facilities and benefits that the resort could jointly participate with governmental or private agencies and groups.

In addition, the following indirect public benefits would result from the proposed project:

- Continued impetus to establish and implement a West Hawaii regional water quality/marine ecology monitoring/survey program.
- Continuation of a regional ciguatera monitoring program recently initiated by Mauna Lani Resort, Inc.
- Additional impetus to continue development and establishment of a privately financed and endowed marine resources research center.
- Continued impetus to assist and cooperate with the University of Hawaii Puako marine research center

- Development of a working model for the maintenance and operation of public and private small boat marinas in Hawaii.

Each of the direct and indirect public benefits listed above are described in more detail in Chapter II, Section 5.

6. PROJECT DESCRIPTION

Mauna Lani Resort proposes to develop an integrated residential marina project to include 90 to 140 residential lots or units, a boat basin and related boating facilities to be known as The Landing, as well as various shoreline improvements. The project includes a total of approximately 185 boat slips or docks with the capacity to moor about 250 boats. The design concept for Mauna Lani Cove is that of a low-density village interspersed by waterways, with the boating and boat-support activities concentrated at The Landing. Utilizing comprehensive and strict rules and regulations (see Appendix Q), a harbor master will manage operations at this high service marina.

6.1 PROJECT SETTING

Mauna Lani Cove is designed to add a new dimension to the existing resort while adhering to the concept, design and operation guidelines followed in the development of other Mauna Lani Resort projects: provide facilities and amenities which are of world class quality and at the same time sensitive to the natural environment and surrounding community.

Mauna Lani Resort has been master planned as a luxury destination resort since the mid-1970's. Built to date are the 351-room Mauna Lani Bay Hotel and Bungalows, the 550-room Ritz-Carlton, Mauna Lani Hotel, the 80-unit Mauna Lani Terrace condominiums, the 116-unit Mauna Lani Point condominiums, the Francis H. I'i Brown championship golf course and golf clubhouse, a beach club, a racquet club, the Eva Parker Woods museum, and a public park. The Kalahuipua'a fishponds are held in conservation and are open to the public as an ethnobotanical reserve. The Ala Kahakai (shoreline trail), the Ala Loa (King's Trail), and two historic park preserves are also available and easily accessible to the general public as well as resort guests. These amenities are enhanced by interpretive signs.

Scheduled for completion in the fall of 1990 is Holoholokai public beach park, which will have ample parking and family picnic facilities, such as picnic tables, bar-b-ques, restrooms and showers. The park will be located north of the Ritz-Carlton, Mauna Lani Hotel at Pauoa Bay. The Puako Petroglyph Archaeological Park is scheduled for completion at the end of 1990 as Hawaii's prototype rock art park. Mauna Lani Resort, Inc., in cooperation with the Waimea Hawaiian Civic Club, nominated the Puako Petroglyph Archaeological District to the State and Federal Registers of Historic Places in 1983.

Mauna Lani Cove will be situated between the Mauna Lani Bay Hotel and Bungalows and the Ritz-Carlton, Mauna Lani Hotel. The project will include the following elements which are assessed in this document as to their potential impacts in both the short-term and long-term.

6.2 CHANNEL NETWORK

Development of Mauna Lani Cove will necessitate dredging a channel in relatively shallow (less than 20 feet deep) state owned submerged lands to allow for approaching vessels as well as inland excavation to allow for the construction of waterways and a boat basin. Approximately 1.3-million cubic yards of basalt material will be excavated for the channels and boat basin, of which 60,000 cubic yards would be excavated seaward of the state certified shoreline to create the access channel and 1.24 million cubic yards would be excavated landward of the certified shoreline to create the interior channels and boat basin. A Conservation District Use Application (CDUA) has been filed with the Board of Land and Natural Resources for use of the public lands. Future actions will include negotiations with the state for permission to dredge the channel and the compensation to be paid for that permission.

Dredged Channel in Submerged Lands

- Channel approximately 150 feet wide and 625 feet long, with a depth of -18 MLLW.
- Approximately 60,000 cubic yards of basaltic materials to be excavated.
- Construction period of 2 to 4 months.

Inland Waterways

- Approximately 23 acres of channels fronting residential lots.
- Approximately 1.24 million cubic yards of basaltic materials to be excavated prior to opening access channel to the sea.
- Channel depths to vary from -6 MLLW to -15 MLLW to accommodate vessels of varying size.
- Construction period of approximately 10 to 12 months (to start prior to or concurrent with access channel construction).

Opening Marina to Dredged Channel

- Natural shoreline to be left in place as a dike until the entire channel network is excavated.
- Existing certified shoreline to remain in its present location, i.e, shoreline of interior channels to be owned by the developer as is the practice with similar marinas in Hawaii.
- Construction period of approximately one month (to be initiated following construction of access channel and inland waterways).

6.3 RESIDENTIAL DEVELOPMENT

- 90 to 140 residential lots/units. Final number of residential lots to be determined following detailed planning and design work for the project. Current program calls for 105 residential units, 75 of which would have private mooring floats fronting the units, 10 lots that would have ocean views but no direct water access, and 20 clustered single-family detached units.

- Minimum lot sizes will be between 10,000 and 15,000 square feet.

- Median home value is projected at $2.25-million.

- Total residential development value based on a maximum 140 residences is $315-million.

- Two 125-foot long vehicular bridges will provide access to residential lots on the islands. The bridges will have a clearance of at least 6 feet, allowing skiffs to pass underneath.

6.4 THE LANDING: BOAT BASIN AND COMMERCIAL FACILITIES

- Boat basin with a 110-vessel capacity: All slips, with the exception of 10 that will be reserved for commercial charter fishing boat operations and 10 that will be reserved for transient (30 days or less) boats, will be for the exclusive use of Mauna Lani Resort residents and guests. The Cove project will have a total capacity for 250 vessels inclusive of residential moorings. Dive boat, sightseeing and sunset dinner type commercial operations will not be allowed at the Cove. The primary emphasis of the Cove boating activities will be placed on recreational sailing, fishing and cruising.

- Marina facilities will include the harbormaster's office, laundry, restroom/locker areas, and other support space.

- The boat launching area will be open to everyone and all users will be subject to the same fees for services and will be expected to abide by the established marina regulations (see Appendix Q).

- A public waterfront restaurant with adequate meeting space for a sponsored yacht club, canoe clubs and other groups.

- Ocean interpretive center at the yacht clubhouse to contain sea-life exhibits of museum quality.

- Other amenities including a fuel dock facility, a sewage pumpout facility (the Big Island's first), dry storage for smaller boats, and limited retail facilities including a general store.

- Parking for boat owners, marina visitors, retail facility visitors, and commercial boat passengers and crew.

Mauna Lani Resort, Inc. recognizes that exclusive use of the Cove boat slips by its residents and guests does not assist in alleviating the general public demand for small boat slips in West Hawaii. In this regard, Mauna Lani Resort, Inc. is working with the state and county in an effort to either provide additional public boat slips in existing small boat harbors (Honokohau or Kawaihae) or other public recreational facilities off-site.

6.5 PUBLIC ACCESS

- Pedestrian shoreline access will be uninterrupted, and more so, enhanced.

- A 150-foot long and 6-foot wide pedestrian bridge (with a 50-foot moveable span) to ensure public pedestrian access while allowing the passage of high-masted vessels. The bridge will have a minimum 14-foot vertical clearance, allowing most power boats to pass underneath.

- A 10-foot wide pedestrian easement around the entire outer channel for an ocean promenade open to the public, connecting the shoreline trail to the boat basin and commercial parking area.

- Vehicle/pedestrian drop off areas at the end of the roadways within the residential lots surrounding the Cove.

6.6 SHORELINE IMPROVEMENTS

- Improvement of the Ala Kahakai trail into an ocean greenbelt/passive park between the Mauna Lani Bay Hotel and Bungalows and Ritz-Carlton, Mauna Lani Hotel.

- A bridge operator's roost and interpretive center will be provided in the shoreline area.

- Existing anchialine ponds in poor condition near the shoreline will be restored, with the addition of interpretive signs if the State desires attention to be brought to them.

6.7 RELOCATION OF GOLF HOLES AND ADDITION OF FLUSHING RESERVOIR

- Two existing golf holes (11 and 12) adjacent to the Mauna Lani Bay Hotel and Bungalows will be relocated mauka of The Landing

- Flushing reservoir to service the marina and to serve as a water feature adjacent to one of the relocated golf holes.

7. SUMMARY OF POTENTIAL ADVERSE IMPACTS AND MITIGATION MEASURES

Impacts to the environment are expected as a result of the construction and operation of Mauna Lani Cove and The Landing. Adverse impacts will be mitigated where possible and offset by benefits resulting from the project. The following identifies the expected short- and long-term adverse impacts and corresponding mitigation measures that will be taken to minimize and/or eliminate the potential adverse impacts. Each of the mitigation measures summarized below is discussed in detail in Chapter IV.

7.1 SHORT-TERM CONSTRUCTION PERIOD IMPACTS/MITIGATION MEASURES

IMPACT: Intermittent interruption of continuous lateral public shoreline access during the period the shoreline dike is removed and pedestrian bridge is constructed-approximately 3 months.

MITIGATION: Pedestrian bridge across channel to allow continued public lateral shoreline access following opening of the channel to the ocean. Temporary lateral shoreline access to be provided.

IMPACT: Increased turbidity of ocean waters resulting in temporarily lowered water quality standards within the immediate dredging area.

MITIGATION: Siltation curtains to be used to surround the construction area and limit siltation to the immediate construction area. Special care will be taken to remove materials from the bottom of the curtains prior to removal and/or relocation of the curtains.

IMPACT: Disturbance of marine biological community in the vicinity of the dredged channel.

MITIGATION: Use of siltation curtains to limit increased turbidity to immediate dredge area. Channel sides to provide stable, hard substrate replacement habitat for sessile organisms and feeding areas for grazing motile organisms.

IMPACT: Temporary disturbance of anchialine ponds in the shoreline area with the addition of windblown debris and silt resulting from construction.

MITIGATION: Removal of debris and regular maintenance of ponds to allow ponds to regain original appearance and biota.

IMPACT: Potential construction impacts on humpback whales and turtles frequenting project site.

MITIGATION: Offshore construction to be performed during summer months only. Visual inspections to be performed daily to assure that turtles and other sensitive marine organisms are not in construction area.

IMPACT: Lowered air quality from excavation and construction vehicles.

MITIGATION: Excavated areas to fill with groundwater. Those above water level to be planted with ground cover as soon as possible. All construction areas to be regularly water sprayed and all construction vehicles to meet federal emission standards.

IMPACT: Noise impacts from construction vehicles and machinery.

MITIGATION: Construction to be limited to normal daytime work hours and all construction vehicles and machinery to be equipped with mufflers in compliance with federal and state rules and regulations.

7.2 LONG-TERM IMPACTS

IMPACT: Permanent loss of about 2 acres of naturally occurring and stressed shoreline reef which will be lost due to the construction of the Cove's access channel (see Chapter IV for reef characteristics).

MITIGATION: Existing lava reef terrace, subjected to strong surge and wave action, to be replaced with deeper channel sides below surge and wave zones, to provide a stable, roughened, hard substrate on which sessile organisms can become attached and a grazing area for motile organisms.

IMPACT: Permanent loss of about 28 acres of fast land mauka of the shoreline due to the excavation of interior channels and the boat basin.

MITIGATION: Terrestrial habitat to be replaced with brackish water habitat of channels, thereby providing new nursery, cover and feeding areas for fish and other motile organisms.

IMPACT: Loss of naturally occurring stands of native Pololei fern.

MITIGATION: Pololei fern to be replanted and incorporated into resort landscaping.

IMPACT: Loss of about 125 linear feet of natural shoreline due to the channel connection to the interior marina.

MITIGATION: Natural shoreline to be replaced by new hard, non-surge subjected marine habitat and natural characteristics of shoreline to be retained to maximum extent possible. Additions and improvements to be made to the public shoreline access trail. Anchialine ponds to be restored to their natural character.

IMPACT: Loss of two golf holes (11 and 12) mauka of the Mauna Lani Cove project.

MITIGATION: Golf holes to be relocated to resort lands mauka of the Cove project.

IMPACT: Loss of naturally occurring kiawe scrub vegetation.

MITIGATION: Natural vegetation to be replaced with native and other appropriate landscape materials, such as the Pololei fern, within the public areas and strict landscape design standards, emphasizing use of native plant materials, to be enforced for private areas.

IMPACT: Loss of naturally occurring terrestrial wildlife habitat.

MITIGATION: Terrestrial habitat to be replaced by landscaped areas and new marine/brackish water habitat.

IMPACT: Loss of archaeological sites (see Chapter IV for sites significance).

MITIGATION: Designated archaeological sites to be preserved in compliance with applicable federal, state and county rules and regulations. Archaeological information to be collected and interpreted according to recommendations of a professional archaeologist in consultation with the State Preservation Program and Hawaii County Planning Department.

IMPACT: Open space character of the project site to be lost.

MITIGATION: Open space character to be replaced by marine water areas, residences, and The Landing boat basin and related commercial uses. Water areas to retain a portion of the present open space character.

IMPACT: Increase in vehicular traffic due to the project.

MITIGATION: Project and resort roadway systems have been designed to promote efficient and safe flow of traffic. Resort wide traffic controls to be monitored and enforced.

IMPACT: Potential for boat motor oil spills and other events which could affect water quality in the marina.

MITIGATION: Fuel dock and the Landing areas to be equipped with emergency oil containment booms; Cove management and staff to receive regular emergency response training; and all applicable federal and state rules and regulations pertaining to fuel docks to be followed. Sewage pumpout station provides means for disposing of boat sewage. Flushing of boat toilets directly into the Cove to be strictly prohibited and controlled. Deep wells and a pumping system to be used to ensure adequate circulation within the marina. Maintenance and monitoring programs will be established and implemented to ensure that water quality within the channels is to governmental standards. Control of non-point source pollution by restrictive covenants for homeowners and a rigorous marina management plan.

IMPACT: Loss of the site for hotel development, for which it is zoned, as well as for other potential uses.

MITIGATION: Project provides less dense development of site.

8. SUMMARY OF ALTERNATIVES CONSIDERED

Alternatives to the proposed project have been considered and rejected because they do not meet the applicant's objectives or because they would have greater adverse environmental impacts than would the proposed project.

The "no action" alternative is to develop the resort-zoned parcel as a hotel site with several hundred hotel units as allowed by current zoning. This alternative would have greater socioeconomic and traffic impacts, among others, and would not allow the applicant to achieve its objectives of adding a new water-related dimension to the resort and maximizing water-related benefits. Additionally, the "no-action" alternative would not allow Mauna Lani Resort the opportunity to assist in reducing the West Hawaii demand for small boat mooring space.

The alternative of developing a smaller residential marina project which does not necessitate relocating the two existing golf holes would allow the applicant to achieve its objective of adding a new water-related dimension to the resort. However, the number of waterfront residential lots would not be maximized. The order-of-magnitude cost of project construction would generally be the same, as would the anticipated environmental impacts. Similarly, the alternative of developing the Cove without an access channel to the ocean would allow development of waterfront residential lots and would reduce construction impacts on the marine environment, but would most likely result in reduced water quality within the channel areas and would not provide the small boat recreational facilities that are needed in West Hawaii.

The alternative of developing an offshore marina basin or breakwater marina project on the reef either between the Mauna Lani Bay and Ritz-Carlton, Mauna Lani hotels, at Honoka'ope Bay or at any other location fronting the resort, would allow the developer to achieve its objective of adding a major new water-related element to Mauna Lani Resort. However, no waterfront residential lots would be added to the resort. This alternative would also result in more severe impacts to the environment, particularly the ocean environment. Similarly, the development of a new small boat marina facility off Mauna Lani Resort property would provide the needed public small boat recreational facilities but would not provide Mauna Lani Resort a marketable product within the resort property. An off-site marina facility would also likely result in impacts similar to, if not greater than those of the proposed project.

9. SUMMARY OF UNRESOLVED ISSUES

During the pre-permitting and the continuing permitting process, the applicant and its representatives have held several meetings with government officials and staff as well as with concerned citizens and community groups. Resulting from this, specific issues have surfaced and are being addressed in this Supplemental EIS.

Mauna Lani Resort, Inc. is aware of many questions and public concerns at this time regarding the proposed project. Mauna Lani Resort, Inc. has been and will continue to work with the residents and businessmen of the area, as well as administrative and elected officials to assure that the final development plans meet the developer's project objectives and satisfactorily address concerns that have been raised to date as well as those that may be raised during public review of this EIS.

The following issues remain unresolved at this time:

- Project's consistency with the State's Coastal Zone Management Program.
- Applicability of State water quality certification requirements.
- Extent of environmental monitoring required prior to, during and following construction.
- Long-term impact of operations on marine environment.
- Permit condition requirements.

One of the purposes of this Final Supplemental EIS is to provide governmental agency technical staff and decision makers the information required to fully address and respond to the permitting and policy issues that remain unresolved. Given the extent of information provided herein regarding the potential impacts of the construction, operation and maintenance of small boat marinas, it is believed that more than adequate technical information is provided to assist decision makers in their deliberations.

10. SUMMARY OF COMPATIBILITY WITH LAND USE PLANS AND POLICIES

The proposed Mauna Lani Cove project site is located within the Urban district boundary as defined by the State Land Use Commission and within Resort lands as designated by the Hawaii County General Plan. Hence, the project is consistent with current State and County land designations. However, to move forward, the project requires several governmental permits which are listed below.

11. NECESSARY APPROVALS AND PERMITS

This Supplemental EIS supports various Hawaii County permit applications and a State Conservation District Use Application for work in submerged lands. Table I-1 is a listing of *major* approvals and permits required for the Mauna Lani Cove project. Other approvals and permits are also required for development to go forth after the following have been obtained.

TABLE I-1

MAJOR PERMITS/APPROVALS REQUIRED

APPROVAL	APPROVING AGENCY OR BODY
HAWAII COUNTY	
Change of Zone	County Council
Special Management Area Use Permit	Planning Commission
Shoreline Setback Variance	Planning Commission
Use Permit	Planning Commission
Plan Approval	Planning Department
Subdivision Approval	Planning Department
Planned Unit Development	Planning Department
STATE OF HAWAII	
Conservation District Use Permit	Board of Land and Natural Resources
Historic Sites Review	Department of Land and Natural Resources, Historic Preservation Program
Coastal Zone Management Consistency Determination	Office of State Planning
Water Quality Certification*	Department of Health
FEDERAL GOVERNMENT	
River and Harbor Act of 1899 Section 10 Permit for Work in navigable Waters	U.S. Army Corps of Engineers
Bridge Permit	U.S. Coast Guard

* Applicability not fully defined at this time.

CHAPTER TWO

CHAPTER II

DESCRIPTION OF THE PROPOSED PROJECT

1. INTRODUCTION

Mauna Lani Resort, Inc., developer of the master planned Mauna Lani Resort, proposes to develop a water-oriented residential marina -- Mauna Lani Cove -- on an 88-acre waterfront parcel between the existing Mauna Lani Bay Hotel and Bungalows and Ritz-Carlton, Mauna Lani Hotels (TMK 6-8-22: portions of 1, 3 and 9). The project also includes the relocation of two existing golf holes (now at The Mauna Lani Cove site) to an area mauka of the Cove and the construction of a lake which will serve both as a water feature for one of the relocated golf holes and a flushing reservoir for inland Cove waterways. The project site has long been designated for resort and open uses in the Mauna Lani Resort master plan.

2. REGIONAL SETTING

The regional setting of the proposed project area is fully described in the Revised Master Plan Final Environmental Impact Statement for Mauna Lani Resort (Belt Collins & Associates, 1985). In brief, Mauna Lani Resort is located between Puako Beach Lots and the Waikoloa Beach Resort along the South Kohala shoreline on the island of Hawaii (Figure II-1). The South Kohala coastline, from the district boundary north to Kawaihae Harbor, has long been recognized as a desirable location for the development of large-scale planned resort activities. Mauna Lani Resort is one of three South Kohala District resort destination nodes identified in the West Hawaii Regional Plan (Office of State Planning, 1989).

3. PROJECT BACKGROUND

Mauna Lani Cove is designed to add a new dimension to the existing resort while adhering to the concept, design and operation guidelines followed in the development of other Mauna Lani Resort projects: provide facilities and amenities which are of world class quality and at the same time sensitive to the natural environment and surrounding community.

Mauna Lani Resort has been master planned as a luxury destination resort since the mid-1970's. (See Figure II-2 for the current resort master plan.) Built to date are the 351-room Mauna Lani Bay Hotel and Bungalows, the 550-room Ritz-Carlton, Mauna Lani Hotel, the 80-unit Mauna Lani Terrace condominiums, the 116-unit Mauna Lani Point condominiums, the Francis H. I'i Brown championship golf course and golf clubhouse, a beach club, a racquet club, the Eva Parker Woods museum, and a public park. The Kalahuipua'a fishponds are held in conservation and are open to the public as an ethnobotanical reserve. The Ala Kahakai (shoreline trail), the Ala Loa (King's Trail), and two historic park preserves are also available and easily accessible to the general public as well as resort guests. These amenities are enhanced by interpretive signs.

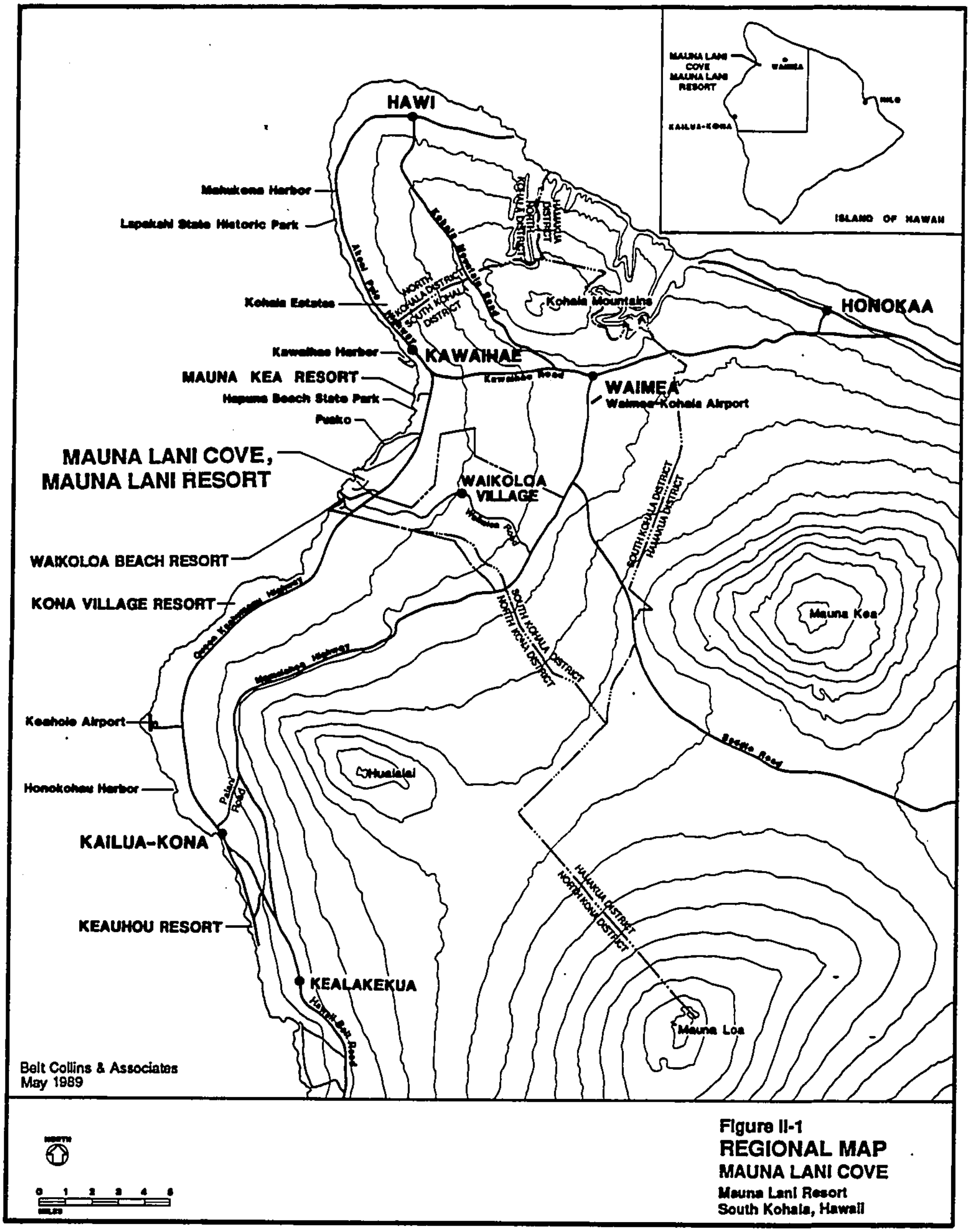
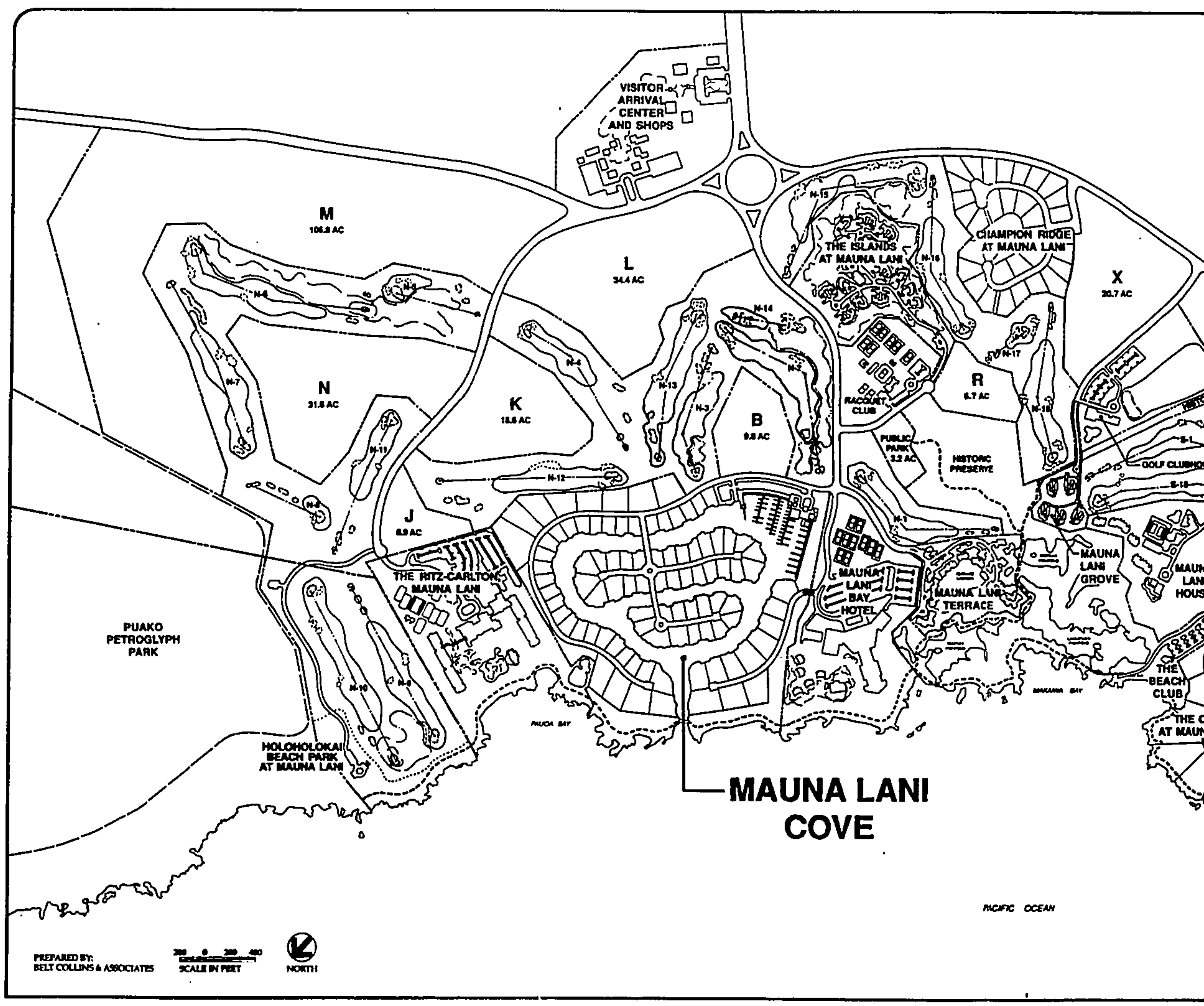


Figure II-1
REGIONAL MAP
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii


VISITOR ARRIVAL CENTER AND SHOPS
M
106.8 AC
N
31.6 AC
L
34.4 AC
K
18.6 AC
J
6.9 AC
B
9.8 AC
R
6.7 AC
X
20.7 AC
THE ISLANDS AT MAUNA LANI
CHAMPION RIDGE AT MAUNA LANI
RACQUET CLUB
PUBLIC PARK 3.2 AC
HISTORIC PRESERVE
GOLF CLUBHOUSE
MAUNA LANI GROVE
THE RITZ-CARLTON MAUNA LANI
MAUNA LANI BAY HOTEL
MAUNA LANI TERRACE
THE BEACH CLUB
PUAKO PETROGLYPH PARK
HOLOHOLOKAI BEACH PARK AT MAUNA LANI
MAUNA LANI COVE
PACIFIC OCEAN
PREPARED BY: BELT COLLINS & ASSOCIATES
SCALE IN FEET
NORTH

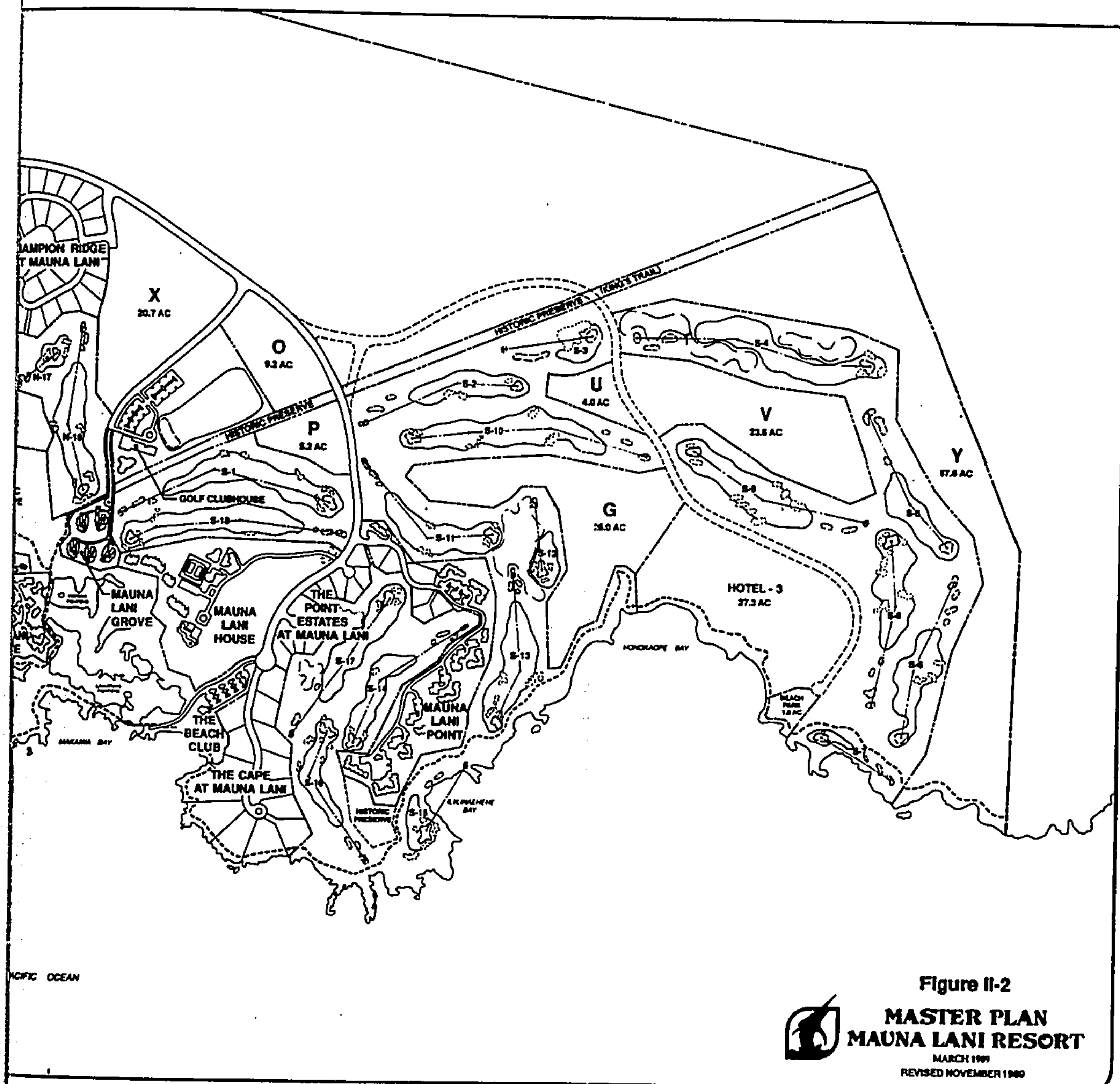


Figure II-2

MASTER PLAN
MAUNA LANI RESORT
MARCH 1989
REVISED NOVEMBER 1989

Scheduled for completion in the fall of 1990 is Holoholokai public beach park, which will have ample parking and family picnic facilities, such as picnic tables, bar-b-ques, restrooms and showers. The park will be located north of the Ritz-Carlton Mauna Lani Hotel at Pauoa Bay. The Puako Petroglyph Archaeological Park is scheduled for completion at the end of 1990 as Hawaii's prototype rock art park. Mauna Lani Resort, Inc., in cooperation with the Waimea Hawaiian Civic Club, nominated the Puako Petroglyph Archaeological District to the State and Federal Registers of Historic Places in 1983.

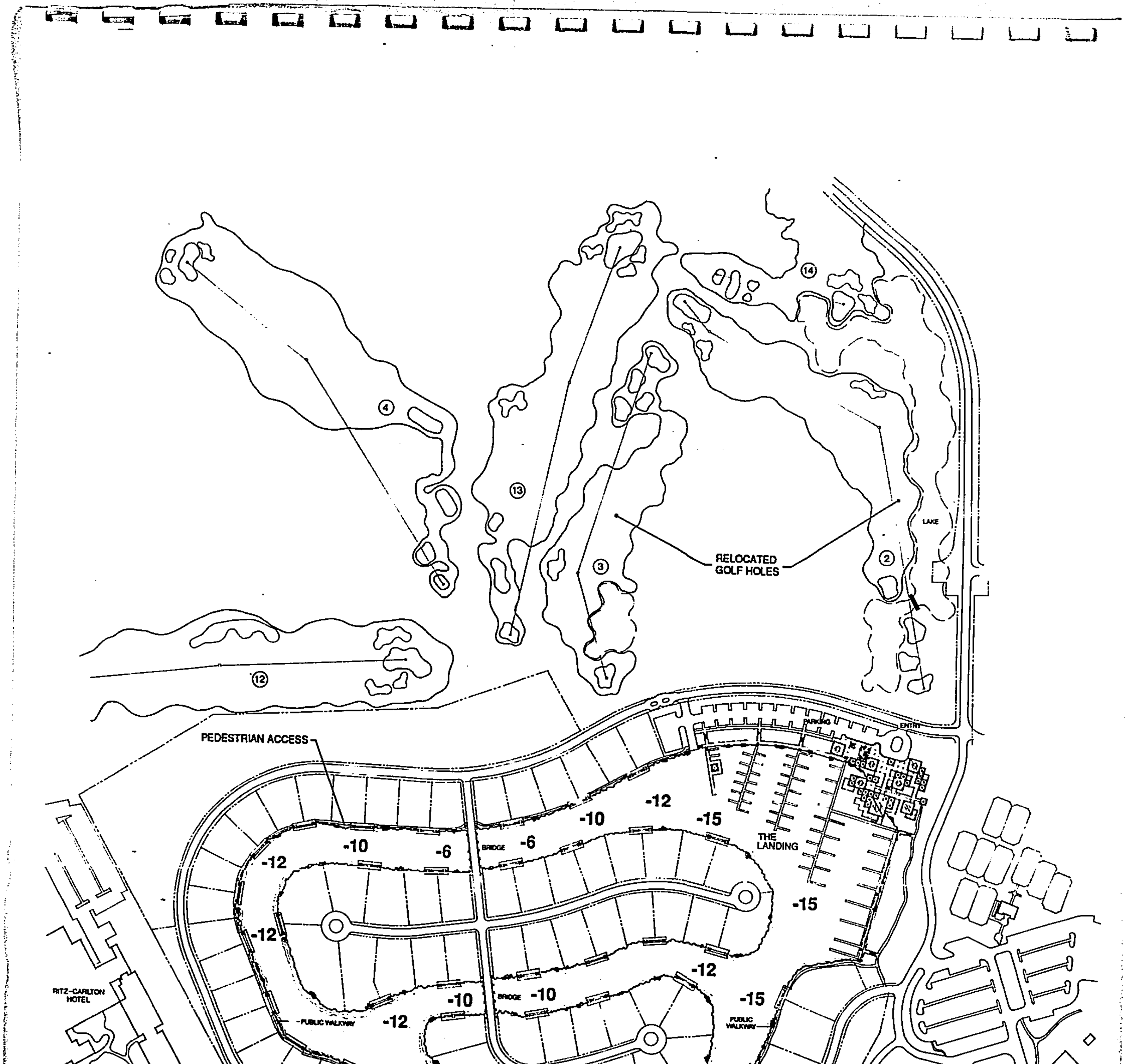
4. DEVELOPMENT CONCEPT

Mauna Lani Resort intends to develop an integrated residential marina project to include 90 to 140 residential lots or units, a boat basin and related boating and commercial facilities to be known as The Landing, as well as various shoreline improvements (see Figure II-3). The design concept for Mauna Lani Cove is that of a low-density village interspersed by waterways, with the boating and boat-support activities concentrated at The Landing. The final number of residential units to be developed will be determined following detailed planning and design work for the project. The current program calls for 105 residential units, 75 of which would have private mooring floats fronting the units, 10 lots that would have ocean views but no direct water access, and 20 clustered single-family detached units. A harbor master, utilizing comprehensive and strict rules and regulations (see Appendix Q) will manage operations at this high service marina.

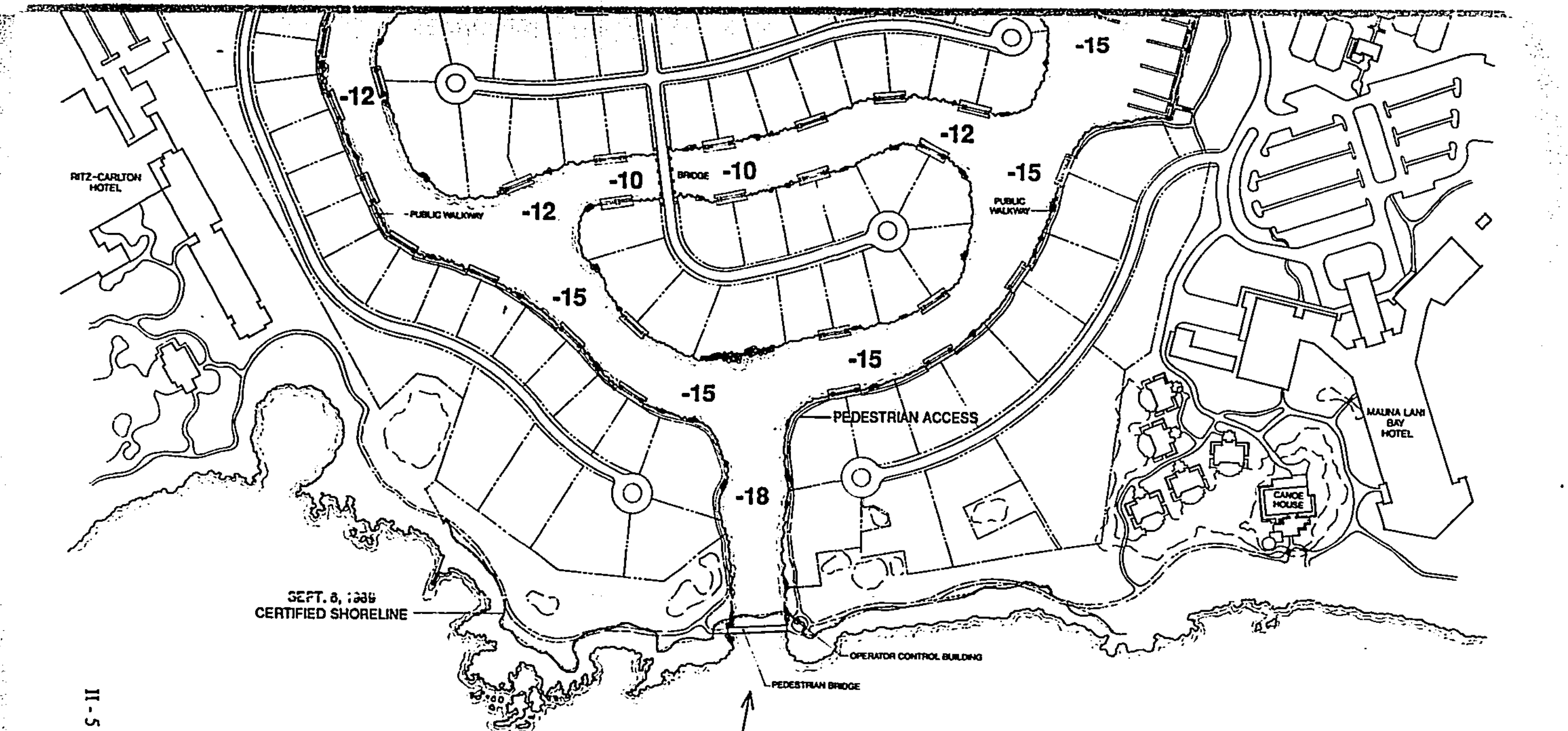
The open space, low-rise character of the resort will be maintained at The Cove, with land portions heavily vegetated to blend in with surrounding development (see Figure II-4). Public pedestrian access will be maintained and increased along the shoreline as well as around the marina and recreational and commercial activities at The Landing will be available to the general public. Additionally, vehicle/pedestrian drop off areas will be provided at the end of the roadways within the residential lots surrounding the Cove.

5. STATEMENT OF OBJECTIVES

Mauna Lani Resort is one of three major destination resort nodes on the Kohala coast that were planned and established many years ago. Based on an updated master plan, the resort is being developed in an orderly manner, responding to market demand within the context of the important objective of creating and maintaining an attractive world-class visitor and residential complex with strong ties to the local community. An important overall goal is to continue the operation and expansion of a successful venture which supports the developer's ability to make meaningful community contributions.



RELOCATED GOLF HOLES
LAKE
ENTRY
PARKING
THE LANDING
PEDESTRIAN ACCESS
BRIDGE
PUBLIC WALKWAY
RITZ-CARLTON HOTEL
-15
-12
-10
-6



APPROXIMATE
ENTRANCE CHANNEL

Note: The proposed Mauna Lani Cove is shown in concept only. Design of facilities is subject to change, based on engineering analysis.

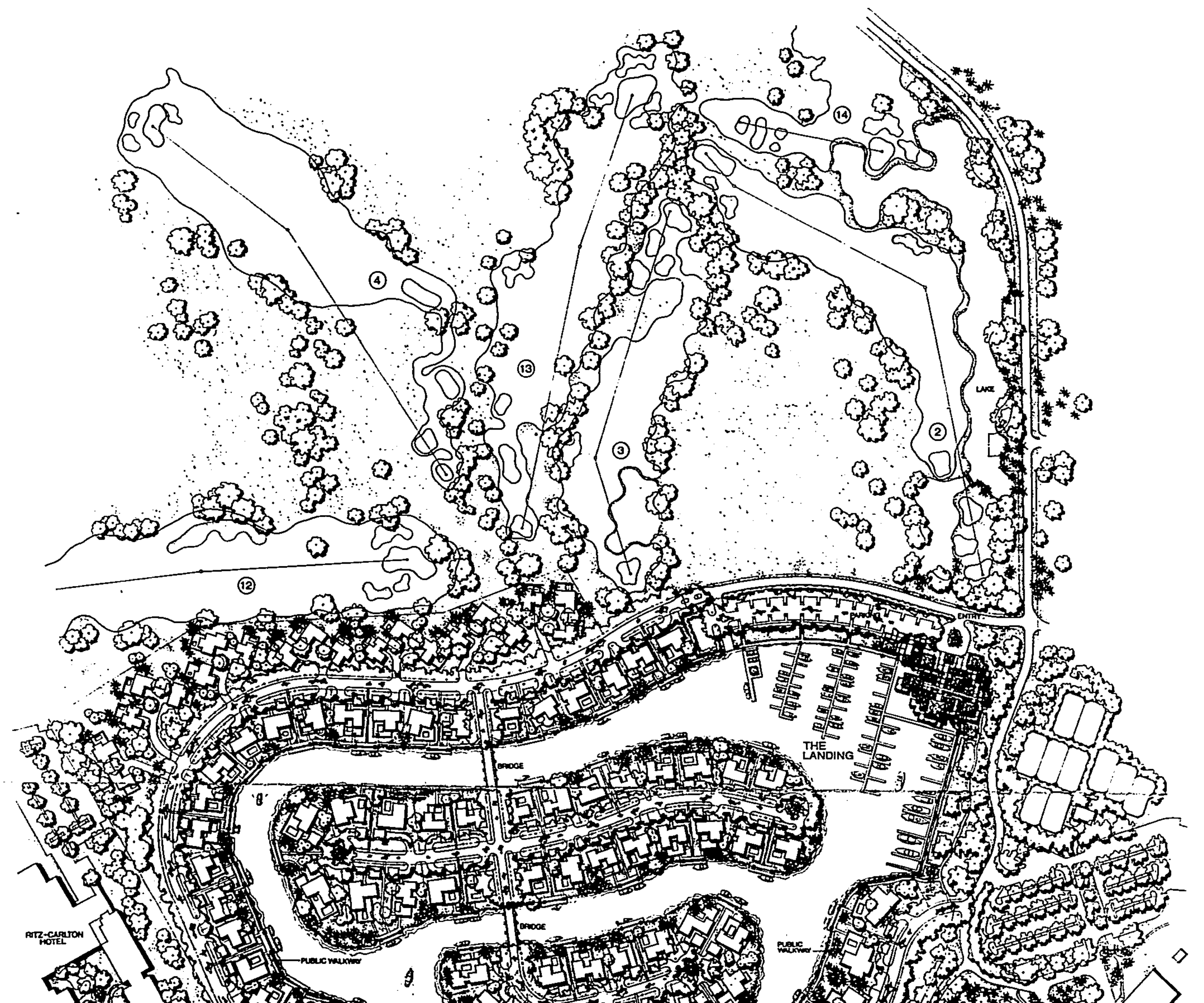
-12 PROPOSED CHANNEL DEPTH (FT)

0 80 160 320
SCALE IN FEET

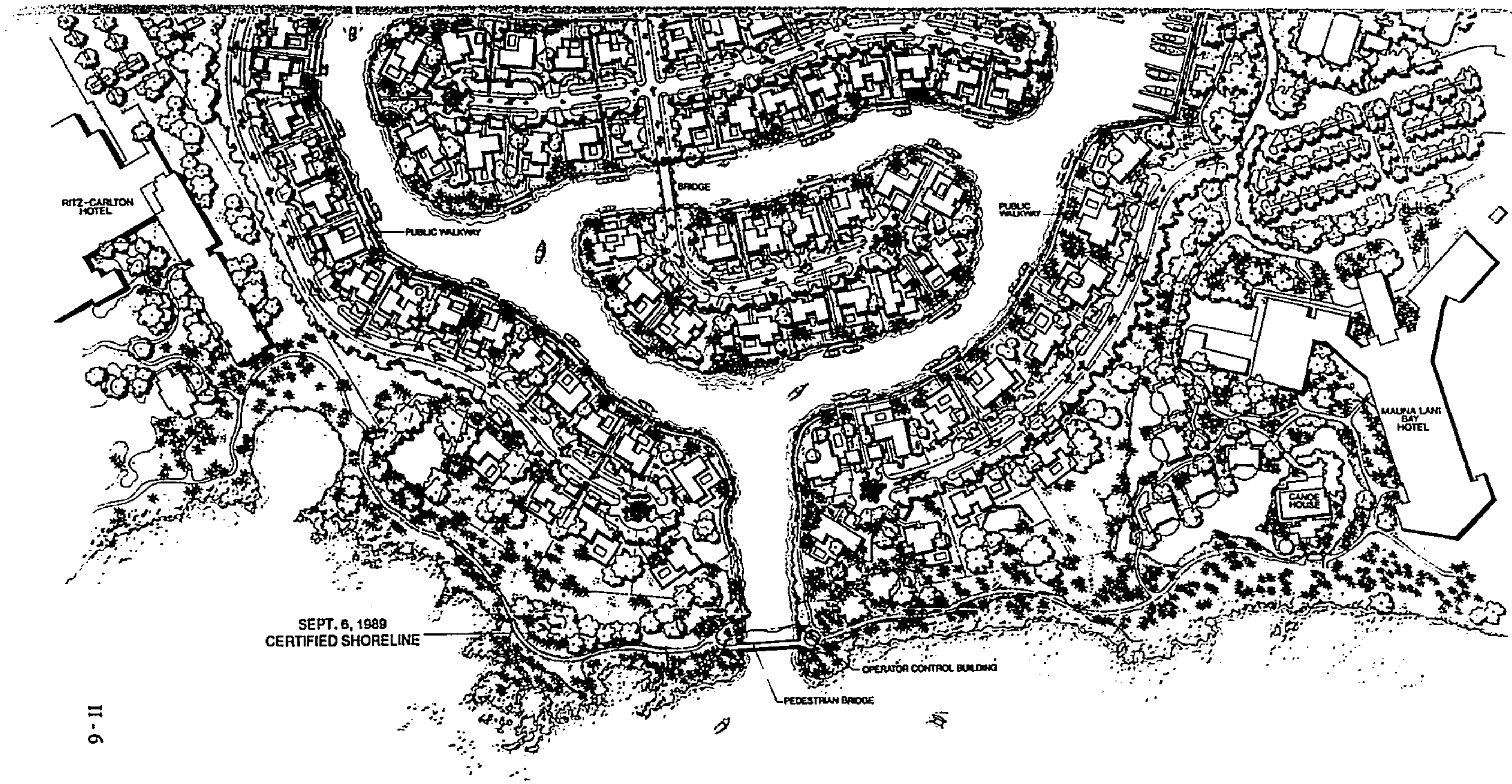
NORTH

Source: ROMA Design Group and Belt Collins & Associates December 1989

Figure II-3
CONCEPT PLAN
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii



THE LANDING
RITZ-CARLTON HOTEL
PUBLIC WALKWAY
PUBLIC WALKWAY
BRIDGE
BRIDGE
LAKE
PARKING
ENTRY
2
3
4
12
13
14



Source:
ROMA Design Group

0 60 160 320
SCALE IN FEET

NORTH

Source: ROMA Design Group
and Belt Collins & Associates
December 1989

Figure II-4
LANDSCAPE CONCEPT
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Community Contributions

Included in community contributions that Mauna Lani Resort has made to date are:

- Current on-site employment force of approximately 1,500 persons (including construction forces) with an estimated annual payroll of about $40 million. A variety of job opportunities in a wide range of areas are presently provided by the Mauna Lani Bay Hotel and Bungalows and Ritz-Carlton, Mauna Lani Hotels, the golf course and residential projects. The majority of the positions, including management positions, are staffed by local residents and on- and off-site job training programs are offered to allow employees to improve their positions.

- Annual financial support of numerous youth and adult education/activity programs including high school scholarship and trust funds, canoe and equestrian clubs, arts and dancing programs, Boys/Girls Clubs and mental illness and crisis programs.

- Financial and manpower support of environmental groups and programs such as Sierra Club, Kona Outdoor Circle, Pacific Game Fish Research Foundation, Pacific Ocean Research Foundation, Puako Petroglyph Archaeological District, Green Turtle Restoration Program, Hawaii International Billfish Tournament, West Coast Whale Research Foundation, Hawaii Nature Center, Kona Historical Society and the state endangered species propagation program.

- Annual financial support of community medical and health programs including Lucy Henriques Hospital, North Hawaii Community Hospital, American Cancer Society, American Lung Association, suicide prevention programs, DARE Program and child and family service programs.

- Manpower and financial support for various community functions such as North Kohala Country Fair, Earth Day, Ironman Triathalon, Merrie Monarch Festival and various rodeos, art fairs and other community functions.

- Mauna Lani School - a child care center on-site for Mauna Lani Resort employees (the only company sponsored facility of this type in West Hawaii).

Project Objectives

Mauna Lani Cove plays a specific role in the ordered development of the master planned resort. Mauna Lani Resort, Inc. hopes to attain several major objectives with the residential marina:

- Balance private and public benefits derived from the project.

- Further the mission of the Kohala Coast as set forth in the 1958 State Plan for Tourist Destinations and the 1967 Olohana Corporation land development plan, "The Kohala Coast Resort Region."

- Add an amenity which will be an integral part of Mauna Lani Resort, compatible with the resort's established character: low density and designed for maintenance of environmental integrity.

- Add a new water-related dimension which will enhance the resort's competitive market position and add to the character of the Kohala Coast.

- Avoid building another hotel, for which the land is zoned, and instead add a distinct, low density residential product to those currently offered by the resort.

- Maximize the number of waterfront residential lots at Mauna Lani Resort (some residences will have frontage onto navigable waters and direct access to a private dock) and community water-related opportunities.

- Create an attractive project that is accessible to the public as a park/community center, including use of the boat basin and channels by community water sport clubs and use of the commercial center. This will be a community center where people will come to enjoy water front or water oriented activities such as walking, running, paddling, boating, sailing, fishing, dining, shopping, and visiting the interpretive center.

- Assist in satisfying the demand for small boat docking facilities among existing Mauna Lani homeowners and the general public.

- Provide the impetus for expanding the pleasure boat service industry in Hawaii.

- Create a state-of-the-art, high-service marina with fuel dock, sewage pump station and strict operation and maintenance plans that can serve as a model for other public and private marinas.

- Provide transient moorings to discourage and minimize proliferation of "open roadstead" moorings.

Public Benefits

Of the above objectives, continuing to balance the private and public benefits to be derived from the project is of utmost importance to Mauna Lani Resort, Inc.. The direct public benefits to be derived specifically from the proposed project include the following:

- Additional small boat mooring and launch facilities in West Hawaii. As will be noted later in this chapter, there is a demonstrated need for over 300 small boat mooring spaces in West Hawaii. The proposed project will assist in satisfying that need.

- Additional and improved public access to the shoreline. Two new public access points will be provided as part of the proposed project. In addition, vehicle/

pedestrian drop off points will be provided, thereby allowing relatively easy shoreline access for the elderly and children and allowing others to drop off picnic and beach supplies close to the point at which they will be used.

- Additional and improved public shoreline park facilities. The proposed project includes the creation of a greenbelt and passive shoreline park along the seaward margins of the Cove. Such a park will be ideal for family picnics while still allowing beachgoers and fishermen close access to the shoreline.

- Improved anchialine pond, coastal pond and nearshore marine conditions. The existing anchialine ponds in the vicinity of the Cove access channel will be cleaned of the debris that has accumulated and the ponds will be restored to their natural condition. Should state and county agencies desire, interpretive signage would be erected in close proximity to the ponds, thereby increasing their educational value.

- Increased state and county tax revenues. The proposed project is expected to generate an additional $2.7 million for the County of Hawaii General Fund and Highway Fund and approximately $173,000 annually in state gross receipts taxes. In addition, state income taxes will be generated.

- Increased employment opportunities in a variety of positions and industries. As noted previously, there are approximately 1,500 persons employed at Mauna Lani Resort. The Cove project is estimated to require an additional 85 to 90 employees, to service the various planned operations at the Cove.

- Increased small boat, canoe and kayak recreational opportunities. The channels inside the Cove as well as the access channel will allow an increase in small boat activities within protected as well as open ocean waters. The boat launch facility will easily accommodate the launching of racing canoes and the ocean area immediately offshore will provide another venue for open ocean canoe and sailboat regattas.

- Additional small boat dry storage facilities in West Hawaii. A key element of the proposed project is the dry storage facilities. These facilities will allow boaters to keep their boats close to the launch ramp, thereby facilitating their use and storage.

- Additional safe, protected small boat anchorage facilities along the West Hawaii coastline for all boaters during emergency and storm condition situations. This is another key element of the proposed Cove project. The ability of a boater to seek refuge in a safe, protected harbor in time of emergency or sudden storm is of utmost importance and can only be appreciated by the boater who is unable to find that refuge.

These direct public benefits would be in addition to those already provided by Mauna Lani Resort and they would be provided at essentially no cost to the public. These additional public benefits have been developed and planned in consultation and cooperation with the County Planning Department and private groups such as Public Access Shoreline Hawaii (PASH).

In addition, the following indirect public benefits would result from the proposed project:

- Continued impetus to establish and implement a West Hawaii regional water quality/marine ecology monitoring/survey program. Many people, including the scientific consultants who have participated in the preparation of this EIS have noted that it would be far easier to define the potential coastal impacts of proposed West Hawaii projects if there were a uniform and long-term data base of water quality and marine ecology information to draw from. Mauna Lani Resort has, for many years, sought the vehicle to launch and financially support a regional program that would develop and maintain that data base. The proposed Cove project would provide that vehicle and a portion of the funding for such a program.

- Continuation of a regional ciguatera monitoring program. Mauna Lani Resort, independent of the proposed project, has recently initiated a comprehensive University of Hawaii proposed, ciguatera monitoring program. The general purpose of this program is to determine the causative agents of ciguatera fish poisoning and to assist in the development of means of preventing the occurrence of ciguatera poisoning. This program would be aided by the facilities to be included in the project as well as the earnings to be realized from the project.

- Additional impetus to continue development and establishment of a privately financed and endowed marine resources research center. Mauna Lani Resort, in association with other interested private and corporate citizens, has long dreamed of the opportunity to establish a Pacific Rim marine research center. Such a center would be funded through an annual endowment provided by private interests and allow researchers from around the world the opportunity to carry out their research in an ideal setting.

- Continued impetus to assist and cooperate with the University of Hawaii Puako marine research center. University of Hawaii marine researchers must compete with other university researchers for financial and personnel resources. The ability of the Puako researchers to utilize the facilities that would be established at the Cove would be an invaluable resource.

- Development of a working model for the maintenance and operation of public and private small boat marinas in Hawaii. The general public perception of small boat marinas is that they are polluting and only serve a very small segment of the population. The ability to perform water quality, marine and brackish water ecological studies as well as personnel and operations studies on a working and operating marina would also be an invaluable tool for both public and private agencies and would lead to the development of the "best" methods of operating such facilities.

6. NEED FOR THE PROJECT

Market studies prepared specifically for the 1985 Revised Master Plan Final Environmental Impact Statement for Mauna Lani Resort included the projected marketability of resort/residential units for the entire resort, including the Cove parcel which is designated for resort use. The concept of the current water-oriented residential marina has been refined based on the studies' findings and on current market trends as reflected in the region's and Mauna Lani Resort's record of sales. Given current trends, it has become apparent that the residential projections performed during the market analysis for the revised master plan understate the present potential demand for residential units.

A survey of Mauna Lani Resort residents focusing on the demand for the marina component of the project was completed earlier this year (Appendix A). Results of the survey indicate a definite demand for marina facilities at Mauna Lani Resort. Of the respondents (half of the households included in the survey responded), over 60 percent were interested in having at least one boat at the proposed marina. Among those interested in mooring a boat at The Cove, nearly 47 percent were owners of power boats or sailboats. Almost 65 percent indicated a preference for boats under 30 feet in length and more than 85 percent for boats under 40 feet.

A recent report (Lal, 1990) indicates that 74 percent (1,588) of the registered vessels on the Big Island are personal (recreational) vessels. The state (Department of Transportation, 1990) indicates that at present, there are a total of 378 small boat moorings on the Island of Hawaii: 250 at Honokohau Small Boat Harbor; 55 at Kawaihae Small Boat Harbor; 15 at Keauhou Small Boat Harbor; 31 at Wailoa Small Boat Harbor; and about 27 within Hilo Harbor. All of these moorings are under the control of the State Department of Transportation, Harbors Division. Concurrently, there are a total of 310 valid applications on file for additional moorings (Department of Transportation, 1990). Of the applications on file, 289 or 93 percent, are for moorings in West Hawaii (Honokohau, Kawaihae, Kailua-Kona and Keauhou). It has also been reported (Lal, 1990) that at least another 300 persons would apply for moorings if there were any chance that applicants would secure a mooring within a five-year period. The State Department of Transportation recognizes the need for additional mooring space throughout the state and has, for the past several years, submitted budget requests to the legislature for additional small boat harbor facilities. However, because of increasing demands for limited financial resources, the legislature has reluctantly had to defer these requests in deference to more critical needs.

The need for the project is also demonstrated in the desire of Mauna Lani Resort to retain its position as one of the premier destination resorts in West Hawaii. The Cove project will allow Mauna Lani Resort to offer water oriented residential units as well as mooring and associated facilities to its clientele thereby adding to its position in the market place. Further, Mauna Lani Resort's market position can be strengthened while significantly increasing public sector revenues. The latest projections indicate that the county costs associated with the proposed project would be approximately $85 thousand and will be more than offset by the projected $2.7 million in anticipated revenues. Costs to the state will also be minimal and should be more than offset by the $173 thousand generated annually from general excise taxes.

Mauna Lani Cove will not meet all of the demand for small boat mooring space in West Hawaii. However, the above noted waiting list figures clearly demonstrate a demand for additional small boat mooring space in West Hawaii. Similar numbers exist on a state-wide basis. Hawaii has the lowest per capita boat ownership in the nation, a factor that is, in part, driven by the lack of mooring space within the state. The need for additional small boat mooring space is recognized by the state in the West Hawaii Regional Plan [Office of State Planning (OSP), 1989]. OSP, in the West Hawaii Regional Plan, has indicated that the state should "Explore creative implementation and development expansion methods, including privatization and joint ventures for the provision of additional boat slips and harbor facilities." The proposed Cove project is in concert with this state action element of the regional plan. Additionally, Mauna Lani Resort, Inc. has and will continue to support the state in its efforts to expand either Honokohau or Kawaihae Small Boat Harbors to help meet the demand for small boat mooring space in West Hawaii.

7. PROJECT DESCRIPTION

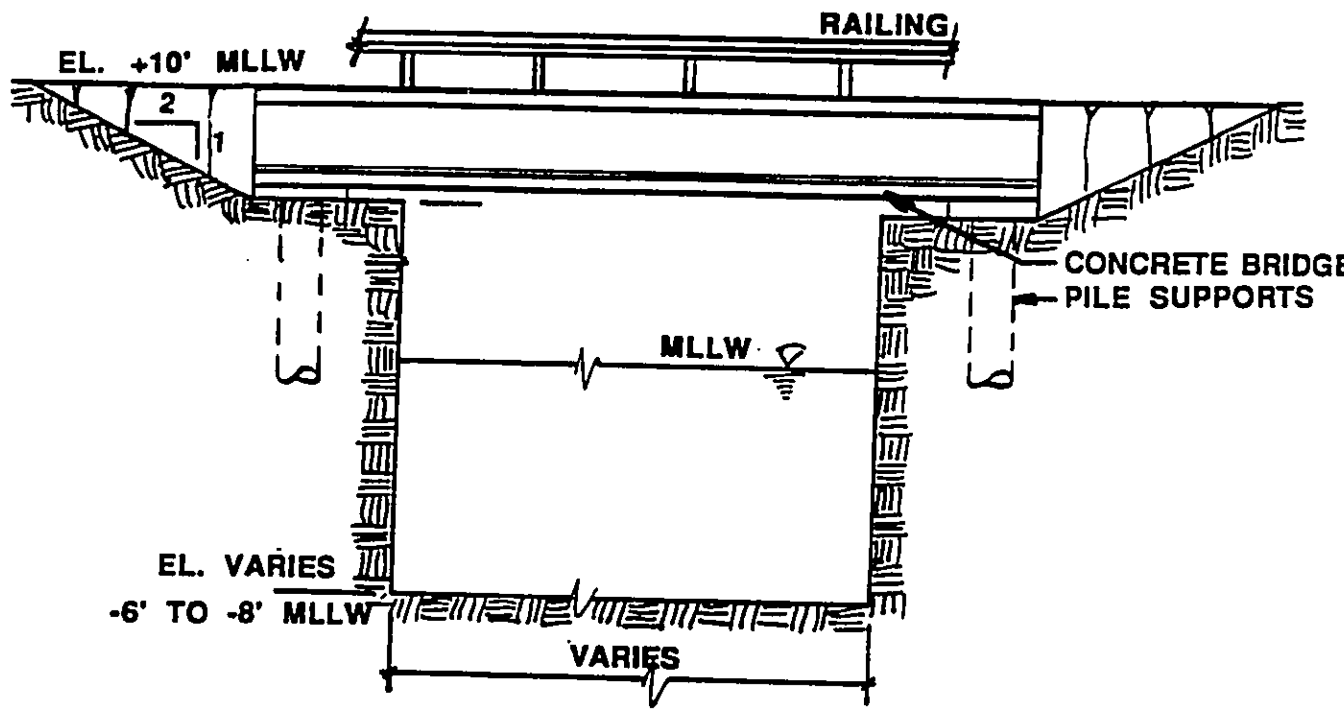
The following sections describe the various components and the various uses and activities of the Cove residential marina. The various elements of the proposed project are shown in Figures II-5 to II-14.

7.1 CHANNEL NETWORK

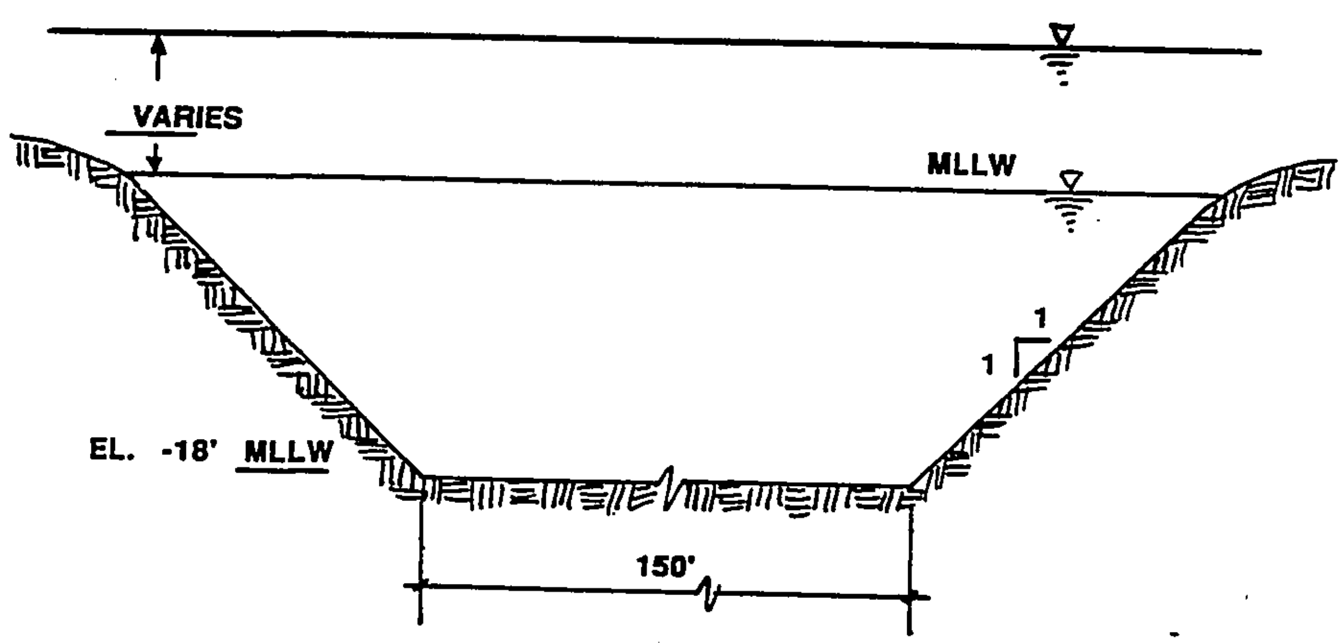
Development of *Mauna Lani Cove* will necessitate dredging a channel in relatively shallow submerged lands to allow for approaching vessels as well as inland excavation to allow for the construction of waterways and a boat basin. Approximately 1.3 million cubic yards of basalt material will be excavated for the channels and boat basin, of which 60,000 cubic yards would be excavated seaward of the state certified shoreline to create the access channel and 1.24 million cubic yards would be excavated landward of the certified shoreline to create the interior channels and boat basin.

The dredged channel in submerged State-owned lands will be approximately 150 feet wide and 625 feet long, with a depth of -18 feet mean low low water (MLLW). Approximately 23 acres of channels fronting the residential lots and units will be excavated, with channel depths varying from -6 feet MLLW to -18 feet MLLW, the deepest at the entry. A depth of -15 feet MLLW will be maintained in the channels closest to the shoreline and in the boat basin, allowing free movement of the larger vessels. Within the marina, channel widths will be a minimum of 125 feet. The certified shoreline would remain in its present location with the shoreline within the Cove being under the ownership of the developer, as has been the practice at similar marinas in Hawaii.

Excavation seaward of the existing shoreline and excavation inland will proceed as two independent projects, to be linked when both operations are essentially complete. The natural shoreline will be left in place as a dike until the entire channel network is excavated.



TYPICAL VEHICLE BRIDGE PROFILE



TYPICAL SEAWARD CHANNEL

Source:
Peratrovich, Nottingham & Drage, Inc.
November 1989

Figure II-5
TYPICAL CHANNEL AND VEHICLE BRIDGE PROFILE
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

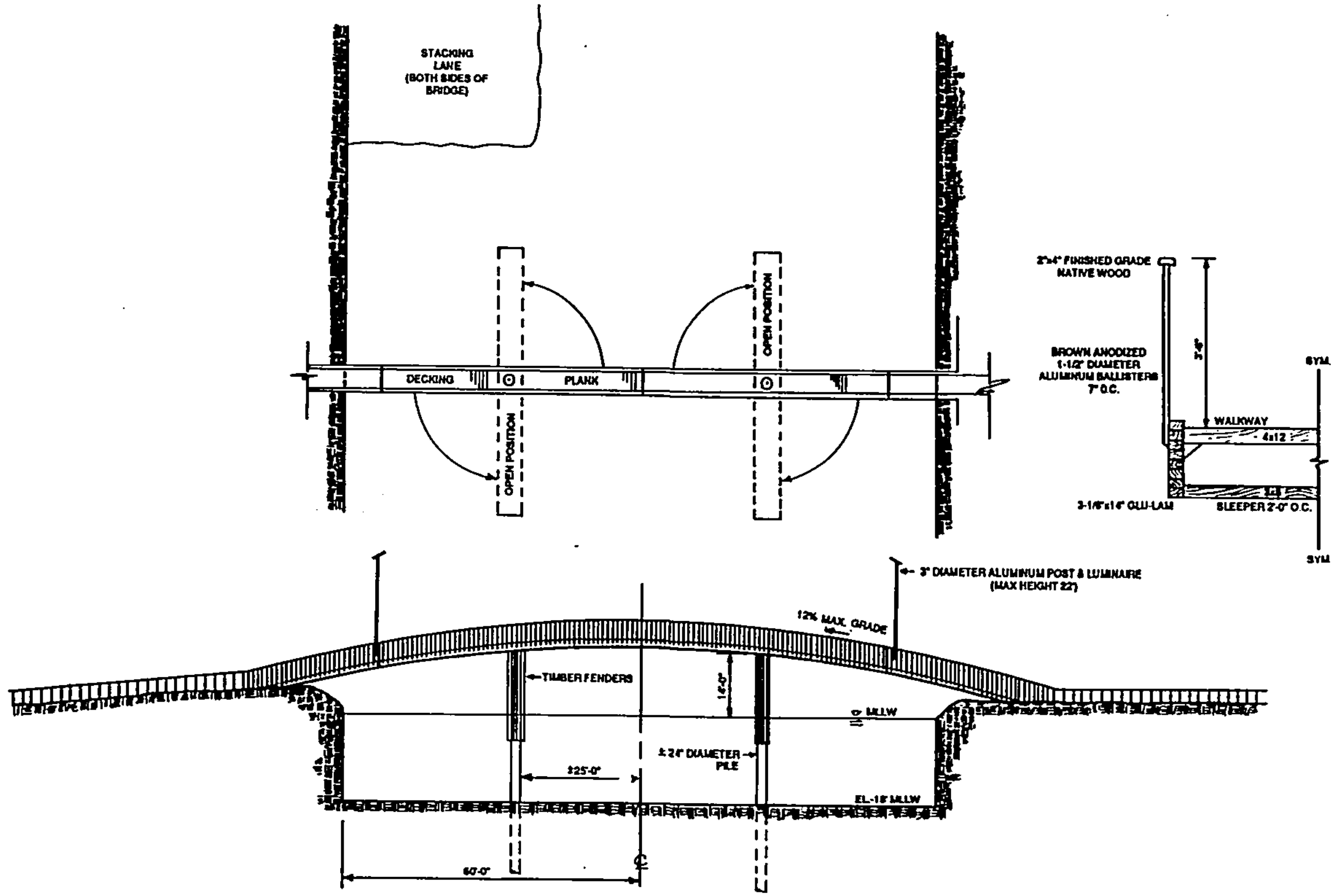
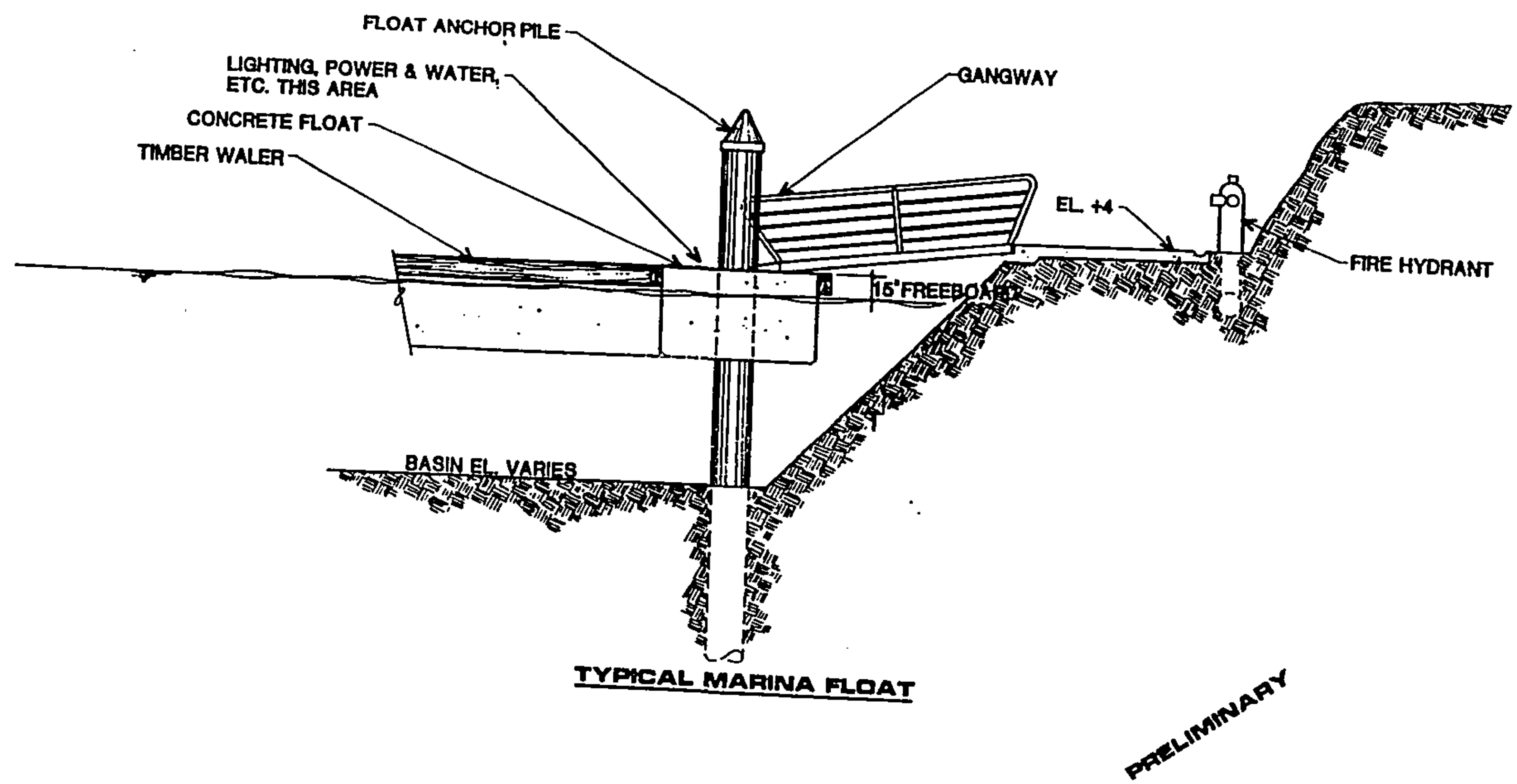


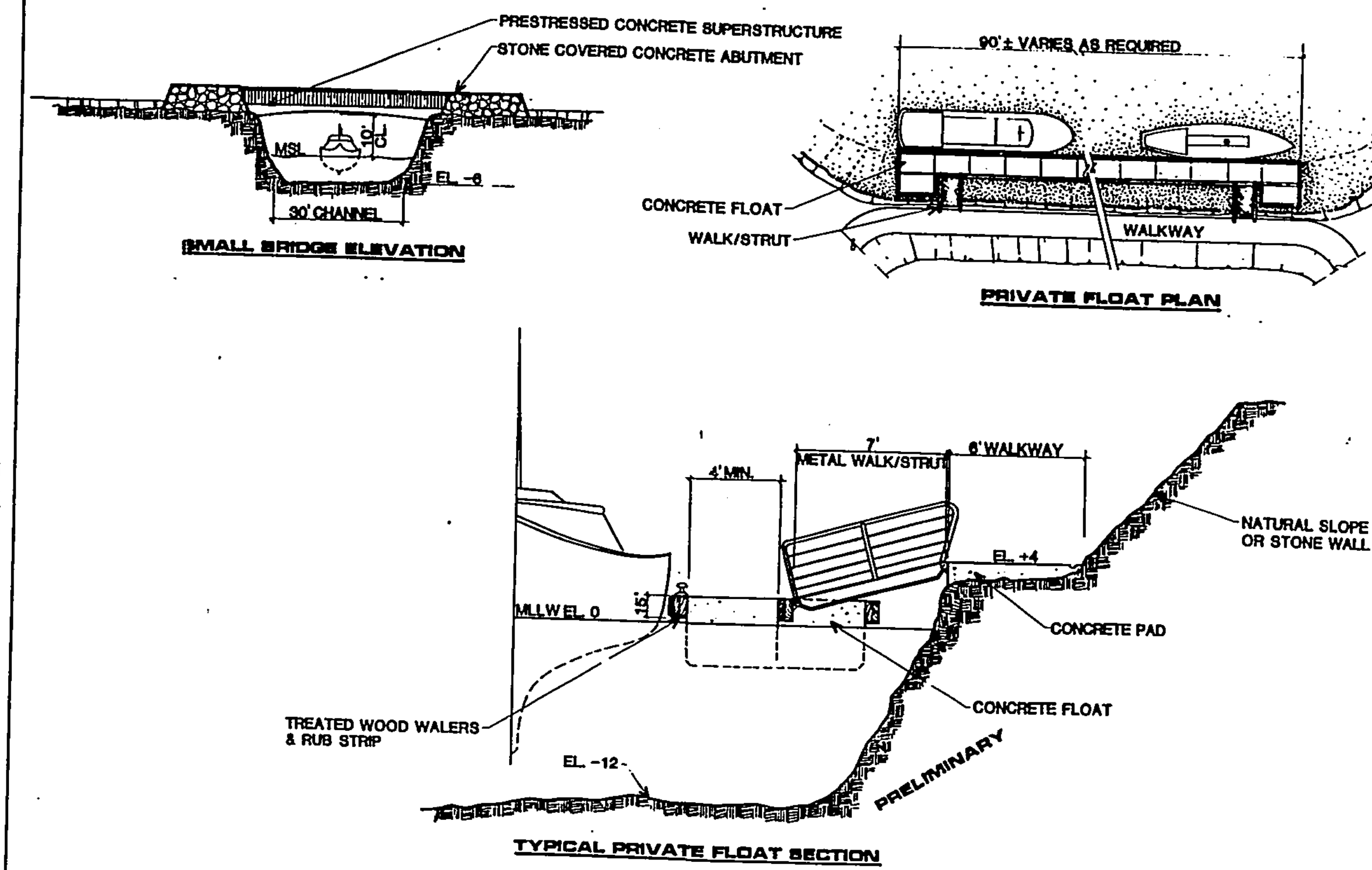
Figure II-6
TYPICAL DETAILS FOR MARINA ENTRANCE PEDESTRIAN BRIDGE
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
Peratrovich, Nottingham & Drage, Inc.
May 1989



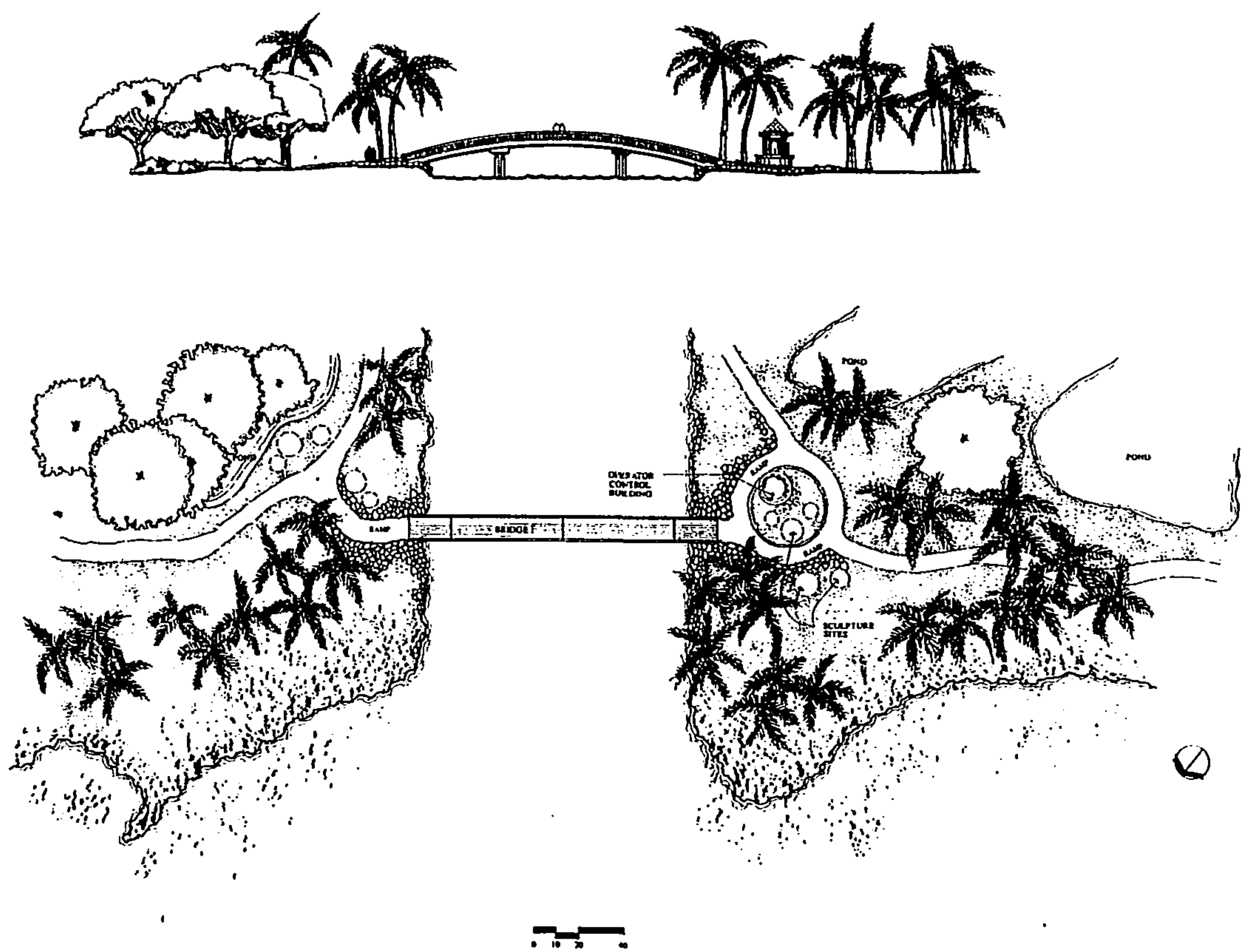
Source:
Peratrovich, Nottingham & Drage, Inc.
May 1989

Figure II-7
TYPICAL DETAIL FOR MARINA FLOAT IN BOAT BASIN
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii



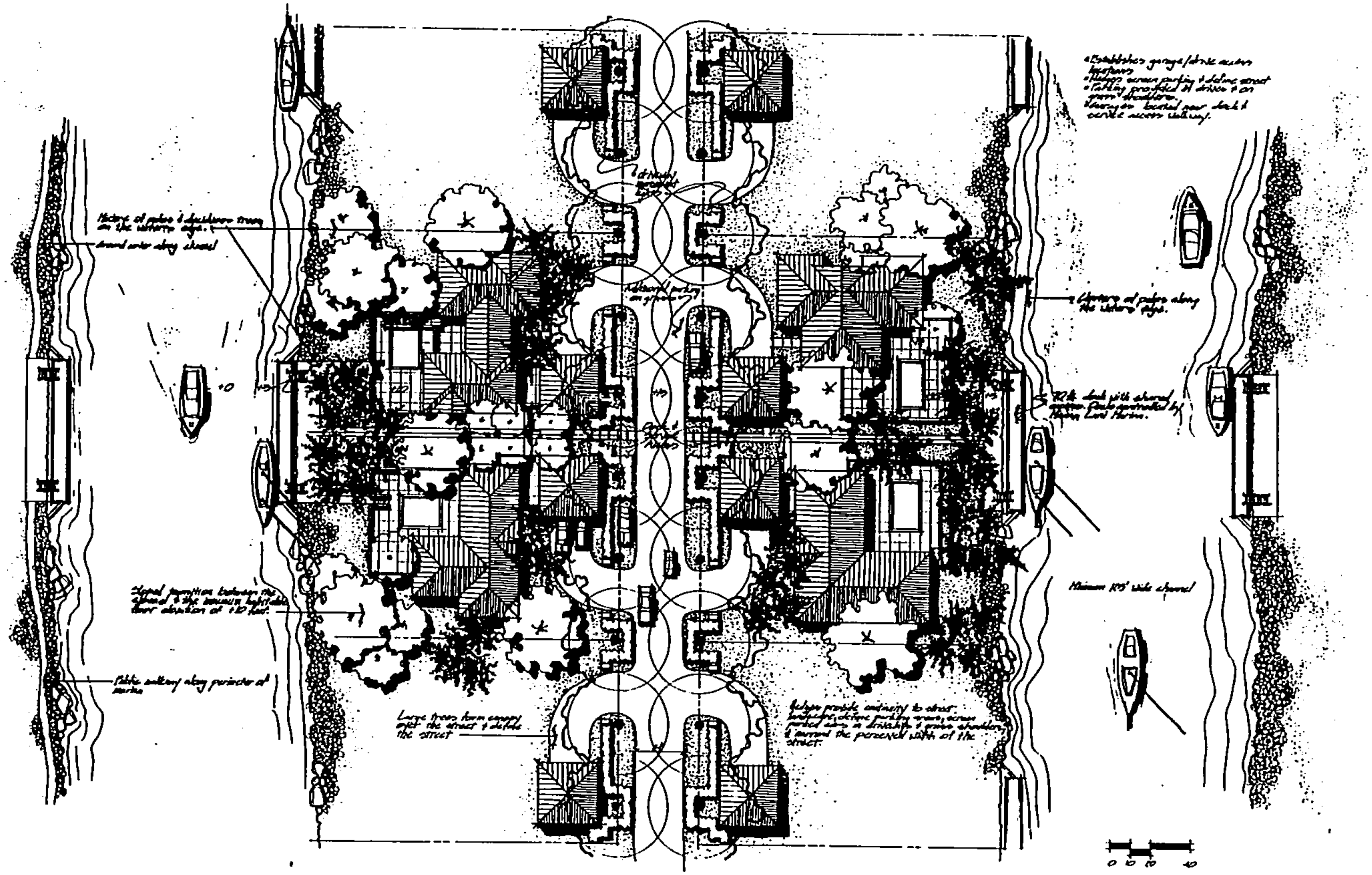
Source:
Peratrovich, Nottingham & Drage, Inc.
May 1989

Figure II-8
TYPICAL DETAILS FOR RESIDENTIAL LOTS
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii



Source:
ROMA Design Group
November 1989

Figure II-9
PEDESTRIAN BRIDGE
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii



Source:
ROMA Design Group
November 1989

Figure II-10
RESIDENTIAL SITE PLAN
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

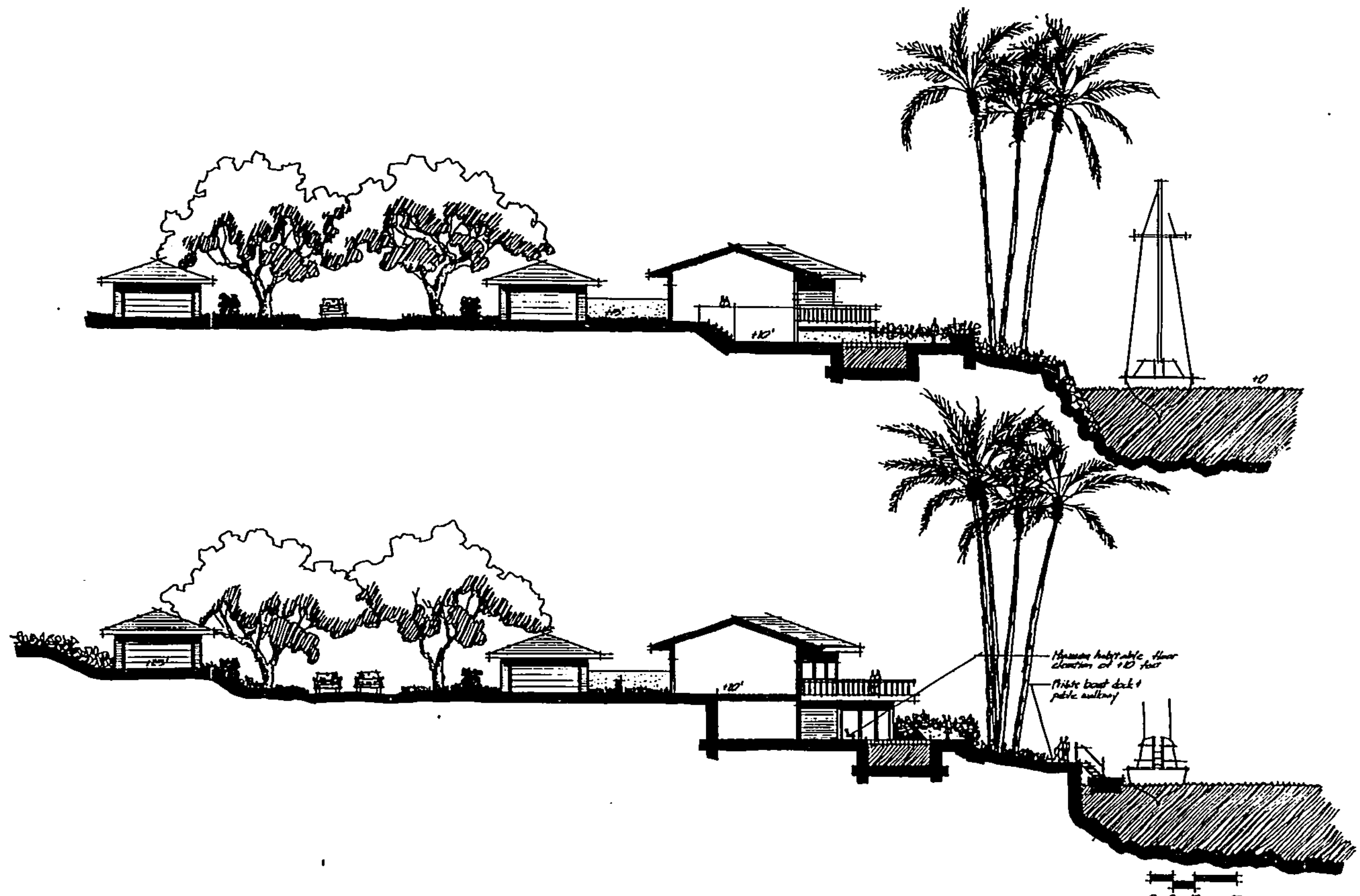


Figure II-11
RESIDENTIAL SECTION
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
ROMA Design Group
November 1989

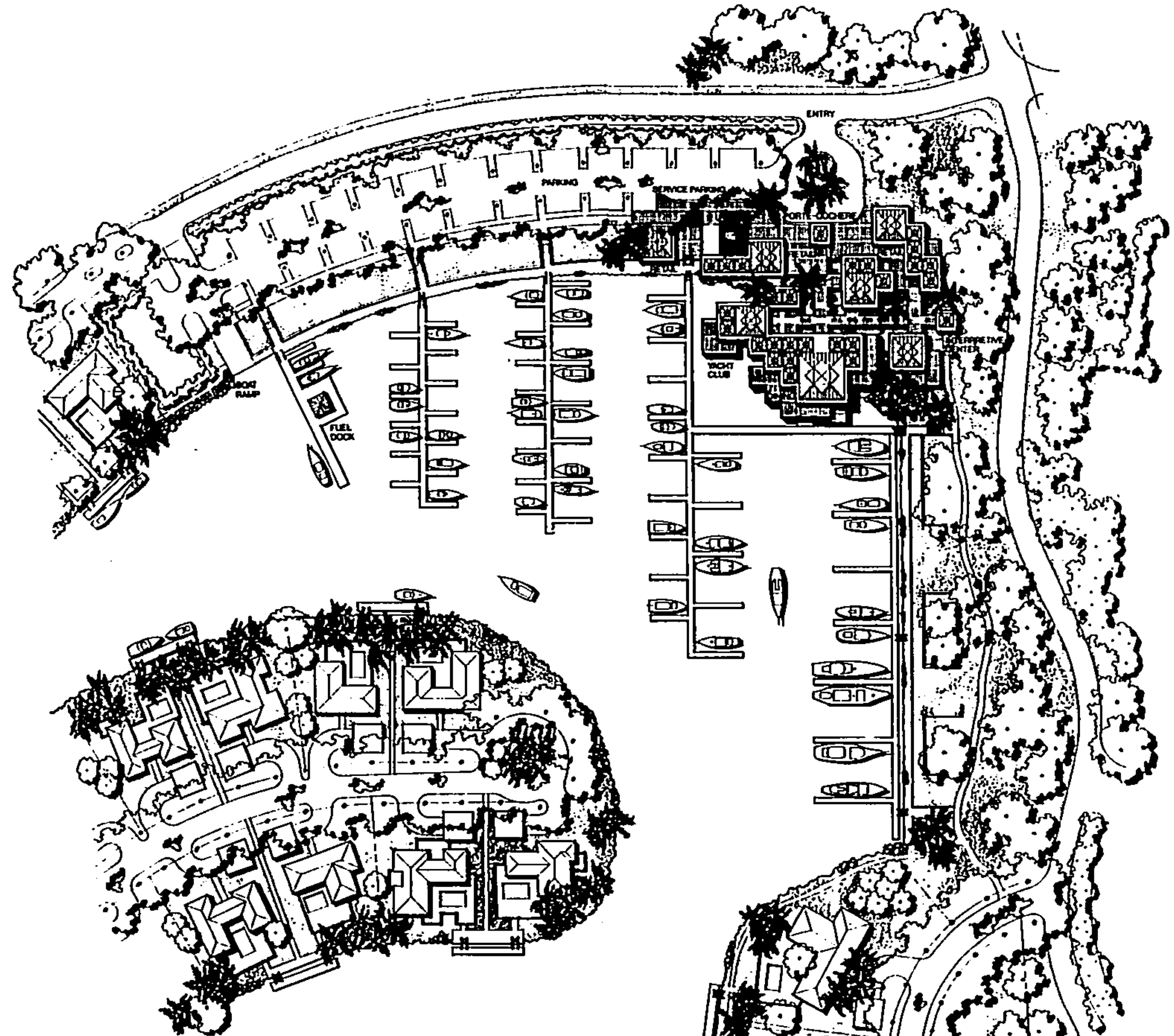


Figure II-12
SITE ILLUSTRATIVE
THE LANDING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
ROMA Design Group
November 1989

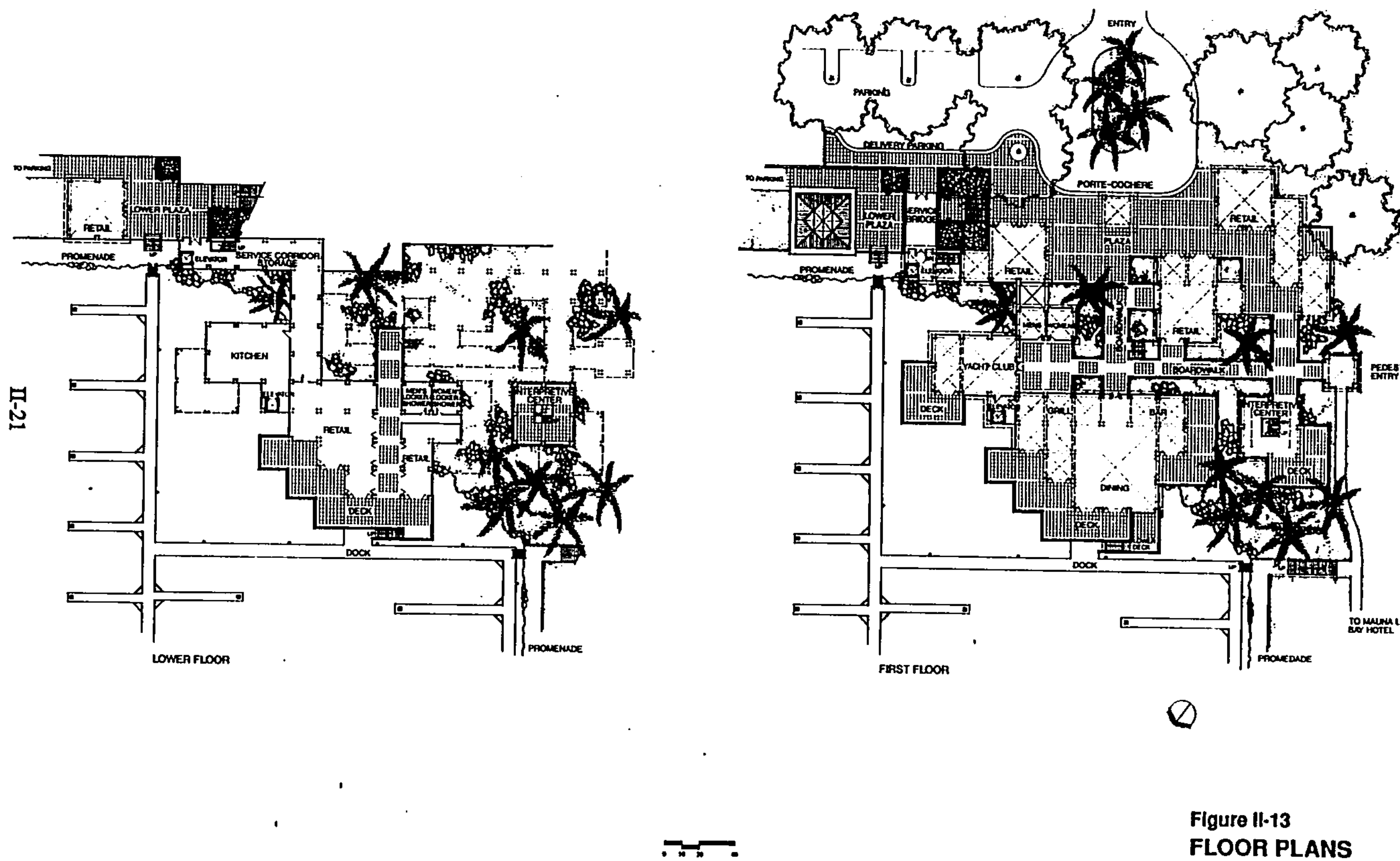
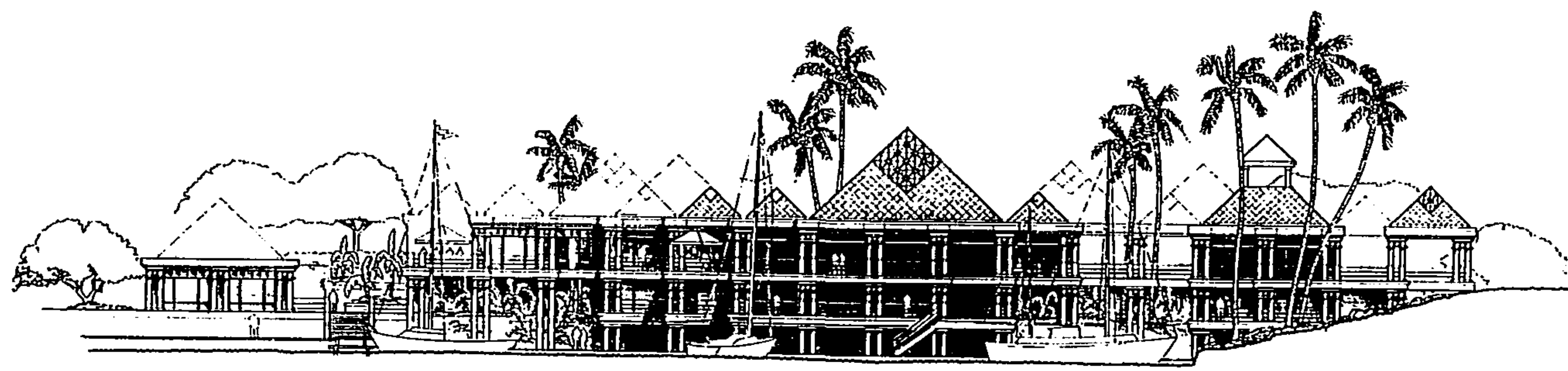


Figure II-13
FLOOR PLANS
THE LANDING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
ROMA Design Group
November 1989

ENTRY ELEVATION



MARINA ELEVATION

Source:
ROMA Design Group
November 1989

Figure II-14
ELEVATIONS
THE LANDING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

During construction of the access channel, a jack-up barge will be used to drill and load holes for subsequent blasting. As presently planned, a 50-foot by 100-foot grid pattern of holes, about 10 feet apart, will be drilled and loaded with blasting powder and primacord. The barge will then be moved away from the shot site, the area visually swept of turtles (underwater and on the surface) and the shots detonated. The blasting powder size is kept small enough so that the rock is fractured but not thrown out of place. Hence, there is very little surface expression of the blasting, if any.

Once the entire area has been blasted, a mobile barge with a large backhoe or dragline will excavate the material obtained from blasting and load it onto another barge for transport to an upland stockpiling site at Mauna Lani Resort (by way of Kawaihae Harbor). It is anticipated that all work will be performed using barges and that there will be no fixed structures or fill placed in marine waters. Silt retention curtains, similar to that shown in Figure II-15, will be used to control siltation. These curtains, which have been used successfully in other Hawaii projects, assure that fines generated by the blasting and dredging operations are retained in the immediate vicinity of the construction area and are not allowed to create a silt plume extending out into the deeper reef areas and/or along the shoreline. It is noted that, in general, the basaltic materials that will be dredged do not produce fines that would cause a silt plume. All offshore, as well as onshore construction would be subject to the preconstruction, construction and post construction ocean monitoring plan included as Appendix P to this EIS. Compliance with the provisions of that plan and any other applicable state or county environmental protection rules and regulations would be the responsibility of the contractor and these provisions would be included in the construction contract specifications.

The channels within the marina will be excavated using conventional land-based equipment and blasting will be used if required. Experience in similar basalts indicates that the material can be ripped without the use of explosive charges. However, blasting is an option if ripping alone is determined to be too time consuming and cost-prohibitive.

7.2 RESIDENTIAL DEVELOPMENT

Mauna Lani Resort will market 90 to 140 residential lots/units, with lot owners contracting to construct their own residences in accordance with Mauna Lani Cove design standards. The proposed zoning for the residential lots/units is RM-3 and RM-10, although it is anticipated that actual development will be to lower densities than that allowed, with house lots of over 15,000 square feet. The current program calls for 105 residences: 75 single-family lots with private mooring floats, 10 single-family lots with ocean view but no direct water access, and 20 clustered single-family detached units.

The median unit value, including the combination of the lot and completed house, is projected to be $2.25 million. Total built-out residential development value, based on a maximum of 140 residences, would be $315 million.

Two 125-foot long vehicular bridges will provide access to residential lots on the islands. The bridges will have a clearance of at least 6 feet, to allow skiffs to pass underneath.

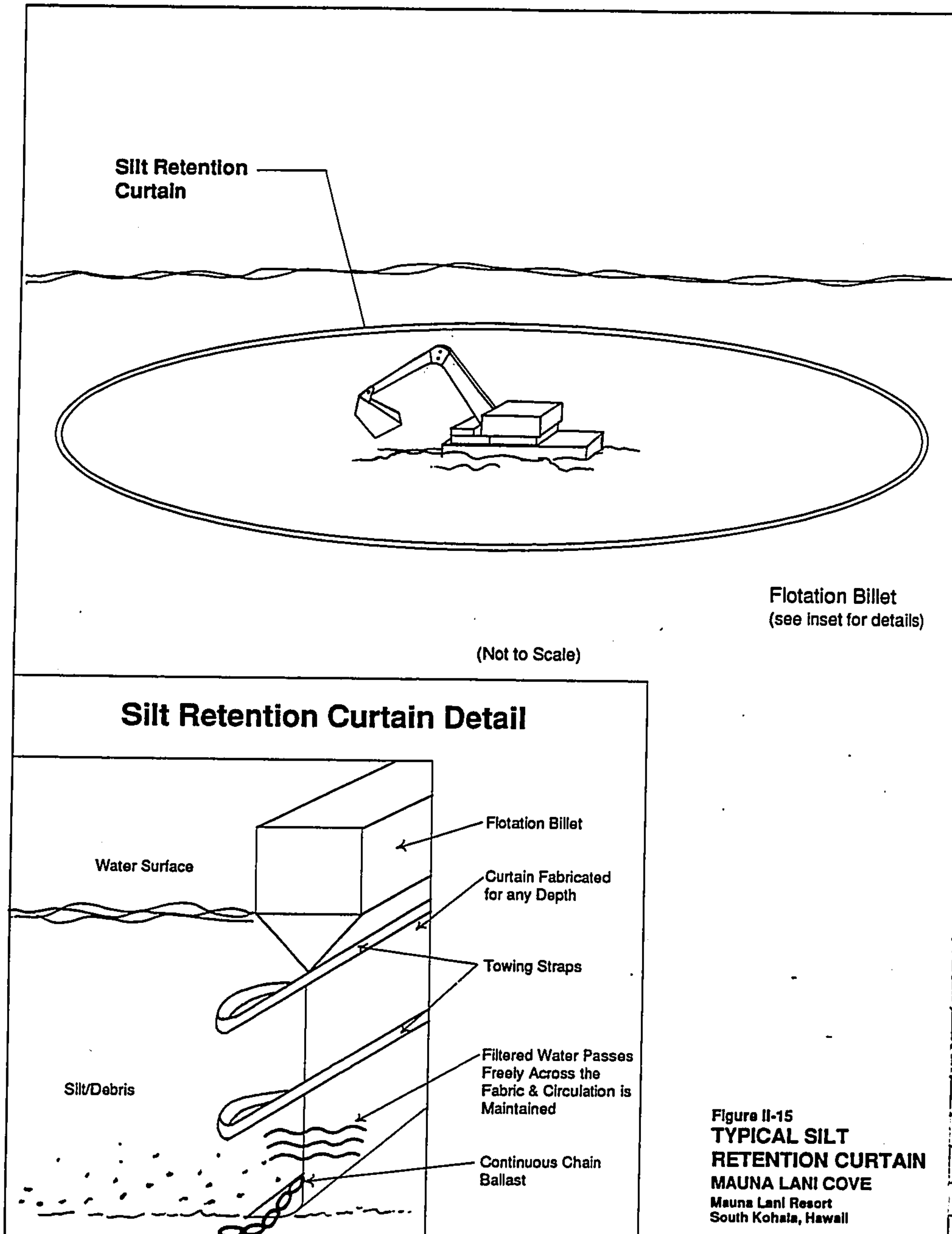


Figure II-15
TYPICAL SILT RETENTION CURTAIN
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

7.3 THE LANDING: BOAT BASIN AND COMMERCIAL FACILITIES

The boat basin and related facilities, as shown in Figures II-12, 13 and 14, will be adjacent to the Mauna Lani Bay Hotel tennis courts and screened from the roadway by a landscaped buffer. As currently planned, The Landing will include the following:

- Boat basin with a 110-vessel capacity: All slips, with the exception of 10 that will be reserved for commercial charter fishing boat operations and 10 that will be reserved for transient (30 days or less) boats, will be for the exclusive use of Mauna Lani Resort residents and guests. The Cove project will have a total capacity for 250 vessels inclusive of residential moorings. Dive boat, sightseeing and sunset dinner type commercial operations will not be allowed at the Cove. The primary emphasis of the Cove boating activities will be placed on recreational sailing, fishing and cruising.

- Marina facilities will include the harbormaster's office, laundry, restroom/locker areas, and other support space.

- The boat launching area will be open to everyone and all users will be subject to the same fees for services and will be expected to abide by the same marina regulations.

- A public waterfront restaurant with adequate meeting space for a sponsored yacht club, canoe clubs and other groups.

- Ocean interpretive center at the yacht clubhouse to contain sea-life exhibits of museum quality.

- Other amenities including a fuel dock facility, a sewage pumpout facility (the Big Island's first), dry storage for smaller boats, and limited retail facilities including a general store.

- Parking for boat owners, marina visitors, retail facility visitors, and commercial boat passengers and crew.

Mauna Lani Resort, Inc. recognizes that exclusive use of the Cove boat slips by its residents and guests does not assist in alleviating the general public demand for small boat slips in West Hawaii. In this regard, Mauna Lani Resort, Inc. is working with the state and county in an effort to either provide additional public boat slips in existing small boat harbors (Honokohau or Kawaihae) or other public recreational facilities off-site.

Mooring fee rates have not been finalized at this time but would be competitive with similar U.S. mainland marina facilities offering the same types of services and facilities as the Cove. As noted previously, the Landing and Cove complex would be under the jurisdiction of an experienced and qualified Harbor Master who would report directly to Mauna Lani Resort. A draft of the Cove operations rules and regulations has been developed and is included as Appendix Q. As noted in

Appendix Q, boat owners and users of the Cove facilities will be responsible for compliance with all applicable federal, state and county environmental protection rules and regulations. Similarly, the Harbor Master will have rather broad powers and authority to assure compliance with governmental agency, as well as Mauna Lani Resort, environmental protection regulations and policies.

The fuel storage tanks necessary to feed the boat dock will be underground tanks that are located, designed and constructed in compliance with all applicable federal, state and county rules and regulations. At present , it is planned that the tanks would be constructed below ground near the present Mauna Lani Bay Hotel service area. The fuel dock will be operated in compliance with all applicable federal, state and county rules and regulations. Additionally, Cove management and staff will undergo extensive emergency response training and the fuel dock will be equipped with emergency oil containment booms that can be deployed in case of a fuel spill. Similarly, the fuel dock will be equipped with appropriate fire fighting devices and other emergency equipment such as pumps and life saving devices.

7.4 CIRCULATION AND ACCESS

Vehicular traffic to the residential marina will be through the main resort road from Queen Kaahumanu Highway. The major Cove project road will branch off to the right of the existing road which continues to the Mauna Lani Bay Hotel and Bungalows and traffic to the two residential islands will be bridge. Those residential lots closest to the Mauna Lani Bay Hotel and Bungalows will be served by a roadway which branches off from the hotel roadway near the hotel parking. Vehicle/pedestrian drop off areas will be provided at the ends of the roadways serving the residential lots and leading to the shoreline greenbelt/passive park around the perimeter of the Cove.

7.5 SHORELINE IMPROVEMENTS

The existing Ala Kahakai coastal trail (which serves as a demonstration project for Na Ala Hele) and surrounding area, will be improved into an ocean greenbelt/passive park between the Mauna Lani Bay and Ritz-Carlton hotels. The natural vegetation will be trimmed but maintained in those areas closest to the shoreline. A bridge operator's roost and interpretive center will be provided in the shoreline area. Existing anchialine ponds in poor condition near the shoreline will be restored, with the addition of interpretive signs if the State desires attention to be brought to them.

7.6 PUBLIC ACCESS

Public pedestrian shoreline access will be uninterrupted, and more so, improved through the addition of two mauka-makai public access routes to the shoreline as well as access around the inland channels. Public shoreline access will also be provided from the end of the cul-de-sacs near the access channel (see Figure II-3), thereby allowing vehicles to drive to the end of the roadways, drop off their passengers and return to the public parking areas. A 150-foot long and 6-foot wide pedestrian bridge (with a 50-foot movable span) to ensure public pedestrian access along the shoreline while allowing the passage of high-masted vessels. The bridge will have a minimum

14-foot vertical clearance, allowing most power boats to pass underneath. It is presently estimated that the access channel bridge would most likely be open no more than one hour per day, primarily in the early morning and late afternoon. Management may require that opening only occur at set times, requiring boats to form a queue. Continuous lateral access along the shoreline is a priority, hence the bridge will be operated and managed with particular sensitivity to the importance of public access.

A 10-foot wide pedestrian easement around the entire outer channel for an ocean promenade open to the public, connecting the shoreline trail to the boat basin and commercial parking area will also be provided. Access from the cul-de-sacs to the promenade will also be provided.

7.7 RELOCATION OF GOLF HOLES

The proposed project includes relocating two golf holes which are adjacent to the Mauna Lani Bay Hotel and Bungalows. See Figure II-3 for relocated holes 11 and 12 mauka of The Cove. Preliminary analysis indicates that the size of the currently designated resort-parcel is insufficient for the development of an economically viable project with both residential and marina components. Relocating the two golf holes to a more upland location would allow additional acreage to be used for The Cove.

7.8 FLUSHING RESERVOIR

The lake planned to be adjacent to hole 11, as shown on Figure II-3, will serve as a water feature for the golf course as well as a flushing reservoir to service the marina. The reservoir would be used to improve water circulation within the marina, particularly in The Landing area (boat basin), should it be determined that groundwater and ocean water inflows are not adequate to ensure proper mixing and flushing in the marina.

The flushing reservoir would include three parts: (1) a lined pond of about 4.6 acres with a valved discharge pipe extended into The Landing area, (2) the well system to feed the pond, comprised of at least three saltwater wells, and (3) the flushing system.

Based on hydraulic model studies (Appendices B and S), conducted under varying tidal and groundwater efflux conditions, for a majority of the time, use of the flushing reservoir may not be necessary to maintain water quality in compliance with state water quality standards. Use of the flushing reservoir may be necessary under certain conditions, such as decreased freshwater inflow.

7.9 OPERATION OF THE COVE

Mauna Lani Cove will be the first private residential marina on the Island of Hawaii and provides Mauna Lani Resort an opportunity to seek a balance of public and private use of facilities and to institute a sound operations plan. It is envisioned that the residential component of the Cove will be managed by a homeowners association and that the marina component will be managed by Mauna Lani Resort through an executive manager and a harbor master.

Marina regulations, as presently drafted (Appendix Q), address the needs of security, safety, environmental protection and financial liability of the boat owners and operators. Areas covered in the Draft Mauna Lani Cove Management and Operations Rules and Regulations include:

- Environmental protection measures, especially those applying to endangered and threatened species.
- Guidelines and restrictions on the types of crafts (houseboats, commercial length, storage and mooring of dinghies, etc.);
- Compliance with navigational laws;
- Management right to inspect seaworthiness and general condition of craft;
- Operator's acceptance of responsibility for damage to craft and property or injury to persons within the marina;
- Management's right to lease berths during absence and prohibition of subletting berths;
- General safety regulations;
- Pollution control (disposal of effluent, control of non-point source pollution, oil spillage, etc.);
- Use of boat handling equipment;
- Control of repair to craft within the marina;
- Use of facilities at The Landing; and
- Rates and payment of fees.

As indicated in the Draft Management Rules and Regulations (Appendix Q), key components are environmental protection and safety, especially with regard to the mix of uses inside and outside the Cove, such as scuba diving, surfing and shoreline fishing.

CHAPTER THREE

CHAPTER III

ALTERNATIVES CONSIDERED

1. INTRODUCTION

The proposed project is designed to provide a mix of residential, recreational and commercial uses that would add to the Mauna Lani Resort destination concept currently being developed in conformance with the existing land use designations of the Hawaii County Plan and State Land Use Commission. The proposed project site environment would be protected by well established design and maintenance standards and maintained for the betterment of the entire community. The proposed project is being planned to be sensitive to the needs of the general public as well as the resort community and to integrate the use of the facilities by both.

The Mauna Lani Cove Plan is shown in Figure II-3. Based upon preliminary site planning and environmental studies, the marina project would utilize a mix of land uses that economically and environmentally satisfies the project objectives as stated in Chapter II, Section 5.

In compliance with the provisions of Title 11, Department of Health, Chapter 200, Environmental Impact Statement Rules, Section 11-200-17(f), the "known feasible" alternatives to the proposed project are discussed in this chapter. Those alternatives which could "feasibly" attain the objectives of the project are described and evaluated. An exploration and evaluation of the environmental impacts of all reasonable alternative actions, particularly those that might enhance environmental quality or avoid or reduce some or all of the adverse environmental impacts, cost and risks, is included in order not to prematurely foreclose options which might enhance environmental quality or have less detrimental effects. In each case, the analyses have been sufficiently detailed to allow the comparative evaluation of the environmental benefits, costs and risks of the proposed action and each reasonable alternative. Also, in compliance with the applicable rules, the alternatives have been evaluated relative to their capability to meet the proposed project objectives.

2. ALTERNATIVES ANALYZED

2.1 DEVELOPMENT OF THE COVE AS PROPOSED

As described in this Supp EIS, development of The Cove will have definite positive natural environmental, social and economic benefits.

- The proposed project is expected to benefit the natural ecological conditions of the area by providing new terrestrial and marine habitat as well as provide preservation and protection for the coastal and anchialine ponds found within the project boundaries.

TABLE III-1

COMPARATIVE EVALUATION OF ALTERNATIVES INVESTIGATED

ALTERNATIVE	EVALUATION FACTOR						
	ABILITY TO MEET OBJECTIVES	TERRESTRIAL ECOLOGY IMPACTS	MARINE ECOLOGY IMPACTS	SOCIO-ECONOMIC IMPACTS	FINANCIAL/ FISCAL IMPACTS	DEVELOPMENT COSTS	DEVELOPMENT REVENUES
PROPOSED PROJECT	●	○	○M	●	●	○	●
NO ACTION (Hotel Alternative)	■	○	■	■	■	○	●
SMALLER MARINA	○	○	○M	○	○	○	○
LAKE MARINA	■	○	○	○	○	○	○
OFFSHORE MARINA	■	○	■	○	○	■	○
CORPORATE RETREATS	■	■	○	■	■	○	○
CONDOMINIUMS	■	■	○	○	●	○	○
HOUSELOTS	■	■	○	■	●	■	○
COMMERCIAL	■	■	○	○	●	○	○

Legend:
- ● = Significant positive factor
- ○ = Insignificant factor
- ■ = Significant negative factor
- M = Mitigation of potential adverse impacts possible

2.2 "NO-ACTION" ALTERNATIVE

The "no-action" or "no-project" alternative is to develop the resort-zoned parcel as a resort hotel project. This alternative would not allow Mauna Lani Resort, Inc. to attain its objective of adding a major new water-related dimension to the resort. Similarly, this alternative could potentially have far greater adverse environmental impacts than the proposed marina. These impacts would be in the areas of increased competition for labor, traffic, housing requirements, over taxing infrastructural components and increased demands on public services and facilities. Because this alternative would not allow the objectives of the proposed project to be met and because of potentially greater adverse environmental impacts, this alternative was rejected early in the planning stages.

2.3 SMALLER MARINA ALTERNATIVE

The alternative of developing a smaller marina project with houselots on the existing resort-zoned acreage would not necessarily require relocating the two golf holes adjacent to Mauna Lani Bay Hotel and Bungalows. It does attain the developer's objective of adding a major new water-related element to the resort, but preliminary analysis indicates that the larger proposed project would be more feasible from an economic viewpoint. Preliminary construction cost analysis revealed that except for the cost of mass grading, other construction costs would be similar to those for the preferred alternative (cost of building a shoreline pedestrian bridge, clubhouse, retail facilities, etc.).

As indicated by waiting lists at regional harbors, there is a definite pent up demand for small boat slips and facilities in West Hawaii. As noted previously in Chapter II, there presently are 230 persons on a waiting list for slips at Honokohau and 49 persons on the waiting list for Kawaihae Harbor. A portion of this demand is planned to be met by the state with the expansion of Honokohau Harbor and the Corps of Engineers' and state's plans to expand Kawaihae Harbor. However, these expansion plans are not expected to meet the entire demand, thereby continuing to frustrate existing and potential pleasure boat owners in West Hawaii. Additionally, despite repeated efforts by the state and Corps of Engineers, funding for either of these two small boat harbors has not been authorized or appropriated and there appear to be serious environmental impact questions with both projects.

The size of the proposed Cove project has been determined taking into account the planned expansion of Honokohau and Kawaihae Harbors and would complement those facilities. The natural environmental impacts resulting from construction of a smaller marina project would most likely be similar to those that would result from the proposed project. There would still be a need to construct an access channel of about the same size and depth as that planned to assure adequate flushing of the marina and for the larger boats that would use the marina.

As noted, an access channel of essentially the same size as that proposed would be required and, although less dry, scrub, lava land would be required, it is not clear that this is either a significant positive or negative situation. A smaller marina project would not generate as many new jobs as that planned and would not require the same level of infrastructural requirements (sewer, water and electrical power) as that planned. However, it is likely that the roadway system planned would still be required, but fewer vehicles would utilize that roadway system. As indicated above, the smaller marina alternative, because of projected lower economic feasibility, as well as resulting in essentially the same natural environmental impacts, both positive and negative, as the planned marina, has resulted in the rejection of this alternative.

2.4 LAKE ALTERNATIVE

This alternative would include the present Cove design and configuration except that the access channel would not be constructed; that is, a large "lake" would be constructed with the two residential islands and perimeter houselots as presently planned. The primary environmental advantage of this alternative would result from not having to dredge the access channel. This alternative would allow the developer to meet the residential and commercial objectives of the proposed project but would not result in a decrease in the demand for small boat mooring space in West Hawaii.

This concept would require a pumping system to provide adequate flushing of the nutrient rich brackish waters that would flow into the "lake". As an alternative, the "lake" could be lined with an impervious liner to prevent the inflow of brackish groundwater, but a pumping/filtration/aeration system would still be required to maintain acceptable water quality.

With the exception of the impacts to the marine environment, the impacts of this alternative could be expected to be similar to the proposed project. As noted above, a pumping/filtration/aeration system would be required, thereby increasing electrical energy requirements and this alternative would not assist in reducing the demand for small boat mooring space in West Hawaii. This alternative would allow for development of water-oriented houselots and would provide limited water-related recreational opportunities. The financial and fiscal gains to be realized from this alternative are estimated to be less than those that would be earned from the proposed Cove project.

This alternative has been rejected because it would not allow the developer to fully meet the objectives of the proposed project; could result in greater consumption of electrical energy; and would result in lower financial/fiscal gains than the proposed project.

2.5 OFFSHORE MARINA ALTERNATIVE

The development of an offshore marina would include construction of a rock or man-made rectangular-shaped protective structure completely around the area that would serve as the marina (with the exception of the entrance channel) and the construction of the piers and docks within the resultant offshore water area. This type of marina could be constructed offshore of the proposed Cove site, in Honoka'ope Bay or any other location fronting the resort. This would entail the placement of the rock on the seafloor and building the protective structure to a height greater than, or at least equal to the height of the historical high wave height (12 feet). This would result in a massive structure on the ocean floor off the resort and the resultant covering of the marine biota on the nearshore reef platform. This alternative would allow the developer to attain its objective of adding a major new water-related element to the resort that would benefit the public, resort guests and residents. However, this alternative would not allow Mauna Lani Resort, Inc. to offer a new waterfront residential product and to maximize the benefits of waterfront residential and commercial development. Additionally, construction of an offshore or breakwater type marina would have significantly greater adverse natural environmental impacts than the proposed project.

An offshore marina would require the covering of a significant portion of the nearshore reef environment and would subject the marina users to potentially greater natural (storm) hazards than the planned project. The construction of an offshore marina would also result in greater adverse impacts during construction than the planned facility. Water quality would be degraded from siltation generated during construction and, given the nearshore surge and wave conditions, it does not appear likely that siltation curtains could be used effectively during the construction of the protective structure. However, the protective breakwater structures around an offshore marina would provide new habitat for fish and invertebrates and could possibly serve as better habitat than the existing rocky, coral reef bottom conditions offshore of Mauna Lani Resort. An offshore marina project would be more costly, thereby forcing the developers to charge higher use fees than the proposed marina. Additionally, an offshore marina could adversely affect access along the public beach. This alternative has been rejected because of the potential adverse natural environmental impacts of the offshore marina concept and because an offshore type marina would not allow the developers to meet the objectives of the proposed project.

2.6 DEVELOPMENT OF THE COVE AT ANOTHER ON-PROPERTY LOCATION

The development of the proposed project at another on-property location, that is within the Mauna Lani Resort property boundaries, was briefly investigated during the initial planning for the project. As depicted on Figure II-2, the selected site is the only undeveloped area within the resort boundaries that is (1) large enough to accommodate the project and (2) is located in undeveloped land with direct access to the ocean. Other undeveloped sites further inland would require extensive excavation, result in major disruptions to present and planned resort operations and would be too costly. This alternative was rejected because of these reasons.

2.7 USE OF COVE SITE FOR OTHER PURPOSES

To assure that all reasonable and prudent alternatives to the proposed project have been examined, other potential uses of the site have been investigated. These potential uses include:

- Corporate Retreats
- Single and/or Multifamily Condominiums
- Single Family Houselots
- Commercial Center

The potential environmental impacts of each of these alternatives, relative to the proposed project, are summarized below.

2.7.1 Corporate Retreats

The 88-acre Cove site could be subdivided into corporate retreat sites with facilities similar to the existing Nomura Securities complex. This 23-acre complex features a 12-unit corporate retreat with private meeting and recreational facilities. The complex is for the exclusive use of their international personnel. The property is owned in fee by Nomura Securities, headquartered in Japan.

Use of the Cove site for other similar facilities would entail the one-time fee interest sale of various sized parcels to corporations with the design, construction and operations of any facilities under the control of the corporate owners. Projects of this type would retain the low-density character of the resort, but the majority of any resulting social or economic benefits would accrue to the corporate owners. There would be few, if any, impacts on local or statewide socioeconomic factors other than those noted below. Similarly, projects of this type would result in relatively minor impacts on the terrestrial ecology of the Cove site, and, most likely, few impacts on the marine environment. Coastal and anchialine pond impacts could be the same as those that would result from the Cove project. This alternative would not generate the same level of financial and fiscal benefits as the Cove project, nor would it allow Mauna Lani Resort to assist in the alleviation of demand for small boat mooring space in West Hawaii. For the most part, this alternative would not allow the objectives of the proposed project to be met.

This alternative has been rejected because of the adverse impacts noted above and because it would not allow the objectives of the proposed project to be met.

2.7.2 Single and/or Multifamily Condominiums

At present, there are two completed condominium projects at Mauna Lani: Mauna Lani Terrace and Mauna Lani Point. Both projects have been completed and are in resales. Two new projects, "Mauna Lani Grove" and "The Islands at Mauna Lani" are in the building permitting or initiation of construction phase of development. Both projects are scheduled for completion in 1992. The "Grove" project consists of five detached units on a 4.42 acre site and the "Islands" project is a 46-unit townhouse project on a 22-acre site. Both are luxury projects aimed at the affluent domestic market.

The entire 88-acre Cove site could be developed for additional luxury condominiums while retaining the low-density character of the resort. Prudent planning indicates that a maximum of 6 units per acre would maintain the present low-density character of the resort, allow sufficient income to be generated and provide the levels of service and amenities that typify Mauna Lani Resort properties. However, present and forecast market conditions indicate that incremental development of this type of product would be required and that the absorption of the units would require 20 or more years. Hence, the financial and fiscal benefits that would accrue from this type of project would not be realized for an extended period of time.

The terrestrial environmental impacts of this alternative would be similar to the Cove project while impacts on the marine environment would presumably be much less. However, it can be expected that there would be an increase in the use of shoreline and nearshore resources by a greater number of people. Impacts on state and county services and facilities would likely be greater than the Cove project due to the greater number of people that would be utilizing those services versus the number of people who would be living at the Cove (88-acres x 6 units/acre = 528 units x 2.5 persons/unit = 1,320 persons vs. 120 lots-units x 2.5 persons/unit = 300 persons).

This alternative has been rejected because it would not allow the developer to meet the objectives of the proposed project and because of the potential adverse social and economic impacts that would result from the alternative.

2.7.3 Single Family Houselots

At present, there are three permitted Planned Unit Development (PUD) subdivision projects at Mauna Lani Resort: "The Point Estates at Mauna Lani", "The Cape at Mauna Lani" and "Champion Ridge at Mauna Lani." Each subdivision has its own special golf, oceanfront or view amenities.

Based on the marketing studies that have been performed for Mauna Lani Resort, the luxury single family house lot market in West hawaii appears to be reaching the saturation point and is expected to remain at that point for several years. Consequently, the marketability of this type of alternative would be extremely risky, potentially affecting the financial condition of the entire resort. In addition, adoption of this alternative would not allow the developer to meet the objectives of the proposed project. Consequently, this alternative has been rejected.

However, if this alternative were to move forward, the terrestrial environmental impacts would be similar to the Cove project; marine impacts would likely be greater from increased numbers of people utilizing the shoreline and nearshore waters; and there would likely be greater impacts on state and county provided services and facilities. Additionally, potentially the fiscal and financial impacts of this alternative would be less beneficial due to the lack of marketability and resultant reduced state and county tax revenues.

2.7.4 Commercial Center

The Cove site could possibly be developed as a commercial center with a combination of retail stores, restaurants and other services catering to resort guests and residents as well as local residents. The commercial center could be similar to that being constructed at Waikoloa Resort, or one based on something other than a water-oriented theme.

However, based on the marketing studies performed for Mauna Lani Resort, the marketability of another commercial center on the Kohala Coast would be marginal at best over the next 20 to 40 years because of the relatively low population base and existing and/or under construction commercial facilities.

Because of these reasons, and because this alternative would not allow the objectives of the proposed project to be met, this alternative has been rejected.

3. COMPARATIVE EVALUATION

As indicated previously, it is Mauna Lani Resort, Inc.'s intention to provide a water oriented feature that will best serve the needs of the general public and resort as well as a feature that is economically viable and has the least adverse environmental impacts. In general, none of the alternatives evaluated provide the degree of satisfaction of meeting the project objectives as the preferred alternative. Although some of the alternatives could result in a greater or fewer number of residential units and/or a larger or lesser amount of recreational facilities, it does not appear that the projected residential or resort needs of the area would be satisfied nor does it appear that the market for the boat slips and single family residential units planned would be met as rapidly as projected. This would result in less than full utilization of the property, a reduction in the projected state and county revenues and a lower rate of return to the developer.

The alternative of "no-action" similarly would not result in meeting the project objectives. The preferred alternative satisfies the project objectives and provides the best opportunity to assist in the satisfaction of the Big Island's projected residential/resort/recreational facility needs over the forecast period of development. Although each of the alternatives considered have some merits that are worthy of consideration, none of the alternatives has as many or the degree of positive merits as the proposed project.

Table III-1 provides a comparative evaluation of the alternatives evaluated.

TABLE III-1

COMPARATIVE EVALUATION OF ALTERNATIVES INVESTIGATED

ALTERNATIVE	EVALUATION FACTOR						
	ABILITY TO MEET OBJECTIVES	TERRESTRIAL ECOLOGY IMPACTS	MARINE ECOLOGY IMPACTS	SOCIO-ECONOMIC IMPACTS	FINANCIAL/ FISCAL IMPACTS	DEVELOPMENT COSTS	DEVELOPMENT REVENUES
PROPOSED PROJECT	●	○	○M	●	●	○	●
NO ACTION (Hotel Alternative)	■	○	■	■	■	○	●
SMALLER MARINA	○	○	○M	○	○	○	○
LAKE MARINA	■	○	○	○	○	○	○
OFFSHORE MARINA	■	○	■	○	○	■	○
CORPORATE RETREATS	■	■	○	■	■	○	○
CONDOMINIUMS	■	■	○	○	●	○	○
HOUSELOTS	■	■	○	■	●	■	○
COMMERCIAL	■	■	○	○	●	○	○

Legend:
● = Significant positive factor
○ = Insignificant factor
■ = Significant negative factor
M = Mitigation of potential adverse impacts possible

CHAPTER FOUR

CHAPTER IV

DESCRIPTION OF THE AFFECTED ENVIRONMENT, ENVIRONMENTAL CONSEQUENCES AND MITIGATION MEASURES

1. INTRODUCTION

The general and specific physical, natural and social environmental characteristics, archaeological and cultural resources and infrastructural component and public facilities serving the proposed project and area have been described in the Final Environmental Impact Statement for the Revised Mauna Lani Resort Master Plan (Belt Collins & Associates, 1985) and The Ritz-Carlton Mauna Lani Final Environmental Impact Statement (Belt Collins & Associates, 1987). The information presented below covers those resource areas and issues that would be directly affected by the proposed Mauna Lani Cove project. Complete general descriptions of resources and issues are not provided in this Supplemental EIS (Supp EIS). Rather, this Supp EIS provides information regarding probable impacts and mitigation measures relative to those resources and issue areas that will be impacted to a greater degree than originally contemplated in the above two listed environmental impact statements. The reader is referred to the two above noted references for background and general information regarding the resource areas and issues.

The proposed Mauna Lani Cove project will be located in an area of Mauna Lani Resort that is presently zoned for a hotel and golf. The proposed Mauna Lani Cove project will be developed instead of the previously planned hotel. As such, the physical, natural and socioeconomic environmental impacts of the proposed project as well as the impacts on the public services and facilities impacts resulting from the proposed project are expected to be significantly less than those that would accrue from a higher density hotel project. Public benefits, in the form of increased small boat mooring space in West Hawaii and access to ocean activities, will be greater. The mitigation measures described herein for the various resource areas have been designed to minimize and/or eliminate potential short-and long-term adverse impacts that might result from the proposed Mauna Lani Cove project.

2. PHYSICAL ENVIRONMENT

2.1 GEOLOGY, PHYSIOGRAPHY, SOILS AND AGRICULTURAL POTENTIAL

2.1.1 Existing Conditions

The project site is situated within the physiographic bowl created by the Kohala Mountain, Mauna Kea, Mauna Loa and Hualalai volcanoes. The overall slope of the Mauna Lani Resort land is about 10 percent. The slope of the project site is almost flat and the natural topography of the surrounding area has been modified by the construction of the Mauna Lani Bay Hotel and Bungalows, Ritz-Carlton, Mauna Lani Hotel and adjoining Francis I'i Brown Golf Course.

The surrounding mountains are of volcanic origin and, consequently, the geology of the project site and area is volcanic. The project site is set on an extensive pahoehoe lava flow from Mauna Kea that reached the sea from Makaiwa Bay on the south to at least Puako Bay on the north. Two different land and soil types have been identified on the project site by the Soil Conservation Service: Beaches (BH) and Pahoehoe Lava Flows (rLW). Neither of the soil or land types are significant agriculturally. The soil is rated E320 by the Land Study Bureau and the soils covering the project site lava are alluvial soils that have washed down from mauka areas. They are not weathered remains of pahoehoe flows. Based on soil borings taken in and around the project site, soft and hard pahoehoe, dense a'a lava and a'a clinker underlie the thin covering of alluvium soils where they are present on the project site. The thin soil cover is absent on a majority of the project site.

None of the land within the project site is classified within the Agricultural Lands of Significance to the State of Hawaii (ALISH) system due to its unsuitability for agricultural use.

2.1.2 Probable Impacts

The proposed project is not expected to affect the geology of the project site or area. However, the grading and excavation work for the project will affect the physiography of the site. Impacts to the geology, physiography, soils and agricultural potential of the project site are expected to be minimal and insignificant. Soils removed for water portions of the Cove will be used at other locations within the Mauna Lani Resort. It is presently planned that the excavated soils will be trucked to mauka parcels within the resort boundaries (makai of Queen Kaahumanu Highway) and used as fill for future residential sites. All soil disposal activities and fill operations would be engineered to assure that stable, buildable sites are created. The soil disposal area is shown on Figure IV-1.

2.1.3 Mitigation Measures

Because no significant impacts to the geology, physiography, soils or agricultural potential of the project site or area are expected to result from the proposed project, mitigation measures are not warranted. Appropriate engineering and landscape architecture precautions will be taken with the soils that are excavated and to be used in other areas within Mauna Lani Resort. Also, further archaeological investigation of fill sites will be performed prior to soil disposal. Excavated areas above water will be water sprayed during construction and planted with appropriate ground cover as soon as practical, minimizing wind blown fugitive dust.

2.2 GROUNDWATER, HYDROLOGY, SURFACE WATER AND DRAINAGE

2.2.1 Existing Conditions

All along the Mauna Lani Resort shoreline, groundwater occurs in a basal lens configuration. A layer of brackish water saturates the lavas at and near sea level. Estimates of groundwater flow toward the shoreline of the Mauna Lani Resort property are in the range of 2 to 6 million gallons per day (mgd) per mile of coastline. Existing chloride levels of the groundwater vary from approximately 700 milligrams per liter near Queen Kaahumanu Highway to several thousand milligrams per liter close to the shoreline. Ground water geochemistry and water quality of Mauna Lani Resort area producing wells are provided in Table IV-1.

At present, the resort utilizes about 2.0 mgd of this groundwater flow for golf course and landscape areas irrigation. The groundwater is pumped primarily from three wells: Well #1 (STP), Well #2 (Fire Station) and Puako Well #4. The second golf course, which is presently being constructed, will also use basal groundwater for irrigation. Three new wells are being developed for this purpose. (See Figure IV-2.)

There are no streams or natural drainageways crossing the project property. The low average rainfall in the area (approximately 9 inches annually) and permeable surface of the lava which dominates the site preclude significant surface runoff.

2.2.2 Probable Impacts

Excavation of the marina will impact groundwater in several ways:

1. The excavation will bring the seawater shoreline into the perimeter of the marina. As a result, the salinity of groundwater in the near vicinity will increase via the process known as seawater intrusion.

2. The marina excavation will function as a focal point for groundwater discharge. Groundwater flowlines generally run perpendicular to the shoreline. The marina excavation will intercept these flowlines within its perimeter and cause flowlines outside its perimeter to be diverted toward it.

3. Groundwater discharge will have several effects on the quality of water within the marina: the volume of "new" water will contribute to the marina's flushing (see Appendix R); the contrast in density between groundwater and seawater will tend to create vertical stratification; and the nutrient load of influent groundwater may cause a biologic response.

The impact of groundwater on the marina's water quality is discussed in Section 3.4 below and Appendix R. To characterize the marina's impacts on the occurrence of groundwater inland of the project, computer modelling techniques have been used (Appendix R). One model is a two-dimensional plan view which simulates changes to groundwater flowlines and quantifies the discharge rate into the marina itself. Another model is a two-dimensional vertical section which has been used primarily to anticipate the movement of seawater inland. The following is a summary of anticipated effects that can be expected based on the computer simulations that have been performed:

1. The marina project will not change the quantity of groundwater flow; it will simply redirect it into the marina itself.

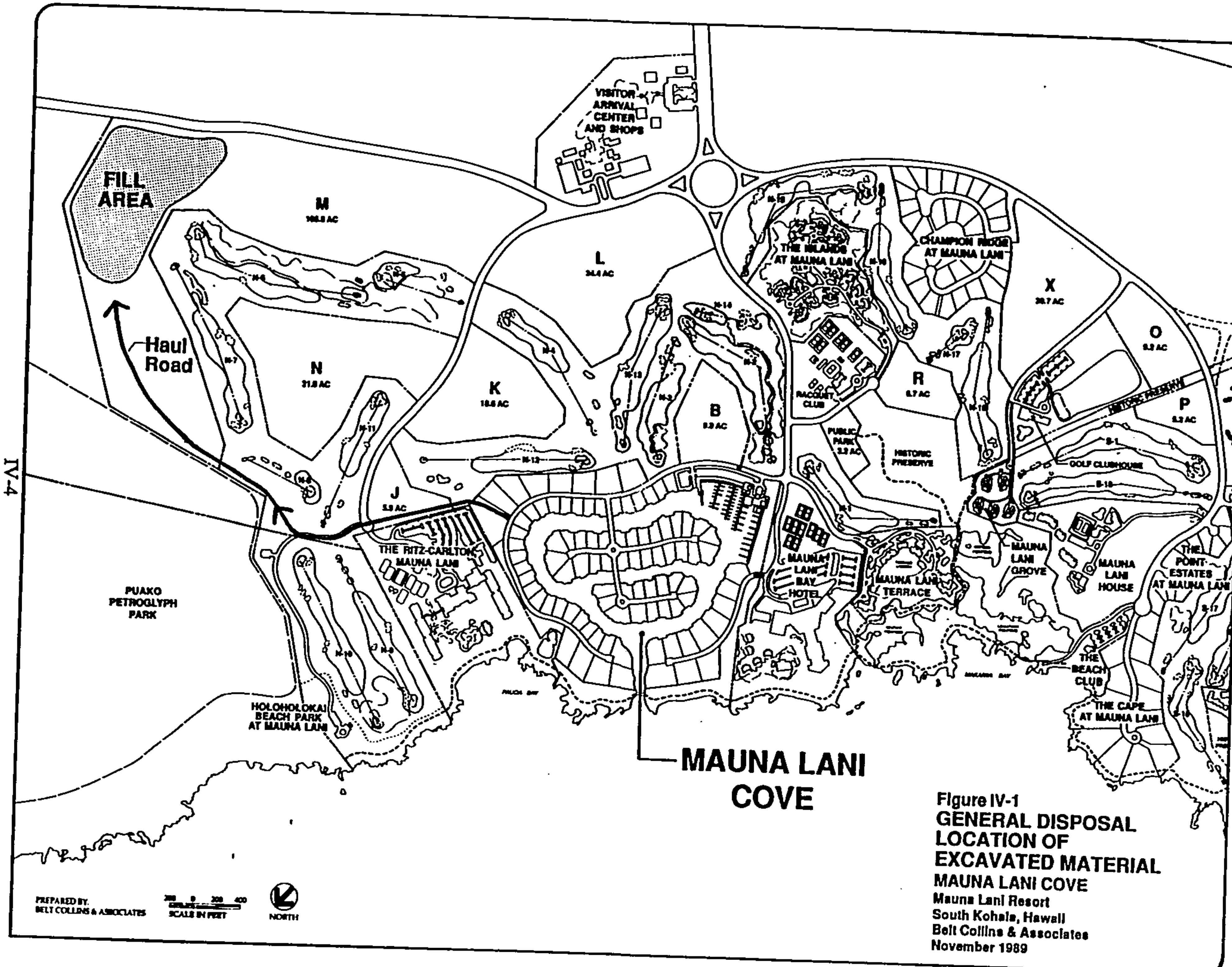


Figure IV-1
GENERAL DISPOSAL LOCATION OF EXCAVATED MATERIAL
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii
Belt Collins & Associates
November 1989

TABLE IV-1

REPRESENTATIVE GEOCHEMISTRY OF WATER WELLS IN THE MAUNA LANI RESORT AREA

WELL NO.	TEMP. (°C)	pH	D.O	Na	K	Ca	Mg	Si	Cl	Fe	PO_4	SO_4
8-5548-01 Waikoloa Village Parker #1	28.8	8.0	6.1	335	22.0	26.0	58.0	30.5	590	40.0	0.12	100.2
8-5745-02 Waikoloa Village Parker #4	26.5	8.1	6.9	34.0	4.2	7.58	12.5	30.0	27.0	38.0	0.21	21.4
8-5946-02 Lalamilo B	26.1	8.0	6.9	40.0	4.6	9.42	14.0	30.0	42.0	30.0	0.26	20.7
8-5948-01 State	26.0	7.8	7.2	250	15.0	23.0	48.0	29.5	438	20.0	0.22	70.0
Puako #4 Mauna Lani	27.5	7.6	6.9	480	27.0	28.0	80.0	30.0	820	44.0	0.18	145.0
Puako #6	29.0	---	6.5	415	27.0	26.5	71.5	30.5	~900	46.6	0.19	119.3

Source: Mauna Lani Resort, Inc.

Concentrations stated in terms of mg/l except Fe which are in $\mu g/l$.
Concentrations are averages of water samples taken between 1982 and 1990.

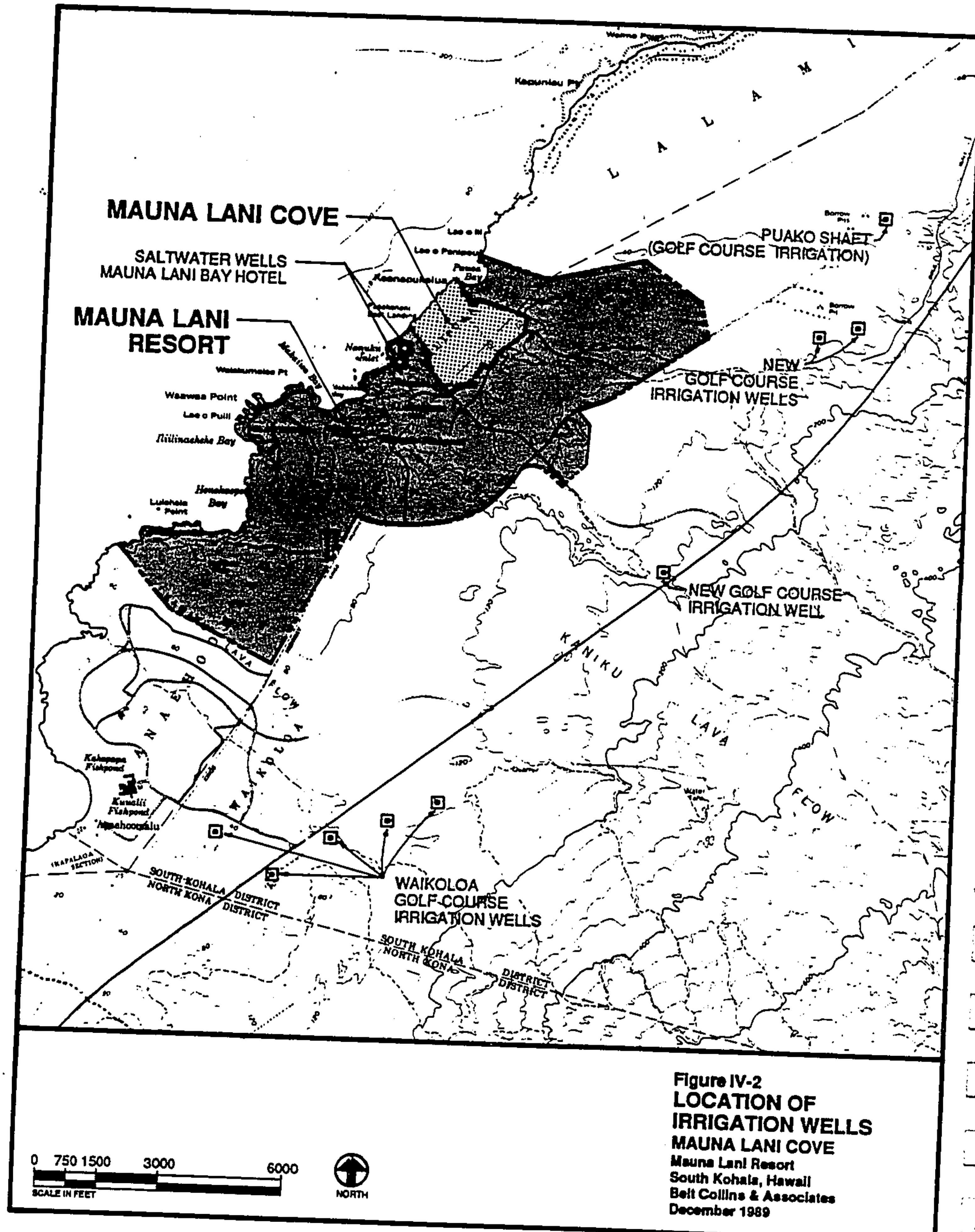


Figure IV-2
LOCATION OF IRRIGATION WELLS
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii
Belt Collins & Associates
December 1989

2. All groundwater intercepted by the 2,000-foot wide marina will discharge into it. In addition, a portion of the flow for up to 1500 feet to either side of the marina will also empty into it. The total discharge will be in the range of 2.5 to 5.9 MGD. In contrast to the existing linearly distributed discharge along the shoreline, all of this flow will move out the marina's entrance.

3. Seawater intrusion is the principal source of groundwater contamination. Excavation of the marina will bring this contaminating source 2,000 feet inland. Groundwater salinity immediately inland of the excavation and to either side of it will be increased.

4. The salinity increase will be a localized effect, confined to the several thousand feet surrounding the marina's perimeter. The only existing wells in this area of influence are saltwater wells at the Mauna Lani Bay Hotel. Mauna Lani's nearest golf course irrigation well is 6,000 feet away. The effect of increased salinity will not extend that far.

Table IV-2 indicates the predicted changes in head in the groundwater aquifer at existing well locations for different groundwater flowrates and development scenarios. Head declines as a result of the marina are considered relatively insignificant impacts (Appendix R) and less than the head drops predicted to occur as a result of near-future pumping increases.

2.2.3 Mitigation Measures

While salinity intrusion resulting from the marina excavation is not a desirable effect, it will be limited to the near vicinity of the project and is not expected to compromise existing or future uses of the brackish water resource. For this aspect of the project, then, no mitigation measures are needed. (In the event that the salinity intrusion is more extensive than expected, Mauna Lani Resort's irrigation wells would be the only uses affected. Relocating those wells further inland would be necessary.)

2.3 NATURAL HAZARDS/MAN-INDUCED HAZARDS

2.3.1 Existing Conditions

The natural hazards to which the project site is subjected include volcanic events, earthquakes, tsunamis and high wave floods. Volcanic hazards on the Big Island have been described by Mullineaux, *et al.*, (1987). The proposed project is located in lava flow hazard Zone 3, bordered by Hualalai Zone 4. On Mauna Loa about 1 to 3 percent of the land surface in most of Zone 3 has been covered by lava during historical time; however, a single flow during the 19th century covered about 10 percent of the area on the northwest flank of the volcano. During the last 750 years, lava flows have covered about 15 to 20 percent of the flanks of Mauna Loa within Zone 3. The hazard on Mauna Loa decreases progressively downslope from its summit and the rift zones across zones 2 and 3. Zone 4 embraces only Hualalai Volcano where a few percent of the land surface was covered by lava flows in 1800 to 1801, but less than 15 percent has been covered in the last 750 years (Mullineaux, *et al.*, 1987). The project site is also located in tephra fall and

TABLE IV-2

CHANGES IN HEAD PREDICTED FOR FUTURE IRRIGATION AND THE COVE EXCAVATION

GROUNDWATER FLOWRATE AND DEVELOPMENT SCENARIO	MAUNA LANI RESORT HEADS (Ft)		WAIKOLOA BEACH RESORT HEADS (Ft)	
	At The Puako Shaft	At the New Well Next to STP	At the Nursery Well	At Well No. 3
Flux of 3 MGD per Coastal Mile				
Existing Draft Rates	1.36	1.61	0.95	1.57
Future Draft Without Cove	1.25	1.42	0.86	1.38
Future Draft With Cove	1.22	1.38	0.85	1.35
Flux of 6 MGD per Coastal Mile				
Existing Draft Rates	1.48	1.66	1.17	1.68
Future Draft Without Cove	1.43	1.57	1.13	1.59
Future Draft With Cove	1.41	1.53	1.12	1.57

Source: Groundwater Assessment Summary, Appendix R.

volcanic gases hazard Zones 2. Tephra falls from lava fountains should be frequent but thin and gas effects could be significant. The project site is outside the one pyroclastic surge hazard zone on the island, that zone being limited to the area surrounding Kilauea caldera on the southeast side of the island. Ground fractures and subsidence hazards are relatively low in the project area, with the site being located in Zone 4, which includes the majority of the island.

Earthquake hazards at the project, as with the rest of the island, cannot be avoided. However, the project site is not subjected to greater earthquake hazards than other areas of the island and standard engineering and design precautions are used to mitigate potential earthquake hazards.

Development along the South Kohala coastline must take into account the possibility that a tsunami will strike. Because tsunamis occur infrequently and due to the paucity of shoreline development along the coast until recent years, reliable tsunami runup information for the area is scarce. Of the 85 tsunamis that have been observed in Hawaii since 1813, the one occurring in 1946 was the largest. It reached a height of about 12 feet above mean low low water (MLLW)

Kawaihae, a few miles to the north of the project site. It is probable that the same runup height was experienced at the project site. The Flood Insurance Rate Map (FIRM) (Figure IV-3) for the project site (Community Panel Number 155166 0278 C, Revised September 16, 1988) indicates that the access channel area of the proposed Cove is in Zone VE, which extends about 100 feet inland and Zone AE which extends about 250 feet inland of Zone VE. Zone VE is defined as coastal flood area with velocity hazard (wave action); base flood elevation determined (8 feet). Zone AE is defined as an area in which the base flood elevations are determined (8 feet). Both areas are within the special flood hazard areas that are inundated by 100-year floods. The remainder of the project site is in Zone X, which are areas outside the 500-year flood plain.

As part of the overall Cove planning process, a wave disturbance test, utilizing a hydraulic model, and a tsunami modeling analysis, were conducted to determine the potential hazards due to storm waves (Appendices B and C). In general, the modeling indicated that the entrance configuration protects the Cove from storm waves. The highest wave generated at the access channel is under 3 feet in height and generated by very long-period swell or by the very severe hurricane. Wave heights within the Cove were generally less than 1-foot in height and waves within the landing area were less than 0.5 feet. However, tsunami waves could affect the project site as described below.

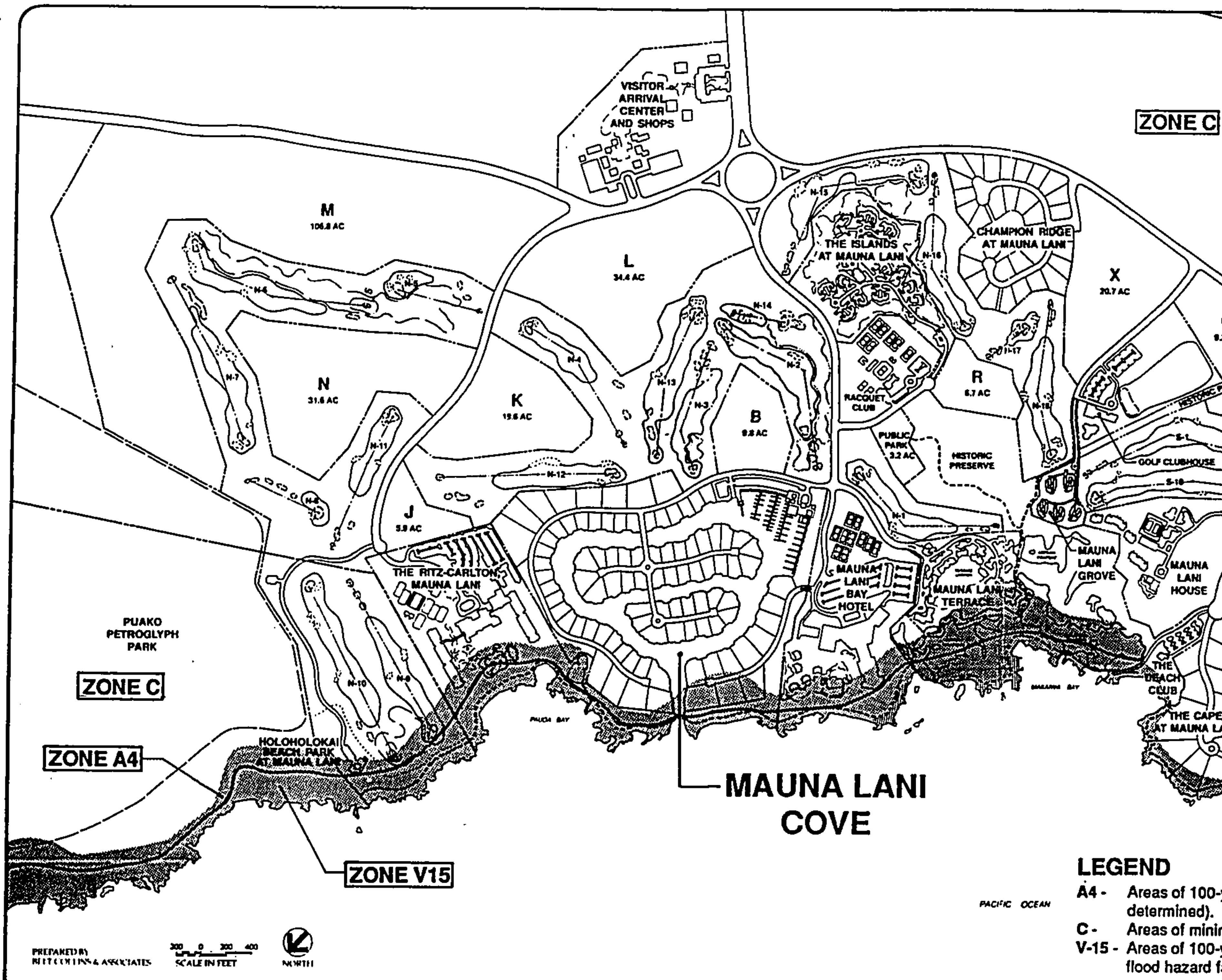
Man-induced hazards that would affect the project are those associated with the establishment of onshore boat fuel tanks that would feed the fuel dock. As presently planned, the tanks, which would have less than 5,000 gallon capacity and be limited to gasoline and diesel fuels, would be located near the Mauna Lani Bay Hotel service area. The tanks would be constructed below ground and in compliance with all applicable federal, state and county rules and regulations. Regular periodic monitoring of the tanks would be performed to detect any leakage that might occur. Should leakage be detected, immediate action would be taken to correct the situation.

The fuel dock would also be constructed in compliance with applicable federal, state and county regulations and would be equipped with appropriate safety and fire fighting equipment, containment devices and other safety features deemed necessary. Boats would be required to be securely tied to the dock prior to fueling, with all engines turned off, hatches and ports closed and the fuel pipe securely touching the fill pipe during fueling operations. Subsequent to fueling, fuel pipes would be securely closed, hatches and ports opened and the vessels allowed to ventilate prior to starting the engines.

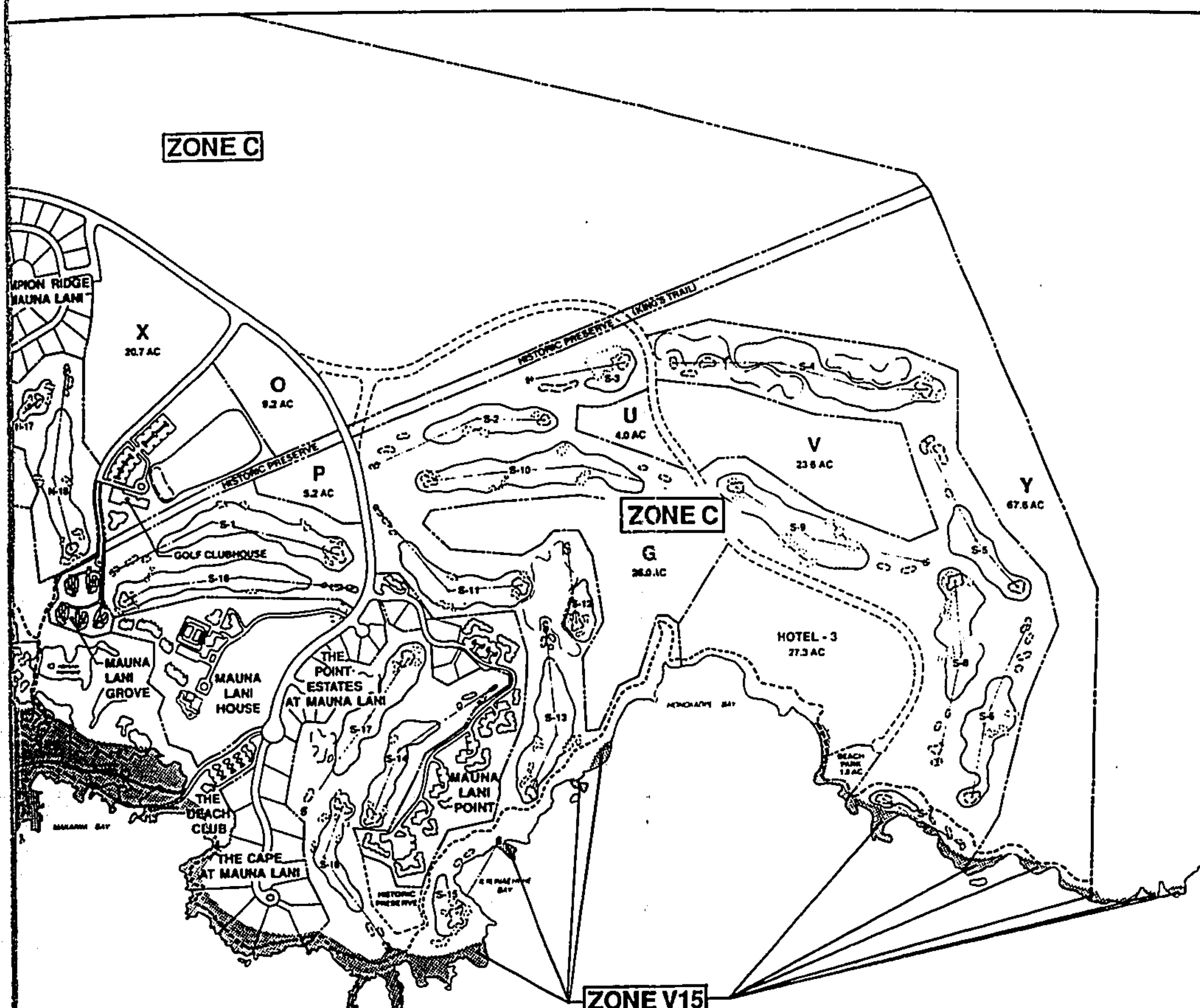
2.3.2 Probable Impacts

Volcanic event hazards are low, with the latest lava flows in the project site area being over 100 years old. Although volcanic events could occur in the future, there is no way of predicting when they would occur or the magnitude of any event that might occur.

Earthquake hazards are a constant factor on the Big Island and potential damage from strong earthquakes is widespread and cannot be avoided. Adherence to federal, state and county building codes and standards generally precludes most earthquake damage, although a very strong quake would cause damage to most structures.



VISITOR ARRIVAL CENTER AND SHOPS
ZONE C
M
106.8 AC
L
34.4 AC
THE ISLANDS AT MAUNA LANI
CHAMPION RIDGE AT MAUNA LANI
X
20.7 AC
N
31.6 AC
K
19.6 AC
B
9.8 AC
RACQUET CLUB
R
6.7 AC
PUBLIC PARK 3.2 AC
HISTORIC PRESERVE
GOLF CLUBHOUSE
J
5.9 AC
THE RITZ-CARLTON MAUNA LANI
MAUNA LANI BAY HOTEL
MAUNA LANI TERRACE
MAUNA LANI GROVE
MAUNA LANI HOUSE
PUAKO PETROGLYPH PARK
ZONE C
THE BEACH CLUB
THE CAPE AT MAUNA L
ZONE A4
HOLOHOLOKAI BEACH PARK AT MAUNA LANI
MAUNA LANI COVE
ZONE V15
PACIFIC OCEAN
LEGEND
A4 - Areas of 100-
determined).
C - Areas of minir
V-15 - Areas of 100-
flood hazard f
PREPARED BY BELT COLLINS & ASSOCIATES
SCALE IN FEET
NORTH



LEGEND

A4 - Areas of 100-year flood (Base flood elevations and flood hazard factors determined).

C - Areas of minimal flooding.

V-15 - Areas of 100-year coastal flood with velocity (Base flood elevation and flood hazard factors determined).

Figure IV-3
FLOOD INSURANCE RATE MAP
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Tsunami and flood hazards, due to high waves, could cause damage at and within the proposed Cove. Based on the hydraulic and tsunami modeling that has been performed (Appendices B and C), high storm waves are not expected to occur within the Cove but tsunamis could reach a height of up to eight feet as much as 300 feet inland. Historical tsunami and storm wave heights are known and all structures would be constructed above those heights, that is to a height of at least +10 feet MLLW as recommended in the tsunami modeling study (Appendix C). Boat docks would be designed to float and rise and fall with storm waves and in the case of a tsunami, appropriate warnings and safety measures would be taken to protect life and property. Similarly, the pilings on which piers are attached would be positioned such that the docks are unable to break away under storm wave conditions.

Impacts resulting from the fuel tanks and/or fuel dock are not expected. The fuel storage tank area will be designed, constructed and operated in compliance with all applicable federal, state and county rules and regulations. As noted above, regular periodic monitoring of the tanks would be performed to detect leakage. Should any leakage be found, immediate steps would be taken to correct the situation.

2.3.3 Mitigation Measures

Volcanic events cannot be predicted with any degree of certainty. Generally most historical events have allowed sufficient time for areas to be evacuated. The Mauna Lani Resort area has a tsunami warning system (siren) that would be extended throughout the Cove complex and used in case of a volcanic event that could impact the resort area. The system would also be used in the event of a tsunami and/or high storm waves. In general, the primary measures that will be employed to mitigate potential loss due to natural hazards will be to utilize standard federal, state and county building codes during the design and construction of the facilities. This will include constructing facilities above the historical high water level and use of proper materials. Additionally, the existing resort-wide civil defense/tsunami warning system will be extended to cover the Cove and The Landing areas. A county approved evacuation plan for the resort is already in effect and would be expanded to cover the Cove complex.

The safety, construction and operations procedures noted above regarding operation of the fuel storage tanks and fuel dock will mitigate potential impacts resulting from the operation of the fueling facilities.

2.4 VISUAL ATTRIBUTES

2.4.1 Existing Conditions

The proposed project would be located about 1.6 miles makai of Queen Kaahumanu Highway and visible from the highway, primarily as a water dominated open space. This will be in contrast to the present lava/scrub brush character of the area which is interrupted by the Mauna Lani Bay Hotel and Bungalows and Ritz-Carlton, Mauna Lani Hotel and other resort facilities.

Common Myna (*Acridotheres tristis*), Zebra Dove and House Sparrow (*Passer domesticus*) may increase with development of the project site.

3.2.3 Mitigation Measures

Given the lack of expected significant adverse impacts that might result from the proposed project, mitigation measures are not warranted. As indicated above, newly landscaped areas will provide habitat for introduced and some native species. In addition, retention of the anchialine ponds and the creation of new water areas will provide some habitat for shore and waterbirds.

3.3 COASTAL POND/MARINE ENVIRONMENT

3.3.1 Coastal Ponds

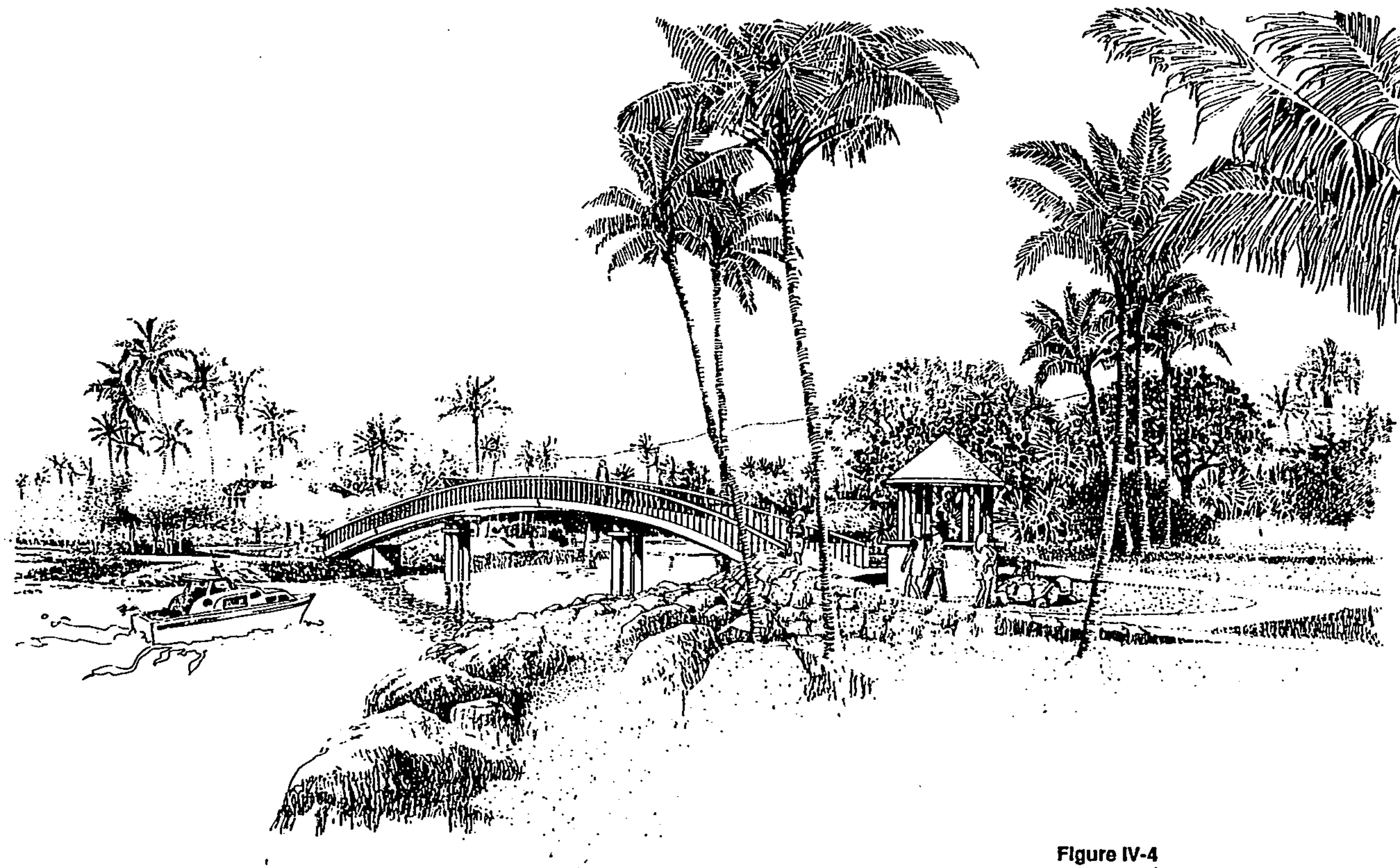
3.3.1.1 Existing Conditions

The shoreline area of the project site contains several anchialine and old fish ponds (see Figure IV-10). There are five major ponds with surface areas of more than 3,000 square feet and several smaller ponds ranging in size from a few square feet to a few hundred square feet grouped into 2 pond "systems". The ponds are in various stages of senescence, with some exhibiting anaerobic conditions due to infilling by windblown sand, vegetation and detritus. Those that are in relatively good condition contain the typical assemblage of Hawaiian anchialine pond organisms, such as the small red shrimp (*Halocaridina rubra* and *Metabetaeus lohena*) and the usual algal crust *Schizothrix caricola* and *Rhizocloniumm sp.*

The overall biological, chemical and physical characteristics of the coastal pond environment of the Mauna Lani Resort area have been discussed in detail in the Mauna Lani Resort Revised Master Plan EIS (Belt Collins & Associates, 1985), Ritz-Carlton, Mauna Lani Final EIS (Belt Collins & Associates, 1987) and references and technical reports attached thereto. In addition, for historical comparisons with previous surveys of the ponds within the resort boundaries (Brock, 1985a), a coastal pond and marine survey was conducted specifically for the proposed Cove project (Appendix F). The information presented below is that which is directly applicable to the proposed Cove project. Information relative to the areas outside of, but adjacent to, those that would be directly impacted by the proposed project is included in the above referenced documents and is not repeated here.

3.3.1.2 Physical Characteristics

The geomorphology of the coastal area makai of the proposed Cove is composed of several distinct physical zones. The shoreline is composed of narrow beaches covered with coarse sand and basaltic rock. Several "systems" of inter-connected anchialine ponds occur on the shoreline in topographically low areas. Based on the marine/coastal pond survey conducted for this Supp. EIS (Appendix F), the anchialine ponds that could be affected by the proposed project are in the latter stages of senescence due to in-filling by sediment and organic plant material. Similar conditions were found in the 1985 survey (Brock, 1985a).



Source:
ROMA Design Group
November 1989

Figure IV-4
VIEW OF PEDESTRIAN BRIDGE AT ENTRANCE TO COVE
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

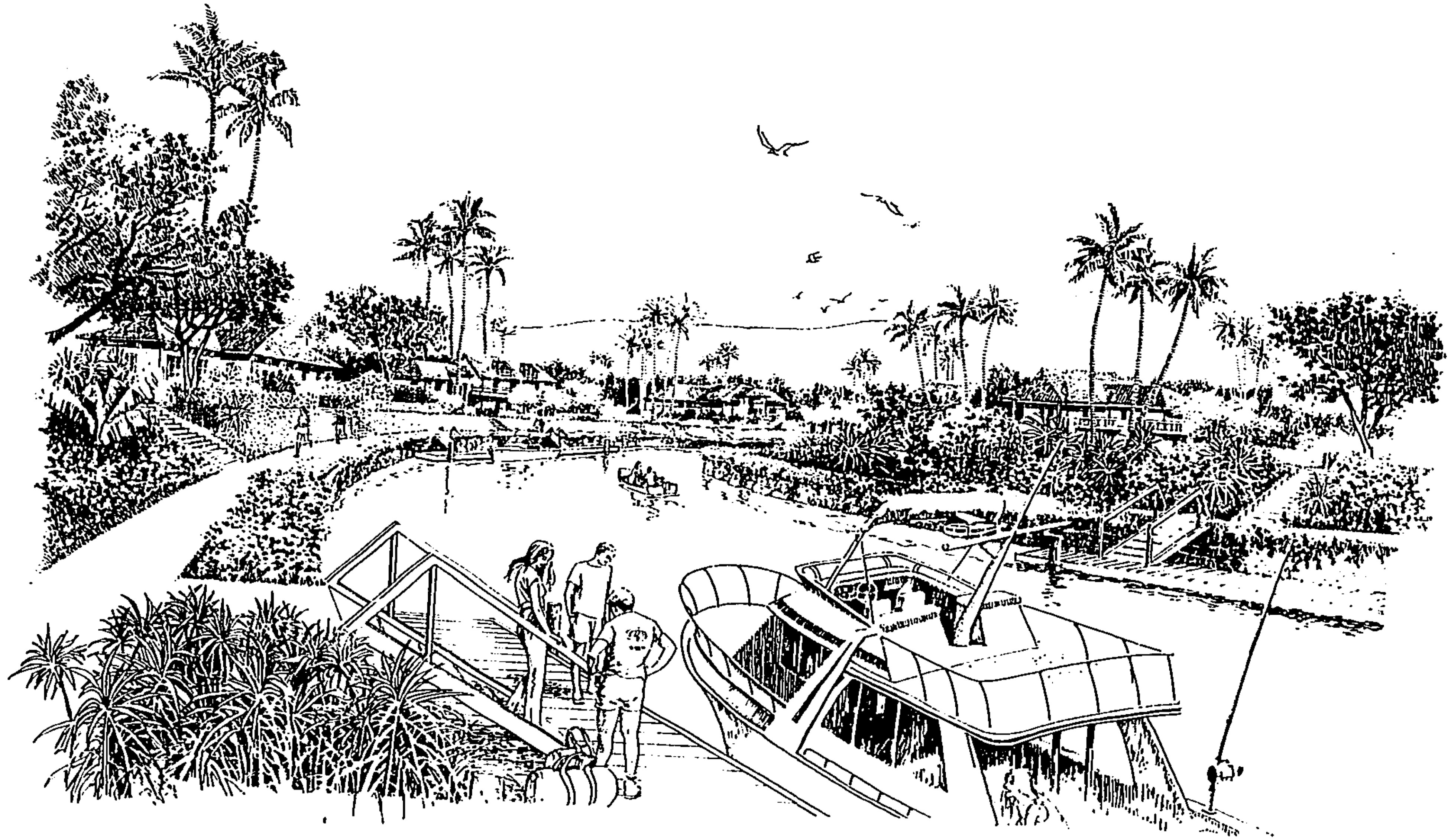
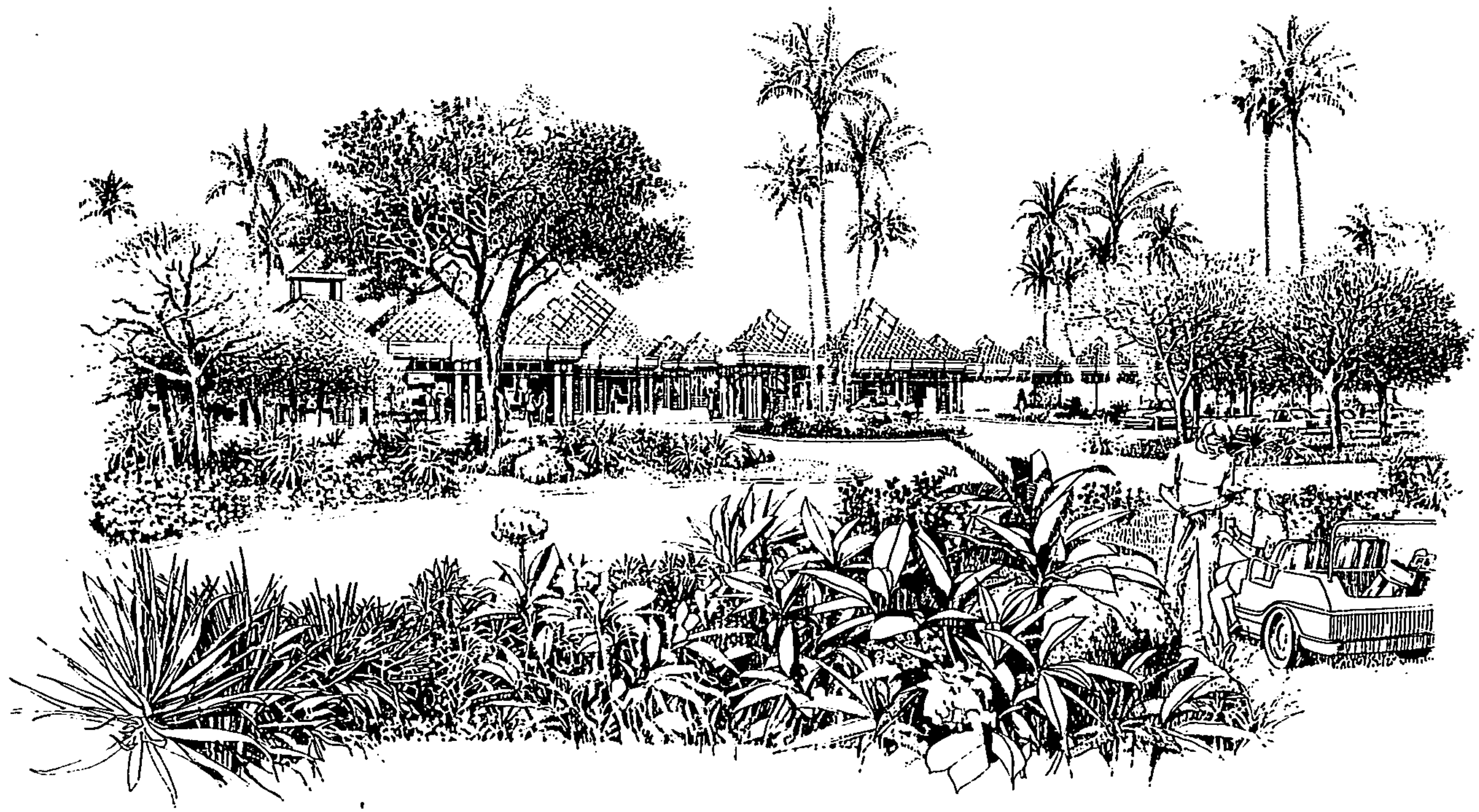


Figure IV-5
VIEW OF WATERWAY, PEDESTRIAN PATH AND RESIDENCES
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
ROMA Design Group
November 1989



Source:
ROMA Design Group
November 1989

Figure IV-6
VIEW OF THE LANDING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

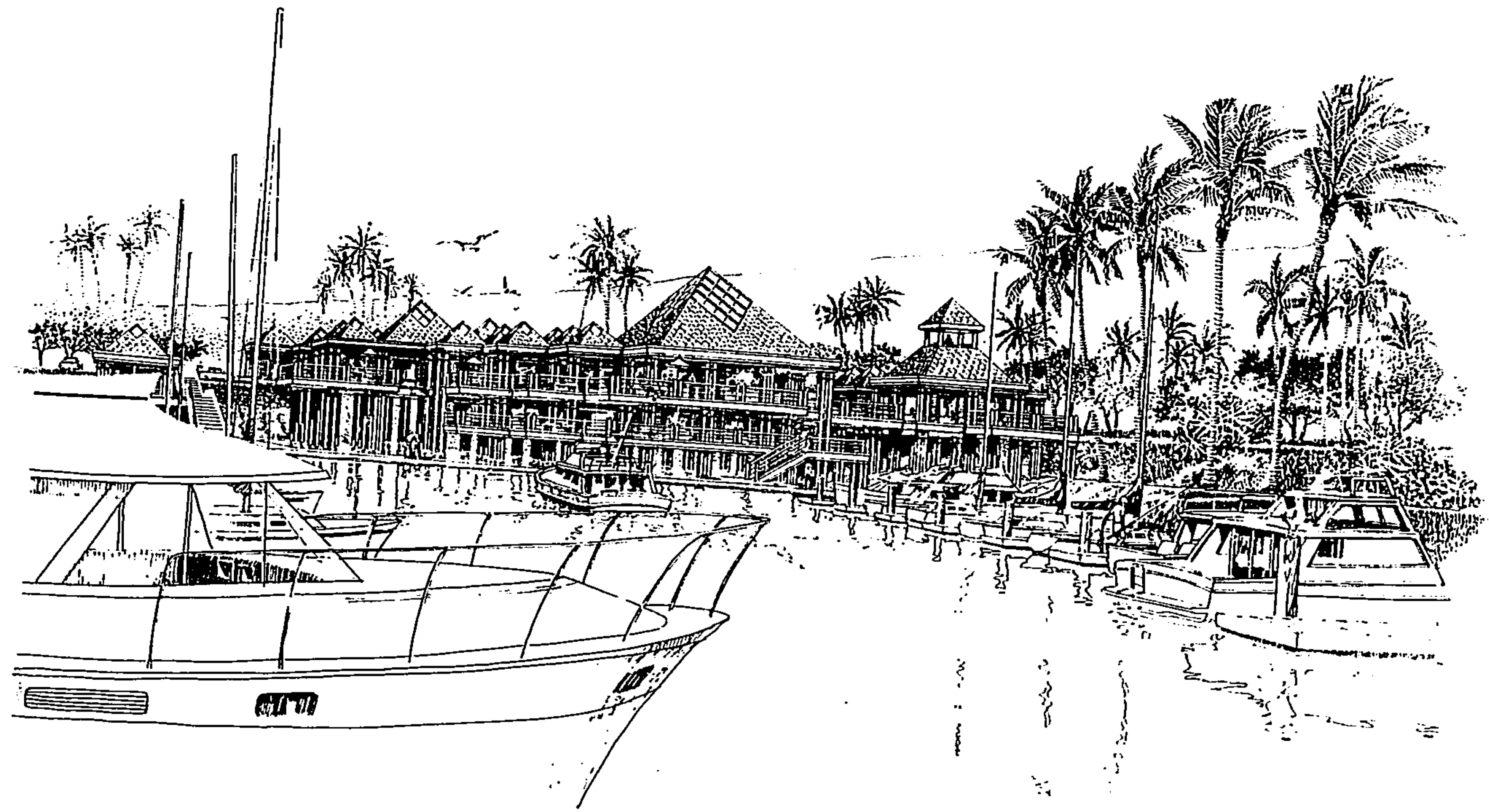
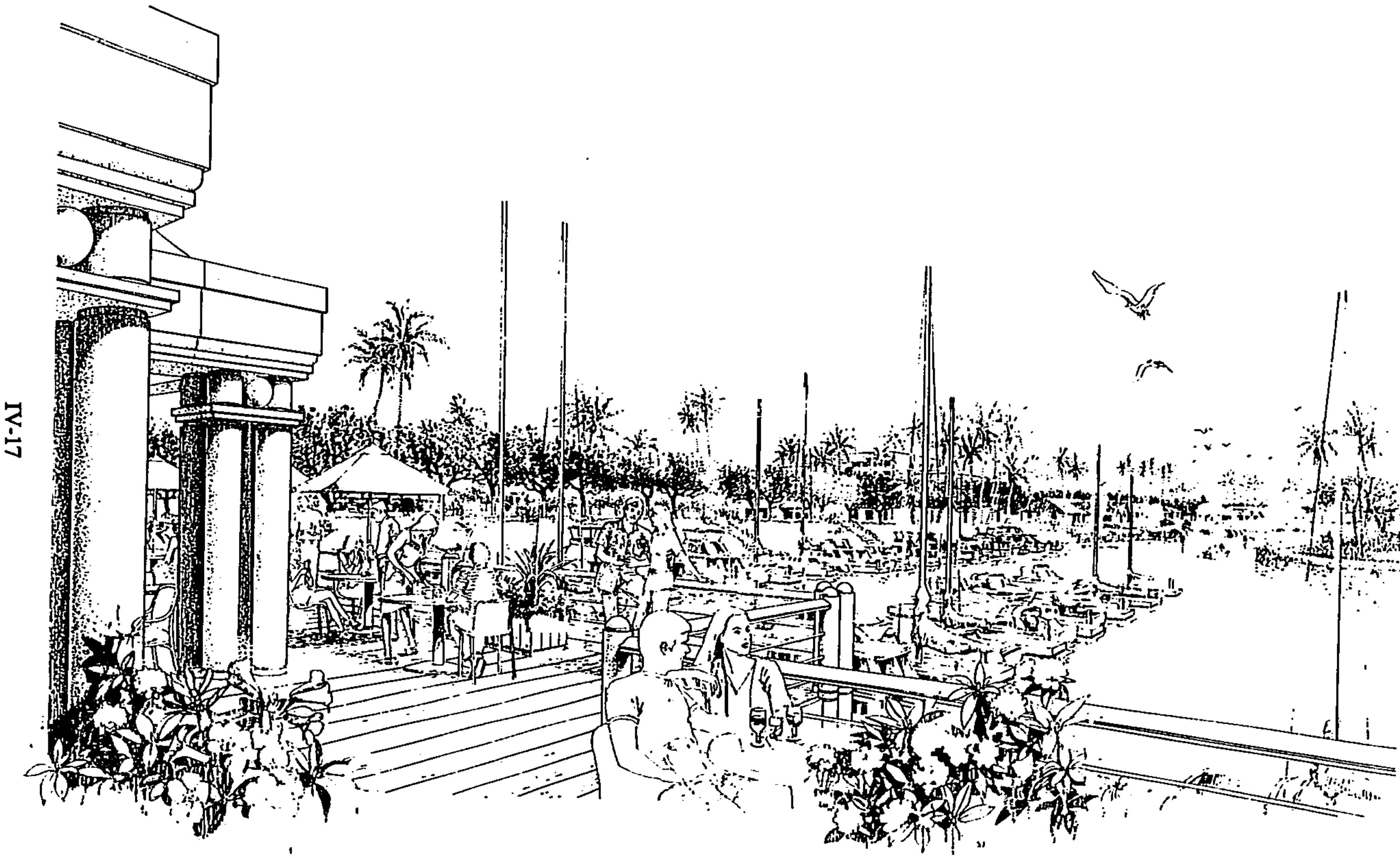


Figure IV-7
VIEW OF BOAT BASIN AT THE LANDING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
ROMA Design Group
November 1989



Source:
ROMA Design Group
November 1989

Figure IV-8
VIEW FROM DINING AREA AT THE LANDING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

and ohelo kai (*Lycium sandwicense*) form tangled clumps. The brackish ponds are usually surrounded by dense milo thickets (*Thespesia populanea*) and a few noni (*Morinda citrifolia*), loulu (*Pritchardia sp.*), pandanus (*Pandanus tectorius*) and two kinds of kou (*Cordia sebestena* and *subcordata*). Two sedges, kaluha (*Bolboschoenus maritimus*) and makaloa (*Schoenoplectus lacustris*) are restricted to the pond areas.

The scrub vegetation occurs on the a'a and pahoehoe lava flows and is usually sparse to almost absent on the a'a flows. The scrub vegetation is characterized by kiawe trees (*Prosopis pallida*) and introduced grasses; the most abundant being buffel grass (*Cenchrus ciliaris*) and sixweeks threeawn (*Aristida adcenisonis*). Locally abundant in scattered patches of varying sizes are fountain grass (*Pennisetum setaceum*) and the native pili grass (*Heteropogan contortus*) Smaller shrubs of hi'aloha (*Waltheria indica* var. *americana*) and ilima (*Sida fallax*). Ubiquitous throughout the site is threadstream carpetweed (*Molluga cerviana*).

As indicated above, two types of scrub vegetation are found on the project site, depending of the cover of kiawe trees. Open scrub is characterized by very widely scattered kiawe trees among a low grass-shrub association. All of the above noted plants occur in this vegetation type in addition to such species as pigweed (*Portulaca oleracea*), hairy spurge (*Chamaesyce hirta*), wild cucumber (*Cucumis dipsaceus*), coat buttons (*Tridax procumbens*), 'ihi (*Portulaca pilosa*) and wild spider plant (*Cleome gynandra*), all of which are occasional in this cover type.

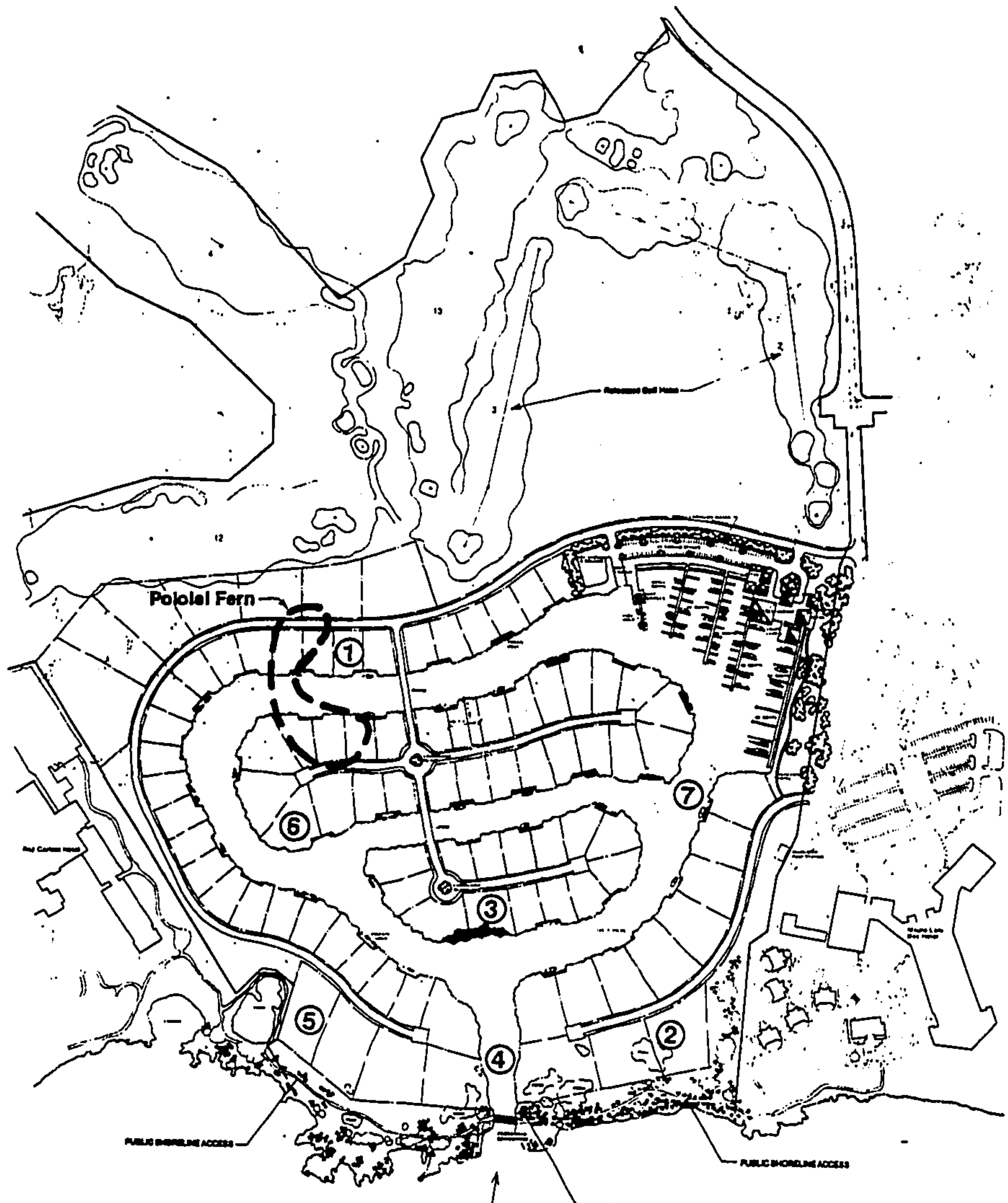
Where the substrate is broken pahoehoe, there is often an accumulation of soil and organic material between the cracks. The pololei fern, (*Ophioglossum concinnum*), a category 1 candidate endangered species, may be found in the damp pockets of soil during rainy months (see Figure IV-9).

The Kiawe Scrub vegetation type occurs where the kiawe tree cover varies from an open forest situation where the plants form about a 50 percent cover to a dense thicket which may be almost impenetrable in places. Trees may vary in height from 12 to 18 feet to as much as 25 feet. All of the species noted above occur here, but in fewer numbers because of the shade of the kiawe trees and more competition for available moisture.

3.1.2 Probable Impacts

The vegetation of the project site is dominated largely by introduced (or alien) species such as kiawe and buffel grass, although in places the native 'ilima and pili grass may be common. Of a total of 66 species inventoried during the botanical survey for the proposed project (Appendix D), 43 or 65 percent are introduced; 4 or 6 percent are originally of Polynesian introduction; and 19 or 29 percent are native. Of the native plants, 16 are indigenous, i.e., native to the islands and elsewhere; and 3 are endemic, i.e., native only to Hawaii and not found elsewhere.

None of the native plants are officially listed as endangered or threatened by the U.S. Fish and Wildlife Service. However, one native plant, the pololei fern (*Ophioglossum concinnum*), is considered a category 1 candidate endangered species and should be regarded as a candidate for addition to the endangered and threatened species list. The pololei fern is a small, perennial fern



Note: The proposed Mauna Lani Marina is shown in concept only. Design of facilities is subject to change, based on engineering analysis.

① Bird Census Station

0 100 300
SCALE IN FEET

NORTH

Figure IV-9
LOCATION OF POLOLEI FERN AND BIRD CENSUS STATIONS
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii
ROMA Design Group
Belt Collins & Associates
January 1989

with long, paddle-shaped leaves, 3 to 5 inches long. The plants appear after the first heavy downpour of the rainy season, produce leaves and a simple, spiked reproductive structure. They die back with only the underground stems surviving until the next rainy season. The fern has been recorded from Oahu, Molokai, Maui and Lanai, as well as the Big Island. The fern may not be as rare as previously believed as more recent findings indicate that the plants appear widely scattered along the leeward coast of Hawaii from Pu'ukohola Heiau to Manuka. Seven colonies of the plants occur on the project site within a relatively short distance of each other. Potential relocation sites for the fern colonies are shown of Figure IV-9.

Extensive earthwork and excavation would accompany development of the Cove. Portions of the site will be left intact where feasible, especially along the shoreline. Potential impacts to the vegetation of the site will be significant in that much of the existing vegetation will be lost. However, as noted below, the potential adverse impacts will be largely mitigated.

3.1.3 Mitigation Measures

To mitigate the loss of both native and introduced species, a broad shoreline park area and landscaped planting area near the anchialine ponds will be created. The pololei fern will be relocated and incorporated into the landscape planting that will utilize native dryland and strand material.

In keeping with past actions of Mauna Lani Resort, Inc., to mitigate the loss of naturally occurring vegetation, natural landscape elements, including endemic species, would be used in landscaping plans for the Cove and houselots, particularly along the coastline. Table IV-3 indicates the species of plants now used in the resort landscaping. Individual owners of houselots will be encouraged to utilize native and naturally occurring plant species to the maximum extent possible in their landscape plans. The pololei fern colonies that will be disturbed by the project will be relocated and use in the resort landscaping plans.

3.2 TERRESTRIAL FAUNA

3.2.1 Existing Conditions

The terrestrial fauna of the project site and area has been surveyed for the proposed project and is described Appendix E as well as for the EIS's prepared for the Mauna Lani Resort Revised Master Plan and Ritz-Carlton, Mauna Lani Hotel. Bird censusing stations are shown on Figure IV-9. Based on the field surveys conducted, the terrestrial fauna of the project site is characterized as follows:

- No endemic (native) land or water birds were recorded during the March 1989 survey. The only potential endemic resident species that might occasionally occur in the area would be the Short-eared Owl or Pueo (*Asio flammeus sandwichensis*).

TABLE IV-3

TYPICAL MAUNA LANI RESORT LANDSCAPE PLANTS

SCIENTIFIC NAME	HAWAIIAN NAME	COMMON NAME	ORIGIN
<u>Ground Covers</u>			
Lagenaria siccraria	Ipu	Gourd	Introduced
Graminea (Grasses)	Pili	Tanglehead	Indigenous
Sporobolus virginicus	'Aki'aki		Indigenous
Capparis sandwichiana var. *sandwichiana*	Pua-Pilo, Maiapilo	Native Caper	Endemic
Sesbania tomentosa var. *tomentosa*	'Ohai	Sesbania	Endemic
Lipochaeta ssp.	Nehe		Endemic
Scaevola coroacea	Naupaka	Naupaka	Indigenous
Portulaca hawaiiensis		Hawaiian Portulaca	Endemic
<u>Shrubs</u>			
Argemone glauca var. *glauca*	Pua-Kala	Prickly poppy	Endemic
Gossupium sandvicense	Ma'o	Hawaiian Cotton	Endemic
Sida fallax var. *fallax*	'Ilima	Ilima	Indigenous
Thymeliaceae wilkstroemia spp.	'Akia	False 'ohelo	Endemic
Tephrosia purpurea	'Ahuhu 'Ahuhu	Fish Poison plant	Introduced
<u>Trees</u>			
Cocos nucifera	Niu	Coconut	Introduced
Hibiscus tiliaceus var. *tilaceus*	Hau		Introduced
Erythrina sandwicensis var. *sandwicensis*	Wiliwili	Hawaiian Coral Tree	Endemic
Santalum ellipticum var. *ellipticum*	'Ili-Ahi-A-Lo'e	Coast Sandalwood	Endemic
Morinda citrifolia	Noni	Indian Mulberry	Introduced
Calophyllum inophyllum	Kamani		Indigenous
Pritchardia ssp.	Loulu	Palm	Endemie
Aleurites moluccana	Kukui	Candlenut Tree	Introduced
Bobea manii	Ahakea		Indigenous
Messerschmidia argentea	Hinahina	Tree Heliotrope	Introduced

- No live resident indigenous (native) birds were sighted during the survey. One relatively fresh carcass of a Black-crowned Night Heron (*Nycticorax nycticorax*) was recovered beside one of the coastal ponds in the project boundaries. This species may forage at the site but no live individuals were sighted during the March 1989 survey.

- Migratory indigenous (native) birds sighted during the March 1989 survey included Pacific Golden Plover (*Pluvialis fulva*) and Wandering Tattler (*Heteroscelus incanus*). No other migratory species were encountered. However, the Ruddy Turnstone (*Arenaria interuptus*) and Sanderling (*Calidris alba*) are two common migrants to Hawaii and likely occur along the coastal portions of the project property.

- No resident indigenous (native) seabirds were observed on the property.

- A total of 15 exotic (introduced) species of birds were observed during the March 1989 survey. The most abundant species were the Wandering Silverbill (*Lonchura malabarica*), Zebra Dove (*Geopelia striata*) and House Finch (*Carpodacus mexicanus*). Black Francolin (*Francolinus francolinus*) and Gray Francolin (*Francolinus pondicerianus*) were also numerous.

- Given the project area habitat and location, it is possible the Barn Owl (*Tyto alba*), Ring-necked Pheasant (*Phasianus colochicus*), California Quail (*Callipepla californicus*), Japanese Quail (*Coturnix japonica*), Chestnut-bellied Sandgrouse (*Ptercles exustus*) and Yellow-fronted Canary (*Serinus mozambicus*) may also occasionally occur on the property.

- A complete list of all species recorded, their relative abundance and those species that might occur on the property is included in Appendix E.

- Feral mammals occurring on the property include Goats (*Capra hircus*) and the Small Indian Mongoose (*Herpestes auropunctatus*). The endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) may frequent the site, but none have been sighted during bird or mammal surveys of the area and none have been reported in the area since a dead specimen was found a few years ago on the grounds of the Royal Waikoloan Hotel, approximately two miles south of the project site.

3.2.2 Probable Impacts

Development of the proposed Cove and house lots is not expected to significantly affect the bird or mammal species found within the project area. Newly landscaped areas could provide more habitat for the common introduced species and the native Pacific Golden Plover. In addition, new shallow water shoreline areas could provide additional feeding grounds for the common shoreline species. The water areas are expected to be too deep to provide suitable habitat for endangered native species. Populations of Warbling Silverbill and Nutmeg Mannikin (*Lonchura punctulata*) may decrease with a decrease in the dry brushland habitat. Populations of other species such as the

Common Myna (*Acridotheres tristis*), Zebra Dove and House Sparrow (*Passer domesticus*) may increase with development of the project site.

3.2.3 Mitigation Measures

Given the lack of expected significant adverse impacts that might result from the proposed project, mitigation measures are not warranted. As indicated above, newly landscaped areas will provide habitat for introduced and some native species. In addition, retention of the anchialine ponds and the creation of new water areas will provide some habitat for shore and waterbirds.

3.3 COASTAL POND/MARINE ENVIRONMENT

3.3.1 Coastal Ponds

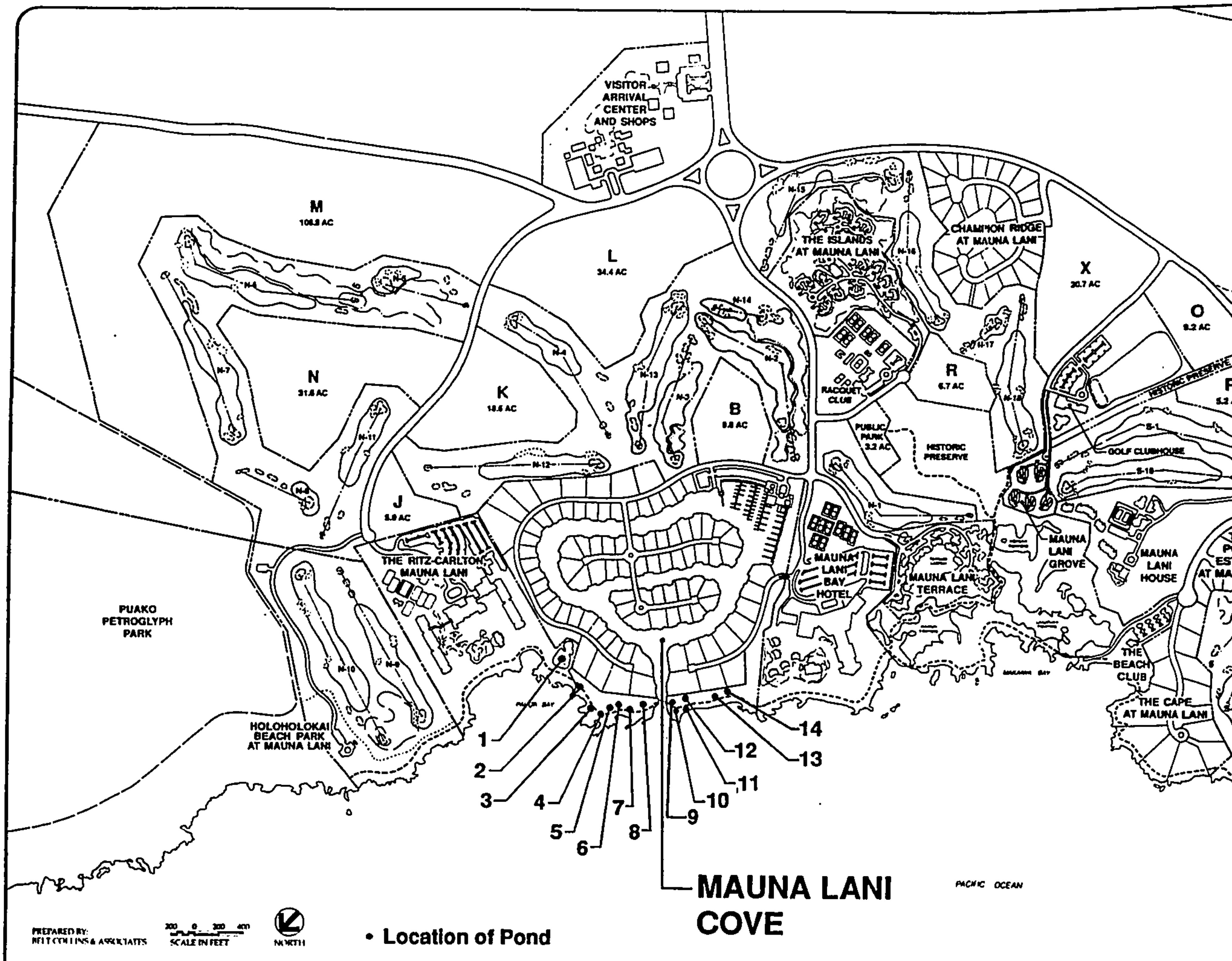
3.3.1.1 Existing Conditions

The shoreline area of the project site contains several anchialine and old fish ponds (see Figure IV-10). There are five major ponds with surface areas of more than 3,000 square feet and several smaller ponds ranging in size from a few square feet to a few hundred square feet grouped into 2 pond "systems". The ponds are in various stages of senescence, with some exhibiting anaerobic conditions due to infilling by windblown sand, vegetation and detritus. Those that are in relatively good condition contain the typical assemblage of Hawaiian anchialine pond organisms, such as the small red shrimp (*Halocaridina rubra* and *Metabetaeus lohena*) and the usual algal crust *Schizothrix caricola* and *Rhizocloniumm sp.*

The overall biological, chemical and physical characteristics of the coastal pond environment of the Mauna Lani Resort area have been discussed in detail in the Mauna Lani Resort Revised Master Plan EIS (Belt Collins & Associates, 1985), Ritz-Carlton, Mauna Lani Final EIS (Belt Collins & Associates, 1987) and references and technical reports attached thereto. In addition, for historical comparisons with previous surveys of the ponds within the resort boundaries (Brock, 1985a), a coastal pond and marine survey was conducted specifically for the proposed Cove project (Appendix F). The information presented below is that which is directly applicable to the proposed Cove project. Information relative to the areas outside of, but adjacent to, those that would be directly impacted by the proposed project is included in the above referenced documents and is not repeated here.

3.3.1.2 Physical Characteristics

The geomorphology of the coastal area makai of the proposed Cove is composed of several distinct physical zones. The shoreline is composed of narrow beaches covered with coarse sand and basaltic rock. Several "systems" of inter-connected anchialine ponds occur on the shoreline in topographically low areas. Based on the marine/coastal pond survey conducted for this Supp. EIS (Appendix F), the anchialine ponds that could be affected by the proposed project are in the latter stages of senescence due to in-filling by sediment and organic plant material. Similar conditions were found in the 1985 survey (Brock, 1985a).


VISITOR ARRIVAL CENTER AND SHOPS
M
N
K
L
J
B
R
X
O
THE ISLANDS AT MAUNA LANI
CHAMPION RIDGE AT MAUNA LANI
RACQUET CLUB
PUBLIC PARK
HISTORIC PRESERVE
GOLF CLUBHOUSE
THE RITZ-CARLTON MAUNA LANI
MAUNA LANI BAY HOTEL
MAUNA LANI TERRACE
MAUNA LANI GROVE
MAUNA LANI HOUSE
THE BEACH CLUB
THE CAPE AT MAUNA LANI
PUAKO PETROGLYPH PARK
HOLOHOLOKAI BEACH PARK AT MAUNA LANI
1
2
3
4
5
6
7
8
9
10
11
12
13
14
MAUNA LANI COVE
PACIFIC OCEAN
PREPARED BY: BELT COLLINS & ASSOCIATES
SCALE IN FEET
NORTH
• Location of Pond

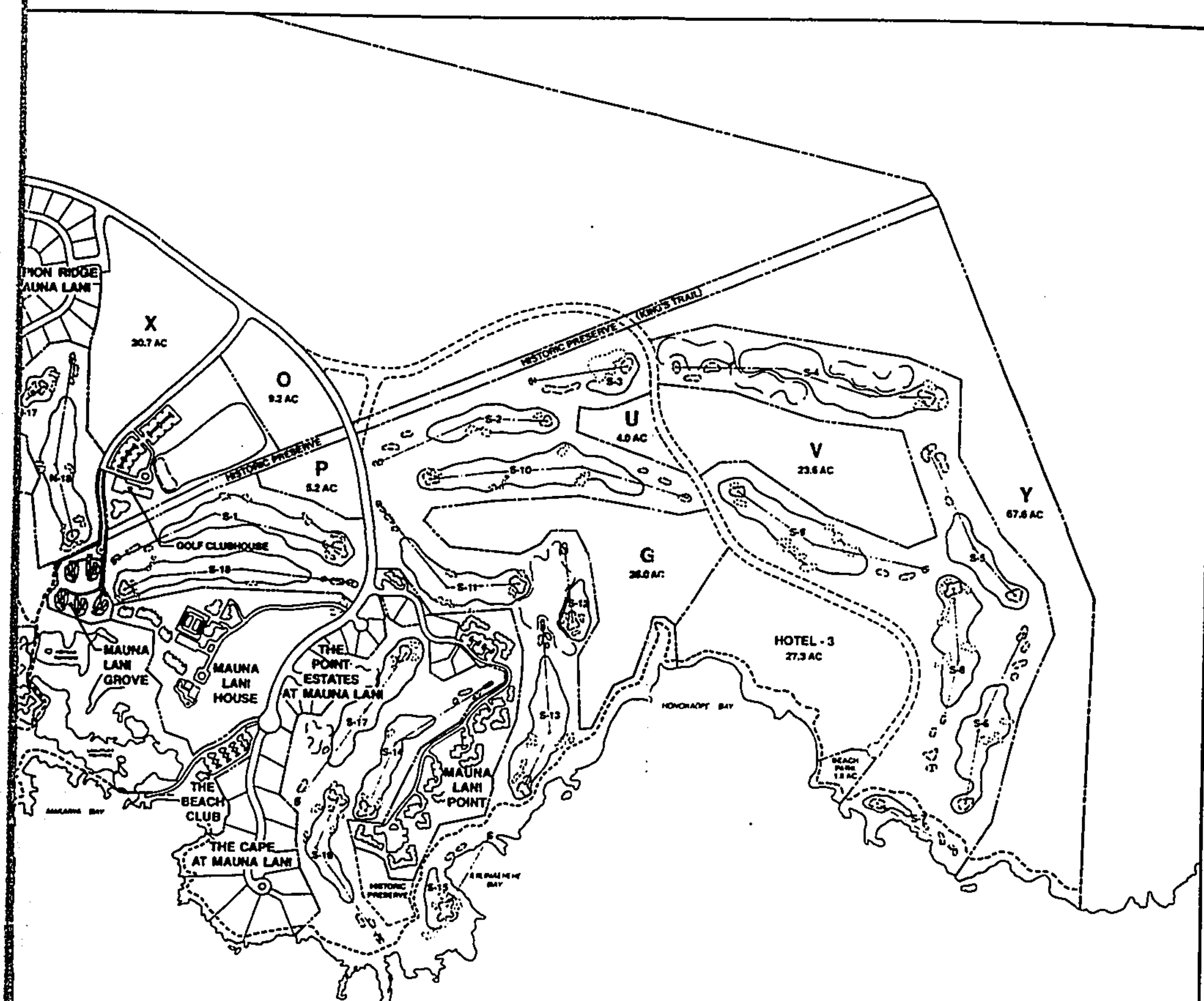


Figure IV-10
ANCHIALINE COASTAL PONDS LOCATIONS
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Water samples from the two pond "systems" indicated much higher nutrient levels, especially NH_4^+, than those from the ocean stations. This would be expected given the volume of groundwater inflow and the extent of organic debris decomposition that is occurring in the ponds. Chlorophyll a levels in all samples were below state standards (see Table 1, Appendix F).

Salinity of the ponds ranged from 4.757 o/oo (Pond 2) to 5.171 o/oo (Pond 1). The low salinity levels are indicative of the groundwater inflow. Based on analyses of water chemistry parameters as a function of salinity, it is evident that the concentrations of dissolved Si, $NO_3^- + NO_2^-$ and PO_4^{3-}, all found in high concentrations in groundwater, are the result of high rates of groundwater efflux, not from a potential pollution source. As noted above, the relatively high concentrations of NH_4^+ in the ponds is likely due to leaf litter decomposition.

3.3.1.3 Pond Biotic Community

The biotic community structure of anchialine ponds has been described by Maciolek and Brock (1974) and others, especially for ponds along the West Hawaii coastline (for example see Brock, 1985a and 1985b; Dollar, 1982; Oceanic Institute, 1977). The biota of the two ponds that could be affected by the proposed project was similar in that no native or exotic fish were observed; crustaceans included the red shrimps *Halocaridina rubra* and *Metabetaeus lohena* and the transparent shrimp *Palaemon debilis*. Qualitative estimates indicated that the shrimps were not overly abundant. Mollusks observed included *Assiminea sp.*, *Melania sp.* and *Theodoxis cariosa*. The former two mollusks were abundant in both ponds while only several individuals of the third were noted.

No vascular pond plants or algal mats were present in either of the ponds at the time of the survey.

3.3.1.4 Probable Impacts

Impacts to the coastal and anchialine ponds could result from the Cove excavation activities, increased public usage of the pond areas, increased sediment loading during Cove excavation and dredging activities, increased nutrient loading due to the maintenance of newly landscaped areas and the possible introduction of oily discharges from boat motors operating in The Cove.

The majority of the ponds in the vicinity of the project site would be left in their natural condition and substantially directly unaffected by the proposed project. Secondary impacts could occur as a result of development of the water areas of the Cove and the potential resultant alteration of groundwater flows into the ponds.

The two anchialine pond "systems" (Figure IV-10) that will be adjacent to the proposed Cove entrance will be cleaned of debris and overhanging vegetation. This will allow the ponds to become better habitats for typical anchialine pond biota. No filling of the ponds or other alterations are planned. As such, the proposed project is expected to result in positive benefits to the ponds. No impacts to Keanapou Pond (see Figure IV-10) are expected to occur as a result of the proposed project due to its location and relative distance from the interior of the Cove and shoreline.

Based on studies conducted at other similar coastal and anchialine ponds in the vicinity of the project site and area (Waikoloa and Mauna Lani Resort), impacts to ponds as a result of increased human activity and/or landscaped area maintenance and operations appears to be minimal. Although present groundwater flows into the ponds would be intercepted to some extent, flows of both brackish groundwaters and sea water would continue following completion of The Cove.

It is expected that the potential discharge of oily wastes within the Cove would be limited to relatively small, surface discharges and rapidly diluted and dispersed throughout the Cove areas prior to possible entrance into the ponds or ocean. Evaporation will also remove much of the petroleum products that may be found on the surface of the Cove waters.

3.3.1.5 Mitigation Measures

Measures that would be taken to minimize potential adverse environmental impacts on the ponds include the retention of the ponds in a natural condition following removal of debris and organic material. Further, the ponds will be integrated into an educational interpretive center that also includes native plants and typical strand vegetation. Precautions, in compliance with the Ocean Monitoring Program (Appendix P) and in keeping with past Mauna Lani environmental protection measures, including the use of siltation barriers, would be taken as necessary to prevent increased and accelerated sediment loading of the ponds during excavation and dredging activities. All dredging and excavation operations would be in accordance with applicable federal, state and county environmental protection rules and regulations. To assure that Cove operations are in compliance with applicable federal, state and county rules and regulations, a Draft operations plan for the Cove has been developed (Appendix Q). This plan will be administered and strictly enforced by a harbor master.

3.3.2 Marine Environment

3.3.2.1 Existing Physical Conditions

As indicated above, the geomorphology of the coastal area off the proposed Cove is composed of several distinct physical zones. The intertidal zone consists primarily of a basaltic ledge that is barren of most organisms. From the shoreline to about 800 feet offshore, the bottom consists of a shallow terrace that is bisected by sand channels. The terrace is composed of a basaltic shelf covered with a calcium carbonate (limestone) veneer. The entire reef terrace is covered with a layer of fine sandy sediment. Other than sand channels, the only relief in the area is shallow depressions filled with coarse sand. Sandy sediment on the limestone pavement is in a constant state of resuspension by current and wave forces. Based on the coastal processes investigations performed for the proposed project (Appendix G), offshore only small, widely separated patches of sand occur. Onshore, most of the sand is limited to a zone landward of the MLLW elevation and most of this sand is only affected by wave action during storm or high wave conditions. Based on soils borings taken within the Cove project site, it appears that the basaltic shelf is composed of hard and soft pahoehoe and a'a lavas and clinker.

At the seaward edge of the shallow reef terrace, the bottom slope steepens into a sharp drop-off that extends to depths of approximately 30 feet (see Figure IV-11). Beyond the drop-off bottom, topography consists of a sloping reef platform typical of the nearshore coastal region of West Hawaii.

Current measurements in the vicinity of the proposed Cove (Appendix H), indicate that currents are relatively slow, typically 5 to 7 cm/sec (0.1 knot), with an overall net transport to the southwest of 1.3 cm/sec. The maximum measured velocity was 33 cm/sec (0.6 knot). No apparent correlation with the tide was evident. However, the net transport to the southwest weakens during flood tide.

Deep water wave climate investigations (Appendix I), indicate that the project area is well sheltered from northeast tradewind waves by the island and is partially sheltered from North Pacific swell by the islands to the northwest, i.e., Maui, Molokai and Oahu. A north swell can reach the project site if the wave approach is very west-northwesterly or if the waves come from a very northerly direction. Kona storm waves and southern swell approach the coast in the project area directly. Deep water waves, as measured off Kawaihae Harbor (Appendix I), range from 0.5 feet to 6.2 feet, after having been altered due to refraction off the island and shoaling effects around the wave gauge. Wave periods ranged from 5 to 28 seconds for a six-month winter period. Based on the measurements taken, which closely approximate wave conditions offshore of Mauna Lani Resort, wave height exceedences for 50 percent, 10 percent and 1 percent frequency of occurrence are 2.6 feet, 3.3 feet and 5.1 feet respectively, with typical wave periods of 10 to 18 seconds. The analysis of extreme deep water waves (Appendix I) indicates the possible occurrence of these waves off the leeward coast of the island, but it does not necessarily mean that these waves would reach the project area. For hurricane waves, the predicted "worst case" condition, assuming that a hurricane passes very near to the west coast of the Big Island and the project site, indicates a predicted wave height of 31 feet and 12.0 second period. The actual likelihood of this is estimated to be very low and the wave height at the project site would depend on the storm track and decay distance over which the waves travel.

3.3.2.2 Existing Water Chemistry/Quality Characteristics

To determine the existing baseline water chemistry/quality characteristics of the area that could be impacted by the proposed project, water samples from a series of four water quality stations along three transect lines were taken (Figure IV-12). In general, the measurements taken indicate water chemistry/quality fairly typical of the West Hawaii coast (Appendix F). For comparison purposes, Figure IV-13 and Table IV-4 show typical water quality data from several surveys performed along the West Hawaii coastline. The results of the measurements indicated that geometric mean concentrations for all chemical parameters, except nitrate + nitrite, are below State of Hawaii "geometric mean not to exceed" criteria for "wet" conditions in open coastal waters (Hawaii Administrative Rules, Title 11, Department of Health, Chapter 54, Water Quality Standards, November 20, 1989). The data indicated that the relatively high geometric mean of nitrate + nitrite is a result of concentrations in excess of 15 μM within 10 m (30 feet) of the shoreline at stations 1 and 3. No such increase is present at station 2.

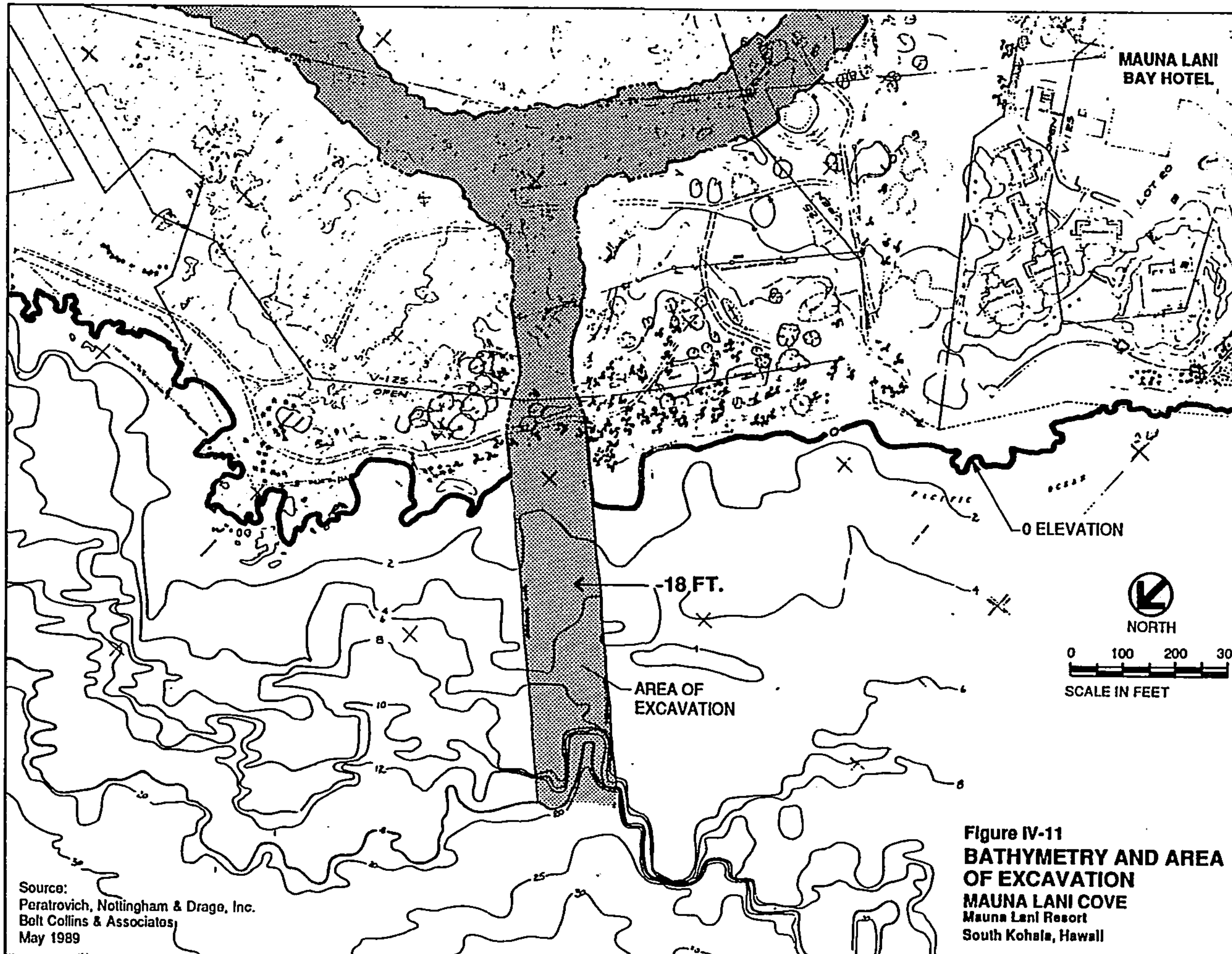
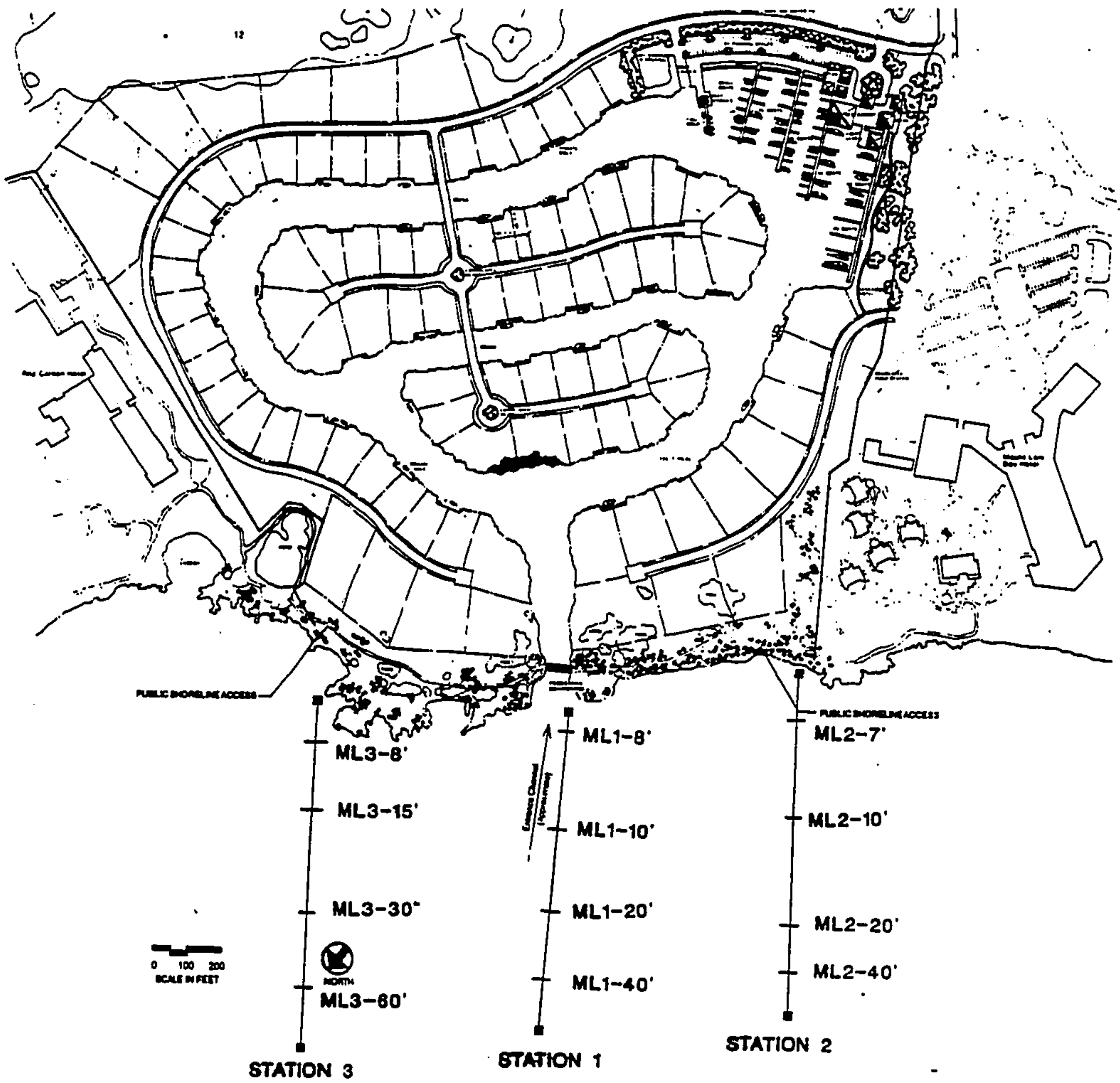


Figure IV-11
BATHYMETRY AND AREA OF EXCAVATION
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
Peratrovich, Nottingham & Drage, Inc.
Belt Collins & Associates
May 1989



Map of shoreline between Mauna Lani Bay Resort and Ritz-Carlton Hotel site showing location of planned Mauna Lani Cove entrance channel. Water chemistry sampling stations 1-3 are also shown, as are locations of reef transect survey sites.

Figure IV-12

LOCATION OF SAMPLING STATIONS

MAUNA LANI COVE

Mauna Lani Resort
South Kohala, Hawaii

Source: Marine Research Consultants
October 1989

HAWAII
THE BIG ISLAND

1:330 000

0 1 2 3 4 5 miles
0 1 2 3 4 5 6 7 8 km

LEGEND

1 - $NO_3^- + NO_2^- = 79.1 \mu g/l$
$NH_4^+ = 2.4 \mu g/l$
$PO_4^{-3} = 3.69 \mu g/l$

2 - $NO_3^- + NO_2^- = 22.0 \mu g/l$
$NH_4^+ =$ N/A
$PO_4^{-3} = 21.4 \mu g/l$

3 - $NO_3^- + NO_2^- = 129.2 \mu g/l$
$NH_4^+ = 2.4 \mu g/l$
$PO_4^{-3} = 9.9 \mu g/l$

4 - $NO_3^- + NO_2^- = 222.0 \mu g/l$
$NH_4^+ = 7.0 \mu g/l$
$PO_4^{-3} = 9.0 \mu g/l$

5 - $NO_3^- + NO_2^- = 38.9 \mu g/l$
$NH_4^+ = 4.1 \mu g/l$
$PO_4^{-3} = 6.2 \mu g/l$

6 - $NO_3^- + NO_2^- = 59.0 \mu g/l$
$NH_4^+ = 8.0 \mu g/l$
$PO_4^{-3} = 11.0 \mu g/l$

7 - $NO_3^- + NO_2^- = 2.8 \mu g/l$
$NH_4^+ = 5.1 \mu g/l$
$PO_4^{-3} = 5.0 \mu g/l$

8 - $NO_3^- + NO_2^- = 1.7 \mu g/l$
$NH_4^+ = 3.1 \mu g/l$
$PO_4^{-3} = 7.4 \mu g/l$

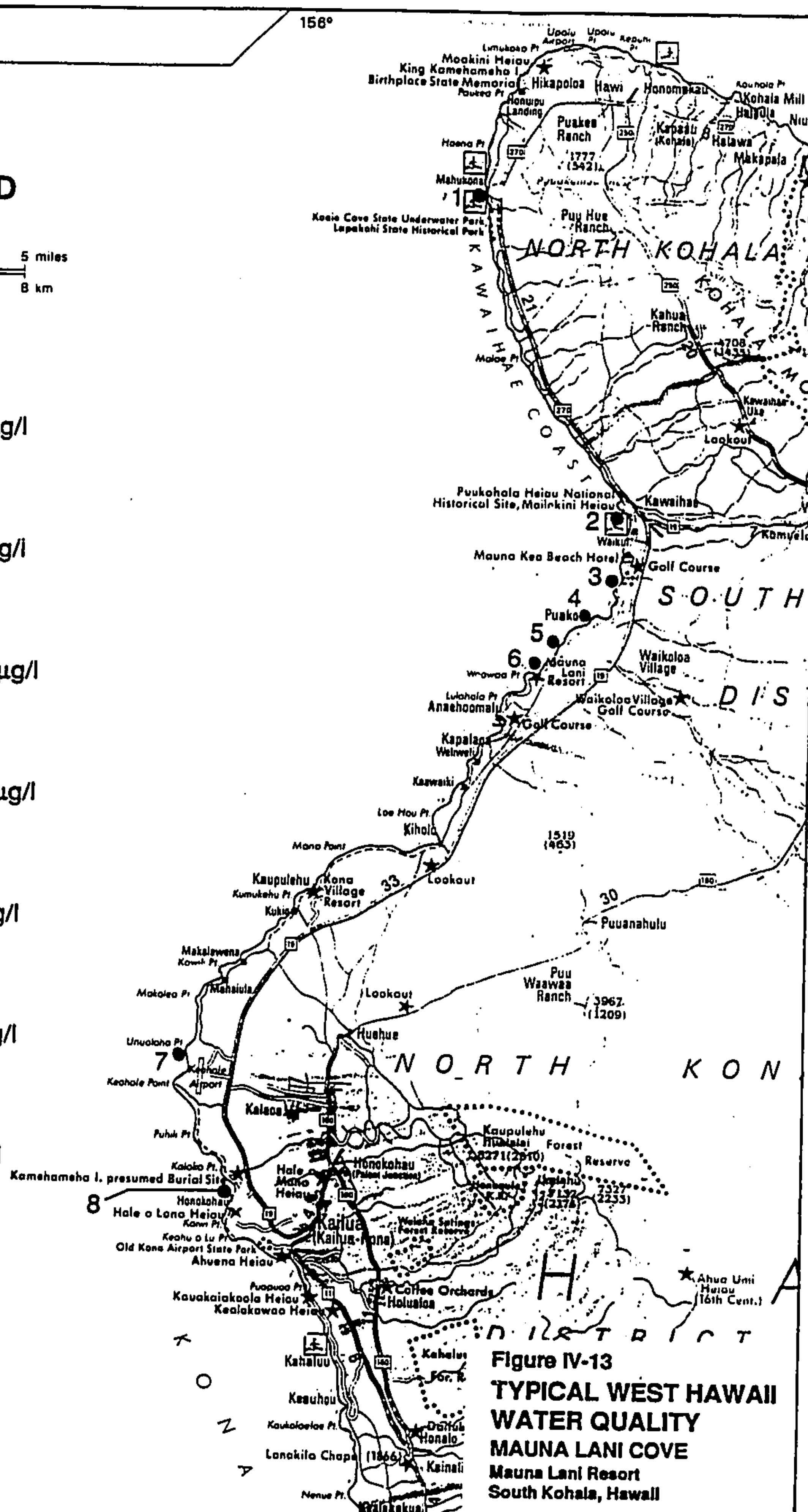


Figure IV-13
TYPICAL WEST HAWAII WATER QUALITY
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

TABLE IV-4
SELECTED WEST HAWAII WATER QUALITY DATA

LOCATION	DEPTH (m)	$NO_3^- + NO_2^-$ µg/l	NH_4^+ µg/l	PO_4^{-3} µg/l
STATE STANDARDS[1]		5.00	3.5	20.00
Humuhumu Point, Kahuku, Ka'u[a]	0.5	15.8	3.1	7.4
Honokohau Harbor (1983)[b]	0.5	1.7	12.6	7.4
Keahole Point (NELH, 1982-1986 avg.)[c]	13.7	2.8	5.1	5.0
Makaiwa Bay (1987)[d]	0.5	59.0	8.0	11.0
Mauna Lani Cove (1989)[e]	0.5	38.9	4.1	6.2
Pauoa Bay (1986)[d]	0.5	222.0	7.0	9.0
Hapuna Bay (1987)[f]	0.5	129.2	2.4	9.9
Kawaihae (1978)[g]	0.5	22.0	N/A	21.4
Mahukona (1990)[h]	0.5	79.1*	2.4	3.69

Notes:

1 State Standards stated in terms of "Geometric Mean Not to Exceed the Given Value", Wet Criteria, i.e., coastal waters receiving more than 3 million gallons per day of fresh water discharge per shoreline mile.

a Data from Dollar, S. 1987. Baseline assessment of the marine and anchialine pond environments in the vicinity of the Hawaiian Riviera Resort, Ka'u, Hawaii. In Final Environmental Impact Statement Hawaiian Riviera Resort, Kahuku, Ka'u, Hawaii.

b Data from Corps of Engineers, 1983.

c Data from NELH warm water intake pipe weekly samples. Pipe 13.7 m below surface, 92.4 m offshore.

d Data from Dollar, S. 1987. Effects to water quality and marine community structure from beach reconstruction at Makaiwa Bay, Mauna Lani Resort, South Kohala, Hawaii. Phase III. Prep. for Mauna Lani Resort, Inc.

e Data from Dollar, S. 1989. Preliminary assessment of the marine and pond environments in the vicinity of the proposed Mauna Lani Cove, South Kohala, Hawaii. Prep. for Belt Collins & Associates.

f Data from Dollar, S. 1987. A second baseline assessment if the marine environment in the vicinity of the South Kohala Resort, South Kohala, Hawaii. In Final Environmental Impact Statement, South Kohala Resort, South Kohala, Island of Hawaii.

g Data from ORCA, 1978. Reconnaissance surveys of the marine environment Kawaihae Small boat harbor project site, Island of Hawaii, Hawaii. Prep. for Pacific Ocean Division, Hawaii Corps of Engineers.

h Data from Brock, R.E. 1990. In Draft EIR, Mauhukona. Prep. for Chalon International of Hawaii, Inc. * Data represents total N.

Shoreline salinity in the area to be impacted by the proposed project is decreased due to the efflux of groundwater. Such groundwater intrusion is most evident at station 1, where salinity is approximately 24 o/oo at the shoreline, a depression of about 10.5 o/oo compared to the open ocean. Station 2 exhibited almost no salinity depression, with salinity at the shoreline only 0.4 o/oo less than the open ocean. Based on analyses of water chemistry parameters as a function of salinity, it is evident that the concentrations of dissolved Si, NO_3^- + NO_2^- and PO_4^{3-}-all found in high concentrations in groundwater, are the result of high rates of groundwater efflux, not from a potential pollution source. Linear dispersion in the nearshore ocean indicates that presently there are no external sources of these materials emanating from the land. The relatively uniform distribution of Chlorophyll *a* indicates that there are no areas of plankton blooms across the reef platform. As indicated above, and as shown on Figure IV-13, the water chemistry of the area to be impacted by the proposed Cove is typical of natural conditions along the West Hawaii coastline.

It is emphasized here that typically nearshore water quality measurements, along the entire West Hawaii coastline, including areas in which no or only minimal development or human activities have occurred, either along the shoreline or mauka, indicate exceedences of state water quality chemical standards, due primarily to the large volume of naturally high nutrient level groundwater efflux (i.e., 3 to 6 MGD/coastal mile). Offshore water quality measurements indicate that dispersion and dilution of the nearshore waters occurs rapidly and that offshore, all chemical water quality parameters are typical of oceanic conditions, i.e. typically very low nutrient levels. Nearshore surveys also indicate that, ecologically, the naturally high nutrient level groundwaters have little if any effect on the density or diversity of the species that have adapted to the groundwater efflux conditions.

3.3.2.3 Benthic Community Structure

Based on the marine survey conducted for the proposed project (Appendix F), the coral community zonation pattern reflects the physical structure of the reef habitats and natural environmental stresses associated with the various habitats. Living corals are fairly scarce on the shallow reef terrace, with total cover ranging from 5 to 28 percent. The number of coral species is also low on the reef platform. *Porites lobata* and *Pocillopora meandrina* are the only corals that appeared on all shallow (i.e., less than 15 feet) transects. Both species are capable of assuming growth forms that are most resistent to the concussive force of waves.

Beyond the edge of the reef drop-off, coral cover increases. Total coral cover ranges from 49 to 86 percent. Species number is also greater in the deep reef zone than on the shallow terrace, ranging from 3 to 7 species. Dominant coral cover consists of interconnected mats-of *Porites compressa*, and large colonies of *P. lobata*. Smaller species present, with respect to areal coverage, include *Montipora verrucosa*, *M. patula* and *Pavona varians*. The deeper reef zones are considered well-developed coral communities typical of the West Hawaii coastline as described by Dollar (1975 and 1982).

The major species of motile invertebrate benthic organisms observed in the survey area were sea urchins (Echinoidea) including two limestone boring species (*Echinometra matheai* and

Echinostrephus aciculatus). The entire reef surface not inhabited by coral colonies is covered with short mixed-species algal turf. Frondose benthic algae rarely occur in all zones and no areas of dense algae (limu) that might be considered of commercial or recreational harvesting value were observed. Other species of macro invertebrates, such as squid or octopus, were not observed during the marine survey. However, the area fronting Mauna Lani Resort has been reported by local fishermen as an area in which squid and octopus are occasionally caught.

3.3.2.4 Reef Fish Community Structure

A rich and diverse fish community, typical of West Hawaii, was found in the reef areas that would be impacted by the proposed project. This community has been described in detail by Hobson (1974). During the 1989 survey, a total of 67 species were observed on transects. On a single transect, species number ranged from 8 to 32, while individual fish encountered on transects ranged from 43 to 461. Inshore areas displayed fewer species and total individuals, resulting in lower overall species diversity. The lower number of inshore fishes is probably a result of the less favorable physical environment caused by heavy surge from wave action and less habitat complexity from lowered coral growth. The highest species diversity was observed at depths of about 20 feet.

Several representative groups of reef fish were especially abundant on transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. A complete listing of the species observed is included in Appendix F. Several species of "food fishes" were observed during the marine survey. These included parrotfishes (*Scarus spp.*), goatfishes (*Parupaneus* and *Mulloidichthys spp.*), jacks (*Caranx melamphygus*), surgeonfishes (*Acanthurus* and *Naso spp.*) and the introduced tahitian grouper (*Cephalophilis argus*). None of the fishes were particularly abundant. One noteworthy point concerning the fish community off the proposed project site was the relative scarcity of butterfly fishes. Although one species (*Chaetodon multicintus*) was well represented, other species in this genus were not as common as might be expected. Because this group is commercially harvested by aquarium fish collectors, their scarcity may indicate that this fishery is affecting the reef fish community at this site.

3.3.2.5 Threatened or Endangered Species

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by the U.S. Fish and Wildlife Service (Department of the Interior, 1985). The threatened green sea turtle (*Chelonia mydas*) occurs commonly along the shoreline of the major Hawaiian Islands, including along the West Hawaii shoreline, and is known to feed on selected species of microalgae. The resting habitat of green turtles is commonly deeper_ reef areas characterized by undercut ledges and other topographical features. The endangered hawksbill turtle (*Eretomochelys imbricata*) is found infrequently in waters off Hawaii but is known to frequent the southeastern coast of Ka'u District (see PBR HAWAII, 1988). No hawksbill turtles were observed in the project area during the marine survey (Appendix F) or during a turtle survey conducted in October 1989 (Appendix J).

One small green turtle was observed during the marine survey (Appendix F) and during a separate survey specifically for green turtles, two primary resting sites in the vicinity of the proposed project were observed (Appendix J). An area offshore of the resort (popularly known as "Turtles" and a second site seaward of the fringing reef at Puako are the two primary resting sites for green turtles. The "Turtles" site, approximately 1,800 feet from the shoreline and 2,200 feet south of the proposed channel, is frequented by tour dive boats. During the turtle survey a total of ten turtles were seen at the site. The Puako resting site is located approximately 1.5 miles north of Mauna Lani resort and about 1,000 feet offshore. A total of eight green turtles were encountered during the turtle survey (Appendix J). In addition to the two primary resting sites, the area between the two sites was surveyed. Four green turtles, in addition to those previously sighted, were observed during this part of the survey. The turtles observed at both sites and the area in between the two sites, are primarily subadults or juveniles, which is generally characteristic of the green turtles observed off the West Hawaii coast (Appendix J). None of the turtles observed during the survey exhibited any signs of tags or noticeable deformities. Local divers have indicated that occasionally they sight an individual turtle that has lost one of its foreflippers. This turtle was not observed during the survey.

Populations of the endangered humpback whale (*Megaptera novaengliae*) spend winter months (November to April) in the Hawaiian Islands and are frequently observed off the West Coast of Hawaii (Smultea, 1990). Several pods of whales were noted offshore of the proposed channel entrance during the marine survey (Appendix F) which was conducted in mid-March 1989. All whales were at least 1,000 feet from the shoreline and did not transit or rest on the shallow reef terrace or reef platform zones. The total number of whales frequenting the offshore areas is not known. However, it is known that the humpback prefers areas offshore of West Maui, Lanai, Molokai, Kahoolawe and around Penguin Bank (Shallenberger, 1979 and Tinney, 1988). Waters surrounding the Island of Hawaii are utilized to a lesser extent, with the waters north of Kailua-Kona to Upolu Point the area where whales are seen most often (Appendix K). Calving and breeding do take place in Hawaiian waters. As noted in Bauer (1986), the behavior of humpback whales is poorly understood and minimally quantified. Smultea (1990) notes that although regional concentrations of certain age classes have been described for humpbacks on wintering grounds, there has been no attempt to systematically quantify or define habitat parameters for cows with calves or other social groups and her own investigations off Kuili cinder cone (Makalawena/Awakee area of West Hawaii) are inconclusive.

3.3.2.6 Probable Impacts

As indicated in the Project Description (Chapter II, Section 6.1), the proposed project includes excavating a 150-foot wide, 625-foot long access channel to a depth of -18 feet MLLW. The access channel will be located such that it takes advantage of the shortest possible distance between the edge of the offshore reef and The Cove's entrance through the beach. The access channel will cover a total area of about 2 acres, which represents approximately 1.2 percent of the total offshore area fronting the Mauna Lani/Ritz-Carlton resort area (to 600 feet offshore).

In addition to excavation of the access channel. the interior portions of the proposed Cove would be excavated to between -15 to -6 feet MLLW prior to opening the access channel to the ocean. Based on measurements and estimates of groundwater efflux along the coastline fronting the

CORRECTION

THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

Echinostrephus aciculatus). The entire reef surface not inhabited by coral colonies is covered with short mixed-species algal turf. Frondose benthic algae rarely occur in all zones and no areas of dense algae (limu) that might be considered of commercial or recreational harvesting value were observed. Other species of macro invertebrates, such as squid or octopus, were not observed during the marine survey. However, the area fronting Mauna Lani Resort has been reported by local fishermen as an area in which squid and octopus are occasionally caught.

3.3.2.4 Reef Fish Community Structure

A rich and diverse fish community, typical of West Hawaii, was found in the reef areas that would be impacted by the proposed project. This community has been described in detail by Hobson (1974). During the 1989 survey, a total of 67 species were observed on transects. On a single transect, species number ranged from 8 to 32, while individual fish encountered on transects ranged from 43 to 461. Inshore areas displayed fewer species and total individuals, resulting in lower overall species diversity. The lower number of inshore fishes is probably a result of the less favorable physical environment caused by heavy surge from wave action and less habitat complexity from lowered coral growth. The highest species diversity was observed at depths of about 20 feet.

Several representative groups of reef fish were especially abundant on transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. A complete listing of the species observed is included in Appendix F. Several species of "food fishes" were observed during the marine survey. These included parrotfishes (*Scarus spp.*), goatfishes (*Parupaneus* and *Mulloidichthys spp.*), jacks (*Caranx melamphygus*), surgeonfishes (*Acanthurus* and *Naso spp.*) and the introduced tahitian grouper (*Cephalophilis argus*). None of the fishes were particularly abundant. One noteworthy point concerning the fish community off the proposed project site was the relative scarcity of butterfly fishes. Although one species (*Chaetodon multicintus*) was well represented, other species in this genus were not as common as might be expected. Because this group is commercially harvested by aquarium fish collectors, their scarcity may indicate that this fishery is affecting the reef fish community at this site.

3.3.2.5 Threatened or Endangered Species

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by the U.S. Fish and Wildlife Service (Department of the Interior, 1985). The threatened green sea turtle (*Chelonia mydas*) occurs commonly along the shoreline of the major Hawaiian Islands, including along the West Hawaii shoreline, and is known to feed on selected species of microalgae. The resting habitat of green turtles is commonly deeper reef areas characterized by undercut ledges and other topographical features. The endangered hawksbill turtle (*Eretomochelys imbricata*) is found infrequently in waters off Hawaii but is known to frequent the southeastern coast of Ka'u District (see PBR HAWAII, 1988). No hawksbill turtles were observed in the project area during the marine survey (Appendix F) or during a turtle survey conducted in October 1989 (Appendix J).

One small green turtle was observed during the marine survey (Appendix F) and during a separate survey specifically for green turtles, two primary resting sites in the vicinity of the proposed project were observed (Appendix J). An area offshore of the resort (popularly known as "Turtles" and a second site seaward of the fringing reef at Puako are the two primary resting sites for green turtles. The "Turtles" site, approximately 1,800 feet from the shoreline and 2,200 feet south of the proposed channel, is frequented by tour dive boats. During the turtle survey a total of ten turtles were seen at the site. The Puako resting site is located approximately 1.5 miles north of Mauna Lani resort and about 1,000 feet offshore. A total of eight green turtles were encountered during the turtle survey (Appendix J). In addition to the two primary resting sites, the area between the two sites was surveyed. Four green turtles, in addition to those previously sighted, were observed during this part of the survey. The turtles observed at both sites and the area in between the two sites, are primarily subadults or juveniles, which is generally characteristic of the green turtles observed off the West Hawaii coast (Appendix J). None of the turtles observed during the survey exhibited any signs of tags or noticeable deformities. Local divers have indicated that occasionally they sight an individual turtle that has lost one of its foreflippers. This turtle was not observed during the survey.

Populations of the endangered humpback whale (*Megaptera novaengliae*) spend winter months (November to April) in the Hawaiian Islands and are frequently observed off the West Coast of Hawaii (Smultea, 1990). Several pods of whales were noted offshore of the proposed channel entrance during the marine survey (Appendix F) which was conducted in mid-March 1989. All whales were at least 1,000 feet from the shoreline and did not transit or rest on the shallow reef terrace or reef platform zones. The total number of whales frequenting the offshore areas is not known. However, it is known that the humpback prefers areas offshore of West Maui, Lanai, Molokai, Kahoolawe and around Penguin Bank (Shallenberger, 1979 and Tinney, 1988). Waters surrounding the Island of Hawaii are utilized to a lesser extent, with the waters north of Kailua-Kona to Upolu Point the area where whales are seen most often (Appendix K). Calving and breeding do take place in Hawaiian waters. As noted in Bauer (1986), the behavior of humpback whales is poorly understood and minimally quantified. Smultea (1990) notes that although regional concentrations of certain age classes have been described for humpbacks on wintering grounds, there has been no attempt to systematically quantify or define habitat parameters for cows with calves or other social groups and her own investigations off Kuili cinder cone (Makalawena/Awakee area of West Hawaii) are inconclusive.

3.3.2.6 Probable Impacts

As indicated in the Project Description (Chapter II, Section 6.1), the proposed project includes excavating a 150-foot wide, 625-foot long access channel to a depth of -18 feet MLLW. The access channel will be located such that it takes advantage of the shortest possible distance between the edge of the offshore reef and The Cove's entrance through the beach. The access channel will cover a total area of about 2 acres, which represents approximately 1.2 percent of the total offshore area fronting the Mauna Lani/Ritz-Carlton resort area (to 600 feet offshore).

In addition to excavation of the access channel. the interior portions of the proposed Cove would be excavated to between -15 to -6 feet MLLW prior to opening the access channel to the ocean. Based on measurements and estimates of groundwater efflux along the coastline fronting the project area, it is expected that between approximately 1.0 mgd and 4.0 mgd of groundwater will enter the Cove along the mauka shoreline (Appendix R). This efflux of groundwater will assist in the flushing of the Cove.

Impacts to the marine environment resulting from the proposed project could be caused by the channel and interior portion excavation activities and operation and maintenance of the Cove following completion of construction. Both construction and operation activities potentially could cause physical/biological and chemical impacts. The following paragraphs first describe the potential impacts that could result from construction operations and report the results of similar projects on the environment and, secondly describe the potential impacts that could result from operation and maintenance of the proposed Cove.

3.3.2.7 Potential Physical/Biological Impacts Due To Construction

Construction of The Cove's access channel and interior would be performed in three phases: (1) Phase 1 would include excavating the Cove entrance channel up to the beach (see Chapter II, Section 7.1 and below for description of dredging and construction methods); (2) Phase 2 would include excavating the interior channels; and (3) Phase 3 would include excavation of the access channel through the beach. Phases 1 and 2 could occur concurrently.

Excavation of the offshore portions of the access channel would be accomplished by first using a jack-up type barge from which holes, in a set pattern, would be drilled into the basaltic reef, the holes loaded with powder and subsequently detonated after visually sweeping the underwater and surface area for turtles and moving the barge away from the blast zone. Following all blasting, a mobile barge with either a large backhoe, dragline or clamshell would excavate the shot material, load that material on another barge for transport to Kawaihae for offloading and eventual transportation back to Mauna Lani where it would be stockpiled at a suitable disposal site on the resort property for use in other projects (see Section 2.1.2 above). The dredged material would be allowed to drain and dry while stockpiled at Kawaihae prior to transport to Mauna Lani. The disposal site is shown on Figure II-2 (Chapter II, page II-3). Siltation curtains will be used to limit any silt plume that may result from the blasting or dredging operations to the immediate construction area.

The interior portions of the Cove would be excavated using conventional land-based equipment. Blasting would be required to loosen very hard basaltic material below the five-foot depth. Excavated material would be disposed of on the resort property upland of the Cove development (see Figure II-2).

In Phase 3, the "plug" separating the interior portion of the Cove and the exterior access channel would be removed. Groundwater within the interior portions would be allowed to settle and to rise to the same level as the outside ocean waters. The plug would then be excavated with the materials disposed of at the upland disposal site. Siltation curtains will be employed to limit any silt plume that may be created during this part of the operation to the immediate excavation area. Care would also be taken to ensure that a silt plume is not created between the interior portions of the Cove and seawater entering and leaving the access channel.

During construction of the proposed Cove, potential physical/biological environmental impacts could be caused by the proposed excavation work as well as the physical changes to be made to the existing environment. Physical impacts could include potential alteration in littoral transport of sand along the beach fronting the Mauna Lani resort area, the actual removal of benthic organisms, covering coral and other organisms during excavation activities and excavation activities causing biologically intolerable turbidity. Impacts to the biological communities would be those caused by the physical changes to be made to existing conditions.

Based on the littoral transport study conducted for the proposed project (Appendix G), the project area does not appear to experience significant longshore transport. The submarine canyons offshore from the project site and the rocky spits along the project area form classical sand traps when found in longshore transport zones. In the project area, very little sand is found in the channel bottoms and beach shapes are symmetrical between spits rather than skewed toward the downdrift spit. Evidence of longshore transport does exist in nearby areas, particularly just north of the Beach Club and at the Mauna Lani Bay Hotel beach. Any changes in the existing shoreline that would destabilize existing beaches or add littoral material to the transport zone, for example large-scale alterations of the shoreline configuration or the creation of new beaches, could result in additional sand transport. The proposed access channel is not expected to have any adverse effect on existing adjacent beaches (Appendix G).

The proposed Cove access channel will take about 1.2 percent of the Mauna Lani Resort area offshore reef. Survey results indicate that the present bottom cover in this area consists of about 5 to 9 percent living corals. The major group of fauna inhabiting the terrace area to be excavated are boring sea urchins. Further, the area to be excavated is presently subjected to natural physical conditions that are relatively severe due to wave and surge actions. No excavation will take place on the deeper reef platform where coral cover is upwards of 50 percent.

While organisms on the reef terrace to be excavated will be eliminated during construction, a long-term result of the project may likely be an increase of living coral following construction of the channel. Several studies in Hawaii and elsewhere (see for example U.S. Army Corps of Engineers, 1983 and ORCA, 1978), indicate that corals rapidly recolonize an area following construction activities. In many cases, following construction activities, the substrate is improved for recolonization by providing a hard substrate rather than a soft, shifting substrate as exists at Mauna Lani at present.

Further, studies have indicated that coral communities outside harbor projects do not indicate that there are adverse impacts resulting from harbor construction (U.S. Army Corps of Engineers, 1983 and ORCA, 1978). Post-construction environmental monitoring and surveys of the Honolulu International Airport Reef Runway also indicated that coral and other benthic communities rapidly recolonize a disturbed area and in some cases, the percent cover of biota is greater than that which existed prior to the disturbance (AECOS, 1979). Based on the studies that have been performed, it is likely that the newly created substrata will be a more suitable settling area than the naturally occurring setting and coral cover will increase above the present 5 to 9 percent cover. Similarly, it is believe that sea urchins will also recolonize the new surfaces.

In addition to removal by construction, coral and benthic communities could be adversely affected by increased sedimentation and turbidity due to the excavation activities and/or scouring as a result of sediment movement over and on sessile organisms. The effects of sediment stress to coral has been extensively reviewed by several researchers (see for example Johannes, 1975; Dodge and Vaisnys, 1977; Bak, 1978; Brown and Howard, 1985; and Grigg and Dollar, 1989). In summary, while it is clear that increased sedimentation can have a deleterious effect on corals, especially when buried, sedimentation can also result in no negative impacts. Because sediments are suspended by natural processes in many reef environments, most corals can withstand a given level of sediment supply to the living surface (Younge, 1931).

A sediment plume dispersion modeling study for the Cove project blasting, dredging and operations phases has been performed (Appendix T). For the construction phases (blasting and dredging), the study used turbidity data and dredged material settling rates generated during the dredging and construction of the West Beach (Ko Olina) project on Oahu. This material was primarily coralline limestone, which generally is much finer and has longer settling rates than the basaltic lava materials found within the Cove project area. As such, the results of the analysis are believed to be overly conservative and overstate the potential turbidity conditions that would be generated during construction of the Cove (Appendix T). For the blasting activity phase of the construction, the results of this study indicate the following:

- The probable impact areas of a blast generated turbidity cloud would be localized to an area about 2 km (1.2 miles) distance from the access channel.
- The highest probability (51 percent) of impact is confined to an area within 1 km (0.6 mile) of the access channel.
- About 9 hours after blasting, the peak turbidity concentration will be reduced to values that are significantly less than open ocean turbidity.

The above results are based on a turbidity cloud of 40 mg/l, which is considered to be a very conservative estimate, thereby overstating the impact of turbidity during the blasting operations. Additionally, dispersion of the turbidity plume has been estimated based on the assumption that a siltation curtain would not be used during the construction operations. Use of a siltation curtain would limit the turbidity plume to the immediate construction area.

To evaluate the turbidity plume from a continuous source, as would occur during dredging operations, two different methodologies were used. One methodology involved a deterministic estimate using a phenomenological model of transport and settling. Its applicability is in the nearfield surrounding the dredging operations. The second methodology involved a probalistic analysis similar to that used for the blast generated plume and is applicable to the farfield impacts.

The results of the nearfield modeling indicate that with sediment fallout, i.e., settling, at about 1.3 km (0.8 mile) downstream the centerline, sediment concentration is about 0.7 mg/l, which is similar to open ocean turbidity and about 2.0 km (1.2 miles) downstream, the turbidity is reduced to 0.14 mg/l, which is significantly less than ambient ocean turbidity.

The farfield modeling indicated that there will be a slow expansion of the area of impact and even 24 hours after the start of operations, the 0.5 mg/l suspended solids concentration only extends about 0.8 km (0.5 mile) up and down the coast and offshore from the construction site. In general, the results of the farfield modeling show that the turbidity plume from continuous dredging, if not controlled by the use of siltation curtains, will be confined to very limited areas, typically within about 1 km (0.6 mile) from the source point (Appendix T).

As indicated in Appendix F, in case studies of the effects of sedimentation, the range of environmental effects varies through the entire spectrum of stress. In areas of unrestricted circulation, such as that which exists at Mauna Lani, instances of increased sedimentation do not appear to cause any substantial effects to coral reefs (Sheppard, 1980). As noted previously, studies at Honokohau and Kawaihae Harbors showed that coral communities located just outside the harbors are flourishing. As noted previously, dredging of the Cove access channel and resultant sediment generation could stress nearby coral communities through scouring if siltation curtains are not used during the blasting and dredging operations.

At Mauna Lani, during construction of the beach at Makaiwa Bay, while there was a substantial sediment plume during construction, there were no temporary or permanent negative effects to benthos and fish communities (Dollar, 1987). Rapid flushing of the bay by normal current exchange, as would be the case at the proposed project site, and the ability of live corals to remove sediment appeared to prevent measurable changes in community structure parameters. Other studies indicating similar consequences of dredging and sediment loads on coral and benthic communities are cited in Appendix F.

In general, the conclusion reached is that Hawaiian reef communities possess the adaptive ability to maintain community integrity under conditions of substantial, but temporary, sediment stress, provided that there is unrestricted circulation and that the stress is episodic rather than chronic. Unrestricted circulation generally insures that sediments are carried downstream at a rate at which corals and other benthic organisms can naturally protect themselves; and insures that turbidity levels are kept to a minimum, thereby allowing sunlight, which is required for continued growth of corals and marine plants, to penetrate the water column. These conditions are those that would be in effect during the excavation of the proposed Cove access channel at Mauna Lani.

Potential impacts to green turtles by the construction of the Cove facilities primarily relate to the proposed dredging of the access channel because of proximity to resident turtles. The results of the turtle survey indicate that the closest resting aggregation is at the "Turtles" site, about 2,200 feet south of the proposed access channel. Two general potential construction impacts to turtles could occur. First, dredging could cause turbidity which could impact the algal species on which the turtles feed. However, studies (Brock, 1988a) indicate that turtles may favor the more turbid waters. Construction at both West Beach (Ko Olina) and Hawaii Kai marina on Oahu appear not to have had any adverse impact on resident populations of green turtles (Appendix J). The second potential impact could occur during blasting, if required, of the channel. The positive and negative shock waves resulting from blasting could adversely impact both the turtles as well as fish in the area. Post-construction impacts to turtles could be caused by the operation of high speed boats in and around the turtle resting areas. Studies (Brock, 1988a) have noted that despite the heavy use of the Hawaii Kai Marina entrance channel, there has been no evidence of turtles avoiding the area or having been hit.

Impacts to threatened and/or endangered whale species in the project area are not expected to be caused by construction activities. Although humpback whales are frequently observed offshore during the winter months, the proposed project access channel area is not a particularly good feeding or resting area for the whales that venture inshore to the area that would be excavated. Based on the results of a special whale study performed specifically for the proposed project (Appendix K), impacts to the whales resulting from the proposed project could be caused by two major factors: (1) construction activities (dredging and blasting); and (2) increased boating activity in the area. Of these two factors, the latter is the most likely to cause impacts to the whales. There is sufficient evidence from Hawaii and elsewhere to demonstrate that boating and other human activities do have an impact on behavior of individual whales (Bauer, 1986 and Smultea, 1990).

Although studies designed to establish the nature of the relationship between various kinds of boating activities and humpback whale behavior are just beginning (Appendix K), current assumptions are that human activities might be stressful to the individual whales and stress could have a variety of adverse effects on growth, mating behavior and reproductive success. However, as noted in Smultea (1990), these factors have not been quantified. The indirect effect of the proposed project on whales is that of focusing boating activity in an area where whales are known to frequent and transit. However, the effect of increased boating activity that is not directly related to whale watching or other activities directly associated with the whales, is not clear. It has been postulated (Appendix K) that the kinds of boating activities generated from a launch ramp facility alone could be more disturbing to whales than a marina or small boat harbor. This is due to the fact that most small boats, i.e., those that would be launched from a ramp, would be noisier and faster than boats moored in a marina or harbor, especially if the majority of the marina boats were sailboats. It is expected that with respect to the number of craft and their frequency and patterns of use, the Mauna Lani Cove will have relatively low impact potential as compared to a comparable sized public harbor and/or launch facilities.

Another potential biological impact that could possibly occur due to the construction and physical changes that will be made, is an increase in the incidence of ciguatera poisoning. As indicated in Appendix F, while definitive cause and effect relationships between environmental alteration and toxic outbreaks have not been shown, increased incidence of *Gambierdiscus toxicus*, the epiphytic dinoflagellate thought to be responsible for the toxicity of ciguatera, have been associated with initial algal colonization of substrata bared by construction activities such as dredging.

On Oahu, construction of the West Beach (Ko Olina) project has involved a substantial amount of dredging of the nearshore environment with no apparent substantial increase in the toxic potential associated with the project. Similarly, although the State Department of Health has reported 102 incidence of ciguatera poisoning in Hawaii between 1980 and 1986, with 20 of those cases reported from Kona, no substantial increased incidence of the disease was associated with the construction of Honokohou Harbor. Recently, two of the dolphins kept at the Waikoloa Hyatt hotel contracted ciguatera poisoning. However, it did not appear that the cause of the poisoning was linked to any offshore construction project. A link between the type of fish consumed by the dolphins and the length of time those fish were in the hotel lagoons was shown to exist.

Given the extent of information available and the research that has been performed relative to ciguatera poisoning, there does not appear to be any reason to believe that Cove construction at Mauna Lani will cause increased incidence of ciguatera poisoning.

As a further precaution against ciguatera and in an effort to quantify existing conditions, researchers from the University of Hawaii (Appendix U) have sampled algae and fish found offshore of Mauna Lani Resort and from the resort fishponds. Based on the analyses performed, the amount of *Gambierdiscus toxicus* found per gram of alga was approximately 8 to 10. This level of *G. toxicus* is not very significant in terms of ciguatoxin. Generally levels of 100 per gram of alga are considered significant. However, as noted in Appendix U, populations of *G. toxicus* should be carefully monitored before, during and after the proposed project construction. In this regard, Mauna Lani Resort, Inc. has initiated a long-term ciguatera monitoring program that will serve as an advance warning mechanism as well as a model for assessing the potential ciguatera impacts resulting from coastal projects. The results of this monitoring program will be made available to the State Department of Health and County Planning Department on a quarterly basis.

3.3.2.8 Potential Chemical Impacts

Potential chemical impacts, due to decreased water quality during construction, could include decreased dissolved oxygen (DO) levels and lethal or damaging concentrations of nutrients. As indicated above, the unrestricted circulation patterns and wave actions exhibited off the proposed project site, insure that DO levels will be maintained at a high level. During construction, it is expected that DO levels will be saturated. As such, reduced DO levels do not appear to be a potential adverse impact that could be caused by the proposed project. Similarly, because Hawaiian sediments generally have low levels of organic matter (Sakoda, 1975), nutrients are not stored in the sediments. Although the water quality measurements taken for the proposed project (Appendix F) indicate relatively high levels of nutrients within the water column, especially inshore, except for the nutrients that are taken out of the water column by corals and other benthic organisms, the natural circulation and wave patterns tend to move these nutrients offshore and out into the open ocean where they are available to other organisms. As such, increased nutrient levels and/or decreased dissolved oxygen levels are not expected to result from construction of the proposed Cove.

3.3.2.9 Potential Cove Operations Impacts

The construction and everyday operation and use of small boat/pleasure craft marinas can result in positive and negative environmental impacts. As described above, positive impacts include the creation of new protected habitats, as well as increased recreational opportunities, increased visual attributes associated with small boat marinas and increased direct and indirect economic opportunities. These latter issues are discussed in other sections of this Supp EIS. Potential adverse impacts include increased human usage of marine waters and the incidental and accidental introduction of contaminants into marina and offshore waters.

The proposed Mauna Lani Cove is being designed to promote the mixing of Cove waters with open ocean waters. This is accomplished by sloping the bottom of the Cove from the inland areas to the deeper access channel and open ocean and the efflux of groundwaters along the mauka shoreline of The Cove. As a result of these actions, the limited amount of pollutants that may be introduced into the Cove waters are expected to move out of the Cove into the open ocean via water currents, circulation and tidal flushing, where they will undergo natural weathering and degradation. As such, the water column in the Cove is expected to contain pollutants well below toxic (to marine and brackish water biota) levels. It is also expected that the Cove flushing rates will be sufficient to prevent eutrophication. Flushing of the Cove will be accomplished primarily by three mechanisms: (1) tidal action; (2) groundwater flux; and (3) if required, mechanical pumping of water into the inland reaches of The Cove.

Based on the analyses conducted [Hydraulic Modeling and Flushing Reservoir Analysis (Appendices B, S and T)], it is possible that natural groundwater flux would not be sufficient to facilitate complete flushing of the inland water areas each tidal cycle. Therefore, the concept of constructing a "flushing reservoir" around the makai end of the relocated 11th golf hole has been investigated. As a result of this investigation, a flushing reservoir, including supply well system and valved discharge pipe extending into The Landing area, will be constructed. The reservoir would discharge 400,000 cubic feet of water with a maximum drawdown of about two feet. Approximately 4.6 acres and lined to be watertight, the reservoir would be fed by a minimum of three saltwater wells, each capable of delivering 700 gpm with vertical shaft type centrifugal pumps extending to a depth of approximately -10 feet MLLW. The discharge pipe would be 24-inches in diameter and designed to provide a 6.25 hour discharge period. The reservoir filling process would be automatic with pumps running as necessary to replenish evaporation losses. The flushing sequence would be operated manually as needed. The saltwater reservoir would provide a conservative measure to assist in flushing of the inland reaches of the Cove areas should the natural groundwater flux not be sufficient to maintain acceptable water quality within the Cove and The Landing areas.

Because of the likelihood of naturally occurring non-point source groundwater discharges into the Cove, thermal stratification of the Cove surface waters is expected. This will be similar to the present Honokohau Harbor and Mauna Lani offshore situation. Also, a modest depression in Cove surface water salinity is expected to occur. However, based on analyses at other marinas in Hawaii (Bienfang, 1979 and Appendix F), the anticipated salinity and temperature levels in the Cove are not expected to have a substantial influence on biological community development. Additionally, because of the relatively small size of The Cove, significant gradient stratification is not expected in the inland reaches of The Cove.

Dissolved oxygen levels in the Cove waters are likely to vary with Cove exchange rates. Incoming seawater can be expected to be saturated with respect to oxygen. Turbidity within The Cove, should it occur, will decrease light penetration through the water column and consequently reduce oxygen production by photosynthesis. However, vertical mixing from prevailing tradewinds will tend to keep low oxygen levels from developing. Lowest dissolved oxygen level conditions can be expected to occur in the early morning, just prior to sunrise, and during periods of calm winds which would reduce exchange rates and vertical mixing. Although increases in phytoplankton standing stocks are not expected to be significant, the likelihood for development of low and problematic dissolved oxygen problems could ensue in localized areas in the absence of significant flushing (Bienfang, 1979).

The nutrient load, associated with incoming groundwaters, is expected to support near maximum phytoplankton growth rates and higher than baseline standing stocks. However, because of expected ample flushing rates, such increases are unlikely to be noticeable. It is expected that a portion of any phytoplankton "bloom" would be harvested by the herbivorous zooplankton community developing in The Cove. The manner and magnitude with which grazing might attenuate phytoplankton biomass is highly variable and will depend on the acceptability of the Cove water to support zooplankton communities. At Honokohau Harbor, zooplankton stocks in the most inland basin were found to be nearly 30-fold greater (on a numerical basis) than those in the outside ocean waters (Bienfang, 1979). Because this population was almost entirely herbivorous, the grazing pressures exerted undoubtedly had a strong influence on reduction of the chlorophyll levels of that basin. Studies in the Barbers Point basin, on the island of Oahu, demonstrated different results, and indicated much lower standing stocks (on a dry weight basis) of herbivorous zooplankton within the harbor (Bienfang, 1979).

A number of pathways are available for contaminants and debris to be transported into Cove waters and sediments. Storm runoff, wash water, aerial fallout, boat maintenance activities, corrosion, incidental and accidental fuel and oil spills, the discharge of sewage from boats, boat operations and engine combustion and the purposeful or accidental dumping of debris. Once in the water, the fate of the contaminants is dependent upon numerous physical, chemical and biological factors that control dispersal and accumulation. Movement of water-borne contaminants is governed by water turbulence, circulation and currents. Dissolved pollutants can become associated with particulates that are transported with water currents and tides. The dispersion of these particulates and subsequent incorporation into sediments is a function of particle size and density. Once in the sediments, the particulates can be resuspended and dispersed with bottom currents, tides, storm waves and maintenance dredging. Similarly, dissolved pollutants can also degrade and weather naturally. Undissolved pollutants generally float on the water surface or sink to some level in the water column and would be dispersed throughout the water column within the Cove or are carried out to sea via water currents, tides, circulation and flushing of the Cove.

In general, there are six basic types of "pollutants" that can be introduced into Cove waters. These are:

- Hydrocarbon contaminants (fuels and lubricants);
- Antifouling paint contaminants;
- Vessel discharges (sewage);
- Floatable debris and biological contaminants resulting from hull cleaning activities;
- Nutrients and biocides (fertilizers, pesticides and herbicides); and

- Freshwater.

The potential effects of these "pollutants" on the water quality and biota of the Cove and offshore waters is discussed below.

Normal operations within marinas result in the incidental and accidental spilling of a limited amount of fuels and lubricating oils. The discharge of boat sewage is closely regulated by state and federal regulations and raw sewage cannot be discharged directly into the Cove waters. However, illegal discharges of boat sewage do occur. Floatable debris enter marina waters either incidentally, accidentally or purposefully. Because of the urbanization of the area in and around the proposed Mauna Lani Cove site, surface water runoff due to rainfall and/or irrigation of landscaped areas is expected to increase. It is likely that a portion of that runoff will enter The Cove. The mixing of surface runoff waters (and associated nutrients derived from landscaped areas and agricultural activities) with Cove waters may result in periodic stimulation of algal and phytoplankton growth and decreased dissolved oxygen levels. Similarly, surface runoff waters may carry pesticides and biocides that have been applied to landscaped or agricultural areas.

During heavy rainfall events, there will be low salinity (fresh) water, in addition to the low salinity groundwater, flowing into The Cove. These low salinity waters will mix with the ocean waters, causing localized, minor and short-term effects on the ocean waters.

Recreational vessels use leaded and unleaded gasoline and diesel fuels that can be a source of contamination to Cove waters. The combustion of these fuels creates contaminated particulates (soot) which are emitted into the air and ultimately into ocean and Cove waters and sediments. In addition, small oil and fuel spills, bilge pumping and fuel leakages contribute Polynuclear Aromatic Hydrocarbons (PAHs) to coastal waters. Generally, most fuel and oil spills are incidental to fueling activities, accidental and small (less than 2 gallons). PAHs are known to be toxic to marine life as documented in numerous field and laboratory studies of oil pollution (Neff and Anderson, 1981).

Toxicity threshold levels of PAH contamination on organisms might be between 5 and 15 micrograms/gram ($\mu g/g$) total organic carbon (TOC) and around 200 to 500 ($\mu g/g$) TOC (Anderson and Gossett, 1986). Unlike chlorinated hydrocarbons (PCBs and DDTs), PAHs do not accumulate to high levels in fish flesh and are not accumulated by food web transfer. The concern about PAHs stems from the effects on marine organisms at polluted sites. Some PAHs may produce mutagenicity and carcinogenicity in mammals (Anderson and Gossett, 1986), but the effects may not be as severe in lower trophic level benthic marine organisms (Young, *et al.*, 1980). In addition to toxicity, PAHs (oil and grease) may cause a short-term reduction of light penetration and thereby reduce photosynthesis and primary production in poorly flushed areas. In sediments, oil and grease may foul benthic organisms' feeding apparatus and add to chemical oxygen demand (COD).

Floating petroleum products and oil have not been conclusively shown to damage corals (Grant, 1970; Rutzler and Sterrer, 1970; Johannes, 1975), and reef communities can exist in areas subjected to chronic long-term oil pollution (Spooner, 1970; Shinn, 1972). Similarly, hydrocarbon contaminants, as generally released in marinas and harbors, do not appear to adversely affect algal, invertebrate or fish populations within marinas or harbors unless there is a massive spill. However, minor spills could cause short-term tainting of desirable (edible) species living within a marina. The Cove walls, docks and slips would provide a substrate for the development of a diverse benthic algal community. Both encrusting and macrothallic algae would likely be present. Algal mats would also provide grazing habitat for echinoderms (urchins), food for herbivorous fish and a nursery for juvenile fish. Surveys of Honokohau Harbor on the Big Island and Maalaea Harbor on Maui (Bienfang, 1979; Brewer, 1987; Maciolek, 1971) have shown the presence of numerous species of algae. Similarly, although fish populations generally do not contain high biomass levels as algae or invertebrates do, researchers (Bienfang, 1979; Brewer, 1987; and Buske and McCain, 1972) have noted several species of fish, including reef and pelagic species, within Honolulu, Maalaea, Barbers Point and Honokohau harbors. The presence of several species of algae, invertebrates and fish within actively operating large and small harbors in Hawaii tends to suggest that hydrocarbon contaminants do not limit the biota of the harbors and that, baring large scale spills, the biota and hydrocarbons coexist.

Most metallic ions occur naturally in seawater and sediments in low concentrations and many are essential for normal metabolic processes. However, wastes that are discharged into the marine environment from municipal and industrial treatment plants and vessel maintenance operations are known to increase the concentrations of these trace elements and result in contaminated nearshore environments, bays, marinas and estuaries. In the open ocean, most metals are in the dissolved form but in nearshore waters, bays and harbors, most metals are associated with particulates (Katz and Kaplan, 1981) that eventually sink to the bottom. These metals are adsorbed onto sediment particles or react with organics in the sediments. Eventually, the organics may degrade and the previously adsorbed metals are released back into the water in their dissolved states. Decay of organic compounds results in Eh and Ph changes of the water, making the metal compounds more soluble and more readily available to marine organisms (Guthrie, et al., 1979). Trace metals that are known to be toxic to some organisms include arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, tin and zinc. Although the concentrations of mercury and PCBs in antifouling paints is much less today than in the past, due to federal regulations, copper, chromium, arsenic, tri-butyl tin (TBT) and PCBs are still used as toxicants in antifouling paints (Stallard, et al., 1987). Chromium, lead and zinc are important components of boat bottom primers and cadmium occurs in certain paint pigments. Zinc is also utilized in the sacrificial anodes that are attached to boat bottoms to prevent corrosion of metal parts (Young and Alexander, 1977). Chromium is most toxic in its dissolved hexavalent form (Oshida, et al., 1976). Mercury and tin are toxic when bound to organic molecules (methylmercury and TBT).

In Southern California, sediments near boat works have been found to contain extremely high levels of trace elements (Wehner, et al., 1972; Wood, et al., 1972; SCCWRP, 1973; Young et al., 1974; Young and McDermott, 1975; Young and Alexander, 1977; and Wehner, 1978). These investigators concluded that antifouling paints, primers, pigments and sacrificial anodes from boat maintenance operations were the sources of arsenic, cadmium, chromium, copper, lead, mercury and zinc. Contaminant levels were directly related to the fine grain sizes and high organic carbon content in the sediments.

Because there will be a lack of industrial heavy metal input into The Cove, any observed concentrations would reflect natural conditions where leaching of soils has concentrated naturally occurring heavy metals in the sediments of the valley floors (Sunn, Low, Tom & Hara, 1974). Soils and sediments in Hawaii, especially those in the immediate offshore and nearshore areas, generally contain low levels of organic materials. This is due to the relatively young (geologically) age of the islands and the lack of time available for the formation of organic materials in the soils that might be washed into the nearshore environment. Given the relatively low level of organics in Hawaiian sediments and soils; the present and forecast future lack of urban development, especially in the proposed Mauna Lani Cove project area; the relatively small size of The Cove; and the provision that the Cove will not be used for industrial purposes, it appears that neither antifouling paints nor urban development will significantly contribute toxic substances to the Cove or offshore waters. As such, with regard to antifouling paints, operation and activities within the Cove are not expected to have a significant effect on the Cove or offshore waters or biota.

The elimination of wastes from vessel holding tanks into marina waters is prohibited by both federal and state laws and regulations. Vessels are required to empty their wastes at local pump-out stations. However, illegal discharges probably occur and can potentially constitute a health hazard. These discharges can contribute bacteria, especially coliform bacteria, and viruses to the marine environment; increase turbidity; and cause unpleasing and unaesthetic conditions. Vessel discharges can also increase nutrient loads that could eventually lead to plankton and/or bacterial blooms. In addition, marine sanitation devices may discharge disinfectants or other chemicals of greater potential harm to marine biota than untreated wastes.

Studies within the man-made portions of Hawaii Kai marina have not shown heavy degrees of fecal contamination associated with harbor operations and activities. Measurements have indicated that median fecal coliform levels range from 2 to 205 most probable number (mpn) per 100 milliliters (ml) versus 2.1 to 4.5 mpn/100 ml in the adjacent Maunalua Bay and ocean (Water Resources Research Center, 1973). Fecal coliform analyses conducted in 1974 demonstrated ranges from 1 mpn/100 ml to 2,000 mpn/100 ml. Estimated T values (the time required for 90 percent disappearance of coliform organisms) were calculated to be approximately 20 minutes, falling within the range of 10 to 35 minutes measured at Sandy Beach. This suggests that the bacteria would not live long in the Cove environment. However, during periods of high rainfall (rare at Mauna Lani), coliform concentrations can increase approximately 10 times over normal conditions, but return to normal within two days.

As presently planned, the proposed Cove will include shoreside restrooms and holding tank/pump-out facilities, thereby precluding the need to use shipboard facilities while in the Cove and/or discharge vessel wastes directly into The Cove. Chmura and Ross (1978) have shown that fuel docks are the most convenient locations for pump-out services.

Man-made debris, such as paper, plastic and wood, are either intentionally or accidentally discarded into marina environments. In addition, in some instances, drainage channels open into marinas and carry man-made debris into the marina, such as at Ala Wai Marina on Oahu. The fate of these materials, largely nuisance items, is dependent upon tidal flushing and the ability of these items to decompose and settle to the marina bottom sediments. Some non-floatable debris, such as glass and metal are aesthetically unpleasing and a potential hazard to the biota and man. Discarded plastics, if eaten or serving as entrapment mechanisms, are a hazard to marine animals (Wallace, 1985). In addition, hull cleaning operations may result in barnacles, tunicates, sponges and hydroids being released and becoming floating "organic debris" for a time or settle to the bottom and decompose within the marina sediments.

Although floating debris is a potential Cove contaminant, in general most boaters are cognizant of the need to properly collect and dispose of their rubbish and trash. In the case of Mauna Lani Cove, trash receptacles will be conveniently placed and emptied on a regular basis. There are no drainage channels or streams that will empty into and carry floatable debris into The Cove. Floatable debris is not expected to be a significant contaminant of Mauna Lani Cove.

Nutrients (fertilizers) and biocides (pesticides and herbicides) are generally carried into marina and marine waters via groundwater discharges, drainage channels directly discharging into the marine environment and non-point source rainwater runoff.

Several studies have been performed in Hawaii and elsewhere (see Brock, et al., 1987; Bienfang, 1977 and 1980; Chang and Young, 1977; Cox, et al., 1969; Marsh, 1977; Kay, et al., 1977; Maciolek and Brock, 1974; Smith, et al., 1981; Sunn, Low, Tom & Hara, 1974; Sakoda, 1975; and U.S. Army Engineer District, 1975) regarding the effects of increased nutrients and biocides on the marine and coastal environment. In general, although increased levels of these potential contaminants do occur, there have been no noticeable or significant adverse effects. For example, based on data developed for the Hawaii Kai marina, levels of total nitrogen and total phosphorus may be expected to increase after periods of heavy rainfall. Nutrients carried in the runoff experienced after heavy rainfall were found to influence conditions in Hawaii Kai and adjacent Maunalua Bay waters, but no adverse impacts were detected. Similarly, while pesticides were found in marina and adjacent offshore waters, natural degradation and dilution of the chemicals apparently rendered the pesticides (associated with the adjacent housing development and related use of termite treatment pesticides and preservatives) impotent to marine organisms (U.S. Army Engineer District, 1975).

Other studies (see Brock, et al., 1987 and PBR HAWAII, 1988) have shown similar non-impacts resulting from increased levels of nutrients and biocides entering the marine environment. In many cases, increased nutrients lead to increased algal growth, resulting in increased food stocks for herbivorous fish and invertebrates. At Punaluu in Ka'u, increased nutrient loads contribute to the growth and reproduction of *Pterocladia*, an algae species favored by green turtles. As such, the area is a favorite resting and feeding area for the turtles, who coexist in close proximity with commercial and recreational boating activities in the bay. Krasnick (in PBR HAWAII, 1987) demonstrated that most pesticides and herbicides degrade naturally relatively soon after application to golf courses and turfgrass areas. Also, Murdock and Green (in Group 70, 1988 and in W.E. Wanket, Inc., 1989) note that fertilizers and biocides only reach groundwaters if the infiltration rate is higher than the evapotranspiration rate. At Mauna Lani, where the average annual rain fall is about 9 inches, infiltration of fertilizers and biocides is expected to be much less than the evapotranspiration rate (approximately 90 inches/year). Similarly, fertilizers and biocides that may be carried by stormwater runoff would be further diluted and degraded to non-toxic and non-impact levels. As such, although increased nutrient levels in the Cove and offshore areas may be experienced, adverse impacts are not expected to result. Further, increased nutrient and biocide levels will not be a direct result of Cove operations, but would be a secondary effect of the proposed residential and commercial activities.

Freshwater, resulting from rainfall, although not a direct result of marina operations, can be a "contaminant" to marine life if it is in sufficient quantity to lower salinity to intolerable levels. Freshwater inflow is expected to increase due to increased paved and roofed surfaces in the immediate vicinity of The Cove. However, freshwater inflow is not expected to be sufficient to cause tolerable limits to be exceeded. Most marina dwelling organisms, especially those that are sessile, are euryhaline, i.e., able to live in both salt and brackish waters, and their tolerance to freshwater is generally higher than purely marine organisms. In addition, most purely marine organisms are motile and are able to move out of stressed areas during the period of stress, i.e., increased inflow of freshwater. As such, increased freshwater inflow during periods of heavy rainfall is not expected to adversely affect the marine life of the Cove or offshore areas.

Other potential Cove operation activities that may cause adverse impacts to the Cove water quality or biota include maintenance dredging, if needed, and the effects of vessel operations on water mixing.

If required, maintenance dredging of the Cove would be performed every 10 years or so to maintain safe navigational depths. Resuspension of sediments associated with this dredging could release organic material collected in the sediment. This in turn would release nutrients within the sediments and stimulate planktonic growth. However, based on the relatively small size of the Cove and the presumed high daily flushing rate of The Cove, it is unlikely that the resuspension of nutrients would stimulate phytoplankton growth. Typically, phytoplankton growth and density are related to the residence time of marina water (Sunn, Low, Tom & Hara, 1974). Similarly, it is expected that the nutrient and organic content of the Cove sediments would be low, suggesting that dissolved oxygen will not be depressed by resuspended organic matter.

Based on the water quality and exchange characteristics modeling that has been performed for the project (see Appendix S), it is expected that water residence times will be short enough (a maximum of approximately 20 days in the inner regions of the Cove) and water turnover will be sufficient for the Cove to meet or exceed applicable state water quality standards.

An additional concern relative to maintenance and/or the initial dredging of marinas in Hawaii is the potential to cause ciguatera poisoning in fish and man. It is generally believed (Dawson, 1958 and Randall, 1958), that a connection exists between algal growth on new surfaces and ciguatera. It has been postulated that disturbance of coral reef communities causes the release or growth of a dinoflagellate that carries the poison. The disturbance can be caused by dredging, anchor movement and a host of other factors. In Hawaii, ciguatera poisoning has been linked to harbor dredging activities at Pokai Bay on Oahu as well as to activities where there is no coral apparently disturbed. Control of ciguatera poisoning is generally by monitoring dredging activities and testing fish for the poison. Also, general public warnings are issued, cautioning people not to fish in the vicinity of dredging activities for a period of time.

State Department of Health data indicate that during the 1984 to 1988 time period a total of ten confirmed cases of ciguatera poisoning have occurred as a result of eating fish caught in the project area. Fish implicated or confirmed as having caused the ciguatera incidence include Kawelea, Kamasu, Barracuda and Pa'ou. There have also been incidence of ciguatera from fish purchased from markets. The cause(s) of these incidence is unknown. There were no known dredging and/or other offshore activities that would cause disturbances to the bottom or coral communities during the time period. It is presumed that these incidence were caused by natural factors which could include high wave-induced changes or disturbances. As noted previously, recent fish and algae sampling at Mauna Lani has indicated low levels of *Gambierdiscus toxicus*. However, the low levels measured are not considered significant (Appendix U).

Mixing of the water column resulting from vessel maneuvers and propeller action has been shown to be an important oceanographic parameter in Pearl Harbor (Evans, 1974). "Ship mixing" has been shown to reduce the bottom water residence times and raise large amounts of silt. Benthic sediments typically have a very large exchange capacity which can operate to remove heavy metals from the water column. Vessel stirring would, in effect, greatly increase the active exchange surface and hence the efficiency of the exchange process. This effect might be beneficial to marine inhabitants of the upper water layers. For smaller vessels, with propellers near the surface, churning of the surface waters with the resultant emulsification of surface oil films can increase the toxicity of oil to marine life. However, vessel movements, possibly interacting with surface oil and bottom materials may operate to reduce the biological availability of those metals to organisms dwelling in the upper portion of the water column (Evans, 1974).

Another factor associated with vessel operations is the potential impact on turtle resources in the vicinity of marinas. Among possible impacts are those associated with harassment of the turtles that are resting or foraging in the area. However, available information suggests that green turtles, which presently rest and feed in the vicinity of the proposed Mauna Lani Cove, as well as off the Hawaii Kai marina entrance channel, coexist with moored and moving boats (Brock, 1988b). At Mala Wharf, on Maui, a number of turtles rest offshore of the wharf around an old sunken vessel that now serves as a mooring for at least one commercial boat. These turtles forage around the wharf and moored vessels.

Based on the above, it would appear that although maintenance dredging and vessel operations have the potential to adversely affect the Cove waters and biota, adverse effects are not expected due to the relatively small size of the proposed Cove; the lack of expected inflow of fine sediments that would collect and hold nutrients or other chemicals; the fact that most vessels will be small, i.e., less than 30 feet, and will primarily churn the surface waters; and the biological benefits of vessel operations, i.e., propeller mixing of surface waters.

The potential impact of the discharge of Cove waters on the nearshore and offshore marine environment also has been investigated (Appendix T, Section 3.0). In general, the results of the analysis indicates that due to the relatively slow movement of water out of the Cove, due to tidal flushing and increased head at the inner reaches of the Cove, and the dispersion and dilution of that water with "open" ocean waters, the extent of areal impact would be limited to a very short distance (1.5 km or less than one mile) of the access channel.

Although it has been shown that the operation and activities that take place in marinas on the mainland U.S. can have adverse effects on the water quality and biota of those marinas, similar impacts have not been shown in Hawaii. This is generally due to the relatively small size of Hawaiian marinas compared to mainland marinas; the lack of urban development in and around Hawaiian marinas; different geological and soils/sediment characteristics of Hawaii versus the mainland; and generally good flushing and circulation within Hawaiian marinas. It is recognized that massive inflows of hydrocarbon, nutrient and biocide contaminants could adversely affect Hawaiian marina water quality and biota. However, such massive inflows have not been and are not expected, especially given the lack of sources of these contaminants. It is expected that the development and subsequent operation of the Mauna Lani Cove will have beneficial impacts on the natural and socioeconomic environments and that adverse impacts, if any, would be minimal, short-term and reversible.

3.3.2.10 Mitigation Measures

To assure that the proposed project does not adversely affect the coastal pond/marine environment, the following measures will be taken during construction and operation of the proposed Cove:

- All construction would be conducted in compliance with the Ocean Monitoring Program developed specifically for the proposed project (Appendix P).

- Offshore excavation work will be limited to the summer months to avoid potential impacts on humpback whales.

- Siltation curtains will be used to contain sediment plumes. Sediment collected at the bottom of the curtains will be removed prior to moving or relocating the curtains to minimize scouring on sessile organisms makai of the construction area.

- To minimize the chances of propagation of significant shockwaves during blasting (if required), charges will be set in drilled holes, thereby directing the shockwave vertically; charge sizes will reduced and individually detonated; and, just prior to detonation, a program of careful searching and removal of turtles from the area within several hundred yards of the detonation site will be conducted.

- The access channel through the beach will be opened only after all interior excavation work has been completed and revetment placed on those interior shoreline areas that might be subject to wind and wave erosion. As indicated above, excavation work, including opening the access channel will be performed in summer months to avoid potential impacts to humpback whales.

- An experienced harbor master and staff of dock workers will be employed to assist in the launching of boats, maintenance of the docks and facilities and assist in the enforcement of Cove rules and regulations (see Appendix Q), especially those related to environmental protection and safe boat operation. This may include the preparation and distribution to all slip owners/renters of a booklet explaining federal and state environmental protection rules, regulations and penalties for violating those regulations, especially those relating to endangered and threatened species. Slip sales/rental agreements will contain clauses allowing Mauna Lani Resort Inc. to heavily penalize, including expelling, anyone violating county, state or federal environmental protection regulations.

- The fuel dock will be equipped with oil containment booms rigged for rapid deployment and the Cove management and staff will undergo extensive emergency preparedness training.

- The Cove will be cleaned on a regular periodic basis of debris and rubbish that may collect in the Cove.

- The flushing reservoir will be constructed and activated as necessary to promote circulation.

- Coastal/anchialine ponds will be cleaned of leaf litter and other debris and vegetation will be cleared. The ponds will not be filled or altered in any manner.

- Special dye tablets will be placed in the toilets of all incoming and resident boats. Discharge of boat toilets into the Cove will be strictly prohibited and appropriate punitive actions taken against violators of Cove operations rules and regulations (Appendix Q).

- Sewage pump-out stations and restrooms will be provided.

- Trash receptacles on the docks and around shoreside facilities will be provided.

- The resort-wide civil defense/tsunami warning system will be extended to the Cove area.

4. HISTORICAL AND ARCHAEOLOGICAL RESOURCES

4.1 EXISTING CONDITIONS

The historical and archaeological resources of the Mauna Lani Resort area have been investigated for the Final Environmental Impact Statement for The Revised Master Plan for Mauna Lani Resort (Belt Collins & Associates, 1985 and The Final Environmental Impact Statement for The Ritz-Carlton, Mauna Lani Hotel (Belt Collins & Associates, 1987). As a result of these investigations and Mauna Lani Resort, Inc.'s desire to preserve and protect the cultural resources of the resort area, several interpretive displays have been established and it is Mauna Lani Resort, Inc.'s policy to preserve and protect those resources.

An archaeological inventory survey of the Mauna Lani Cove project area, including the adjacent relocated golf holes area has been conducted specifically for this Supp EIS (Appendix L).

The objectives of the survey, which covered approximately 133 acres, were to (a) identify all sites and site complexes present within the project area, including relocating and evaluating previously recorded sites; (b) evaluate the potential significance of all identified archaeological remains; (c) determine possible impacts of any proposed development upon the identified remains; and (d) define the general scope of any subsequent archaeological work that might be deemed necessary or appropriate.

Eighteen archaeological sites containing 46 component features were located within the 133-acre project area (Figure IV-14). Of the 18 sites, none could be unequivocally linked with previously recorded resources. Formal feature types present at the sites include caves, surface habitation features including C-shaped enclosures and short linear wall segments, cairns, petroglyphs, abrader basins, one modified bedrock outcrop and a historic rock fence. Functional types present include temporary habitation, markers, recreation, historic ranching operations and production activities related to the manufacture of abraders.

4.2 PROBABLE IMPACTS

Impacts to the features found within the project boundaries would essentially be a loss of the features due to excavation and/or construction of the planned facilities.

The significance of individual sites and features have been evaluated based on the definitions derived from the National Register of Historic Places criteria for evaluation (Table IV-5). The Hawaii State Historic Preservation Office also employs these criteria for evaluating cultural resources.

Of the 18 identified sites, all have been assessed as significant for information content. For 17 of these sites, no further work is considered necessary as the present inventory level recording is considered adequate mitigation of potential project effects. For the one remaining site, a cave, additional data collection in the form of subsurface excavation of a portion of a cave floor deposit is recommended prior to finalizing a determination of the site's full information potential. No unusual, one-of-a-kind, or otherwise unique or especially well-preserved features were encountered within the project area. As indicated above, further excavation was recommended for one of the features and that work has been performed. As a result of the subsurface excavation work, the informational content of the site has been obtained and no further work is required. No sites possessing potential cultural value were identified during the field work or in conjunction with the background historic documentary research.

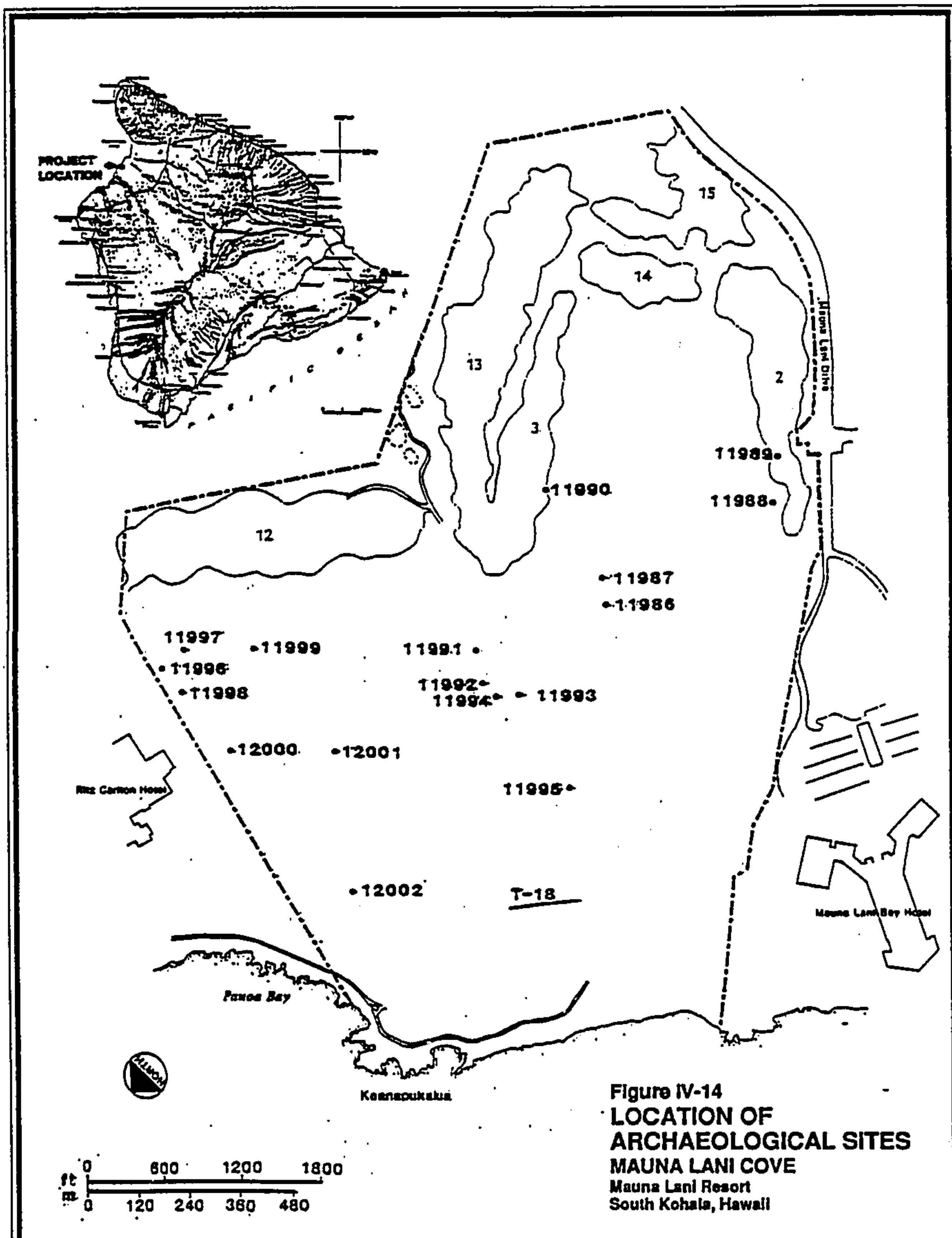


Figure IV-14
LOCATION OF ARCHAEOLOGICAL SITES
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source: Paul H. Rosendahl, Ph. D., Inc.
November 1989

TABLE IV-5

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

SITE OR FEATURE NO.	SIGNIFICANCE CATEGORY				RECOMMENDED TREATMENT			
	A	X	B	C	FDC	NFW	PID	PAI
11987 (T-3)	-	+	-	-	-	+	-	-
11988 (T-4)	-	+	-	-	-	+	-	-
11991 (T-7)	-	+	-	-	-	+	-	-
11992 (T-8)	-	+	-	-	-	+	-	-
11993 (T-9)	-	+	-	-	-	+	-	-
11994 (T-10)	-	+	-	-	-	+	-	-
11995 (T-11)	-	+	-	-	-	+	-	-
11996 (T-12)	-	+	-	-	-	+	-	-
11997 (T-13)	-	+	-	-	-	+	-	-
11998 (T-14)	-	+	-	-	-	+	-	-
12000 (T-16)	-	+	-	-	-	+	-	-
12402 (T-18)	-	+	-	-	-	+	-	-
Subtotal: 12	0	12	0	0	0	12	0	0
11986 (T-1)	+	-	-	-	+	-	-	-
11989 (T-5)	+	-	-	-	+	-	-	-
11990 (T-6)	+	-	-	-	+	-	-	-
11999 (T-15)	+	-	-	-	+	-	-	-
12001 (T-17)	+	-	-	-	+	-	-	-
12002 (T-19)	+	-	-	-	+	-	-	-
Subtotal: 6	6	0	0	0	6	0	0	0
TOTAL 18	6	12	0	0	6	12	0	0

Source: Appendix L

General Significance Categories:
A= Important for information content, further data collection necessary.
X= Important for information content, no further data collection necessary.
B= Excellent example of site type at local, region, island, state or national level.
C= Culturally significant.

Recommended General Treatments:
FDC= Further data collection necessary.
NFW= No further work of any kind necessary, sufficient data collected, archaeological clearance recommended.
PID= Preservation with some level of interpretive development recommended
PAI= Preservation "as is" with no further work or minimal further data collection necessary.

A separate archaeological inventory survey of the area to be used as the excavated soil disposal site will be conducted prior to the disposal of any soil materials. This survey will be coordinated with appropriate state and county agencies to assure that any archaeological or cultural resources that may be found are appropriately preserved. The area to be used as the soil disposal site was included in the original reconnaissance survey of the Mauna Lani Resort property. At this time, no known archaeological sites or cultural resources are located within the disposal area.

4.3 MITIGATION MEASURES

Because of the lack of significant impacts to the historical and archaeological resources of the project area, mitigation measures are not warranted. As indicated previously, one site received further treatment following the initial inventory survey, and that treatment served to mitigate the potential loss of the informational content of that site. Based on the consulting archaeologist's recommendations, as concurred with by the State Historic Preservation Officer, no further mitigation measures are required. However, Mauna Lani Resort, Inc. will continue to work with consulting archaeologists and the community in preserving the cultural resources of the project area and providing interpretive displays of those resources.

Also, should any site be uncovered during construction, work will stop and the appropriate State and County officials notified. Work will resume upon approval of the State Preservation Officer and the Hawaii County Planning Department.

5. SOCIOECONOMIC FACTORS

5.1 ECONOMIC FACTORS

5.1.1 Existing Conditions

The socioeconomic and fiscal impacts of the overall Mauna Lani Resort and The Ritz-Carlton, Mauna Lani Hotel are described in the previously referenced EIS's prepared for those projects. An economic and fiscal impact analysis specifically for the Cove project has been performed and is included in Appendix A. Much of the information provided below has been derived and summarized from that analysis.

The primary economic activities in the South Kohala are tourism, agriculture, ranching, high technology businesses and activities, shipping and construction. Of these, the role of tourism is increasing due to the resort development that began in the 1960's. Overall sugar production in the area has decreased since the North Kohala mill closed in 1975. Diversified agriculture, including coffee and macadamia nut production, has increased recently as has the production of vegetable crops. Ranching continues to play an important economic role in the area, led by the Parker Ranch headquartered in Waimea. High technology industries include the support facilities for the observatories on Mauna Kea, the Natural Energy Laboratory of Hawaii (NELH) and the Hawaii Ocean Science Technology (HOST) Park, both of which are located at Keahole Point.

Shipping, through Kawaihae Harbor, plays an important role in the economic picture of the area. In 1987, the latest year for which data are available, Kawaihae Harbor handled almost 870,000 short tons of cargo ((Data Book, 1989). The harbor receives and ships general cargo, bulk sugar, molasses, lava cinders, petroleum products and bulk fertilizers.

With the development of resorts and housing projects in the Mauna Lani Resort area, construction has become a major employer in the area. August 1990 estimates indicate that the island's unemployment rate was 3.5 percent (DILR, 1990). Unemployment on the island has shown a general steady decline over the past two years although for any given month unemployment may be greater or less than the same month the previous year. The state-wide unemployment rate for August 1990 was 2.5 percent, while the national rate was 5.4 percent.

The construction of the new Hyatt Regency Waikoloa resulted in significant employment as well as adding to the demand for new residential units. Similarly, the construction Ritz-Carlton, Mauna Lani Hotel is continuing construction employment in the immediate vicinity of the proposed project and other Mauna Lani Resort residential development will provide continued construction employment. It is also noted that as of September 30, 1990 there were over 1,500 persons employed at Mauna Lani Resort, including construction forces, with an estimated annual payroll of about $40 million. The estimated annual payroll of Mauna Lani Resort, including the Mauna Lani Bay Hotel, is about $30 million.

5.1.2 Probable Impacts

The proposed Cove project will have both direct short-term and direct and indirect long-term economic impacts. The peak number of employees required during the nine-month project construction period is expected to approach 230 workers. It is estimated that approximately 30 percent would be present Big Island residents while the remainder would be from Oahu. These employees would include administrative staff, equipment operators, carpenters, laborers, electricians and other construction trades. In the long-term, direct employment would include a harbor master/ Cove manager, secretarial staff, maintenance personnel and dock assistants. Excluding the retail and restaurant establishments, it is estimated that from 7 to 10 full-time personnel will be required.

In addition to the direct employment, employees will be generated by commercial boat operations, including boat service businesses such as mechanics, sail makers and maintenance personnel. It is estimated that the combined direct employment from commercial operations and large yachts should approach about 60 persons. Additional employment will be generated from operating requirements of the restaurants and shops serving The Cove. The restaurant operations are expected to generate about 15 jobs and shops at least another 4 to 6 employees.

Visitor expenditures directly related to the Cove are estimated to range from $150 to $200 per day and the average visitor population is expected to be about 200 persons in the year 2,000. This translates into an estimated $6.26 million visitor expenditures for retail goods in the year 2000.

The fiscal impacts of the proposed project have been examined within the specific local context of the proposed project. In essence, county expenditures are generally for general government operations, public services and facilities such as sanitation, public health/welfare/education/safety, road maintenance and repair, culture and recreation, retirement and pensions, debt service and other miscellaneous services. The general government expenditures for the project will be primarily paid for by the permit application fees and other processing charges. Public safety, fire, police civil defense, etc., costs to the county are expected to be minimal because the resort will provide police and security forces for the Cove and the present South Kohala fire station facilities and manpower are sufficient to handle the project. Other public protection costs (civil defense, liquor control and prosecuting attorney's office) are expected to be minimal and are estimated to be about $6,700 per year. Road maintenance and repair costs to the county should also be minimal in that all of the roadways associated with the project will be constructed and maintained by Mauna Lani Resort. It is recognized that local residents and visitors will have a minor cost impact emanating from their use of the region and local roadways located outside the resort.

Public costs associated with sanitation and waste removal will also be negligible because the resort sewage treatment plant will handle wastewater and solid wastes will be picked up and disposed of by the resort. There would be some public cost associated with solid waste disposal if a county sanitary landfill is used.

The primary public cost impacts that the proposed Cove project might generate with regard to health, welfare, education, culture and recreation are expected to be minimal. The project is not expected to generate significant numbers of children who would be enrolled in public schools and the resort and project provide recreational opportunities for both guests and residents of the resort. There may be some use of public recreation facilities outside the resort by resort guests and residents and, therefore, some minor public cost.

The proposed Mauna Lani Cove project is expected to have minimal financial impacts on the public sector. Projected in 1988 constant dollars, the incremental public costs associated with the project have been estimated to be less than $10 thousand on an annual basis.

Expected county revenues generated by the proposed Cove project have been estimated to be $2.68 million, at buildout, for property taxes; $10 thousand for business licenses and fees; and $4.3 thousand in highway fund revenues. These revenues should more than offset the projected increases in county expenditures required by the development of the proposed project.

The fiscal impact to the state, as a result of the project, is also expected to be positive. Little, if any state expenditures would be required to support the project and it is possible that development of the Cove and Landing would relieve some of the pressure on the state to expand Honokohau and Kawaihae Harbors. It is estimated that total state revenues directly attributable to the project, in the form of gross receipts tax revenues, would be about $173 thousand per year. In addition, the state would receive personal and corporate tax income from the project.

5.1.3 Mitigation Measures

Given that the proposed project is expected to result in significant positive economic impacts, mitigation measures are not warranted. Construction of the Cove project will provide short-term construction jobs and operation will provide long-term jobs and increased economic opportunities for the residents of West Hawaii. As such, mitigation measures are not warranted.

5.2 SOCIAL FACTORS

5.2.1 Existing Conditions

In 1980 nearly one-third of the Big Island's population resided in North and South Kohala and North and South Kona districts. The island population in 1980 was 92,053. The latest population estimates (Honolulu Star-Bulletin, September 7, 1989), indicate that the present Big Island population is 117,500 an increase of 27.6 percent over the 1980 population. Further, it is estimated that by the year 2005 the Big Island population will reach 180,500 persons, nearly doubling its 1980 population in 25 years.

The proposed project is located in census tract 217, which had a 1980 population of 4,607 persons which represented about 5 percent of the island population. If that percentage is still valid, the population of census tract 217 in 1988 would be estimated to be about 5,873 persons. However, the four above noted districts have grown at a faster pace than other parts of the island and it is estimated that the 1988 census tract population is greater than 5 percent of the island total. It is now estimated that the 1988 population of South Kohala is 7,562 persons.

Between 1970 and 1980 the ethnic composition on the Big Island changed as the percentage of Hawaiians increased from 12.3 percent to 18.8 percent. The percentage of Caucasians increased from 28.8 percent to 35.0 percent and the percentage of Japanese decreased from 37.5 percent to 26.6 percent. In addition, although island-wide the percentage of families living below the poverty level increased from 9.7 percent to 10.3 percent, the percentage decreased in North Kona and South Kohala. Also, the percentage of population with a college degree increased from 7.5 percent to 15.2 percent. The civilian labor force increased from 25.9 thousand to over 41.0 thousand persons and the total year around housing units increased from almost 19,000 units to almost 34,000 units.

5.2.2 Probable Impacts

The proposed Mauna Lani Cove project is generally expected to have positive social impacts. The average daily population of the Cove residential community is expected to range from 197 to 306 persons, exclusive of housekeeping assistance and depending ultimately on the number of units constructed. During the peak periods of occupancy between December and March, the population is expected to typically range between 284 and 441 persons. During this period many people in this population are expected to be visitors who are guests of the homeowners. Full-time residents are expected to range between 18 and 28 persons. The expected age level of the majority of the homeowners is between 45 and 64 years with persons under 45 expected to be about 10 percent of the population and those 65 and older making up about 20 percent of the population.

The annual median income for the majority of the homeowners is expected to range between $100,000 and $500,000. However, about 42 percent of the homeowners are expected to have median incomes above $500,000 per year.

The off-site population impacts of the project are expected to be minimal. Housekeeping and gardening maintenance workers would probably come from the existing island labor pool, as would The Cove, restaurant and other workers noted in the previous section. As such, the proposed project is not expected to add to the present demand for affordable or market housing on the island. Given that the majority of the homeowners would not be full-time residents, the project, as indicated previously, is not expected to appreciably add to the demand for public services and facilities. Also, being more affluent, the homeowners and guests are expected to add to the economy of the region.

5.2.3 Mitigation Measures

The proposed project is expected to result in significant positive social impacts through the provision of additional recreational amenities and income opportunities for the residents and visitors of West Hawaii. As such, mitigation measures are not warranted. It is expected that the Cove project will blend in with the existing and under construction Mauna Lani Resort facilities and amenities and serve as an additional positive social and economic contribution to the community.

6. INFRASTRUCTURE AND PUBLIC FACILITIES

6.1 TRANSPORTATION FACILITIES

6.1.1 Highways and Public Access

6.1.1.1 Existing Conditions

The highway network serving the Mauna Lani Resort area is described in detail in the Final EIS for the Revised Master Plan (Belt Collins & Associates, 1985). In brief, access to the resort from either the north or south is via Queen Kaahumanu Highway. Access within the resort is via an internal roadway system that is owned and maintained by Mauna Lani Resort, Inc. (Figure IV-15).

Vehicular traffic to the project would be via the main resort road from Queen Kaahumanu Highway. The major project road would branch off to the right of the existing road which continues to the Mauna Lani Bay hotel and traffic to the two residential islands will be by 125-foot vehicular bridges. Those residential lots closest to the Mauna Lani Bay Hotel would be served by a roadway which branches off from the hotel roadway near the hotel parking.

Traffic count data collected specifically for the proposed project (Appendix M), indicate that the morning peak hour occurs from 6:15 am to 7:15 am and that the afternoon peak hour occurs from 3:30 pm to 4:30 pm.

Traffic flows are described in terms of Levels of Service (LOS). Levels of Service are labelled A through F, reflecting best to worst conditions. For unsignalized intersections, LOS is an evaluation of gaps in major street traffic flow and a calculation of capacities available for left turns across oncoming traffic and for left and right turns onto a highway from a minor street. For

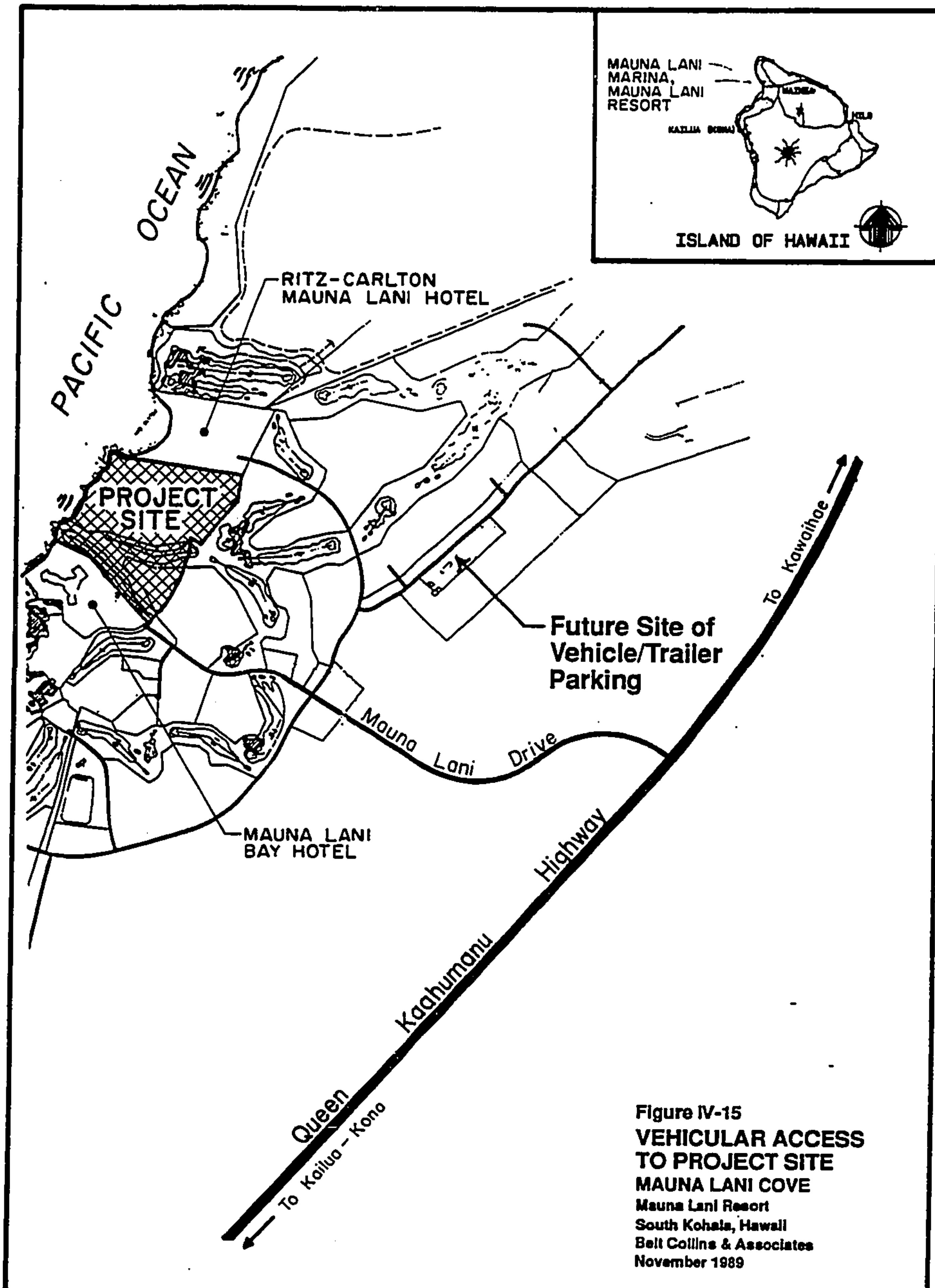


Figure IV-15
VEHICULAR ACCESS TO PROJECT SITE
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii
Belt Collins & Associates
November 1989

unsignalized intersections, LOS A is little or no delay; LOS B is short delays; LOS C is average traffic delays; LOS D is long delays; LOS E is very long delays; and LOS F is a condition where traffic volume demand exceeds the capacity of the roadway, resulting in extreme delays with queuing that may cause severe congestion and affect other traffic movements at an intersection. For signalized intersections, the LOS definitions are close to those for unsignalized intersections. LOS is measured in terms of delay, with delay being a measure of driver discomfort, frustration, fuel consumption and lost travel time. For signalized intersections, LOS A is less than 5.0 seconds delay per vehicle; LOS B is 5.1 to 15.0 seconds delay per vehicle; LOS C is 15.1 to 25.0 seconds delay per vehicle; LOS D is 25.1 to 40.0 seconds per vehicle; LOS E is 40.1 to 60.0 seconds delay per vehicle; and LOS F is delay in excess of 60 seconds per vehicle. With each increase in delay, for signalized intersections, there is also a corresponding effect on turning movements, passing capacity and ability and flow rates along the roadway. Complete descriptions of the LOS are included in Appendix M.

Relative to the proposed project, presently at the Queen Kaahumanu Highway/Mauna Lani Drive intersection, eastbound traffic on Mauna Lani Drive executing a left turn onto the highway experiences an LOS C during both peak hours. Eastbound traffic on Mauna Lani Drive executing a right turn onto the highway operates at LOS A during both peak hours. The northbound left turn movement on the highway presently operates at LOS A during both the am and pm peak hours. Existing two-way traffic volumes on Queen Kaahumanu Highway are greater to the north of Mauna Lani Drive. Analyses of these volumes yield LOS B conditions during the am peak hour and LOS C during the pm peak hour.

Lateral pedestrian shoreline access from the adjacent parcels would be maintained by way of a shoreline path and a pedestrian bridge. Although the type of bridge to be constructed has not yet been determined, pending further analysis, it is probable that it will be a drawbridge that allows both boat access and convenient pedestrian access. Based on preliminary planning and engineering, the bridge is expected to be about 150 feet long, about 5 feet wide and have a 50-foot movable span with 14-foot clearance from the bottom of the bridge to the water level. Public access all around the Cove will be provided via a landscaped promenade. Access along the beach and across the pedestrian bridge will only be interrupted when the bridge is open to allow vessels to enter or leave the Cove. An interpretive cottage by the bridge is planned.

6.1.1.2 Probable Impacts

Traffic impacts related to the overall Mauna Lani Resort development have been thoroughly analyzed and described in the Mauna Lani Resort Revised Master Plan and Ritz-Carlton, Mauna Lani Hotel EIS's. In addition, a traffic analysis specifically for the proposed Cove project has been performed and is included as Appendix M.

A review of traffic projections for 1998 [the expected year of project completion (total buildout of all residential units)] without the proposed project, indicates that traffic volumes on Queen Kaahumanu Highway would be expected to increase at a rate of 15 percent per year (see Final Environmental Impact Statement - Ritz-Carlton, Mauna Lani, Belt Collins & Associates, 1987). This growth rate includes traffic from other resort developments along the South Kohala coastline.

Traffic on Mauna Lani Drive would also be expected to increase due to completion of the Ritz-Carlton, Mauna Lani Hotel and residential/resort single family units in the area. The increase in traffic volumes at the highway/Mauna Lani Drive intersection would cause a reduction of capacity resulting in LOS E conditions for eastbound left turn movements from Mauna Lani Drive during the am peak hour and over-capacity or LOS F conditions during the pm peak hour. The eastbound right turn movements would continue to experience LOS A conditions during both peak hours. The northbound left turns on the highway would operate at LOS B during the am peak hour and at LOS A during the pm peak hour. Levels of Service for traffic on the highway would also be affected as LOS E conditions would prevail during am and pm peak hours.

Traffic volumes at the highway/Mauna Lani Drive intersection with the project can be expected to increase by 5 percent during the am peak hour and by 9 percent during the pm peak hour. Eastbound traffic at the intersection would experience over-capacity or LOS F condition during both the am and pm peak hours. The eastbound right turn movements would also remain unchanged at LOS A during both peak hours. The northbound left turn traffic would continue to experience LOS B conditions during the am peak hour and would change from its present LOS A and LOS A without the project to LOS B with the project. Traffic on the highway would continue to experience LOS E conditions during both peak hours, i.e., with or without the project. Table IV-6 compares LOS for existing and future conditions both with and without the project. If the originally planned hotel were constructed on the project site rather than the proposed Cove project, traffic conditions on both Mauna Lani Drive and Queen Kaahumanu Highway would range from LOS B at best (northbound left turn on the highway during pm peak hours) to LOS F or over-capacity conditions during the am and pm peak hours.

Based on the traffic analyses performed, it is evident that for the year 1998 without the project, the capacity of the eastbound left turn movements at the Queen Kaahumanu Highway/Mauna Lani Drive unsignalized intersection would be exceeded even without the addition of the Cove project traffic. Three alternative mitigation measures that could improve this situation have been examined (Appendix M): (1) Signalization of the intersection would allow traffic to operate at LOS C for both peak hours with or without the project; (2) A grade separated interchange would eliminate conflicting turn movements on the Highway; (3) a second unsignalized intersection could provide access to the Mauna Lani Resort area.

6.1.1.3 Mitigation Measures

The proposed Cove project, which is presently designed to add from about 90 to 140 residential lots/units and 185 boat slips, a portion of which would front houselots, is not expected to significantly add to the overall traffic levels or patterns on state and county roadways or in and around the resort area. As indicated in the EIS for the Revised Master Plan for Mauna Lani Resort, a hotel had been planned for the location of Mauna Lani Cove. The traffic projections for that EIS and the subsequent Ritz-Carlton, Mauna Lani Hotel EIS included the traffic that would be generated by a hotel rather than a marina and single family residences. As such, traffic generated by the Cove project is expected to be less than that which would be generated by a hotel. However, in keeping with appropriate advance planning techniques and procedures, the resort internal roadway system has been designed and planned to handle increased traffic levels beyond that which would be generated

TABLE IV-6

LEVELS OF SERVICE WITH AND WITHOUT PROJECT

UNSIGNALIZED INTERSECTION	EXISTING		FUTURE CONDITIONS (1998) W/O PROJECT		W/PROJECT	
	am	pm	am	pm	am	pm
Mauna Lani Drive						
Eastbound Left	C	C	E	F	F	F
Eastbound Right	A	A	A	A	A	A
Queen Kaahumanu Highway						
Northbound Left	A	A	A	A	B	B
<u>HIGHWAY</u>						
Queen Kaahumanu Highway	B	C	E	E	E	E

Source: Appendix M.

by the proposed project. Additionally, appropriate state and county agencies, through the above noted EIS's and discussions, have been alerted to the potential need for improvements along Queen Kaahumanu Highway. As planning and design for the proposed marina project continue, traffic analyses would be updated to reflect the expected traffic levels that would be generated by the proposed project, and that information would be included in the EIS for the proposed project.

Possible future mitigation measures could include the construction of a new Mauna Lani Resort entry, located south of the present Mauna Lani Drive/Queen Kaahumanu Highway intersection a sufficient distance to allow the continued safe and efficient flow of traffic. Another potential mitigation measure would be the construction of a grade separated crossing at the present Mauna Lani Drive/Queen Kaahumanu Highway intersection. Future actual traffic volumes would, in part determine the appropriate measure that could be put into effect.

6.1.2 <u>Air Transportation Facilities</u>

6.1.2.1 Existing Conditions

As indicated in both the Mauna Lani Resort Revised Master Plan and Ritz-Carlton, Mauna Lani Hotel EIS's, the majority of the visitors to the Mauna Lani Resort area would transit through

Keahole Airport. Keahole Airport served about 160,000 overseas and 1.66 million interisland passengers in 1988. Enplaned and deplaned air cargo passing through Keahole Airport in 1988 was approximately 15,000 tons (Data Book, 1989). As a result of existing as well as planned resort developments in West Hawaii, passenger levels, air cargo and aircraft operations at the airport are forecast to significantly increase in the future. Present planning for the airport by the State Department of Transportation includes expansion of the airport facilities, including extension of the runway, to accommodate forecast increases in passenger and air cargo levels and direct mainland U.S. flights by wide-bodied aircraft.

6.1.2.2 Probable Impacts

The proposed marina project, in and of itself, is not expected to significantly affect air passenger and/or cargo levels at Keahole or any of the other state airports on the island. However, as part of the overall Mauna Lani Resort development, it is likely that a portion of the visitors to and homeowners within the proposed marina project will transit through Keahole Airport. These visitors and owners are not expected to significantly affect Keahole Airport's service or facilities requirements.

6.1.2.3 Mitigation Measures

Because of the lack of significant impacts attributable to the proposed project, mitigation measures are not warranted. Mauna Lani resort, Inc. would continue to cooperate with the State Department of Transportation in the planning of the airports serving the resort.

6.1.3 Harbors

6.1.3.1 Existing Conditions

Kawaihae Harbor, north of the proposed project, is the only deep water harbor in West Hawaii and is used primarily by interisland barges. Cargo transiting through the harbor includes building materials, consumer goods, large equipment and machinery, as well as the provisions and supplies required to service the hotels and resorts in South Kohala and Kona. Shipping, through Kawaihae Harbor, plays an important role in the economic picture of the area. In 1987, the latest year for which data are available, Kawaihae Harbor handled almost 870,000 short tons of cargo ((Data Book, 1989).

Kawaihae Harbor also serves as a recreational harbor facility. At present there are approximately 55 small boat moorings at Kawaihae Harbor and soon to be implemented alterations will add another 10 moorings. The State and Corps of Engineers have proposed enlarging the small boat harbor to accommodate about 320 boats. However, because neither state nor federal funds have been authorized or appropriated for the expansion it is not known when construction on the new facilities will begin. There are 49 people presently on a waiting list for moorings at Kawaihae.

The Honokohau Small Boat Harbor, about 30 miles south of the Mauna Lani Resort area, presently is the only small boat harbor in West Hawaii. Honokohau serves commercial, charter and recreational fishing boats and privately owned recreational sail boats and has a small boat launch ramp. There currently are about 250 small boat moorings with about 230 people on a waiting list. There are no known firm State plans to enlarge Honokohau Harbor. However, reportedly the state has discussed possible expansion with various private and public agencies in conjunction with housing projects in the vicinity of Honokohau Harbor, e.g. the state's proposed Kealakehe affordable housing project. Additionally, a private firm has proposed leasing Honokohau, Kawaihae and Hilo small boat harbors, making improvements to those harbors and providing all necessary services within those harbors. This proposal is currently (October 1990) under review by various state and county agencies.

6.1.3.2 Probable Impacts

Based on analyses conducted for the Mauna Lani Resort Revised Master Plan and Ritz-Carlton, Mauna Lani Hotel EIS's, the commercial facilities at Kawaihae are adequate to accommodate the foreseen long-term water transportation needs of West Hawaii. A new 350-slip, small boat harbor at Kawaihae is currently in the planning and environmental analyses stages. The state and Corps of Engineers had planned that construction would begin in December 1990 and be completed in the latter part of 1992. The project would be a joint federal-state funded project and the new facility would be owned and operated by the state. This new facility would assist in satisfying the present demand for small boat mooring space in West Hawaii. However, neither state nor federal funds have been authorized or appropriated for the facility and there appear to be several unresolved environmental impact questions relative to the facility.

Honokohau Harbor does not appear adequate to serve the West Hawaii demand for small boat mooring space given the fact that there are approximately 230 people on a waiting list for the existing 250 moorings and there are no known firm State plans to expand the harbor.

Development of the proposed Cove would add a maximum of approximately 185 new small boat (less than 100 feet) slips to the West Hawaii inventory. As presently planned, at least 75 slips would be private mooring floats attached to Cove houselots and 110 slips would be available at The Landing. Of the latter, at least 10 would be for public transient boat use and 10 slips would be reserved for commercial fishing charter or similar operations. In addition, a launching ramp would be available to everyone. Because there is a lack of parking space around The Cove, Cove employees would assist boat owners with the launching operations and then park their vehicles and trailers at a secure, i.e., fenced and locked site away from the Cove (see Figure IV-15). Upon return to the Cove, the employees would retrieve the vehicle and trailer and assist the boat owner with retrieval of the boat. A fee for these services would be charged and that fee would be the same for all persons. Similarly, a boat-slip fee would be charged and it too would be consistent throughout the Cove and The Landing areas. Because the proposed project would provide a maximum of an additional 250 boat moorings in West Hawaii, the demand for increased mooring space in publicly controlled harbors could be reduced. However, the Cove project is not expected to satisfy the total demand for small boat mooring space in West Hawaii and it is expected that the proposed 350-slip state marina at Kawaihae will be filled as moorings become available.

Although there will be some slips set aside for commercial vessels at The Landing, commercial use of slips at the Cove will be restricted, whereas commercial use is not restricted at State small boat harbors.

6.1.3.3 Mitigation Measures

The proposed Cove project has been designed to provide additional boat slips and launching facilities in West Hawaii. As such, the impacts of the project will be positive and not require mitigation measures. As indicated previously, specific rules and regulations for operation and maintenance of the Cove will be established and administered an experienced harbor master.

6.2 CLIMATE, METEOROLOGY AND AIR QUALITY

6.2.1 Existing Conditions

The Cove area has a hot, arid, savanna-like climate. Close to the shoreline, sea-breezes serve as a moderating influence on temperature. Mean annual temperature in the area is about 78 degrees F., with relatively small daily or seasonal variations. Daytime temperatures above 90 degrees F. or nighttime lows below 63 degrees F. are extremely rare. Average summer temperatures are only 4 degrees higher than those in winter.

The Mauna Lani Resort area is one of the driest on the island and within the state. Average annual rainfall at the U.S. Weather Service's Puako rain gauge is about 9 inches. Most of this rainfall typically occurs during a few storms in the October to April winter season, with one or two unseasonable rains at other times. Intense storms along the Kohala coast are rare.

Airflow is most commonly offshore from mid-morning until just before sunset and onshore from early evening until the following morning. This diurnal pattern contrasts with the relatively constant northeast tradewind condition prevalent in most other areas of the state. The average wind velocity is also less, averaging 7 to 8 miles per hour (mph) for the land-sea breeze compared to 12 to 14 mph for the tradewinds. Gusty winds blowing through the saddle between Mauna Kea and Mauna Loa do reach the project area under certain atmospheric conditions. Relative humidity is generally low, commonly under 40 percent during the late morning and afternoon hours of warm, cloudless days. The humidity is also relatively constant year-round, showing a significant smaller summer-winter difference than is common elsewhere in the state.

The air quality of the project area has been analyzed in detail for both the Mauna Lani Resort Revised Master Plan and Ritz-Carlton, Mauna Lani Hotel EIS's. In addition, an analysis has been performed specifically for this Supp EIS and is included as Appendix N. In brief, the analysis conducted for this Supp EIS resulted in the following major findings and conclusions:

While there is no air monitoring station in the project area, it seems safe to assume that air quality is good most of the time in that there are no large stationary sources in the immediate vicinity, , and mobile source activity has not yet become a serious concern. The principal source of air pollution in West Hawaii is Kilauea Volcano. During eruptive periods and when the predominant northeasterly tradewinds are blowing, volcanic air pollution builds up, causing a continuous haze over the Kona area. Despite this, state and federal standards continue to be met. During the 1985 to 1986 period, the State Department of Health (DOH) conducted air monitoring at Kailua-Kona, approximately 30 miles south of the project area, and found sulfur dioxide (SO_2) and particulate matter levels well within federal and state standards. As part of the impact analysis for the Mauna Lani Cove project, carbon monoxide (CO) sampling was conducted during the am and pm peak traffic hours, as determined by the traffic analysis for the proposed project (Appendix M), at the Mauna Lani Drive/Queen Kaahumanu Highway intersection. The results of that monitoring indicated CO levels in the 1.0 to 4.0 milligrams/ cubic meter (mg/m^3) level, well below the state standard of 10.0 mg/m^3.

6.2.2 Probable Impacts

During the construction phase of the proposed project, there will be short-term air quality impacts associated with site preparation (fugitive dust) and movement of construction vehicles (exhaust gases and particulates). Heavy construction vehicle traffic on nearby roadways can also reduce roadway capacity. Fugitive dust can be mitigated by frequent watering of exposed soil areas and the soonest possible landscaping and roadway paving to minimize the length of time of soil exposure. EPA estimates that a 50 percent reduction in fugitive dust emissions can be achieved by twice daily water spraying. The impact on Queen Kaahumanu Highway can be reduced by minimizing construction vehicle movement during peak traffic hours.

Off-site short-term impacts associated with construction include the operation of asphalt concrete batch plants that provide material for road building and building foundations. Those plants will emit pollutants while they are producing product for the proposed project. Such plants must have DOH permits to operate and must have demonstrated their ability to meet federal and state air quality standards to receive those permits; thus the production of materials for Mauna Lani Cove can be considered as part of their normal operation and should be in compliance with air pollution control rules and regulations.

The primary long-term impact of the project on air quality will be associated with motor vehicle traffic generated by the project. An air quality impact analysis, based on the project traffic, has indicated that while there will be an increase in CO levels in the vicinity of the Mauna Lani Drive/Queen Kaahumanu Highway intersection, those levels will be largely in compliance with the most stringent state standards. Only in close proximity (within 10 meters) of the intersection did there appear to be a possibility of exceeding the state's one-hour CO standard during the peak pm traffic hour. Construction of a second access road to the project would alleviate predicted queuing at the Mauna Lani Drive intersection and likely eliminate the predicted CO standard exceedence.

Operation of boats at the Cove will also generate air pollution in the area. The scrubbing effect on emissions entering the water, the relatively infrequent occurrence and the relatively small size of most boat engines suggests that the impact will not be great. An emissions analysis based on EPA data and state fuel use by boats indicated relatively small quantities of emissions (less than 0.5 percent of the 1980 county emissions inventory).

Electrical generation required to support the project will also result in off-site emissions from the power plant (Hawaii Electric Light Company's Keahole Power Plant). Estimates of annual emissions resulting from the approximately 1.1 million kilowatt hours needed by the project amounted to less than 0.5 percent of total county emissions. Recent expansion of the Keahole plant required DOH permits and demonstration that state and federal air quality standards would be met.

6.2.3 Mitigation Measures

All construction activities will be required to meet applicable state and federal air quality standards. To reduce fugitive dust emissions, all excavated areas will be water sprayed at least twice daily, excavated areas on which roads and/or buildings will be constructed will be landscaped or paved as soon as possible. It is expected that much of the interior portions of the Cove will be under water soon after excavation due to the intrusion of ground and sea water. As such, fugitive dust emissions from those areas would be minimal and only require water spraying during the initial excavation period. To reduce power plant emissions, the use of solar water heating and cooling, heat pumps, waste heat recovery and other energy efficient devices will be investigated and utilized where possible.

6.3 NOISE QUALITY

6.3.1 Existing Conditions

A complete noise impact assessment of the Mauna Lani Resort Revised Master Plan was prepared in 1985 and re-evaluated relative to the Ritz-Carlton, Mauna Lani Hotel in 1987. A noise impact assessment specifically for the proposed project has also been conducted and is included as Appendix O. Existing and potential project related noise has been evaluated based on actual field measurements and in terms of Day-Night Average Sound Level (L_{dn}). This noise descriptor incorporates a 24-hour average of instantaneous A-Weighted Sound Levels as read on a standard sound level meter. Sound levels that occur in the nighttime hours (10:00 pm to 7:00 am) are increased by 10 decibels (Db) prior to computing the 24-hour average by the L_{dn} descriptor. In urbanized areas that are shielded from high volume streets, L_{dn} levels generally range from 55 to 65 Ldn and are usually controlled by motor vehicle activity. In the Mauna Lani Cove area, noise associated with Queen Kaahumanu Highway is typically less than 55 L_{dn} due to the large separation distances and due to noise shielding effects of intervening terrain features.

For the purposes of determining noise acceptability for funding assistance from federal agencies (FHA/HUD and VA), an exterior noise level of 65 L_{dn} or lower is considered acceptable. This standard is applied nationally. Because of Hawaii's open living conditions, the predominant use of naturally ventilated dwellings and the relatively low exterior-to-interior sound attenuation provided by these naturally ventilated structures, an exterior noise level of 65 L_{dn} does not eliminate all risks of noise impacts. A lower level of 55 L_{dn} is considered to be the "Unconditionally Acceptable" (or "Near-Zero Risk") level of exterior noise. For the purposes of the noise analysis conducted specifically for the proposed project, the level of 55 L_{dn} was used to define the noise impact zones in the project environs.

In general, the present noise quality of the proposed project site is dominated by natural sounds such as the wind moving through the vegetation on-site and surf action on the shoreline. Vehicular generated noise in and around the Mauna Lani Bay Hotel, construction activities at the Ritz-Carlton, Mauna Lani Hotel and natural sounds including surf and wind moving through the vegetation on-site are less than 50 L_{dn}. Present construction activity generated noise is short-term and would cease following construction. Increased vehicular activity at the new hotel is expected to be experienced at the proposed project site and is expected to be less than currently experienced construction activity noise. Based on the measurements taken and calculations of L_{dn} for existing conditions (Appendix O), the 55 L_{dn} contour (stated in terms of distance from the centerline of the roadway) is presently about 220 feet from the centerline of Queen Kaahumanu Highway for traffic moving north and 200 feet for traffic moving south (as measured at the Mauna Lani Drive intersection); 64 feet for the easterly side of Mauna Lani Drive; and 45 feet for the westerly side of Mauna Lani Drive. These distances assume an unobstructed line-of-sight condition for the peak hour traffic as determined from the traffic analysis (Appendix M). (See Figure IV-16 for the location of noise measurement sites.)

6.3.2 Probable Impacts

During construction of the proposed project, construction activity is expected to be the primary noise generator in and around the project site. This would be a short-term impact that would cease upon completion of the proposed project. Following completion, major noise generators at the project site are expected to be vehicular traffic and boat motors. Both sources are expected to be less than construction activity generated noise and both would be for short periods of time during any given daytime period. Little, if any, boat motor noise would be generated during nighttime hours and vehicular activity would generally be limited during nighttime hours. It is expected that all noise levels would be well within state standards.

Traffic generated noise levels (55 L_{dn}) at the Cove's east entrance road are predicted to be less than 30 feet from the centerline of the roadway and less than 15 feet for the west entrance road. It is estimated (Appendix O) that the contribution of project traffic noise to the total noise levels along Queen Kaahumanu Highway would be less than 0.5 L_{dn}, which is considered insignificant. Along Mauna Lani Drive, project related traffic would contribute approximately 1.3 L_{dn} to total future noise levels, which is a moderate increase. With the proposed project, future traffic noise levels along Queen Kaahumanu Highway and Mauna Lani Drive can be expected to be less than they would be with the originally planned hotel on the project site. Based on the analyses conducted, traffic noise levels along the circulation roadways for the Cove are expected to be very low and in the "Minimal Exposure, Unconditionally Acceptable" noise exposure category.

Boating noise has also been assessed, based on a maximum of 175 boats berthed in the Cove. Noise levels from powered boats are expected to range from 55 to 72 Db, and be audible at residences along the Cove's waterways. The worst case noise levels can be expected to occur at the access channel. At this location on a hypothetical day when all 175 boats leave and return to the Cove, boat noise levels could be expected to range from 50 to 55 L_{dn} at approximately 100 feet from the centerline of the access channel. At more inland locations, the noise level would be about 3 L_{dn}

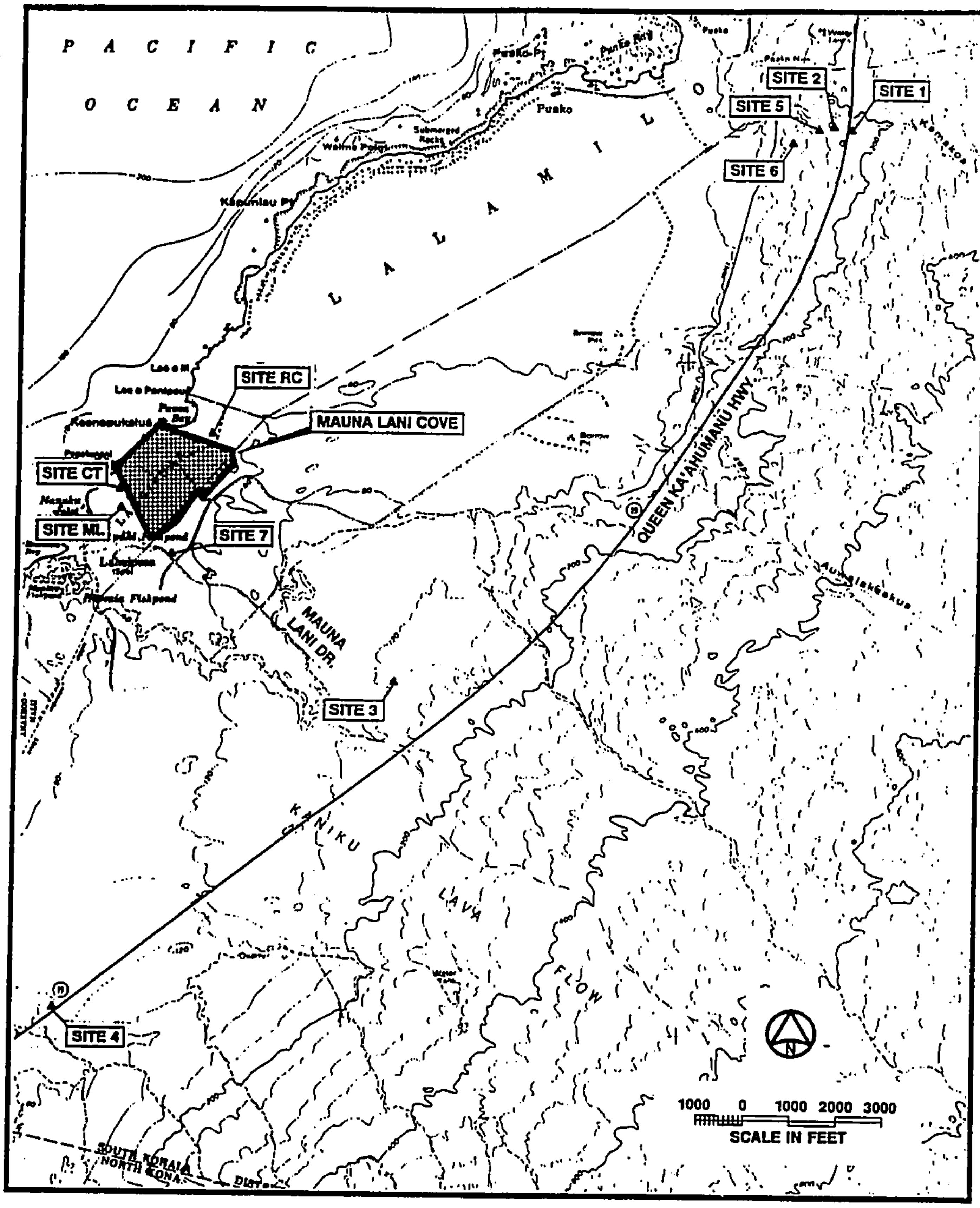


Figure IV-16
LOCATION OF NOISE MEASUREMENT SITES
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source: Yoichi Ebisu
November 1989

less for every 50 percent reduction in the total number of passby events of motor boats. Based on the analyses conducted, boating noise is not expected to generate adverse effects within the Cove.

6.3.3 Mitigation Measures

To mitigate potential traffic and/or boat noise impacts, landscape buffers would be planted along roadways, appropriate building setbacks maintained and nighttime boating activities regulated. To mitigate short-term construction generated noise impacts, especially those that would be related to blasting operations, construction activities would be limited to daytime hours; hotel guests and nearby residents would be notified in advance of any blasting operations; blasting would be limited to warm periods of the day to minimize the possibility of thermal ducting and focusing of air blast noise at large distances from the blast; and the construction contractor would be required to comply with all state and county noise regulations.

6.4 WATER SUPPLY

6.4.1 Existing Conditions

A preliminary analysis of municipal water supply and demand in the South Kohala district was completed by the U.S. Army Corps of Engineers in 1984. Within the South Kohala district, water demand could increase from 2.5-million gallons per day (mgd) to 20 mgd by 2010. The principle cause of increased demand is resort development along the coast. The present supply of 4.5 mgd would be increased to 17 mgd by private development of groundwater. The development of groundwater is regulated by the State of Hawaii, Department of Land and Natural Resources, Water Resources Development Commission. Approval from the State Department of Health must also be obtained.

The principal current source of water for the coastal region of the South Kohala district is the Lalamilo water system operated by the County of Hawaii. The Lalamilo water system serves Mauna Lani Resort, within which the proposed Cove project would be located.

In January 1979, an agreement was signed by the County of Hawaii, Mauna Loa Land, Inc. (the predecessor of Mauna Lani Resort, Inc.) and Olohana Corporation (the predecessor of Mauna Kea Properties, Inc.) to develop a water system utilizing groundwater from the State-owned tract of land known as Lalamilo.

Mauna Lani Resort, Inc.'s reserved maximum day water allocation for the system is currently 0.45 mgd from Well A and 0.50 mgd from Wells B and C. Well D has been drilled and will be outfitted with a pump in late 1990. The results of pump testing for Well D have been submitted to the County of Hawaii. When the well becomes functional, it will yield 1.44 mgd, with 1.30 mgd allocated to Mauna Lani Resort, Inc.

To accommodate projected increasing demand for potable water, four well sites were obtained from Parker Ranch on land now owned by Mauna Lani Resort. Should exploration be successful, these wells will serve the water needs of further development at Mauna Lani Resort.

The estimated demand for potable water required by the proposed Cove Project is 0.26 mgd, which is within the present supply capabilities of existing wells. Should future demand warrant, Mauna Lani Resort, Inc. would develop the required sources and transmission system.

6.4.2 Probable Impacts

Mauna Lani Resort currently uses approximately 0.80 mgd of potable water, and thus has in reserve 1.45 mgd from Wells A, B, C and D. The 0.26 mgd demand for potable water by the proposed Cove project is not expected to significantly affect existing and/or planned water supplies. Public funds would not be expended to provide potable water for the proposed project or to develop additional supplies should they become necessary in the future. In addition to potable water, Mauna Lani Resort also uses non-potable water for golf course irrigation purposes. Non-potable water use is about 3.0 mgd. Potable and non-potable water use by categories is shown below in Table IV-7.

TABLE IV-7

MAUNA LANI RESORT WATER USE BY CATEGORIES

USE CATEGORY	WATER SOURCE/QUANTITY USED (MGD)	
	POTABLE	NON-POTABLE
Mauna Lani Bay Hotel and Bungalows	0.80	
Ritz-Carlton, Mauna Lani Hotel	1.10 (Estimated)	
North and South Golf Courses		2.5 (Max.)*
Dust Control and Misc. Use		.5

*Note: Golf course usage at present (September 1990) is high due to need to establish new planting of North Golf Course.

The non-potable water is drawn from coastal wells and the water has average chloride levels of between about 800 and 900 mg/l as shown previously in Table IV-1. Puako Shaft water has a an average chloride level of between about 900 and 1,000 mg/l, depending on the quantity of water pumped on any given day.

6.4.3 Mitigation Measures

Given the lack of significant impacts to or on the existing and/or planned potable water supplies, mitigation measures are not warranted.

6.5 WASTEWATER TREATMENT AND DISPOSAL

6.5.1 Existing Conditions

There are no public sewage treatment facilities in the South Kohala coastal region. The Mauna Lani Resort, as the other Kohala coast resorts, are served by a privately-operated wastewater treatment plants and underground collection systems. The wastewater treatment plant and collection system was constructed by and is operated by Mauna Lani Resort, Inc. Users connected to the system are assessed to help pay operating and maintenance costs. Treated effluent from the plant is currently used for tree nursery irrigation only.

The existing wastewater treatment plant has the capacity to treat 0.76 mgd and can be expanded to handle 2.10 mgd. Cumulative flow, including that which is expected to be added by the Ritz-Carlton, Mauna Lani Hotel, is estimated at 0.29 mgd, a fraction of the design capacity of the plant. Based on 100 percent occupancy of homes in the proposed Cove project, an additional 0.03 mgd would be generated. A wastewater pump station will be provided at the Landing for use by both resident and transient boats. It is estimated that the quantity of wastewater generated by the boats and the marina facilities, including the Landing, would be 0.02 mgd. The resort treatment facility would have sufficient capacity to process wastewater generated by the proposed project.

6.5.2 Probable Impacts

Given that the proposed project is expected to generate approximately 0.03 mgd of wastewater and that the present capacity of the resort treatment plant is 0.76 mgd, the plant has sufficient capacity to serve the estimated demand.

6.5.3 Mitigation Measures

Given the lack of expected adverse impacts, mitigation measures are not warranted.

6.6 SOLID WASTE COLLECTION AND DISPOSAL

6.6.1 Existing Conditions

The existing Kailua landfill, located at Kealakehe, near Kailua-Kona, will serve the North Kona and South Kohala coastal area until it reaches capacity which is projected in 1992. The County Sewers and Sanitation Bureau, in association with the state, is in the process of evaluating new solid waste disposal sites in West Hawaii. The new site is expected to be operational in 1992 and would accommodate solid waste generated by planned resort development in South Kohala.

6.6.2 Probable Impacts

Solid waste generated by the proposed project is expected to be accommodated at the existing landfill site mentioned above or at other County operated landfills as new sites are designated.

6.6.3 Mitigation Measures

The lack of expected impacts resulting from solid waste collection and disposal indicates mitigation measures are not warranted.

6.7 ELECTRICAL POWER AND COMMUNICATIONS

6.7.1 Existing Conditions

Electricity for the Mauna Lani Resort is currently provided from Hawaii Electric Light Company facilities (HELCo.). HELCo's available generation capacity is approximately 150 MW, with a present peak demand of 132 MW. The Resort Electrical System consists of a network of underground ducts and handholes.

Telephone service for the resort is provided by Hawaiian Telephone Company (HTCo.). Telephone signals are transmitted to the Resort by microwave and are distributed from an office located at the resort service support area via an underground duct system. CATV service for the resort area is provided similarly.

6.7.2 Probable Impacts

Electric and communication facilities must be extended to the project site. However, extension of those facilities will be planned to coincide with the project development and the electrical distribution system will be constructed and maintained according to approved utility standards. The on-site electrical system will be an underground facility with the exception of service transformers and switching equipment. A network of underground ducts and handholes will be provided to facilitate cable installations by the utility companies.

Furthermore, because the utility companies must maintain their lines and structures for the purposes they were installed and for their best use, the lines will have minimal negative impact on the surrounding communities.

6.7.3 Mitigation Measures

Because of the lack of expected impacts to the electrical power, telephone and/or CATV systems presently serving the resort, mitigation measures are not warranted.

6.8 POLICE AND FIRE PROTECTION SYSTEMS

6.8.1 Existing Conditions

Police services for South Kohala are located in Waimea. Other police facilities in the project area are located at the Kapaau station, which serves the North Kohala area, and the Kona station in North Kona. Both the Waimea and Kapaau stations are relatively new and both have room for expansion should it be required in the future.

In addition to the county police department, the resort employs a security force that patrols the resort and generally provides security for its streets and facilities.

Fire protection services for the South Kohala area are located in Waimea and at the newly constructed station on Queen Kaahumanu Highway about one-mile north of Mauna Lani Resort. The stations provide 24-hour service and is supplemented by volunteers from Puako and Waikoloa Village and a fire equipment operator in Kawaihae. Emergency medical service is also stationed at the Kohala Coast fire station. The county building code requires that all resort facilities be equipped with automatic fire sprinkler systems.

6.8.2 Probable Impacts

The proposed project may result in the increased potential for criminal activity associated with growth, as well as an increase in requests for police services. However, previous Mauna Lani Resort projects have not resulted in significant increases in criminal activity within the resort property. Consequently, the proposed project is not expected to cause an increase in county police manpower requirements. As indicated above, the resort employs its own security service, which will be increased as required to serve the Cove and related facilities. As the resident population increases in the project area, the need for additional county police personnel will require evaluation in the context of a county police department needs assessment.

The development of the Cove and related facilities could lead to increased demand for fire protection service and facilities. However, given the close location of the existing fire station and the fact that all new facilities, public and private, would be constructed in accordance with the county fire code, it is expected that any increased demand can be accommodated by existing fire protection services and facilities. As noted previously, the Cove fuel dock would be equipped with appropriate fire fighting and emergency response equipment and trained personnel.

6.8.3 Mitigation Measures

The lack of expected adverse impacts on the present county and private police and fire protection services indicates that mitigation measures are not warranted. As noted, the resort security force will be increased as required to accommodate the proposed Cove and associated facilities.

6.9 HEALTH CARE FACILITIES

6.9.1 Existing Conditions

The Island of Hawaii has five hospitals that provide a range of medical services. The Kohala area is served by two state-operated hospitals, the Kohala Hospital located in Kapaau in North Kohala and the Honokaa Hospital. Kona Hospital is a "full-service" health care facility and, in Waimea, the Lucy Henriques Medical Center provides outpatient health services. All of the health care facilities serving the project area require upgrading and are being handled as such by the State Department of Health and private operators.

6.9.2 Probable Impacts

As indicated above, existing conditions indicate that the health care facilities in the West Hawaii region require upgrading with or without the proposed project. Residents and visitors to the Cove will be able to seek emergency care at the Lucy Henriques Medical Center in Waimea or Kona Hospital. Also, as noted previously, the fire station is equipped with emergency medical service. Private developers have been contributing to the improvement of health care facilities in the project area.

6.9.3 Mitigation Measures

Although the proposed project is not expected to result in significant new demands on health care facilities, existing services are in need of upgrading and the state and private parties are assisting with those upgrades. These measures are expected to result in adequate health care facilities to serve the growing resident and visitor population of West Hawaii.

6.10 SCHOOLS AND EDUCATION FACILITIES

6.10.1 Existing Conditions

The project area is served by public elementary schools located in North and South Kohala, North and South Kona and those located in Hilo. Public high schools are also located in the same areas. Private lower and upper schools serving the project area include the Hawaii Preparatory Academy and Parker School.

6.10.2 Probable Impacts

The proposed project is not expected to have a direct impact on the schools serving the area. The majority of the homes are expected to serve as "second" homes for the owners and "live-aboards" will not be allowed within The Landing complex. As indicated in Section 5.1, the proposed project is expected to generate about 90 new jobs. Presumably these new employees to serve the facilities would be existing residents of the island whose children are in the existing school system. However, the new facilities may induce some in-migration that could add to the demand for public school services.

6.10.3 Mitigation Measures

Given the expected lack of impacts, mitigation measures are not warranted. Mauna Lani Resort, Inc. would continue to work with the State Department of Education to assure that adequate public school services are provided to the employees of the resort.

6.11 RECREATIONAL FACILITIES

6.11.1 Existing Conditions

Kohala and North Kona recreational facilities include golf courses, tennis courts, beaches, riding stables, historic sites, small boat harbors at Honokohau and Kawaihae and other amenities and attractions. The county's Samuel Spencer Beach Park and Hapuna Beach State Recreation Area are the principal developed public facilities in the immediate project area. Mauna Lani Resort's Makaiwa Bay beach and swimming area and the swimming lagoon to be constructed as part of the Ritz-Carlton, Mauna Lani Hotel, as well as the Francis I'i Brown Golf Course and the new golf course that is being added to Mauna Lani Resort, are other recreation amenities in the immediate vicinity of the project. Under construction is an additional public beach park (Holoholokai Beach Park) with parking, restrooms, picnic facilities, and an improved Puako Petroglyph Park, including an outdoor classroom and trail system. As noted previously in this Supp EIS, both Honokohau and Kawaihae small boat harbors are crowded and there are waiting lists for slips at both. In addition, public access to the shoreline, historic areas and fishponds is provided by Mauna Lani Resort. Access along the shoreline will be continued following completion of the proposed project. The coastline fronting Mauna Lani Resort is also a relatively popular shore fishing and surfing site. Based on an informal, daily, visual survey of coastal uses of the resort shoreline that has been in progress since February 1990, a total of approximately 30 shorefishermen and 78 surfers utilized the resort shoreline area during the February through September 1990 period. The most popular surf site is an area the local surfers call "Peaks". This site fronts the 11th golf hole and the Mauna Lani Bay Hotel, approximately 1,200 feet south of the proposed access channel to the Cove. Another site, locally called "Suicides", located about 1,000 feet north of the proposed access channel. Area-wide recreational sites are shown on Figure IV-17. As shown, there are numerous surf sites along the Kohala coast, with the daily existence of most being highly dependent upon height and direction of swell, wind speed and direction and time of year.

6.11.2 Probable Impacts

The proposed project has been designed to assist the State in providing small boat mooring space in West Hawaii as well as small boat launching facilities. Additionally, the public promenade around the Cove will provide the public with access around and to the new facilities. As noted, public access along the shoreline will be retained and improved as will the anchialine ponds and historic features within the project area. These actions will add to the recreational amenities of West Hawaii, serving both the general public and visitors to the area.

The proposed project is not expected to affect either of the two closest surfing sites, "Peaks" or "Suicides", because of the location and depth of the access channel. In general, the surf sites are created by waves breaking on the inshore reef face. It is expected that a "surf zone", about 50 feet wide along both sides of the access channel would be created as waves travel inshore along and through the access channel (Figure IV-18). This zone was observed during the hydraulic modeling studies (Appendix B). However, outside this zone, there would be little, if any, affect on wave energy and/or characteristics.

6.11.3 Mitigation Measures

The proposed project will improve the recreational facilities and amenities of the area. As such, mitigation measures are not warranted.

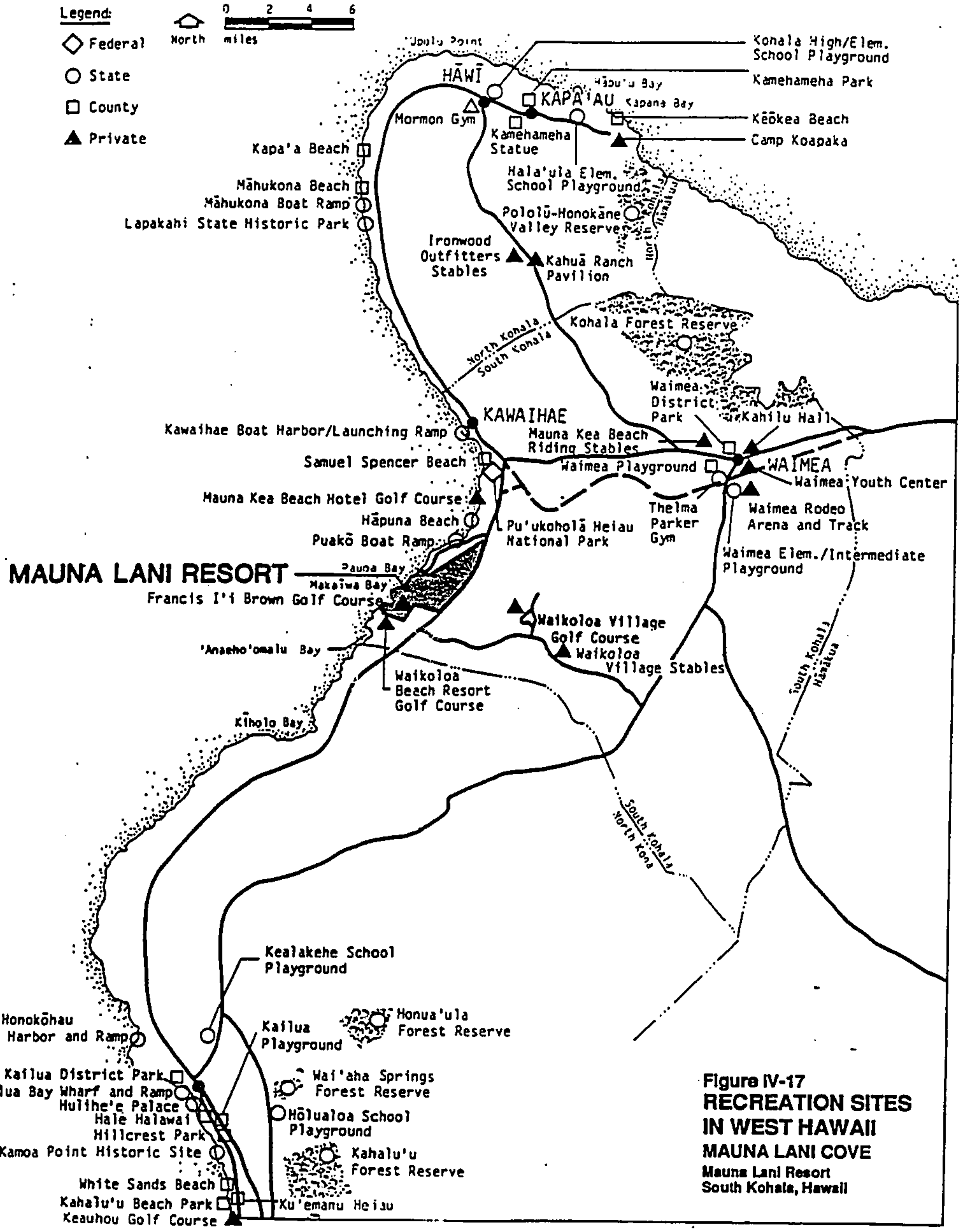


Figure IV-17
RECREATION SITES IN WEST HAWAII
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

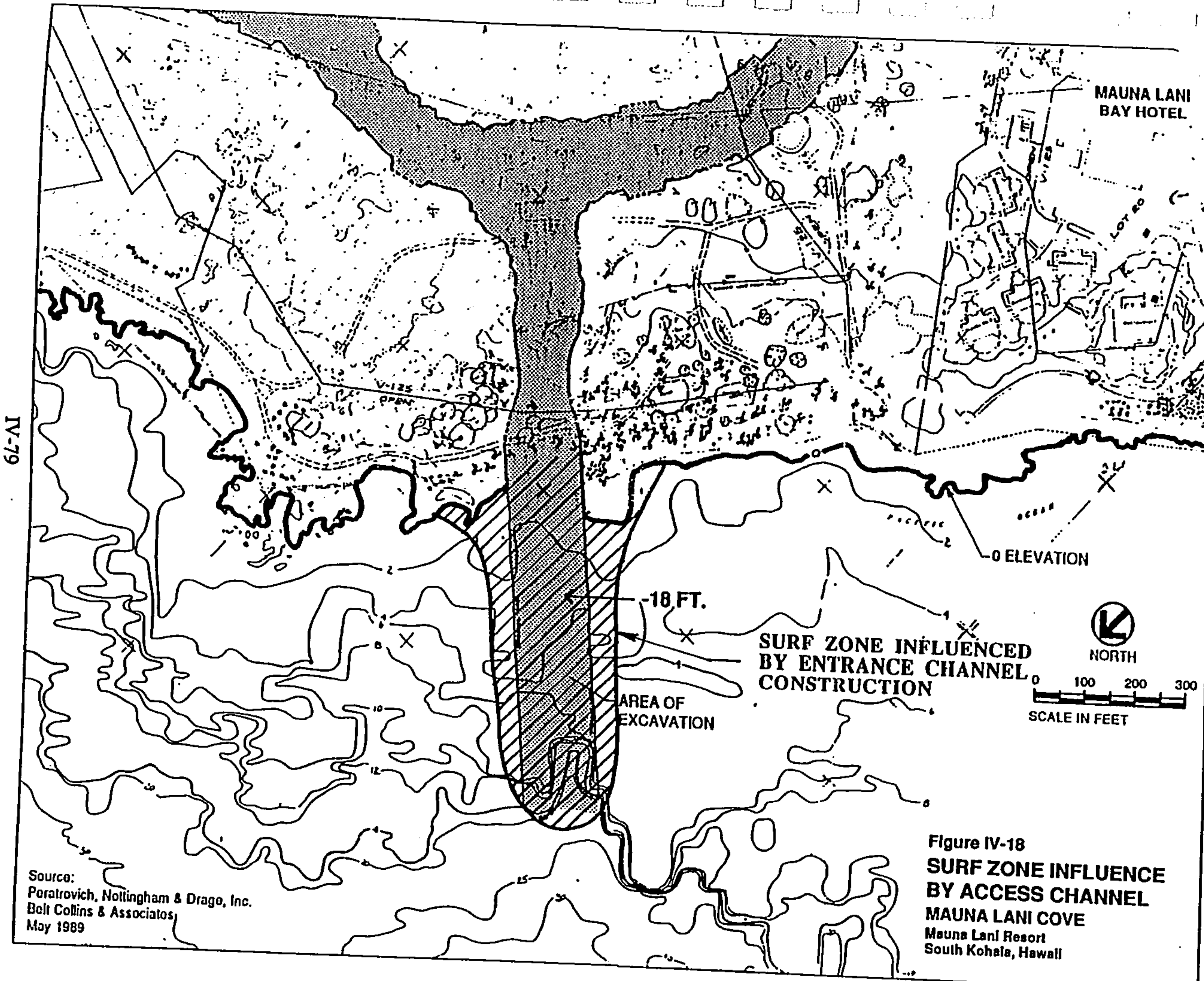


Figure IV-18
SURF ZONE INFLUENCE BY ACCESS CHANNEL
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

Source:
Poratrovich, Nottingham & Drago, Inc.
Belt Collins & Associates
May 1989

CHAPTER FIVE

CHAPTER V

RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES AND CONTROLS FOR THE AFFECTED AREA

1. INTRODUCTION

The applicable governmental land use plans, policies and controls affecting the proposed project include Chapter 205 (HRS) Land Use Commission Rules (Title 15, subtitle 3, Chapter 15), the Hawaii State Plan and State Functional Plans for Agriculture, Conservation Lands, Employment, Energy, Health, Historic Preservation, Housing, Human Resources, Recreation, Tourism, Transportation and Water Resources Development; Hawaii Coastal Zone Management Program, Hawaii County Special Management Area (SMA), Hawaii County General Plan and Hawaii County Zoning. Additionally, the North Kohala Community Development Plan, Kona Regional Plan and Waimea Design Plan are applicable to the proposed Cove project. The proposed project's relationship to these plans, policies and controls is described in the sections that follow. Following receipt of all necessary permits and approvals (see Chapter I, Section 11.0), the proposed project would be consistent with the above noted plans and land use controls.

1.1 CHAPTER 205 (HRS) LAND USE COMMISSION RULES

The proposed project entrance channel and all of the submerged lands within the Cove would be located in Conservation District lands as defined by the State Land Use Commission (SLUC). A Conservation District Use Application (CDUA) has been filed with the Board and Department of Land and Natural Resources (DLNR) for work in the submerged lands to construct the entrance channel. No land use district boundary amendments or other state land use changes are required given the present Urban classification of the Cove area.

1.2 HAWAII STATE PLAN (REVISED 1989)

The Hawaii State Plan (Chapter 226, Hawaii Revised Statutes, as amended and approved May 29, 1986), establishes a set of goals, objectives and policies that are to serve as long-range guidelines for the growth and development of the state. The Plan is divided into three parts. Part I (Overall Theme, Goals, Objectives and Policies); Part II (Planning, Coordination and Implementation); and Part III (Priority Guidelines). Part II elements of the State Plan pertain primarily to the administrative structure and implementation process of the Plan. As such, comments regarding the applicability of this part to the proposed project are not appropriate. The following sections of the Hawaii State Plan are directly applicable to the proposed project:

1.2.1 <u>Part I. Overall Theme, Goals, Objectives and Policies</u>

The Hawaii State Plan lists three "Overall Themes" relating to: (1) Individual and family self-sufficiency; (2) Social and economic mobility; and (3) Community or social well-being [Section 226-3 (1-3)]. These themes are viewed as "basic functions of society" and goals toward which government must strive. To guarantee the elements of choice and mobility embodied in the three themes, three goals were formulated [Section 226-4 (1-3)]:

(1) A strong, viable economy, characterized by stability, diversity and growth that enables fulfillment of the needs and expectations of Hawaii's present and future generations.

(2) A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems and uniqueness, that enhances the mental and physical well-being of the people.

(3) Physical, social and economic well-being, for individuals and families in Hawaii, that nourishes a sense of community responsibility, of caring and of participation in community life.

Response: The proposed Mauna Lani Cove would contribute to the attainment of the three goals. The project would provide direct and indirect short- and long-term employment opportunities for the present and future residents of West Hawaii in general and specifically the Kailua-Kona area; the proposed project would generate increased state and county tax revenues; the project would contribute to the stability, diversity and growth of local and regional economies; and the archaeological, historic and natural site features would be protected. Key elements of the proposed project relative to the above noted goals are that the proposed project would provide additional small boat/pleasure craft mooring and storage opportunities for present and new residents of West Hawaii; that it would provide these opportunities in a planned setting wherein design, operation and maintenance and environmental protection provisions can be effectively, efficiently and economically controlled; that it would provide these mooring and storage opportunities close to existing and planned resort/residential developments such that travel times are minimized and yet separated from planned or existing residential developments such that the activities within the proposed project are not a nuisance to residential communities or other resort related activities; and the proposed project would enhance the sense of community responsibility and participation.

Specific objectives, policies and priority directions of the State Plan most relevant to the proposed project are discussed below. Note, objectives and policies not listed are those that are not applicable to the proposed project.

Section 226-5 Objective and Policies for Population

Objective:

(a) To guide population growth to be consistent with the achievement of the physical, economic and social objectives of the state.

Policies:

(b)(2) Encourage an increase in economic activities and employment opportunities on the Neighbor Islands consistent with community needs and desires.

(b)(3) Promote increased opportunities for Hawaii's people to pursue their socio-economic aspirations throughout the state.

Response: Rapidly increasing population levels in the West Hawaii area are presently a concern to both state and county planners because of the present lack of affordable housing, limited public facilities and services and increased demands on those facilities and services. The proposed Cove and residential project will have an effect on these factors, but that effect would be less than that which would occur should the Cove area be used for hotel facilities as previously planned. The Cove project is expected to provide long-term economic and employment opportunities for businesses servicing and providing equipment and supplies for boats and pleasure craft. The development of the Cove and residential lots is also expected to contribute to the overall growth of the Mauna Lani resort area as a major visitor destination for South Kohala that is consistent with the communities' desire and need as demonstrated in the County General Plan. As previously indicated in this EIS, marketing studies and a survey indicate a definite market for both the Cove and related facilities and the residential lots, thereby indicating resultant positive primary and secondary employment and economic opportunities for socioeconomic growth and development of the area.

226-6 Objectives and Policies for the Economy - General

Objectives:

(a)(1) To increase and diversify employment opportunities to achieve full employment, increased income and job choice, and improved living standards for Hawaii's people.

(a)(2) A steadily growing and diversified economic base that is not overly dependent on a few industries.

Policies:

(b)(2) Promote Hawaii as an attractive market for environmentally and socially sound investment activities that benefit Hawaii's people.

(b)(4) Expand existing markets and penetrate new markets for Hawaii's products and services.

(b)(6) Strive to achieve a level of construction activity responsive to, and consistent with, state growth objectives.

(b)(9) Foster greater cooperation and coordination between the public and private sectors in developing Hawaii's employment and economic growth opportunities.

(b)(10) Stimulate the development and expansion of economic activities which will benefit areas with substantial or expected employment problems.

(b)(11) Maintain acceptable working conditions and standards for Hawaii's workers.

(b)(13) Encourage businesses that have favorable financial multiplier effects within Hawaii's economy.

(b)(14) Promote and protect intangible resources in Hawaii such as scenic beauty and the aloha spirit, which are vital to a healthy economy.

(b)(16) Foster a business climate in Hawaii - including attitudes, tax and regulatory policies and financial assistance programs - that is conducive to the expansion of existing enterprises and the creation and attraction of new business and industry.

Response: As the first private marina in Hawaii, the project would add an environmentally and socially sound investment amenity to the marketing and promotion of Hawaii. Further, the project would expand an existing market and penetrate a new market for Hawaii's products and services. The proposed Mauna Lani Cove project would provide continued construction activity in the Mauna Lani Resort area, thereby ensuring local construction workers continued employment as well as provide employment opportunities for other types of construction trades. Given the present land use approvals for the Cove site, the proposed project is consistent with state growth objectives. The project would foster cooperation and coordination between the public and private sectors in developing Hawaii's employment and economic opportunities in an area (boat sales and servicing) that is currently limited, especially on the island of Hawaii. The proposed project would contribute toward increased employment, income and job choice opportunities for Big Island residents, thereby leading to improved living standards for those residents. The development of the proposed project would also increase the opportunities to control the working conditions of the businesses that would service The Cove, stimulate the development and expansion of businesses in an area that has experienced employment problems, increase the business opportunities for businesses having favorable financial multiplier effects and provide a climate conducive to the expansion of existing businesses and the creation of new business.

226-8 Objective and policies for the economy - visitor industry

Objective:

(a) Planning for the State's economy with regard to the visitor industry shall be directed towards achievement of the objective of a visitor industry that constitutes a major component of steady growth for Hawaii's economy.

Policies:

(b)(1) Support and assist in the promotion of Hawaii's visitor attractions and facilities.

(b)(2) Ensure that visitor industry activities are in keeping with the social, economic and physical needs and aspirations of Hawaii's people.

(b)(3) Improve the quality of existing visitor destination areas.

(b)(4) Encourage cooperation between the public and private sectors in developing and maintaining well-designed, adequately serviced visitor industry and related developments which are sensitive to neighboring communities and activities.

(b)(5) Develop the industry in a manner that will continue to provide new job opportunities and steady employment for Hawaii's people.

(b)(6) Provide opportunities for Hawaii's people to obtain job training and education that will allow for upward mobility within the visitor industry.

Response: The proposed project is in keeping with and would assist in attaining the above stated objective and policies by providing a facility that would be one of Hawaii's premier visitor attractions and facilities; provide a facility that is in keeping with the social, economic and physical needs and aspirations of Hawaii's people; improve the quality of the existing and under construction visitor facilities at Mauna Lani Resort; provide a facility that is well designed to adequately serve the visitor industry as well as residents of Hawaii while being sensitive to neighboring activities and communities; provide new job opportunities and steady employment; and further the policy of providing opportunities for Hawaii's people to obtain job training and would allow for upward mobility within the visitor industry. The proposed development would offer short-term and long-term employment to residents of the state and county of Hawaii and would contribute to sustaining the level of construction activity in the state. As noted in Chapter II, the proposed Mauna Lani Cove is being carefully planned and developed to meet existing and future market demands and the project would provide a diverse range of employment opportunities within the region.

226-10 Objective and policies for the economy - potential growth activities

Objective:

(a) Planning for the State's economy with regard to potential growth activities shall be directed towards achievement of the objectives of development and expansion of potential growth activities that serve to increase and diversify Hawaii's economic base.

Policies:

(b)(1) Facilitate investment and employment in economic activities that have the potential for growth such as diversified agriculture, aquaculture, apparel and textile manufacturing, film and television production and energy and marine-related industries.

(b)(2) Expand Hawaii's capacity to attract and service international programs and activities that generate employment for Hawaii's people.

(b)(3) Enhance and promote Hawaii's role as a center for international relations, trade, finance, services, technology, education, culture and the arts.

(b)(5) Promote Hawaii's geographic, environmental, social and technological advantages to attract new economic activities into the state.

(b)(6) Provide public incentives and encourage private initiative to attract new industries that best support Hawaii's social, economic, physical and environmental objectives.

Response: The proposed project would assist in the achievement of the above state objective and policies by providing a facility that directly promotes marine-related businesses, including boat servicing and recreational fishing and water sport activities; encourages existing business to expand and provides the impetus for the creation of new businesses to service boats and activities centered around the Cove; assist in enhancing and promoting Hawaii's role as a center for international and domestic relations, trade, finance, services and technology, and promote the State's geographic, environmental, social and technological advantages, especially given the project's close location relative to the internationally known fishing grounds off West Hawaii. Granting the requested permits and future zoning requests would represent the extent of public incentives required to encourage the private interests to construct homes and utilize The Cove, thereby supporting the State's social, economic, physical and environmental objectives.

226-11 Objectives and policies for the physical environment - land-based, shoreline and marine resources

Objectives:

(a) Planning for the State's physical environment with regard to land-based, shoreline and marine resources shall be directed towards the achievement of the following objectives:

(a)(1) Prudent use of Hawaii's land-based, shoreline, and marine resources.

(a)(2) Effective protection of Hawaii's unique and fragile environmental resources.

Policies:

(b)(1) Exercise an overall conservation ethic in the use of Hawaii's resources.

(b)(2) Ensure compatibility between land-based and water-based activities and natural resources and ecological systems.

(b)(3) Take into account the physical attributes of areas when planning and designing activities and facilities.

(b)(4) Manage natural resources and environs to encourage their beneficial and multiple use without generating costly or irreparable environmental damage.

(b)(6) Encourage the protection of rare or endangered plant and animal species and habitats native to Hawaii.

(b)(7) Provide public incentives that encourage private actions to protect significant natural resources from degradation or unnecessary depletion.

(b)(8) Pursue compatible relationships among activities, facilities, and natural resources.

(b)(9) Promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational and scientific purposes.

Response: The long-standing and demonstrated policy of Mauna Lani Resort has been to exercise an overall conservation ethic in the use of Hawaii's resources. This has been demonstrated in the care and protection offered the Hawaiian fishpond, anchialine pond and historical/cultural resources found within the resort boundaries. This same ethic would be continued with the proposed Cove project to ensure compatibility between the land- and water-based activities, natural resources and ecological systems that would be affected by the proposed project. As indicated previously in this EIS, the planning and design of the Cove has taken into account the physical attributes of the Mauna Lani area. Further, it is the intention of the developers to manage the natural resources and environs of the resort area such that beneficial and multiple uses are encouraged as to not cause damage to those resources. As has also been demonstrated at Mauna Lani, endangered and threatened plant and animal species and habitats native to Hawaii have been protected and serve as educational and scientific resources. As indicated previously, the only public incentive required to encourage private actions to protect significant natural resources from degradation or unnecessary depletion is the granting of the requested permit and land use actions. This incentive will allow the developers to pursue compatible relationships among the activities, facilities and natural resources of the area. The proposed project would also promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational and scientific purposes.

Plans for the proposed Mauna Lani Cove project are being developed and prepared in conjunction with extensive environmental studies of the site. This EIS documents the process by which these environmental considerations have been integrated into the planning process. Although no historic features of significance or rare (threatened) or endangered species were encountered through these studies, any threatened or candidate species would be respected through appropriate site planning considerations.

226-12 Objective and policies for the physical environment - scenic, natural beauty and historic resources

Objective:

(a) Planning for the State's physical environment shall be directed towards achievement of the objective of enhancement of Hawaii's scenic assets, natural beauty, and multicultural/historical resources.

Policies:

(b)(1) Promote the preservation and restoration of significant natural and historic resources.

(b)(2) Provide incentives to maintain and enhance historic, cultural and scenic amenities.

(b)(3) Promote the preservation of views and vistas to enhance the visual and aesthetic enjoyment of mountains, ocean, scenic landscapes, and other natural features.

(b)(4) Protect those special areas, structures, and elements that are an integral and functional part of Hawaii's ethnic and cultural heritage.

(b)(5) Encourage the design of developments and activities that complement the natural beauty of the islands.

Response: The proposed Mauna Lani Cove was conceived based on the unique site attributes and has thus been planned and designed to maintain and/or enhance the natural features of the site. As with previous projects at Mauna Lani, significant historical/cultural/archaeological sites will be protected as will the anchialine ponds within the project boundaries; building pads have been planned and sited to maintain the primary vistas to the mountains and ocean. The low density, landscaped character of the land portion of the project site as well as the waterways would provide a means for the development to accommodate and be complemented by the surrounding land and ocean environment.

226-13 **Objectives and policies for the physical environment - land, air and water quality.**

Objectives:

(a) Planning for the State's physical environment with regard to land, air and water quality shall be directed towards achievement of the following objectives:

(a)(1) Maintenance and pursuit of improved quality in Hawaii's land, air and water resources.

(a)(2) Greater awareness and appreciation of Hawaii's environmental resources.

Policies:

(b)(1) Foster educational activities that promote a better understanding of Hawaii's environmental resources.

(b)(2) Promote the proper management of Hawaii's land and water resources.

(b)(3) Promote effective measures to achieve desired quality in Hawaii's surface, ground and coastal waters.

(b)(8) Foster recognition of the importance and value of land, air and water resources to Hawaii's people, their cultures and visitors.

Response: An important element of the proposed project is the construction of an interpretive display that will provide educational materials regarding the importance of the area's land and water environmental resources. The proposed project has been designed and would be constructed in such a manner that the land and water resources of the area can be managed in an environmentally compatible and beneficial manner and foster the recognition of the importance and value of the area land, air and water resources to Hawaii's people, their cultures and visitors.

226-17 **Objectives and policies for facility systems - transportation**

Objectives:

(a) Planning for the State's facility systems with regard to transportation shall be directed towards the achievement of the following objectives:

(a)(1) An integrated multi-modal transportation system that services statewide needs and promotes the efficient, economical, safe and convenient movement of people and goods.

(a)(2) A statewide transportation system consistent with planned growth objectives throughout the State.

Policies:

(b)(2) Coordinate state, county, federal and private transportation activities and programs toward the achievement of statewide objectives.

(b)(6) Encourage transportation systems that serve to accommodate present and future development needs of communities.

(b)(9) Encourage the development of transportation systems and programs which would assist statewide economic growth and diversification.

(b)(10) Encourage the design and development of transportation systems sensitive to the needs of affected communities and the quality of Hawaii's natural environment.

Response: The proposed Mauna Lani Cove project is consonant with on-going and planned State sponsored small boat marinas on the islands of Oahu, Maui and Hawaii; is being planned to accommodate the present and future development of the Mauna Lani Resort community; assists in promoting statewide economic growth and diversification; and is being designed to be sensitive to the needs of the affected community and quality of the area's natural environment. As noted previously in this chapter, the proposed Cove project would provide short- and long term employment and economic opportunities. Further, the proposed project would provide needed small boat mooring and storage facilities in the West Hawaii area at private expense, thereby aiding state efforts as demonstrated at Honokohau Harbor. Also, as noted previously, the Cove and associated residential community are being designed and planned to complement existing, planned and under construction resort facilities and the natural environment of the area.

226-19 Objectives and policies for socio-cultural advancement - housing

Objectives:

(a) Planning for the State's socio-cultural advancement with regard to housing shall be directed towards achievement of the following objectives:

(a)(2) The orderly development of residential areas sensitive to community needs and other land uses.

Policies:

(b)(1) Effectively accommodate the housing needs of Hawaii's people.

(b)(5) Promote design and location of housing developments taking into account the physical setting, accessibility to public facilities and services and other concerns of existing communities and surrounding areas.

(b)(7) Foster a variety of lifestyles traditional to Hawaii through the design and maintenance of neighborhoods that reflect the cultures and values of the community.

Response: The proposed Mauna Lani Cove concept has been planned and designed to lend itself towards fostering a sense of community and cohesiveness. It is the intent of the proposed Cove to create a character that reflects the values that are traditional to Hawaii and an appreciation and respect for the beauty of the land. Development of another hotel in the area would add undue burdens on the public facilities and services of the area and not be in keeping with the lower density housing and marina facilities desired by existing communities.

226-23 Objective and policies for socio-cultural advancement - leisure

Objective:

(a) Planning for the State's socio-cultural advancement with regard to leisure shall be directed towards the achievement of the objective of adequate provision of resources to accommodate diverse cultural, artistic, and recreational needs for present and future generations.

Policies:

(b)(1) Foster and preserve Hawaii's multicultural heritage through supportive cultural, artistic, recreational, and humanities - oriented programs and activities.

(b)(2) Provide a wide range of activities and facilities to fulfill the cultural, artistic and recreational needs of all diverse and special groups effectively and efficiently.

(b)(3) Enhance the enjoyment of recreational experiences through safety and security measures, educational opportunities and improved facility design and maintenance.

(b)(4) Promote the recreational and educational potential of natural resources having scenic, open space, cultural, historical, geological, or biological values while ensuring that their inherent values are preserved.

(b)(5) Ensure opportunities for everyone to use and enjoy Hawaii's recreational resources.

(b)(10) Assure adequate access to significant natural and cultural resources in public ownership.

Response: The proposed Cove would provide a new array of recreational opportunities that would be integrated into the community. The proposed project includes provisions for open spaces, continued public shoreline access, public access to the Cove facilities, educational displays and facilities and continued access to significant historical and cultural sites. In addition, opportunities for community activities, such as local boating regattas and water sport activities would be available. As such, a wide range of recreational facilities and opportunities would be made available to the residents of Mauna Lani, as well as residents of the West Hawaii area.

1.2.2 Part II. Planning, Coordinating and Implementation

As indicated previously, this part of the Hawaii State Plan pertains to the administrative structure and implementation process of the Plan. As such, comments are not deemed appropriate.

1.2.3 Part III. Priority Guidelines

The purpose of this part of the Plan is to establish overall priority guidelines to address areas of statewide concern. The Plan notes (Section 226-102) that the State shall strive to improve the quality of life for Hawaii's present and future population through the pursuit of desirable courses of action in five major areas of statewide concern which merit priority attention: economic development, population growth and land resource management, affordable housing, crime and criminal justice and quality education. The priority guidelines applicable to the proposed project are discussed below:

226-103 Economic Priority Guidelines

(a) Priority guidelines to stimulate economic growth and encourage business expansion and development to provide needed jobs for Hawaii's people and achieve a stable and diversified economy:

(a)(1) Seek a variety of means to increase the availability of investment capital for new and expanding enterprises.

(a)(8) Provide public incentives and encourage private initiative to develop and attract industries which promise long-term growth potentials and which have the following characteristics:

(A)(8)(A) An industry that can take advantage of Hawaii's unique location and available physical and human resources.

(a)(8)(B) A clean industry that would have minimal adverse impacts on Hawaii's environment.

(A)(8)(D) An industry that would provide reasonable income and steady employment.

(a)(10) Enhance the quality of Hawaii's labor force and develop and maintain career opportunities for Hawaii's people through the following actions:

(a)(10)(A) Expand vocational training in diversified agriculture, aquaculture and other areas where growth is desired and feasible.

(b) Priority guidelines to promote the economic health and quality of the visitor industry:

(b)(1) Promote visitor satisfaction by fostering an environment which enhances the Aloha Spirit and minimizes inconveniences to Hawaii's residents and visitors.

(b)(2) Encourage the development and maintenance of well-designed, adequately serviced hotels and resort destination areas which are sensitive to neighboring communities and activities and which provide for adequate shoreline setbacks and beach access.

(b)(3) Support appropriate capital improvements to enhance the quality of existing resort destination areas and provide incentives to encourage investment in upgrading, repair and maintenance of visitor facilities.

(b)(4) Encourage visitor industry practices and activities which respect, preserve and enhance Hawaii's significant natural, scenic, historic and cultural resources.

(b)(7) Maintain and encourage a more favorable resort investment climate consistent with the objectives of this chapter.

(f) Priority guidelines for energy use and development:

(f)(3) Provide incentives to encourage the use of energy conserving technology in residential, industrial and other buildings.

Response: The proposed Mauna Lani Cove project would assist in meeting the above stated guidelines by allowing private investment in a facility that would assist in expanding existing businesses that serve boats and pleasure craft as well as provide the impetus for new businesses to be created to serve an expanded market; assist in the development of an industry that can take advantage of Hawaii's location and available physical and human resources; encourage expansion of a clean industry that would have minimal adverse impacts on Hawaii's environment; assist an industry that provides a reasonable income and steady employment; and provide the market for and stimulus needed to increase vocational training in an area where growth is desired and feasible. With regard to promoting the economic health and quality of the visitor industry, the proposed project would provide an ideal visitor and resident oriented boat mooring and storage area while allowing the development of the businesses that would serve the Cove and residents of The Cove; and allow the expenditure of private capital to upgrade and improve the quality of facilities at an existing visitor destination area. The proposed project would also aid in the attainment of the energy related guidelines through the energy conservation measures that would be taken during the operation of the Cove.

226-104 Population Growth and Land Resources Priority Guidelines

(a) Priority guidelines to effect desired statewide growth and distribution:

(a)(1) Encourage planning and resource management to insure population growth rates throughout the State that are consistent with available and planned resource capacities and reflect the needs and desires of Hawaii's people.

(a)(2) Manage a growth rate for Hawaii's economy that will parallel future employment needs for hawaii's people.

(a)(4) Encourage major state and federal investments and services to promote economic development and private investment to the neighbor islands, as appropriate.

(b) Priority guidelines for regional growth distribution and land resource utilization:

(b)(6) Seek participation from the private sector for the cost of building infrastructure and utilities and maintaining open spaces.

(b)(12) Utilize Hawaii's limited land resources wisely, providing adequate land to accommodate projected population and economic growth needs while ensuring the protection of the environment and the availability of the shoreline, conservation lands and other limited resources for future generations.

(b)(13) Protect and enhance Hawaii's shoreline, open spaces and scenic resources.

Response: The proposed Mauna Lani Cove project would comply with and assist in the achievement of the above stated population growth and land resources priority guidelines and objectives. The proposed project would provide the means by which the developers would make available investment capital for the Cove and house lots, thereby providing additional housing, boat mooring and storage areas in an area designated for residential/resort development. As such, growth would continue to be focused in an existing urban area and that growth would be less than that originally planned. Further, the Cove would maintain the open space character of the area better than the previously planned hotel and related facilities; would be designed to protect and enhance the shoreline and coastal resources of the area; and provide additional recreational facilities available to the public. The proposed development would provide employment opportunities paralleling future employment needs; encourage private investment on a neighbor island; and profitably utilize urban lands for urban uses. Infrastructural components required by and for the project would be provided by the developer at no cost to the state or county.

1.3 STATE FUNCTIONAL PLANS

The Hawaii State Plan directs the appropriate state agencies to prepare functional plans for their respective program areas. There are twelve State Functional Plans that serve as the primary implementing vehicle for the goals, objectives and policies of the Hawaii State Plan. The following sections of the listed State Functional Plans are directly applicable to the proposed project:

1.3.1 State Agriculture Functional Plan (1985)

The entire project site is aged basalt lava that is either barren or has sparse vegetation cover of grass, kiawe, coconut palms, milo or hau trees, with the latter primarily around the shoreline anchialine ponds. The entire project site is designated Urban by the SLUC and is not considered suitable for cultivation. It is not designated as important agricultural land on the ALISH (Agricultural Lands of Importance to the State of Hawaii) map of the area. Consequently, the implementing actions of the State Agriculture Functional Plan do not apply either directly or indirectly to the proposed project.

1.3.2 State Conservation Lands Functional Plan (1984)

There are several implementing actions in the State Conservation Lands Functional Plan that are relevant to the proposed project. This functional plan addresses more than officially designated Conservation District lands in that it establishes a conservation ethic that the state should strive to attain and maintain.

MANAGEMENT OF NATURAL RESOURCES

Objective:

A. Effective protection and prudent use of Hawaii's unique, fragile and significant environmental and natural resources.

Policies:

A(1) Exercise an overall conservation ethic in the use of Hawaii's resources by protecting, preserving and conserving the critical and significant natural resources of the State of Hawaii and controlling use of hazardous areas.

A(1)(c) Review the various rules and regulations and permit systems applicable to Conservation District lands for possible simplification and/or consolidation for effective and efficient management controls and compliance with the Coastal Zone Management program.

A(1)(d) Provide for effective enforcement of rules and regulations and permit system applicable to the Conservation District.

A(1)(d) Review applications for use of Conservation lands to control impacts on natural and cultural resources.

Response: The proposed project includes provisions to incorporate the anchialine ponds found within the project boundaries into the project as well as clean those ponds and maintain them for the benefit of the pond biota and as educational tools. In compliance with the Coastal Zone Management Program regulations, a Coastal Zone Management consistency determination will be requested from the Office of State Planning and a Special Management Area permit will be requested from the County Planning Department. Further, the proposed project will comply with the rules and regulations applicable to the Conservation District Use permit system, and this EIS will allow extensive review by governmental agencies and the general public with regard to the potential impacts on natural and cultural resources and the controls (mitigating measures) proposed to minimize potential adverse impacts.

PROTECTION OF ENDANGERED SPECIES

Objective:

B. Protection of rare or endangered species and habitats native to Hawaii.

Policies:

B(1) Protect and preserve habitats of rare and endangered wildlife.

B(2) Protect and preserve unique native plant species.

Response: As noted previously, the proposed project includes provisions to maintain the anchialine pond ecosystems found within the project boundaries. This will assist in the protection and preservation of the critical habitat for the pond biota as well as provide an educational tool that will be available to both residents and visitors.

MANAGEMENT OF OPEN SPACE, WATERSHEDS AND NATURAL AREAS

Objective:

C. Effective protection and management of Hawaii's open space, watersheds and natural areas.

Policies:

C(3) Protect and manage the lands with historic or natural resources value.

C(3)(a) Establish criteria and evaluate and prioritize areas of private lands with historic or natural resources value for possible acquisition by public or private agencies.

C(3)(b) Acquire and maintain historic sites for park and other purposes.

C(4) Provide opportunities and facilities to meet public needs for a wide range of recreational and educational activities within Conservation lands.

C(4)(a) Where possible, make available areas of unique biota or geology for public appreciation and enjoyment.

C(4)(c) Maintain scenic and natural open space areas as part of a Statewide system of parks.

Response: To determine the extent and nature of historic and cultural resources within the project boundaries, an archaeological inventory survey of the project site was conducted. The survey was performed in compliance with draft guidelines that are being established by the State Department of Land and Natural Resources, Historic Sites Section and guidelines developed by the Advisory Council on Historic Preservation. Significance determinations have been assessed in compliance with the criteria established by the above noted groups and those published in the National Register (36 CFR Part 60). The results of the archaeological survey indicated that there are 18 sites within the project boundaries, 17 of which require no further work. For the remaining site, additional data collection is recommended prior to construction of the Cove. No unusual, one-of-a-kind or otherwise unique or especially well preserved features were encountered on the site and preservation is not being recommended for any of the recorded resources. Other cultural sites within the Mauna Lani Resort area have been preserved and serve as educational materials. Similarly, as noted previously, the natural resources of the area, especially the anchialine ponds will be preserved and maintained for the enjoyment of visitors and residents. Further, the proposed project will allow more of the scenic open space character of the site to be maintained than the previously planned hotel facilities.

1.3.3 State Education Functional Plan (1989)

The State Education Functional Plan reflects the Department of Education's strategies to address the policies and priority guidelines of the Hawaii State Plan and the goals of the Board of Education and the concerns of the Education Functional Plan Advisory Committee. As such, it serves as a mechanism for implementing the Hawaii State Plan as it relates to the directions of the Board of Education and the programs of the Department. All of the actions are to be undertaken by the Department of Education and hence, they are not applicable to the proposed Mauna Lani Cove project.

1.3.4 State Higher Education Functional Plan (1984)

There are no objectives, policies or implementing actions in this functional plan that are directly applicable to the proposed project. However, it is noted that the anchialine ponds and regional water quality/ecological surveys will serve as educational resources available to university marine researchers.

1.3.5 State Employment Functional Plan (1989)

The State Employment Functional Plan, the preparation of which was coordinated by the Department of Labor and Industrial Relations, lists four major issue areas under which specific objectives have been defined. These issue areas and objectives are as follows:

ISSUE AREA I. EDUCATION AND PREPARATION SERVICES FOR EMPLOYMENT

Objectives:

I.A Improve the qualifications of entry level workers and their transition to employment.

I.B Develop and deliver education, training and related services to ensure and maintain a quality and competitive workforce.

ISSUE AREA II. JOB PLACEMENT

Objective:

II.A Improve labor exchange.

ISSUE AREA III. QUALITY OF WORK LIFE

Objective:

III.A Improve the quality of life for workers and families.

ISSUE AREA IV. EMPLOYMENT PLANNING INFORMATION AND EMPLOYMENT COORDINATION

Objective:

IV.A Improve planning of economic development, employment and training activities.

Under each of the above listed objectives are defined policies to implement the objectives. The implementation actions are primarily the responsibility of the Department of Labor and Industrial Relations (DLIR) with assistance from other agencies and groups.

Response: The proposed project is generally in concert with the objectives of the State Employment Functional Plan in that new jobs will be created and/or others, such as in construction, continued for a period of time. By providing additional employment opportunities in several areas (boat services, Cove maintenance and operation, landscaping and maintenance, etc.), the proposed project would be one more element of the West Hawaii environment, in particular as to jobs, thereby assisting in the improvement of the quality of life for workers and families.

1.3.6 State Energy Functional Plan (1984)

The State Energy Functional Plan has as an objective the promotion of energy-efficient design. This relates to both overall land use planning and to specific building design and equipment selection decisions. While specific building designs have not been completed, the proposed project will adhere to energy conservation standards whenever possible. Elements of energy conservation that may be incorporated into the project include the use of solar energy for water heating and air conditioning purposes, the use of heat recovery pumps and the use of energy efficient lighting systems.

1.3.7 State Health Functional Plan (1989)

The State Health Functional Plan identifies four major priority issue areas on which the plan focuses. These are (1) preventive health, (2) access to health care, (3) environmental protection, and (4) internal administrative issues. Of these four, the environmental protection issue is the most relevant to the proposed project.

Objective:

> Environmental programs to protect and enhance the environment. Continued development of new environmental protection and health services programs to protect, monitor and enhance the quality of life in Hawaii.

Policy:

> Air, land and water quality programs. The Department of Health (DOH) will develop and implement new programs to prevent degradation ad enhance the quality of Hawaii's air, land and water.

The objective and policy of the DOH will be implemented through programs that will include development and implementation of a comprehensive air toxic control program; development and implementation of a comprehensive solid and hazardous waste management program; development and implementation of a comprehensive recreational water quality monitoring strategy; development and implementation of a non-point source pollution program to protect recreational and other surface waters; development and implementation of an indoor air pollution control program; and development and implementation of a groundwater protection program including groundwater monitoring, safe drinking water and underground injection control. These actions, in concert with existing duties and responsibilities of the DOH, form the primary environmental protection elements of the department.

Response: The proposed project will be in compliance with applicable DOH rules and regulations as well as those established by Hawaii County. A complete marine survey, including water quality analysis, of the area to be impacted by the proposed project has been performed and forms the basis of a part of this EIS (see Chapter IV, Section 3.3.2 and Appendices F, R, S, And T). During construction of the Cove a water quality and marine biological monitoring program will be conducted to ensure that there are no long-term adverse impacts to the area coastal water quality or marine biota as a result of the project. A separate ciguatera monitoring program has already been initiated and the results of that program will be applied to the proposed project. In addition, applicable DOH permit/approval requirements will be complied with. The proposed project will comply with all necessary requirements related to the DOH permitting procedures.

1.3.8 State Historic Preservation Functional Plan (1984)

The objectives, policies and implementing actions of the State Historic Preservation Plan are directed toward state agencies, primarily the Department of Land and Natural Resources, Historic Preservation Program (DLNR-HPP). The archaeological resources at the project site have been surveyed and evaluated by DLNR-HPP. The developers of the project, with approval from the County Planning Department, will implement the mitigation measures recommended by the consulting archaeologist for the one site that requires additional investigation.

1.3.9 State Housing Functional Plan (1989)

The State Housing Functional Plan, prepared by the State Housing Finance and Development Corporation, addresses six major areas of concern: (1) increasing homeownership; (2) expanding rental housing opportunities; (3) expanding rental housing opportunities for the elderly and other special need groups; (4) preserving housing stock; (5) designating and acquiring land that is suitable for residential development; and (6) establishing and maintaining a housing information system. The plan assumes the use of existing programs at both the state and county levels to attain the goals of the Hawaii State Plan. Most of the objectives, policies and implementing actions of the State Housing Functional Plan apply to the government sector. With regard to the provision of employee housing, Mauna Lani Resort, Inc. has satisfied its affordable housing condition for development of the entire planned resort.

1.3.10 State Human Services Functional Plan (1989)

The State Human Services Functional Plan identifies elderly care, children and family support, self-sufficiency and service delivery improvements as the priority issues of the Human Services Plan. The objectives, policies and implementing actions of the plan are directed toward state and county agencies for accomplishment. In general, the proposed project is in concert with the basic philosophy of the Human Services Functional Plan in that it will assist, through the provision of employment opportunities, families in achieving economic and social self-sufficiency.

1.3.11 State Recreation Functional Plan (1984)

The objectives, policies and implementing actions of the State Recreation Functional Plan are oriented toward improving public recreation opportunities both now and in the future. The following objectives and policies of the plan are relevant to the proposed project.

LAND USE PLANNING

Objective:

A. Achieve a pattern of land and water resources usage which is compatible with community values, physical resources, recreation potential and recreation uses which support comprehensive public land use policies.

Policies:

A(2) Ensure that intended uses for a site respect community values and are compatible with the area's physical resources and recreation potential.

A(3) Emphasize the scenic and open space qualities of physical resources and recreation areas.

Response: The proposed project is favored by nearby communities over the originally planned hotel that was to be located on the project site. The proposed project is not only compatible with the area's physical resources but enhances the area's recreation potential and will assist in the realization of that potential. Further, the proposed project emphasizes the scenic and open space qualities of the physical resources and recreation characteristics of the area.

CONSERVATION AND RESOURCE MANAGEMENT

Objective:

B. Establish a system of maintaining natural and cultural resources for present and future generations, and of managing recreation and other uses in accordance with sound conservation principals.

Policy:

B(1) Exercise an overall conservation ethic in the use of Hawaii's resources.

Response: Throughout the development of the Mauna Lani Resort area, the developers have fostered and maintained programs and activities that enhance the physical, cultural and recreational characteristics of the area. These programs have been designed to preserve these valuable resources for the use and enjoyment of visitors and residents. The proposed project will continue to follow the conservation ethic that has been established, as demonstrated through the maintenance of the coastal, anchialine pond and cultural resources of the resort.

RECREATIONAL FACILITIES AND PROGRAMS

Objective:

C. Provide a comprehensive range of opportunities which fulfill the needs of all recreation groups effectively and efficiently.

Policy:

C(1) Maintain an adequate supply of recreation facilities and programs which fulfill the needs of all recreation groups.

Response: The proposed project will assist in implementing the above state objective and policy by providing a facility that will allow boaters, recreational fishermen, sport divers and other water sport oriented groups to pursue and enjoy their recreational needs. The provision of the Cove and associated facilities will be accomplished by private investment, thereby allowing public funds to be available for other recreation oriented programs.

ACCESS

Objective:

D. Assure the provision of adequate public access to lands and waters with public recreation value.

Policy:

D(2) Promote the securing of public access to resources with recreational value.

D(3) Ensure that the community feels safe and comfortable in accessing to public recreation lands.

Response: The proposed project includes provisions to maintain public access along the shoreline and to those lands that have public recreation value. Further, the proposed project, acting in concert with previously established public recreational facilities within and adjacent to the Mauna Lani Resort area, will ensure that facilities for both residents and visitors are enhanced.

1.3.12 State Tourism Functional Plan (1984)

The State Tourism Functional Plan is a guide to help coordinate the various sectors of government and private industry toward achieving the statewide objectives of the Hawaii State Plan and is an expression of legislative policy toward tourism. The following objectives and policies of the State Tourism Functional Plan are relevant to the proposed project.

PHYSICAL DEVELOPMENT

Objective:

B. Development and maintenance of a well-designed and adequately serviced industry and related developments in keeping with the needs and aspirations of Hawaii's people.

Policies:

B(1) Ensure that visitor industry activities are in keeping with the economic and physical needs and aspirations of Hawaii's people.

B(2) Improve the quality of existing visitor destination areas.

B(3) Encourage greater cooperation between the public and private sectors in developing and maintaining well-designed and adequately serviced visitor industry and related developments.

B(4) Ensure that visitor facilities and destination areas are carefully planned and sensitive to existing neighboring communities and activities.

Response: The proposed Mauna Lani Cove has been conceived and is being designed to enhance the attractiveness of the resort area to visitors and residents alike. The Cove is in keeping with the water oriented neighboring communities and needs and will provide a much needed infrastructural component in West Hawaii. The development of the Cove will expand the recreational opportunities available to visitors to the Mauna Lani Resort area as well as to residents of the area. Further, the proposed Cove will utilize the privately developed infrastructure already in existence, thereby greatly reducing the need for new government investment in infrastructure.

EMPLOYMENT AND CAREER DEVELOPMENT

Objective:

C. Enhancement of career and employment opportunities in the visitor industry.

Policies:

C(1) Develop the industry in a manner that will provide the greatest number of primary jobs and steady employment for Hawaii's people.

C(2) Provide opportunities for Hawaii's people to obtain job training and education that will allow for upward mobility within the visitor industry.

Response: The proposed project will add to the variety of primary job opportunities and provide steady employment for those who wish to take advantage of those opportunities. In addition, it is expected that the majority of the existing and new businesses that will service the proposed Cove will provide in-house job training for those that require such training as well as provide opportunities for employees to move upward within the business.

COMMUNITY RELATIONS

Objective:

D. Development of better relations and mutual awareness and sensitivity between the visitor industry and the community.

Policies:

D(1) Ensure that visitor industry activities are in keeping with the social needs and aspirations of Hawaii's people.

D(3) Foster an understanding by visitors of the Aloha Spirit and of the unique and sensitive character of Hawaii's cultures and values.

Response: The proposed Cove project will aid in the development of better relations and mutual awareness and sensitivity between visitors to the Cove and residents of the resort and nearby communities through the development of a mutual respect for each other's knowledge regarding boating, fishing, diving and other water oriented activities. Further, the Cove is in keeping with the social needs of the residents of nearby communities and by preserving archaeological and natural resources, a better understanding of the unique and sensitive character of Hawaii's cultures and values will be developed by visitors to the Cove and surrounding resort community.

1.3.13 State Transportation Functional Plan (1984)

The overall objective of the State Transportation Functional Plan is to provide for the efficient, safe and convenient movement of people and goods. As such, none of the policies or implementing actions of the plan apply specifically to the proposed Cove project. However, the proposed project would assist the state in the provision of mooring and storage facilities for small boats and pleasure craft as well as serving as a safe haven for small boats during storms or emergency situations.

1.3.14 State Water Resources Development Functional Plan (1984)

This functional plan primarily affects governmental operations. The specific purpose of the plan is to set forth specific water-related objectives, policies, programs and projects to guide state and county governments in implementing the broader objectives, policies and priority guidelines of the Hawaii State Plan. In essence, the plan presents guidelines for the regulation of the development and use of water to assure adequate supplies in the future; development of water resources to meet municipal, agriculture and industrial requirements, and the reduction of flood damage; and preservation of water-related ecological, recreational and aesthetic values and the quality of water resources. With regard to the latter, the proposed project includes provisions to preserve and protect the anchialine pond resources within the project site as well as the development and maintenance of a new water recreational resource. Within this context, the proposed project is in concert with the State Water Resources Development Functional Plan.

1.4 COASTAL ZONE MANAGEMENT ACT (CHAPTER 205-A, HRS)

The objectives of the Hawaii Coastal Zone Management (CZM) Program, as set forth in Chapter 205A (HRS), include the protection and maintenance of valuable coastal resources. The proposed project conforms to applicable Chapter 205A (HRS) CZM objectives as indicated below.

1. RECREATIONAL RESOURCES

Objective:

Provide coastal recreational opportunities accessible to the public.

Policies:

1.b. Provide adequate, accessible and diverse recreational opportunities in the coastal zone management area by:

i. Protecting coastal resources uniquely suited for recreation activities that cannot be provided in other areas;

iii. Providing and managing adequate public access, consistent with conservation of natural resources, to and along shorelines with recreational value;

iv. Providing an adequate supply of shoreline parks and other recreational facilities suitable for public recreation;

vii. Developing new shoreline recreational opportunities, where appropriate, such as artificial lagoons, artificial beaches, artificial reefs for surfing and fishing;

viii. Encouraging reasonable dedication of shoreline areas with recreational value for public use as part of discretionary approvals or permits by the land use commission, board of land and natural resources, county planning commissions and crediting such dedication against the requirements of 46-6.

Response: Access to the Cove and all facilities therein, as well as the shoreline fronting the Cove, will be open to the public. Access along the shoreline will be maintained and only interrupted when high-masted boats are entering and leaving The Cove. Beaches and swimming lagoons improved and constructed as part of other Mauna Lani Resort projects are open to the public and provide needed recreational facilities to the residents of nearby communities as well as to visitors to the resort. As noted previously in this EIS, the coastal anchialine ponds found within the project boundaries will be retained and made part of the pond system that the resort developers have already set aside for the use and enjoyment of the public.

2. HISTORIC RESOURCES

Objective:

Protect, preserve, and where desirable, restore those natural and man made historic and pre-historic resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Policies:

2.a. Identify and analyze significant archaeological resources;

2.b. Maximize information retention through preservation of remains and artifacts or salvage operations; and

2.c. Support state goals for protection, restoration, interpretation and display of historic resources.

Response: As has been noted previously, an archaeological survey of the project site has been performed and the recommendations of the consulting archaeologist followed. This would include subsurface investigations of one site and the recording of materials found at that site.

3. SCENIC AND OPEN SPACE RESOURCES

Objective:

Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources.

Policies:

3.b. Insure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline.

3.c. Preserve, maintain, and where desirable, improve and restore shoreline open space and scenic resources.

Response: The proposed Cove project would be in keeping with the present scenic resources of the area. Facilities would be low-rise type buildings that would maintain coastal views from mauka areas and facilities would be located such that views along the coast would not be obstructed. The proposed project also includes provisions to restore the anchialine pond resources within the project boundaries. Coastal scenic resources will not be significantly affected as a major component of the proposed project is open space itself and landscaping will be incorporated into the project design to ensure the smooth visual integration of the project and makai views.

4. COASTAL ECOSYSTEMS

Objective:

Protect valuable coastal ecosystem from disruption and minimize adverse impacts on all coastal ecosystems.

Policies:

4.a. Improve the technical basis for natural resource management;

4.b. Preserve valuable coastal ecosystems of significant biological or economic importance.

Response: A marine and coastal pond survey of the site has been performed to assist in the definition of measures that will be taken to protect those resources during construction and operation of The Cove. The results of that survey and the mitigation measures that will be employed are described in Chapter IV, Section 3.3 of this EIS. As noted previously, the anchialine ponds within the project boundaries will be preserved and protected.

5. ECONOMIC USES

Objective:

Provide public or private facilities and improvements important to the State's economy in suitable locations.

Policies:

5.b. Insure that coastal dependent development such as harbors and ports, visitor industry facilities and energy generating facilities are located, designed and constructed to minimize adverse social, visual and environmental impacts in the coastal zone management area.

5.c. Direct the location and expansion of coastal dependent developments to areas presently designated and used for such developments and permit reasonable long-term growth at such areas, and permit coastal dependent development outside presently designated areas when:

ii. Adverse environmental effects are minimized.

Response: The proposed Mauna Lani Cove would be constructed within the Mauna Lani Resort area which has already received approval of appropriate state and county agencies as a resort destination area. The proposed Cove and associated facilities are being designed and would be constructed such that potential adverse environmental effects would be minimized and mitigated. In general, the social and visual aspects of the proposed project are expected to be positive. The proposed project would add to the visitor and resident facilities of the area and aid in the long-term development of the area as one of the state's premier tourist destination areas as well as a significant income generator of county and state revenues.

6. COASTAL HAZARDS

Objective:

Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion and subsidence.

Policies:

6.b. Control development in areas subject to storm wave, tsunami, flood, erosion and subsidence.

6.c. Ensure that developments comply with the requirements of the Federal Flood Insurance Program.

Response: The governmental agency and public review of this EIS along with the various permits required for the proposed project ensure that adequate governmental controls on the project are being applied. The proposed project will be designed and constructed in compliance with all applicable federal, state and county environmental protection, design and building standards and regulations, including the Federal Flood Insurance Program.

7. MANAGING DEVELOPMENT

Objective:

Improve the development review process, communication and public participation in the management of coastal resources and hazards.

Policies:

7.a. Effectively utilize and implement existing law to the maximum extent possible in managing present and future coastal zone development.

7.b. Facilitate timely processing of application for development permits and resolve overlapping or conflicting permit requirements.

7.c. Communicate the potential short- and long-term impacts of proposed significant coastal developments early in their life-cycle and in terms understandable to the general public to facilitate public participation in the planning and review process.

Response: This EIS has been prepared in compliance with existing state and county environmental rules (Chapter 343, HRS and Chapter 200, Department of Health, Environmental Impact Rules). It will be used in conjunction with the initial environmental assessment prepared for the project, to apply for the required permits. Further, the developer has been meeting with appropriate federal, state and county agency personnel as well as affected and interested community groups and individuals to communicate the plans for the proposed Cove and to solicit their comments for incorporation into the planning process and this EIS. Public review of the Draft EIS also assures adequate public and governmental agency review of the project.

1.5 WEST HAWAII REGIONAL PLAN

The West Hawaii Regional Plan (Office of State Planning, 1989), was prepared because of the state's interest in formulating and implementing a plan for West Hawaii that would (1) coordinate state activities in the region in order to respond more effectively to emerging needs and critical problems, (2) address areas of state concern, (3) coordinate the capital improvements program within a regional planning framework and (4) provide guidance in the state land use decision-making process. The plan addresses critical topical issues which require state attention in order to most effectively meet the region's present and emerging needs. The West Hawaii Regional Plan is meant to complement the County General Plan and Community Development Plans.

With specific reference to the proposed project, the Mauna Lani Resort area is recognized as one of the region's "Resort Destination Nodes". The plan recognizes a high need for improved sandy beaches, beach camping sites and boat moorages as well as the need to increase public access to and along the shoreline. In anticipation of providing relief for existing as well as forecast increased demand for harbor facilities, the plan recommends the exploration of creative implementation and development expansion methods, including privatization for the provision of additional boat slips and harbor facilities. The proposed project meets this action recommendation, at little or no cost to the public sector.

2. HAWAII COUNTY PLANS AND CONTROLS

2.1 HAWAII COUNTY SPECIAL MANAGEMENT AREA

The entire project falls within the "Special Management Area" (SMA) as defined by the Hawaii County Planning Commission under the provisions of Chapter 205A, Hawaii Revised Statutes and the county's Rule 9, Special Management Area. As such, an SMA permit application has been filed with the Hawaii County Planning Commission for the proposed project. That permit application has been supported in part by this EIS. In essence, county objectives and policies regarding the Special Management Area mirror the state objectives and policies as discussed in the preceding section (1.4). County SMA guidelines relevant to the proposed project are as follows:

Guidelines A.1, 2, 3,4 and 5

> These guidelines seeks to minimize alterations to any body of water; impose restrictions on public access to tidal and submerged lands and beaches; interfere with or detract from the line-of-sight toward the sea; and minimize adverse effects on water quality and wildlife habitats.

Response: Although the proposed project would alter the offshore area to the extent required to construct the entrance channel and would cause a break in the shoreline for the entrance channel, the project is intended to expand and enhance the recreational opportunities available to the residents of the area as well as visitors to the resort. All dredging and construction would be performed in compliance with applicable federal, state and county environmental protection rules and regulations. Lateral shoreline access would be maintained by construction of the proposed bridge over the entrance channel and public movement along the shoreline would only be interrupted when the bridge was open to allow boats to enter and leave The Cove. Water quality is not expected to be adversely affected in the long-term although impacts are expected during construction, particularly the increase in sediment. The visual character of the proposed project is expected to be positive and assist in maintaining the open space character of the site. Views inland from the shoreline and views seaward from Queen Kaahumanu Highway are not expected to be adversely affected. The existing anchialine ponds within the project boundaries would be preserved and restored and the proposed project is expected to result in the creation of additional protected water as well as offshore habitat for marine and brackish water species.

Guidelines B.1, 2 and 3

> These guidelines seek to minimize potential adverse environmental impacts; assure that projects are consistent with state objectives and policies; and assure that projects are consistent with the County General Plan.

Response: As indicated in Chapter IV, the proposed project is not expected to result in any adverse impacts that cannot be mitigated. The project is consistent with applicable provisions of the State's coastal zone management objectives and policies as indicated in the preceding section (1.4) and the project is located within the urban area designated for resort development on the Hawaii County General Plan.

Guidelines C.1, 2, 3, 4, 5 and 6

> These guidelines seek to assure adequate public access to publicly owned beaches, recreation areas and natural reserves; reserve public recreation areas and wildlife preserves; and provide liquid and solid waste treatment, disposition and management that will minimize adverse effects on Special Management Area resources.

Response: As indicated previously, the proposed project includes provisions to maintain public access to and along the shoreline; would provide additional recreational opportunities for the residents and visitors to the resort area; and includes provisions to restore and preserve the anchialine pond resources of the project area. Liquid and solid wastes will be treated, disposed of and managed in compliance with applicable federal, state and county rules and regulations. Liquid wastes will be treated and disposed of in the Mauna Lani Resort wastewater treatment and disposal system. Solid wastes would be collected and disposed of at approved county sanitary landfill sites.

2.2 HAWAII COUNTY GENERAL PLAN

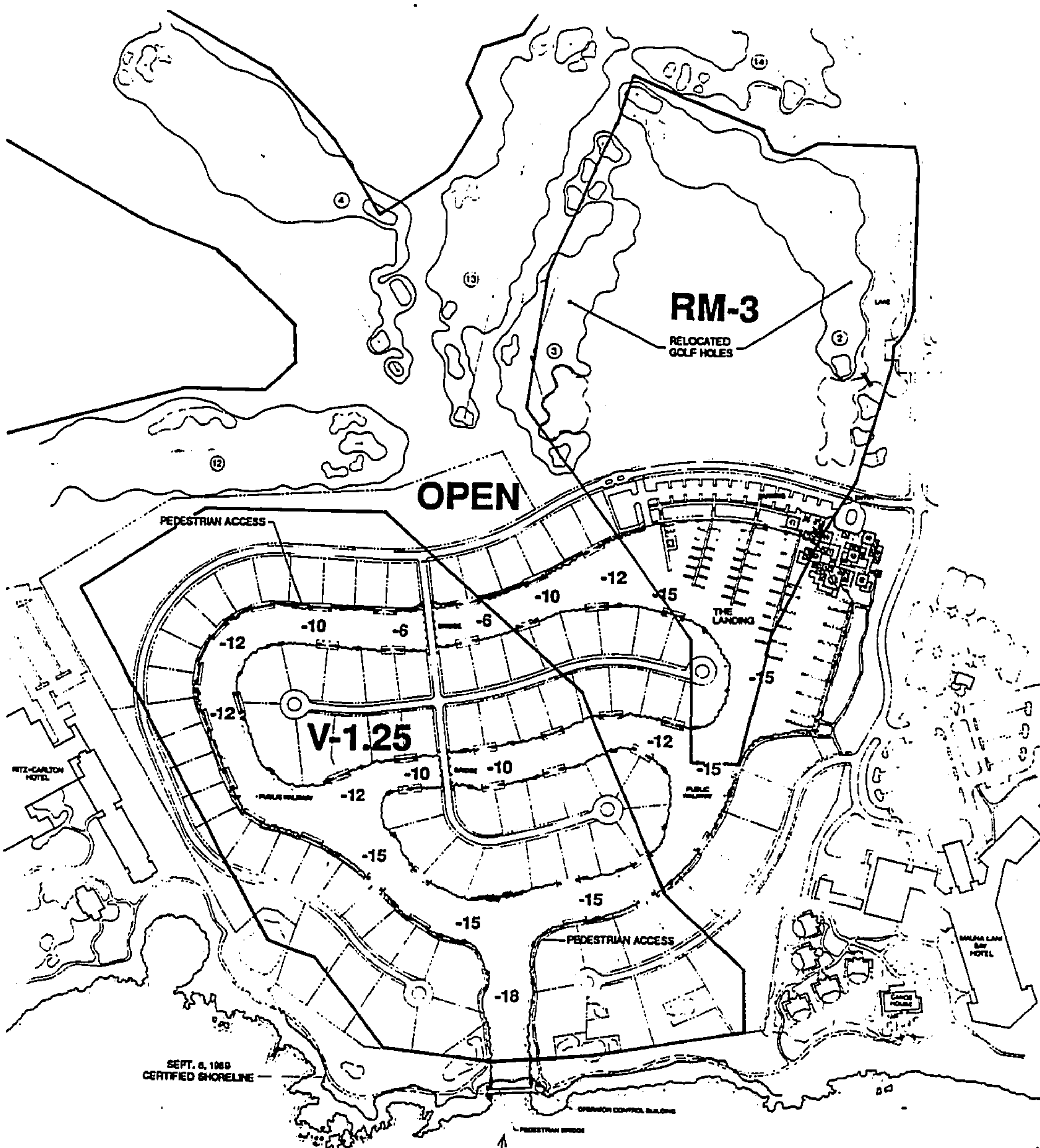
The Hawaii County General Plan is the policy document for the long-range comprehensive development of the island of Hawaii and provides direction for balanced growth of the County. The Plan contains goals, policies and standards concerning twelve functional areas as well as a series of land use maps referred to as General Plan Land Use Pattern Allocation Guide (LUPAG) Maps. The present LUPAG Map designations for the Mauna Lani Resort property are a mixture of resort, medium density urban, low density urban, open and alternate urban expansion. The proposed Cove area is designated resort, low density urban, medium density urban and open. These designations will not require changes to accommodate the proposed Cove. As such, the proposed project is consistent with the present LUPAG Map designations. The proposed project is also consistent with the policies of the County General Plan. The Mauna Lani Resort is on the list (as Puako-Honoka'ope Bay) of "major" resorts in the land use element of the plan. The Cove would be another element of the overall resort in that, as stated in the General Plan, "A major resort is a self-contained resort destination area which provides basic and support facilities for the needs of the entire development. Such facilities shall include sewer, water, roads, employee housing and recreational facilities, etc."

2.3 HAWAII COUNTY ZONING

The present county zoning designation of the subject property is variously Open, V-1.25 and RM-3. The developer has applied for a Change of Zone from Hawaii County to allow development of the proposed Cove. These changes would included Open to RM-3 (6.18 acres), Open to RS-15 (13.51 acres), RM-3 to RS-15 (3.26 acres), V-1.25 to RM-3 (9.36 acres), V-1.25 to RS-156 (37.02 acres) and Open to CV-10 (2.76 acres). See Figures V-1 and V-2 for the current zoning and proposed zoning.

3. PLANS OF NEARBY COMMUNITIES

No regional plan has been prepared for South Kohala. In addition to the West Hawaii Regional Plan, the following plans have been examined to note the relevance and position of the South Kohala resorts in the planning for these nearby communities and the overall West Hawaii area.



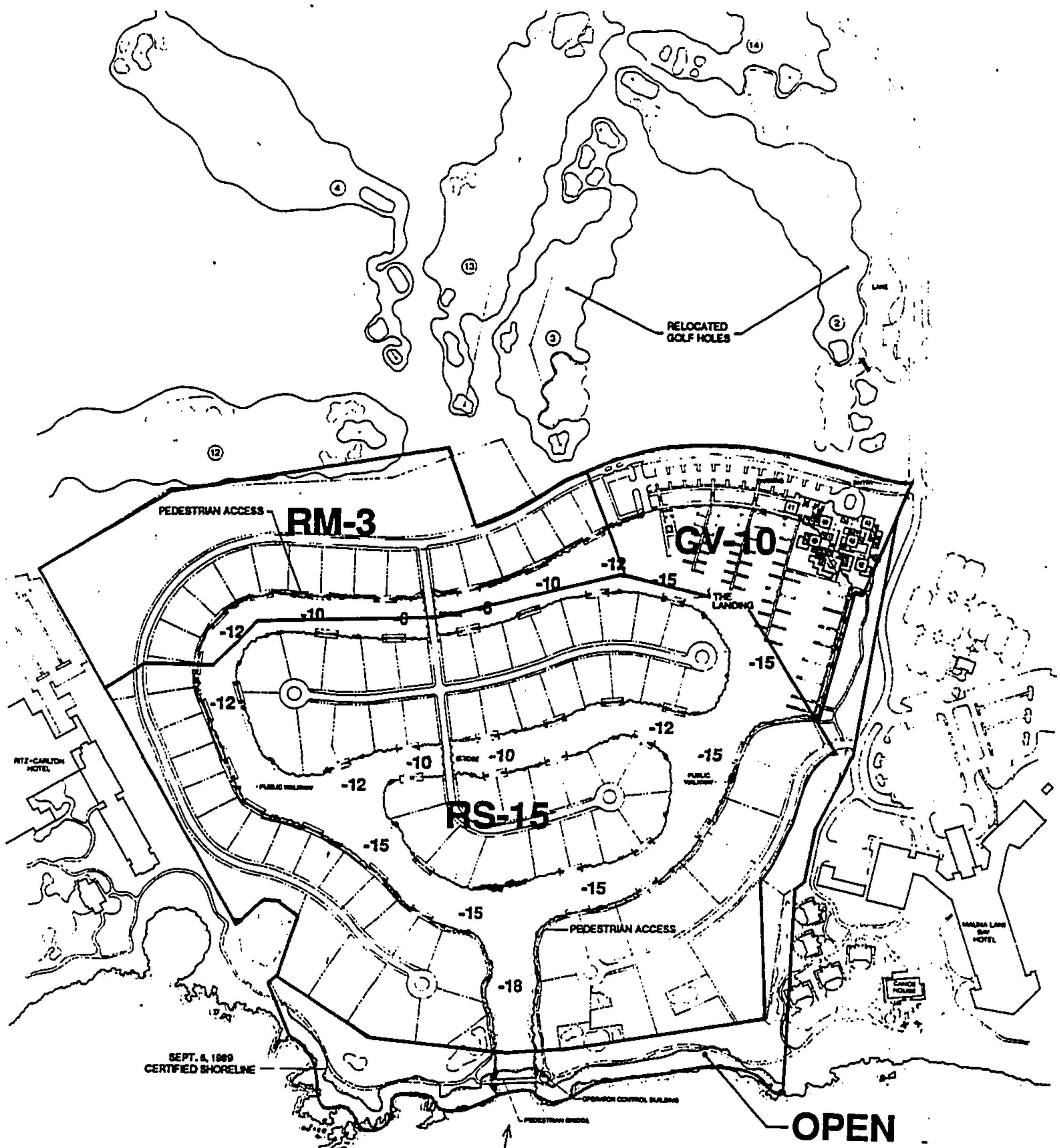
Note: The proposed Mauna Lani Cove is shown in concept only. Design of facilities is subject to change, based on engineering analysis.

-12 PROPOSED CHANNEL DEPTH (FT)

0 80 160 320 SCALE IN FEET — NORTH

Source: ROMA Design Group and Belt Collins & Associates December 1989

Figure V-1
EXISTING ZONING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii



Note: The proposed Mauna Lani Cove is shown in concept only. Design of facilities is subject to change, based on engineering analysis.

APPROXIMATE ENTRANCE CHANNEL

-12 PROPOSED CHANNEL DEPTH (FT)

0 80 160 320 SCALE IN FEET

NORTH

Source: ROMA Design Group and Belt Collins & Associates December 1989

Figure V-2
PROPOSED ZONING
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

3.1 NORTH KOHALA COMMUNITY DEVELOPMENT PLAN

There are numerous references in the North Kohala Community Development Plan to the employment opportunities and economic base which the South Kohala resorts have and will continue to provide for North Kohala residents. The plan notes that the South Kohala resorts and tourism development fill the employment gap that has been left as a result of the closure of North Kohala sugar plantations. This gap is less now than in the past due to progressive development in the North Kohala area itself. However, South Kohala resorts still depend, to a certain degree, on the North Kohala area as a source of employees. The extent of this dependence will undoubtedly change as North Kohala develops. The extent of change is indeterminable at this time and will depend on the pace of development in North Kohala. It is expected that a certain amount of visitor industry employee housing would be developed in North Kohala, but the extent to which such development might be directed to the southern portion of the district is unclear at this time.

3.2 KONA REGIONAL PLAN

The Kona Regional Plan has references to the South Kohala Resorts only in the Economic Activities and Land Use chapters. The relationship between the visitor facilities in the Kona and Kohala districts is noted several times. The competition that the destination resorts in South Kohala will pose for Kona's visitor industry is stressed. Since publication of the Kona Regional Plan, and initial development of the South Kohala resorts, visitor industry facility development in Ka'u District has also been proposed. This development will add to the competition for employees and increase demands on public services as well as increase the need for affordable employee housing. In addition, the opportunities for industrial expansion in the area immediately north of Kailua/Kona is noted in the Kona Regional Plan. At present, there appears to be a need for additional light industrial facilities and siting opportunities, in the Kona area, for businesses that would serve the visitor industry as well as the growing population of the West Hawaii area in general. Employment opportunities related to the industrial and service sectors that the South Kohala resorts, and proposed project, will create for West Hawaii residents are in addition to the direct jobs that the proposed project will provide.

It is expected that the economies of the Kohala and Kona Districts will become more and more interdependent, especially as both are largely based on the tourism industry. Thus, land use and facilities planning has to be coordinated. The proposed project recognizes this interdependence and will provide another recreational facility for use by both residents and visitors to the South Kohala and Kona area resorts.

3.3 WAIMEA DESIGN PLAN

The Waimea Design Plan makes one brief mention of the prospects for continued growth in the town due to the resort developments on the coast. However, as indicated above, increased development of the North Kohala and Waimea areas is occurring and is expected to continue as market demands for "country" type living opportunities increase and are met. As increased development of the Waimea area continues, along with increased development of tourist related facilities in South Kohala, the interdependence of the two areas will also increase.

4. STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

4.1 CHAPTER 343 (HAWAII REVISED STATUTES)

Section 343-5(a) of Chapter 343 HRS (Revised) states that except as otherwise provided, an environmental assessment shall be required for actions that (2) "Propose any use within any land classified as conservation district by the state land use commission under Chapter 205; and (3) Propose any use within the shoreline area as defined in section 205A-41." Accordingly, this Environmental Impact Statement for the proposed Mauna Lani Cove project has been prepared and is submitted pursuant to the provisions of Chapter 343.

Upon acceptance of this EIS and approval of the requested Conservation District Land Use Permit and county permitting requests, the proposed Cove development at Mauna Lani Resort would conform with relevant state and county land use regulations, as well as other regulations pertinent to the proposed development. Beyond this, the thoroughly landscaped and low-scale community character of the Cove and associated house lots will yield a resort destination and community which is in keeping with the high quality of resorts found in the South Kohala area.

CHAPTER SIX

CHAPTER VI

TOPICAL ISSUES

1. RELATIONSHIP BETWEEN SHORT-TERM USES AND MAINTENANCE OF LONG-TERM PRODUCTIVITY

Analyses of various on-site environmental features have found the Mauna Lani Cove property to possess physical attributes that are desirable both as amenities in a residential/resort development and for their own sake. These attributes include magnificent ocean and mountain views, relatively flat terrain and dry, warm climate. The studies performed (see Chapter I, Section 3.0) have also indicated that the proposed project is compatible with and will enhance the existing natural environment. The specific measures that will be employed to mitigate potential adverse environmental impacts, as discussed in Chapter I, Section 6.0 and throughout Chapter IV, would be followed in the design, construction and operations phases of the project.

No short-term exploitation of resources that will have negative long-term consequences have been identified. The proposed Cove/residential/resort development as envisioned by the developer will be of the same high quality as the rest of Mauna Lani Resort and will be designed to last for decades. The principal long-term benefits of the proposed project include the productive use of the property at a lower density than that which is presently allowed and the provision of a needed recreational facility that will serve West Hawaii residents and visitors alike. Increased residential, resort, recreational and economic opportunities for various socioeconomic levels would be provided along with increased community services and activities. The proposed project is a logical extension of the residential/resort community that is developing along the South Kohala-West Hawaii coastline. Open spaces surrounding the project site and vistas to the ocean and mountains would be retained for the long-term benefit of the immediate area residents and visitors to the area.

As noted in the discussion of Alternatives to the Proposed Project (Chapter III), one short-term use of the property would be to retain the present vacant status of the property. This appears to be less than optimum use of the property. As The Cove and residential units and amenities are developed, significant socioeconomic benefits to the community will result, in the form of increased recreational boating facilities and opportunities, increased job opportunities and increased tax revenues. Direct, full-time employment opportunities and temporary construction employment will be generated by the project and these in turn will have benefits that ripple through the regional and island economy. Similarly, indirect and induced employment will be generated in those industries and services that cater to the construction and service related businesses serving the proposed project. Public revenues from excise, personal and real property taxes are expected to more than offset any expenses associated with the expansion of public services to meet the requirements of the proposed project development and indirect population growth (see Chapter IV, Section 5.1).

2. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The development of the proposed Mauna Lani Cove project and resultant construction of detached single family units, ancillary facilities (yacht club, restaurant, boat storage facilities, etc.) and boat docks/slips would result in the irreversible and irretrievable commitment of certain natural and fiscal resources. Major resource commitments include the land on which the project is located and on which the facilities would be constructed, as well as money, construction materials, manpower and energy. The impacts of using these resources should be weighed against the expected positive socioeconomic benefits to be derived from the project versus the consequences of taking no action or adopting another less beneficial use of the property.

A significant portion of the property would remain as open space (Cove water areas, shoreline, public promenade around The Cove and anchialine pond areas). In addition, the project would include landscaping planted along the promenade, around the residential units and along the streets, contributing positively to the aesthetic character of the area. Further, a new greenbelt/passive park will be added to the shoreline fronting the project site, thereby adding to the area's recreational resources.

The commitment of resources required to accomplish the project includes building materials and labor, both of which are generally non-renewable and irretrievable. Construction of and resultant travel to/from the project by residents and visitors, would require the consumption of petroleum products and petroleum based electrical generation. This, too, represents an irretrievable commitment of resources.

The proposed project does not call for a substantial commitment of government supplied services or facilities that would not be required without the proposed project. The project would add to the cultural and recreational facilities available to the residents of the project and the West Hawaii area in general. Similarly, the project would add to the tax revenues of the county and state.

3. OFFSETTING CONSIDERATIONS OF GOVERNMENTAL POLICIES

By the very existence of a complex system of land use policies, plans, goals, objectives and controls at both the state and county levels of government, development proposals requiring land reclassification are often faced with inherent contradictions and conflicts within the land use regulatory system. Similarly, marina projects invariably cause short-term degradation of ambient water quality and ecological conditions. The Mauna Lani Cove project must be reconciled against those privately and publicly planned elements that may appear to conflict with the proposed project. As indicated in Chapter V, the proposed project is generally consistent with the applicable Hawaii State Plan and various Functional Plans, the County General Plan and various Community Plans goals, policies and standards relating to the future growth of the West Hawaii/South Kohala area. Granting the requested Conservation District Use Permit would enable the project to meet the initial land use regulatory requirements. Other actions, including application for and acceptance of zoning and subdivision requests would enable the project to meet all land use regulatory requirements. Further, the analysis of public revenues versus public expenditures indicates an extremely favorable ratio of revenues to expenditures (see Chapter IV, Section 5.1). The proposed project will result in fewer residential/transient accommodation units being developed than are currently approved. Public access to and along the beach would be added to and improved and the coastal anchialine pond resources of the area would be preserved as would significant historical/archaeological sites. Based on the analyses conducted for the proposed project, following construction ambient water quality conditions would return to preconstruction or better levels and ecological/habitat conditions would be more favorable to marine organisms than existing conditions.

4. UNRESOLVED ISSUES

Mauna Lani Resort, Inc. is aware of many questions and public concerns at this time regarding the proposed project. Mauna Lani Resort, Inc. has been and will continue to work with the residents and businessmen of the area, as well as administrative and elected officials to assure that the final development plans meet the developer's project objectives and satisfactorily address concerns that have been raised to date as well as those that may be raised during public review of this EIS.

The following issues remain unresolved at this time:

- Project's consistency with the State's Coastal Zone Management Program.
- Extent of environmental monitoring required prior to, during and following construction.
- Long-term impact of operations on marine environment.
- Permit condition requirements.

5. REFERENCES CITED

AECOS. 1979. Post-Construction Water Quality, Benthic Habitat and Epifaunal Survey for the Reef Runway, Honolulu International Airport. Final Report. Prepared for Parsons Hawaii and State Department of Transportation, Airports Division.

Anderson, J. W. and R. W. Gossett. 1986. Final Report on Polynuclear Aromatic Hydrocarbon Contamination in Sediments From Coastal Waters of Southern California. CSWRCB, Sacramento, CA 95801.

Bak, R. P. M. 1978. Lethal and sublethal effects of dredging on a coral reef. Mar. Poll. Bull. 2:14-16.

Bauer, G. B. and L. H. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawaii. Report prep. for National Marine Fisheries Service.

Belt Collins & Associates. 1985. Final Environmental Impact Statement, Revised Master Plan for Mauna Lani Resort, South Kohala, Hawaii. Prepared for Mauna Lani Resort, Inc.

Belt Collins & Associates. 1987. Final Environmental Impact Statement, The Ritz-Carlton Mauna Lani, Mauna Lani Resort, South Kohala, Hawaii. Prepared for The Ritz-Carlton Hotel Company.

Bienfang, P. K. 1977. Survey of aquatic biota and water quality characteristics of the anchialine ponds at Anaehoomalu, Hawaii. Unpublished report prepared for Boise Cascade Co., Honolulu, Hawaii. Oceanic Institute, Waimanalo, Hawaii.

Bienfang, P. K. 1979. Predictive Analysis of Chemical and Biological Conditions in the Proposed West Beach Marina, A Basin Influenced by Groundwater Intrusion. Report submitted to Alfred A. Yee and Associates.

Bienfang, P. K. 1980. Water quality characteristics of Honokohau Harbor: a subtropical embayment affected by groundwater intrusion. Pacif. Sci. 34:279-291.

Brewer, W. A. 1987. Baseline Marine Environmental Surveys, Maalaea Harbor, Maui, Hawaii. Tech. Report prep. for Maalaea Triangle Partnership. In: Maalaea Triangle - Concurrent State Land Use Boundary Amendment and Rezoning Applications, 1987.

Brock, R. E. 1985a. Aquatic Survey of the Anchialine Pond System at Lahuipuaa, Kona, Hawaii. Report Prepared for Mauna Lani Resort, Inc.

Brock, R. E. 1985b. Assessment of the Conditions and Future of Anchialine Pond Resources in the Hawaiian Islands. In Final EIS, Waikoloa Beach Resort, U.S. Army Corps of Engineer District, Honolulu.

Brock, R. E. 1988a. Green turtles (Chelonia mydas) at Hawaii Kai, Hawaii: An analysis of the impacts with the development of a ferry system. Prepared for Sea Engineering, Inc.

Brock, R. E. 1988b. Assessment of the Resident Green Sea Turtle Population in the Vicinity of Launiupoko State Park, West Maui, Hawaii. In Towill, R. M. 1988. West Maui Marina, Launiupoko, Maui, Hawaii - Draft Environmental Impact Statement.

Brock, R. E., J. E. Norris, D. A. Ziemann and M. T. Lee. 1987. Characteristics of water quality in anchialine ponds of the Kona, Hawaii coast. Pacif. Sci., Vol. 41, Nos. 1-4, pp. 200-208.

Brown, B. E. and L. S. Howard. 1985. Assessing the effects of "stress" on coral reefs. Adv. in Mar. Biol. 22:1-63.

Buske, N. and J. C. McCain, 1972. A Preliminary Survey of the Marine Environmental Impact of the Honolulu Power Plant. Hawaiian Electric Company.

Chang, S. Y. K and R. H. F. Young. 1977. *An investigation into environmental effects* of sewage effluent reuse at Kaneohe Marine Corps Air Station Klipper Golf Course. Water Resources Research Center, Univ. of Hawaii, Tech. Report No.53.

Chmura, G. L. and N. W. Ross. 1978. The Environmental Impacts of Marinas and Their Boats. A Literature Review with Management Considerations. Marine Advisory Service, Univ. of Rhode Island, Narragansett.

Cox, D. C., F. F. Peterson, W. M. Adams, C. Lau, J. F. Campbell and R. D. Huber. 1969. Coastal evidence of groundwater conditions in the vicinity of Anaehoomalu and Lalamilo, South Kohala, Hawaii. Water Resources Research Center, Univ. of Hawaii, Tech. Report No. 24.

Dawson, E. Y. 1959. Changes in Palmyra Atoll and its Vegetation Through Activities of Man 1913-1958. Pac. Nat., 1:1-51.

Department of Transportation. 1990. Small Craft Mooring Facilities Utilization Report, Quarter Ending June 30, 1990.

Dodge, R. E. and J. R. Vaisnys. 1977. Coral populations and growth patterns: Responses to sedimentation and turbidity associated with dredging. J. of Mar. Res. 35:715-730.

Dollar, S. J. 1975. Zonation of reef corals off the Koan Coast of Hawaii. M.S. Thesis. University of Hawaii.

Dollar, S. J. 1982. Wave Stress and Coral Community Structure in Hawaii. Coral Reefs 1:71-81.

Dollar, S. J. 1987. Effects to water quality and marine community structure from beach reconstruction at Makaiwa Bay, Mauna Lani Resort, South Kohala, Hawaii. Prepared for Mauna Lani Resort, Inc.

Evans, E. C., III. (ed.). 1974. Pearl Harbor Biological Survey - Final Report. NUC TN 1128. Naval Undersea Center, San Diego, California.

Grant, E. M. 1970. Notes on an experiment upon the effect of crude oil on live corals. Fish Notes (NS), Dept. Primary Ind., Brisbane 1:1-13.

Grigg, R. W. and S. J. Dollar. 1989. Natural and anthropogenic disturbance on coral reefs. In: Coral Reefs, Vol. 25. Z. Dubinsky, ed. In press.

Guthrie, R. K., E. M. Davis, D. S. Cherry and H. E. Murray. 1979. Biomagnification of heavy metals by organisms in a marine microcosm. Bull. Environm. Contam. Toxicol. 21:53-61.

Hawaii Department of Business and Economic Development. 1988. State of Hawaii data book: A statistical abstract. Honolulu.

Hobson, E. S. 1974. Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii. Fishery Bull. 72:915-1031.

Johannes, R. E. 1975. Pollution and degradation of coral reef communities. Chapter 2. In Ferguson-Wood, E. J. and R. E. Johannes (eds.). Tropical Marine Pollution. Elsevier Oceanographic Series, 12. Elsevier Scientific Publishing Co., New York.

Katz, A. and I. R. Kaplan. 1981. Heavy metals behavior in coastal sediments off Southern California. A critical review and synthesis. Mar. Chem. 10:261-299.

Kay, E. A., L. S. Lau, E. D. Stroup, S. J. Dollar, D. P. Fellows and R. H. F. Young. 1977. Hydrologic and ecologic inventories of the coastal waters of West Hawaii. Water Resources Research Center, Univ. of Hawaii, Tech. Report No. 105.

Krasnick, G. 1987. Impacts of biocides and fertilizers on the nearshore marine environment at Punalu'u Resort, Ka'u, Hawaii. Appendix G. In: PBR HAWAII. 1987. Final Environmental Impact Statement for Punalu'u Resort, Punalu'u, Ka'u, Hawaii. Prepared for C. Brewer Properties, Inc.

Lal, Padma Narsey. 1990. Personal Recreational Boating Survey in Hawaii: Physical Characteristics and Economic Contribution. Draft Report prep. for College Sea Grant Program, University of Hawaii.

Maciolek, J. 1971. Aquatic Ecosystems of Kealia Floodplain and Maalae Bay, Maui. University of Hawaii, Hawaii Institute of Marine Biology Tech. Report No. 27.

Maciolek, J. A. and R. E. Brock. 1974. Aquatic Survey of the Kona Coastal Ponds, Hawaii Island. UNIHI-SEAGRANT-AR-74-04: Grant No. 04-3-158-29, NOAA, Office of Sea Grant.

Marsh, J. A., Jr. 1977. Terrestrial inputs of nitrogen and phosphorus on fringing reefs in Guam, pp. 332-336. In: Proceedings of the 2nd International Coral Reef Symposium, Vol. 1. Great Barrier Reef Committee, Brisbane, Australia.

Mullineaux, D. R., D. W. Patterson and D. R. Crandell. 1987. Volcanic Hazards in the Hawaiian Islands. U.S. Geological Survey Prof. Paper No. 1350.

Murdoch, C. L. and R. E. Green. 1988. Environmental impact of fertilizer and pesticide use on the proposed Waikane Golf Course project. Appendix L. In: Draft Environmental Impact Statement for the Proposed Waikane Golf Course Project, Waikane, Koolaupoko District, Oahu, Hawaii. Prepared by Group 70 for Waikane Development Co.

Murdoch, C. L. and R. E. Green. 1989. Environmental impact of fertilizer, herbicide and pesticide use. In: W. E. Wanket, Inc., Final Environmental Impact Statement, Royal Kunia Phase II, Hoaeae, Ewa, Oahu.

Neff, J. M. and J. W. Anderson. 1981. Responses of marine animals to petroleum and specific petroleum hydrocarbons. Applied Science Publishers, Ltd., London. 177 pp.

Oceanic Institute. 1977. Survey of the Aquatic Biota and Water Quality Characteristics of the Anchialine Ponds at Anaehoomalu, Hawaii. Rept. prep. for Boise Cascade Corp.

Ocean Research, Consulting and Analysis, Ltd. (ORCA). 1978. Reconnaissance surveys of the marine environment; Kawaihae small boat harbor project site, Island of Hawaii, Prepared for Department of the Army, Pacific Ocean Division, Hawaii Corps of Engineers, Fort Shafter, Hawaii.

Office of State Planning. 1989. West Hawaii Regional Plan. 74pp. + App.

Oshida, P. S., A. J. Mearns, D. J. Reish and C. S. Word. 1976. The effects of hexavalent and trivalent chromium on *Neanthes arenaceodentata* (Polychaeta: Annelida). Southern California Coastal Water Research Project TM 225.

PBR HAWAII. 1988. Final Environmental Impact Statement, Punalu'u Resort, Punalu'u, Ka'u, Hawaii. Prepared for C. Brewer Properties, Inc.

Randall, J. E. 1958. A review of ciguatera, tropical fish poisoning with a tentative explanation of its cause. Bull. Mar. Sci. Gulf Caribb., 8:236-267.

Rutzler, K. and W. Sterrer. 1970. Oil pollution damage observed on tropical communities along the Atlantic seaboard of Panama. Bioscience 20:222-224.

SCCWRP (Southern California Coastal Water Research Project). 1973. The Ecology of the Southern California Bight: Implications for Water Quality Management. TR104.

Sakoda, E. T. 1975. The Marine Geology and Sedimentology of Hawaii Kai and Adjacent Maunalua Bay. M.S. Thesis in Geology, Univ. of Hawaii.

Sheppard, C. 1980. Coral fauna of Diego Garcia lagoon following harbor construction. Mar. Poll. Bull. 11:227-230.

Shinn, E. A. 1972. Coral reef recovery in Flora and in the Persian Gulf. Environmental Conservation Dept., Shell Oil Co., Houston, Texas.

Smith, S. V., W. H. Kimmerer, E. A. Laws, R. E. Brock and T. W. Walsh. 1981. Kaneohe Bay sewage diversion experiment: Perspectives on ecosystem responses to nutritional perturbation. Pac. Sci. 35:279-402.

Smultea, M. A. 1990. Habitat utilization patterns of humpback whales off West Hawaii. Draft report in prep. for Marine Mammal Commission.

Sponner, M. 1970. Oil spill in Tarut Bay, Saudi Arabia. Mar. Pollution Bill. 1:166_167.

Stallard, M., V. Hodge and E. D. Goldberg. 1987. TBT in California coastal waters: Monitoring and assessment. Environm. Monit. and Assmt. 9:195-220.

Sunn, Low, Tom and Hara. 1974. Final Report of the Investigation of Hawaii Kai Marina Waters. Prepared for Kaiser-Aetna, Corp.

U.S. Army Corps of Engineers. 1983. A decade of ecological studies following construction of Honokohau small boat harbor. U.S. Army Engineer District, Honolulu, Hawaii.

U.S. Army Engineer District. 1975. Final Environmental Statement for Department of the Army Permit Action in the Hawaii Kai Marina, Oahu, Hawaii. Corps of Engineers, Pacific Ocean Division.

U.S. Fish and Wildlife Service (Department of the Interior). 1985. Endangered and threatened wildlife and plants; Review of plant taxa for listing as endangered and threatened species; Notice of Review. Fed. Reg. 50(188): 39526-39527 plus 57pg. table of plants.

Wallace, N. 1985. Debris entanglement in the marine environment. A review. pp. 259-277 In: R. S. Shomura and H. O. Yoshida (eds.), Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26-29 November 1984, Honolulu, Hawaii. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-54.

Water Resources Research Center. 1973. The Quality of Coastal Waters, Second Annual Progress Report, No. 77. Technical Report No. 31, Estuarine Pollution in the State of Hawaii, Vol. 1.

Wehner, M. P. 1978. Trace elements and pesticides. pp. 88-127 In: Environmental Studies of Newport Bay. Orange County Human Services Agency, Public Health and Medical Services, Environmental Health Division, Water Quality Control Section. Water Resources Research Center, 1973.

Wehner, M. P., J. L. Abati and H. G. Schroth. 1972. (Revised 1977). Analysis of heavy metals and chlorinated hydrocarbons in Newport Bay sediments. Orange County Health Dept. Report.

Wood, D. R., L. Green and C. Tennis. 1972. Field investigation report: boat yards in Lower Newport Bay. U.S. Environmental Protection Agency Report, Region IX, San Francisco.

Young, D. R., T. C. Heeson, K. J. McDermott and P.E. Smokler. 1974. Marine inputs of polychlorinated biphenyls and copper from vessel antifouling paints. SCCWRP Report TM 212.

Young, D. R. and K. J. McDermott. 1975. Trace metals in harbor mussels. SCCWRP Annual Report for the Year Ended 30 June 1975: 139-142.

Young, D. R. and G. V. Alexander. 1977. Metals in mussels from harbors and outfall areas. Southern California Coastal Water Research Project Annual Report for the Year Ended 30 June 1977: 159-165.

Young, D. R., A. J. Mearns, T. K. Jan, T. C. Heeson, M. D. Moore, R. P. Eganhouse, G. P. Hershelman and R. W. Gossett. 1980. Trophic structure and pollutant concentrations in marine ecosystems of Southern California. CalCOFI Report, Vol. XXI.

CHAPTER SEVEN

CHAPTER VII

PARTIES CONSULTED AND THOSE WHO PARTICIPATED IN THE PREPARATION OF THE EIS

1. CONSULTED PARTIES

The notice of availability of the Supplemental EIS Preparation Notice (EISPN) for the Mauna Lani Cove (formerly Mauna Lani Marina) was published in the OEQC Bulletin by the Office of Environmental Quality Control on March 23, 1989. The agencies, organizations, and individuals listed below were sent copies of the EIS Preparation Notice (EISPN) with the Environmental Assessment (EA) and were asked to comment on the project. Everyone believed to have an interest in the project or who requested consulted party status was included in the mailing. Those who responded to the request for comments are marked with an asterisk (*) and copies of the correspondence with them are reproduced in Chapter VIII.

<u>Federal Agencies</u>

- * U.S. Army Engineer District, Honolulu
- * U.S. Department of Agriculture, Soil Conservation Service
- * U.S. Department of Commerce, National Marine Fisheries Service
- U.S. Department of the Interior, Fish and Wildlife Service
- * U.S. Department of the Interior, Geological Survey, Water Resources Division
- U.S. Department of the Interior, National Park Service
- U.S. Department of Transportation, U.S. Coast Guard

<u>State Agencies</u>

- * Department of Accounting and General Services
- * Department of Agriculture
- Department of Business and Economic Development
- * Department of Budget and Finance
- * Department of Education
- Department of Hawaiian Home Lands
- Department of Health
- * Department of Land and Natural Resources
- * Department of Transportation
- * Housing Finance and Development Corporation
- Office of Environmental Quality Control
- * Office of Hawaiian Affairs
- * Office of State Planning
- * University of Hawaii, Environmental Center
- University of Hawaii, Water Resources Research Center

State Legislators

Senator Andrew Levin
Senator Richard M. Matsuura
Senator Malama Solomon
Representative Jerry L. Chang
Representative Harvey S. Tajiri
* Representative Wayne Metcalf
Representative Dwight Y. Takamine
Representative Virginia Isbell
Representative Mike O'Kieffe

Hawaii County

* Office of the Mayor
Civil Defense Agency
* Department of Parks and Recreation
* Department of Public Works
Department of Research and Development
* Department of Water Supply
* Hawaii Redevelopment Agency
Office of Housing and Community Development
* Fire Department
Police Department
Councilman Russell S. Kokubun, Chair
Councilman Takashi Domingo
Councilwoman Helene H. Hale
Councilwoman Lorraine R. Inouye
Councilwoman Merle K. Lai
Councilman Robert H. Makuakane
* Councilman Harry S. Ruddle
Councilman Spencer K. Schutte
Councilman Stephen K. Yamashiro

Public Utilities

Hawaiian Telephone Company
Hawaii Electric Light Company, Inc.
The Gas Company, Hawaii Division

Community Organizations and Other Public Interest Groups

Alu Like, Inc.
American Lung Association of Hawaii
Big Island Business Council

Hawaii Audubon Society
Hawaii Conference Foundation
Hawaii Hotel Association - Big Island Chapter
Hawaii Island Chamber of Commerce
Hawaii Island Board of Realtors
Hawaii Island Economic Development Board
Hawaii Leeward Planning Conference
Hawaii Island Portuguese Chamber of Commerce
Hawaii Visitors Bureau - Big Island Chapter
Kona-Kohala Chamber of Commerce
* Life of the Land, Big Island Chapter
Moku Loa Group, Sierra Club - Hawaii Chapter
Na Ala Hele
Native Hawaiian Legal Corporation
* Puako Community Association
* Public Access Shoreline Hawaii (PASH)
* Sierra Club Legal Defense Fund, Inc.
* The Ocean Recreation Council of Hawaii (TORCH)
Waimea-Kawaihae Community Association

2. DRAFT SUPPLEMENTAL EIS

The Draft Supplemental EIS was officially submitted to the Office of Environmental Quality Control (OEQC) on December 5, 1989 and notice of its availability published in the OEQC Bulletin on December 8 and 23, 1989 and January 8 and 23, 1990. The official date for receipt of comments was January 22, 1990, which was extended by the applicant to February 5,1990 to accommodate additional public review. All comments and responses thereto, received as a result of the 60-day public review period are included in Chapter IX.

3. PUBLIC/COMMUNITY INVOLVEMENT

In addition to preparation, submittal and public review of the Draft Supplemental EIS, Mauna Lani Resort, Inc. is continuing to conduct a community involvement program regarding the proposed project as well as other activities at the resort. The following identifies the community group/governmental agency meetings that have been held to date.

<u>Community Organizations Meetings:</u>

Big Island Economic Development Board, January 6, 1989
Puako Community Association Executive Board, January 12, 1989
TORCH, May 24, 1989
Puako Community Association, December 7, 1989
ILWU Senior Managers, January 8, 1990

Kohala Community Association, February 20, 1990
Hawaii Leeward Planning Conference Executive Board, February 23, 1990
Puako Community Association, March 24, 1990
Big Island Press Club, March 1, 1990
West Hawaii Communicators Group, April 26, 1990
Na Ala Hele, June 16, 1990

Governmental Agency Meetings:

Mayor B. Akana and Cabinet, January 13, 1989
Big Island State Legislators, January 19, 1989
Office of State Planning and Coastal Zone Management Program, September 25, 1989
Governor John Waihee, December 13, 1989
Board of Land and Natural Resources, January 10, 1990
Office of Environmental Quality Control, February 1, 1990
UH Environmental Center, April 11, 1990
Department of Land and Natural Resources, June 7 & 8, 1990
National Marine Fisheries Service, U.S. Fish and Wildlife Service and University of Hawaii, June 28 & 29, 1990

In addition to the above, several informal meetings have been held with individuals of community groups and governmental agencies. As noted above, these meetings will continue as the proposed project moves forward and informational updates become available.

4. ORGANIZATIONS AND INDIVIDUALS WHO ASSISTED IN THE PREPARATION OF THIS EIS

The Environmental Impact Statement was prepared for Mauna Lani Resort, Inc. by Belt Collins & Associates with input provided by subconsultants. The following were involved:

Mauna Lani Resort, Inc.

Kenneth F. Brown	-	Chairman of the Board
Makoto "Max" Yuki	-	President
Francine Duncan	-	Vice President
Gordon A. Chapman	-	Manager of Environmental Affairs
Marcia Stevens	-	Director of Planning and Design
Leilani Hino	-	Director of Community Affairs
Sharon Ishimine	-	Director of Communications
Norman Ah Hee	-	Resort Services Manager

Belt Collins & Associates

James R. Bell	-	Principal in Charge
Anne L. Mapes	-	Contributor/Project Manager
Ed Iida	-	Contributor/Civil Engineer
Neal Kasamoto	-	Contributor/Civil Engineer
Thomas Nance	-	Contributor/Hydrologist
Ken Hamilton	-	Production Coordinator
Karon Aoki	-	Graphic Designer
Amy Yamakawa	-	Graphic Designer
Lynn Fukuhara	-	Word Processor

Subconsultants

Gordon A. Chapman	-	Contributor/Principal Author
Peratrovich, Nottingham & Drage, Inc.	-	Marina Engineering
ROMA Design Group	-	Marina Design/Architectural Concepts
Natelson-Levander-Whitney, Inc.	-	Economic and Fiscal Impact Analysis/Market Survey
Hydro Research Science, Inc.	-	Hydraulic Modeling
Mader Consulting Co.	-	Tsunami Wave Modeling
Char & Associates	-	Botanical Survey
Phillip L. Bruner	-	Avifauna and Feral Mammals Survey

Marine Research Consultants	-	Marine and Pond Environments Assessment
Sea Engineering, Inc.	-	Coastal Processes Investigations and Wave and Current Analysis
Environmental Assessment Co.	-	Green Turtles Study
AECOS, Inc.	-	Humpback Whales Study
Paul H. Rosendahl, Ph.D., Inc.	-	Archaeological Inventory Survey
James Morrow	-	Air Quality Impact Analysis
Y. Ebisu & Associates	-	Noise Impact Analysis
OCEES International, Inc.	-	Water Quality and Exchange Characteristics
Edward K. Noda & Associates	-	Sediment Plume Modeling

CHAPTER EIGHT

CHAPTER VIII

COMMENTS RECEIVED DURING THE EIS PREPARATION NOTICE COMMENT PERIOD AND RESPONSES

The agencies and individuals listed in Chapter VII were all sent copies of the Environmental Impact Statement Preparation Notice (EISPN) with the Environmental Assessment (EA) and a transmittal letter requesting comments. Copies of the EISPN and the transmittal letter, their comment letters, and our responses to them, are reproduced. Those agencies and individuals responding to the transmittal letter with a "no comment" received no letter in response.

AGENCIES, ORGANIZATIONS, AND INDIVIDUALS RESPONDING TO THE TRANSMITTAL LETTER WITH "NO COMMENT"

Federal Agencies

U.S. Department of the Interior, Geological Survey, Water Resources Division

State Agencies

Department of Agriculture
Department of Budget and Finance
Department of Education
Department of Transportation

State Legislators

Representative Wayne Metcalf

Hawaii County

Office of the Mayor
Department of Parks and Recreation
Hawaii Redevelopment Agency
Fire Department
Councilman Harry S. Ruddle

AGENCIES, ORGANIZATIONS, AND INDIVIDUALS RESPONDING TO THE TRANSMITTAL LETTER WITH COMMENTS

Federal Agencies

U.S. Army Engineer District, Honolulu
U.S. Department of Agriculture, Soil Conservation Service
U.S. Department of Commerce, National Marine Fisheries Service

State Agencies

Department of Accounting and General Services
Department of Land and Natural Resources
Housing Finance and Development Corporation
Office of Hawaiian Affairs
University of Hawaii, Environmental Center

State Legislators

Office of State Planning

Hawaii County

Department of Public Works
Department of Water Supply

Community Organizations and Other Public Interest Groups

Life of the Land, Big Island Chapter
Puako Community Association
Public Access Shoreline Hawaii (PASH)
Sierra Club Legal Defense Fund, Inc.
The Ocean Recreation Council of Hawaii (TORCH)

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: 8311174304?4, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 3, 1989
89-583 (849.11)

____
____
____

Dear ____________:

Supplemental Environmental Impact Statement (EIS) Preparation Notice
Proposed Mauna Lani Marina, Mauna Lani Resort, Hawaii

Mauna Lani Resort, Inc. proposes to develop a residential/marina project on 88 acres of land at the existing Mauna Lani Resort and to relocate two existing golf holes. The property is identified as TMK: 6-8-22: portions of 1, 3, and 9. The marina project would be situated between the existing Mauna Lani Bay Hotel and the Ritz-Carlton Mauna Lani Hotel, now under construction. The marina project would include 90 to 140 residential house lots and about 175 boat slips, 100 of which would be grouped in a boat basin.

After reviewing a Shoreline Setback Variance application submitted by Mauna Lani Resort, Inc., the Hawaii County Planning Department determined that the proposed action and its potential impacts required the preparation of a Supplemental EIS. An earlier EIS for the entire Mauna Lani Resort, of which the current proposed project is part, had been accepted in 1985.

A Supplemental EIS Preparation Notice (EISPN) was published in the March 23, 1989 issue of the Office of Environmental Quality Control Bulletin.

We request that you or your organization assist us in preparing the Mauna Lani Marina EIS by providing comments on the proposed project as it relates to your jurisdiction and responsibility, special knowledge, or interest. Please indicate in writing specific questions, issues, and topics you believe to be of greatest concern and the reasons why they are. Attached is a copy of the Supplemental EIS Preparation Notice and environmental assessment which describes the project and the potential impacts.

The EIS Regulations stipulate that, upon publication of a preparation notice, interested groups and individuals have 30 days in which to request to become a consulted party and to make comments regarding the environmental effects of the proposed project. We hope that you will be able to respond within this time period.

Thank you for your cooperation. If you have any questions, please call me at 521-5361.

Sincerely,

Anne L. Mapes

Enclosure

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE

ENVIRONMENTAL ASSESSMENT

MAUNA LANI MARINA

MAUNA LANI, SOUTH KOHALA, ISLAND OF HAWAII

I. APPLICANT: Mauna Lani Resort Inc.
c/o Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

II. EIS CONSULTANT: Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813
(808) 521-5361

III. ACCEPTING AUTHORITY: Planning Department for the the Planning Commission
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

IV. CLASS OF ACTION: Development proposing (1) use of land within the minimum 40-foot shoreline setback area of the County of Hawaii and(2) use of State lands makai of the shoreline.

V. BRIEF DESCRIPTION OF THE PROPOSED ACTION:

The proposed 88-acre Mauna Lani Marina project would be situated on an oceanfront parcel between the existing Mauna Lani Bay Hotel, and the Ritz-Carlton Mauna Lani Hotel at Pauoa Bay and a second 18-hole golf course that are currently under construction, at the master planned Mauna Lani Resort. The 1,432-acre Mauna Lani Resort Complex is located between State-owned lands at the end of Puako Beach Drive, now leased to Mauna Lani for a public beach park now under construction and the Waikoloa Beach Resort, on the South Kohala coast of the Island of Hawaii. The proposed marina project will include 90 to 140 residential house lots, about 175 boat slips, 100 of which would be grouped in a yacht boat basin, a boat launching area, fuel dock, dry storage and docking, retail facilities, yacht club, restaurant and parking areas. The boat basin and related facilities would be adjacent to the Mauna Lani Bay Hotel tennis courts and screened from the roadway by a landscaped buffer. It is envisioned as a private amenity for property owners at Mauna Lani Resort as well as for Mauna Lani Bay Hotel and resort/condominium guests.

TAX MAP KEY: 6-8-22: Portions of 1, 3, and 9.

VI. BACKGROUND

The Mauna Lani Resort has been master planned as a luxury destination resort since the mid-1970's. Built to date are the 351-room Mauna Lani Bay Hotel, the 80-unit Mauna Lani Terrace condominium project, the 116-unit Mauna Lani Point condominium project, the Francis I'i Brown championship golf course and golf

clubhouse, a beach club, a racquet club, and other recreational and resort amenities. Other residential and commercial projects are in various stages of development and planning.

In 1985, an Environmental Impact Statement and Revised Master Plan for Mauna Lani Resort (Belt Collins & Associates) was prepared as part of the environmental review required for considering a request to amend the State Land Use District boundaries from Agricultural and Conservation to Urban. In 1986, an Environmental Impact Statement for the Ritz-Carlton Mauna Lani Hotel (Belt Collins & Associates) was prepared pursuant to Hawaii County environmental review. Both EIS's were accepted and various county and state land use changes have been approved, allowing construction of the two hotels, golf courses and related facilities.

Since the marina project was not specifically described or assessed in either EIS process, the proposed development would require a supplemental statement.

West Hawaii currently has four locations for berthing or mooring boats: Honokohau, Kailua-Kona, Keauhou and Kawaihae Harbors. Another marina at Kohanaiki is currently in the planning and environmental analysis stages of development. Each of the present harbors has limited facilities and mooring wait lists up to several years long. The proposed Kohanaiki marina is expected to primarily accommodate motor boats due to the popularity of sportfishing in the West Hawaii area. The proposed Mauna Lani Marina is expected to primarily accommodate motor sailboats and projections on vessel type and size distributions will be used as guidelines in the design of the marina.

VII. DESCRIPTION OF THE PROPOSED PROJECT

Residential Development

Mauna Lani Resort will market 90 to 140 house lots having a minimum lot size between 10,000 and 15,000 square feet, with buyers contracting to construct their own residences in accordance with Mauna Lani Marina design guidelines. The current marina project plan includes 92 house lots: 75 with dock, 10 with ocean view but no direct water access, and 7 with golf course frontage. It is anticipated that the house lots with docks will be terraced to take advantage of views while providing convenient access to the water.

Since the existing zoning of the parcels will not accommodate the newly proposed uses, the applicant will be using the Supplemental Environmental Impact Statement to support subsequent applications for rezoning, Shoreline Setback Variance, Special Management Area Use Permit, Use Permit, as well as Conservation District Use Permit, U.S. Army Corps Permit, State Department of Health Water Quality Permit, Coastal Zone Management Certification, U.S. Coast Guard Bridge Permit and various other permits.

Boat Basin and Related Facilities

The boat basin and related facilities, as shown in Figure 3, would be adjacent to the Mauna Lani Bay Hotel tennis courts and screened from the roadway by a landscaped buffer. It is envisioned as a private amenity for property owners at Mauna Lani Resort as well as for Mauna Lani Bay Hotel and resort/condominium guests. As currently planned, facilities would include the following:

Boat launching area
Fuel dock
Dry storage and docking
Retail facilities
Yacht Club
Restaurant
Parking
Slips for 100 boats plus rafting

Types of Boat Use		Boat Size	
Non-marina waterfront residents & guests	80	Under 30'	48
		Under 40'	26
Transient	10	Under 50'	10
Commercial	10	Under 60'	8
		Under 80'	8
TOTAL	100	TOTAL	100

The boat ramp and boat services would, in general, be reserved for resort property owner/guest and commercial use. However, the general public would have boat access to the marina from the channel entrance, with the marina serving as a safe harbor in times of harsh weather.

Circulation and Access

Vehicular traffic to the residential/marina project would be via the main resort road from Queen Kaahumanu Highway. The major marina project road would branch off to the right of the existing road which continues to the Mauna Lani Bay Hotel and traffic to the two residential islands will be by bridge. Those residential lots closest to the Mauna Lani Bay Hotel would be served by a roadway which branches off from the hotel roadway near the hotel parking.

Lateral pedestrian shoreline access from the adjacent parcels would be maintained by way of a shoreline path and a pedestrian bridge. Although the type of bridge to be constructed has not yet been determined, pending further analysis, it is probable that it will be a drawbridge that allows both boat access and convenient pedestrian access. An interpretive center by the bridge is planned.

Marina Design and Construction

The shoreline portion of the project (see Figure 3) would be maintained as an open area, with little disturbance to the natural terrain except in the area of the entrance channel and marina approach. Ponds in the shoreline area and in designated house lots are planned to be undisturbed, and those in the residential parcels would be integrated into the overall design.

Channel depths within the marina project would vary between approximately -6 and -18 feet, the deepest at the entry. A depth of -15 feet would be maintained in the channels closest to the shoreline and in the boat basin, allowing free movement of the larger vessels. Channels fronting the mauka house lots would be -6 to -12 feet. Within the marina project, channel widths would be a minimum of 125 feet.

Excavation seaward of the existing shoreline and excavation inland could proceed as two independent projects, to be linked when both operations are essentially completed. The natural beach would

be left in place as a dike until the entire channel network is excavated.

Current bathymetric data indicates that a submerged basaltic lava flow extends seaward of the shoreline for a distance of about 500 to 600 feet, in depths up to -10 feet MLLW (mean low low water). An entrance channel about 150 feet wide, -18 feet deep and 600 feet long would be excavated. During construction of the entrance channel, a jack-up barge would be used to drill and load holes for subsequent blasting, if required. Further analysis is underway to determine the size of charges to be used. A mobile barge with a large backhoe or dragline would excavate the material obtained from blasting and load it onto another barge for transport to an upland stockpiling site at Mauna Lani Resort. It is anticipated that all work would be performed using barges and that there would be no fixed structures or fill placed in marine waters. If required, silt curtains will be used to control siltation.

The channels within the marina would be excavated using conventional land-based equipment. It is currently unknown whether blasting will be used. Experience in similar basalts in the project area indicates that the material can be ripped without the use of explosive charges. However, blasting would be an option if ripping alone is determined to be too time consuming and cost-prohibitive.

Relocation of Golf Holes

The proposed project includes relocating two golf holes which are adjacent to the Mauna Lani Bay Hotel (see Figure 3 for relocated holes 2 and 3). Preliminary analysis indicates that the size of the currently resort-zoned parcel is insufficient for the development of an economically viable project with both residential and marina components. Relocating the two golf holes to a more upland location would allow additional acreage to be used for the marina project.

VIII. DESCRIPTION OF THE AFFECTED ENVIRONMENT

Topography and Soils

The existing topographic relief of the project site results from the layering and buckling of successive lava flows that have emanated from Mauna Loa and Mauna Kea. The overall slope of the project site is less than 10 percent. The topography of adjacent lands has been modified to a limited extent by the construction of the Mauna Lani Bay Hotel and golf course and the present construction of the Ritz-Carlton Mauna Lani Hotel. Due to the recent geologic history of the project site, the soils of the project site and area are thin and poorly developed.

Two soil types (Pahoehoe lava and rock land and Beach Areas), are found on the majority of the projebt site. The narrow beach area occurs along the shoreline. None of the land within the project site is classified in the ALISH classification system due to its unsuitability for agricultural use.

Hydrology and Drainage

There are no streams or natural drainageways crossing the project site. The highly porous nature of the pahoehoe lavas prevents any significant surface runoff. Groundwater flow in the proposed project area and beneath the project site have been

estimated to range from 3.0 to 7.0 million gallons per day (MGD) per coastal mile. The groundwater below the project site is brackish and generally unsuitable for potable or irrigation purposes due to sea water intrusion.

Flora and Fauna

The project site presently consists of two general vegetation cover types: (1) Kiawe scrub rockland and (2) coastal strand. Based on the field surveys conducted for the Mauna Lani Resort EIS, the terrestrial fauna of the project site consists mostly of exotic (introduced) species. A complete botanical survey of the project site would be conducted as part of the EIS field studies

The terrestrial fauna of the project site and area have been described in the previous EIS's proposed for the Mauna Lani Resort Revised Master Plan and Ritz-Carlton Mauna Lani Hotel. Field surveys have found that the fauna consisted mostly of exotic (introduced species) such as the Common Myna (Acrideotheres tristis), House Sparrow (Passer domesticus) and Nutmeg Mannikin (Lonchura punctulata). The only indigenous bird species recorded during a 1984 survey was the Pacific Golden Plover (Pluvialis fulva). Individuals of the indigenous Black-crowned night Heron have also been observed in the project area. Other introduced shorebird species observed in the area include Wandering Tattler (Heterscelus incanus), Ruddy Turnstone (Arenaria interuptus) and Bristle-thighed Curlew (Numenius tahitiensis). All of the bird species recorded in the area are relatively common throughout Hawaii. Due to the lack of appropriate shallow water and wetlands habitat, the project site is not suitable for nesting or feeding by endangered or threatened native birds.

The most common mammals found within the proposed project area include the Small Indian Mongoose (Herpestes auropunctatus) and small herds of feral goats (Capra hircus linnaeus). The endangered Hawaiian hoary bat (Lasiurus cinereus semotus) may frequent the site, but none have been sighted during bird or mammal surveys of the area and none have been reported in the area since a dead specimen was found on the grounds of the Royal Waikoloa Hotel, approximately two miles south of the project site.

Nearshore and Anchialine Ponds

The shoreline area of the project site contains several anchialine and old fish ponds. There are five major ponds with surface areas of more than 3,000 square feet and several smaller ponds ranging in size from a few square feet to a few hundred square feet. The ponds are in various stages of senescence, with some exhibiting anaerobic conditions due to infilling by wind-blown sand and vegetation and detritus. Those that are in relatively good condition are presumed at this time to contain the typical assemblage of Hawaiian anchialine pond organisms, such as the small red shrimp (Halocaridina rubra and Metabetaeus lohena) and the usual algal crust (Schizothrix caricola and Rhizocloniumm sp). It is also possible that some ponds contained tilapia (Tilapia mossambica), mosquito fish (Gambusia sp.) or topminnows (Poecilia mexicana) which would reduce population levels of the small red shrimp; however, none are known to be currently in the ponds. A

complete pond and marine survey of the project site and offshore area would be performed as part of the EIS field studies.

Marine Environment

The ocean waters offshore of the project site are classified Class AA by the State Department of Health. The area is also classified a "wet" coastal area due to the quantity of freshwater discharge along the coastline.

The bathymetry of the project site is gently sloping to a depth of about 60 feet approximately 1,600 feet offshore and then descend rapidly. Based on wave measurements discussed in the Ritz-Carlton Hotel EIS, direct wave exposure of the project site is limited to waves bearing 225 to 300 degrees. Wave heights of flat to less than two feet occur about 47 percent of the time and wave heights less than four feet occur 94 percent of the time. Wave periods are generally less than 12 seconds. Water currents fronting the project site are relatively slow (0.5 knot or less) northeast to southwest drift parallel to the trend of the shoreline.

Based on nearshore marine surveys conducted for the Mauna Lani Resort Revised Master Plan and Ritz-Carlton Mauna Lani Hotel, the existing coastline of the Mauna Lani Resort is comprised of a variety of fringing coral reef environments that are typical of the west coast of the Island of Hawaii. The shoreline consists of carbonate-basalt beach areas and vertical basalt shoreline cliffs. Along portions of the areas having beach shorelines, the shallowest offshore zone (to a depth of about 15 feet) is usually a flat, relatively barren limestone platform having little or no coral cover. In areas where the shoreline consists of a vertical basalt cliff, the nearshore area is characterized by basalt boulders that provide a complex, three-dimensional reef surface sheltering reef fish and mobile invertebrates and solid settlement places for sessile forms. Seaward of both the reef flat and shoreline boulder areas is the Porites-reef building zone, with live coral colonies dominating the bottom cover, forming a solid limestone surface.

The marine biological community of the project site area is expected to be typical of other similar West Hawaii coastlines. As noted previously, reef building Porites coral are found offshore and it is likely that other corals, such as Pocillopora meandrina, are also found in the inshore areas subjected to higher wave energy. Similarly, typical reef and food fishes are expected to occur off the project site area. These fishes would include goatfish, opelu, snapper, squirrelfish, parrotfish, surgeonfish and jacks. Additionally, three species of endangered or threatened marine animals are known to seasonally inhabit the water off the coastline. These include the threatened green turtle, the endangered hawkbill turtle and the endangered humpback whale. The area is now known as a hawkbill turtle resting, breeding or aggregating area.

Bathymetric and marine surveys of the offshore area are underway and a marine biology and water chemistry survey would be conducted as part of the EIS field studies.

Archaeological and Cultural Resources

The Mauna Lani Resort and proposed project area are rich in historic resources and archaeological features and have been the subject of numerous surveys. Mauna Lani Resort, Inc. has adopted an interpretive and management plan to preserve and display these resources in an orderly manner. As a result of previous archaeological resource surveys for both the Mauna Lani Resort and Ritz-Carlton Mauna Lani Hotel, approximately 20 archaeological sites, of varying significance, within the proposed project boundaries have been located and recorded. These sites include shelter cave complexes, cairns, small midden deposits and other features. A complete, detailed archaeological reconnaissance survey of the project area would be conducted as part of the EIS field studies.

Natural Hazards

There are three potential natural hazards to which the proposed project may be subjected: (1) Volcanic hazards; (2) Tsunamis; and (3) Floods caused by high waves and/or storm waves. The US Geological Survey (USGS) has assessed the volcanic hazards of the project site. The project lies within lava hazard Zone 2, indicating that the area is subject to burial by lava flow from Mauna Loa. About 5 percent of the Zone 2 areas have been covered with lava since 1950 and about 20 percent within historical time. The last Mauna Loa lava flow that reached the project area in the vicinity of 'Anaeho'omalu Bay, three miles south of the project site, occurred in 1859. The project site is also located within tephra fall hazard Zone 2, indicating that tephra falls from lava fountains should be frequent but thin. However, the potential hazard for tephra falls diminishes rapidly in severity with increasing distance from vents as both fragment size and thickness decrease. Tephra eruptions from Hualalai have not been known to occur in historical time and the last known eruption of Mauna Kea occurred more than 3,500 years ago. In addition, inundation hazard from slow regional subsidence exists along the entire shoreline of the island. The project area is located in ground fracture and subsidence hazard Zone 4, in which hazards are the least for the entire island.

The project site is subject to tsunamis, with the 12-foot 1946 tsunami being the largest to which the site has been subjected. The Flood Insurance Rate Map (FIRM) for the area and the 1982 Flood Insurance Study for the County of Hawaii, indicate that the 100-year tsunami elevation of the project area ranges from seven to eight feet. The project site falls into designated zones VE and AE indicating that base flood elevations have been determined (8 feet) and coastal flood with velocity hazard (wave action). In the project area, the VE zone extends inland a maximum of about 100 feet from the shoreline and the AE zone extends inland a maximum of about a 100 feet from the inland boundary of the VE zone.

IX. SUMMARY OF MAJOR IMPACTS AND MITIGATION MEASURES

Marine Environment

Impacts to the marine environment resulting from the proposed project could be caused by several factors, including dredging and

blasting (if used) of the marina entrance and water areas, increased sediment loading due to the excavation activities, potential water quality changes due to the development of the marina and the consequent interruption of present groundwater flows and the possible introduction of oily discharges into the marina waters. Other impacts could result from the maintenance of landscaped areas around the marina and houselot landscaping.

During the dredging of the entrance channel, siltation barriers (curtains) would be deployed, if required, to reduce and retard the deposition of coralline silt on adjacent nearshore and offshore marine communities. Should it be necessary, the applicant has indicated that a water quality and marine biological monitoring program could be established during the dredging and excavation activities.

The interruption of groundwater flows directly into the coastline is expected to result in increased groundwater salinity due to the mixing with seawater entering the marina via the entrance channel. This would cause an increase in marine organisms and a decrease in brackish water organisms found along the coastline.

It is expected that the potential discharge of oily wastes would be limited to small surface discharges and rapidly diluted and dispersed throughout the marina areas prior to entrance into ponds or the marina areas prior to entrance into ponds or ocean. These discharges would be similar to those found in other marina areas in the state.

A bathymetric survey of the offshore area is underway and a marine environmental baseline survey to include marine biology and water chemistry would be performed as part of the EIS field studies.

Socio-economic and Land Use Considerations

The irrevocable loss of two acres of naturally occurring reef for the purpose of creating a marina entrance and channel and the establishment of a marine will have direct impacts to current recreational opportunities such as picnicking, swimming, diving, snorkeling and fishing. The extent to which these recreational pursuits are displaced and possible alternative mitigation should be addressed. Public access along the shoreline would be maintained with the exception of the period during which the marine entrance channel is constructed. Management of the public access and the social ramifications of a private marina together with the creation of single-family dwelling parcels along this area of the coastline should be discussed in detail. A socio-economic analyses would be conducted for the EIS.

Nearshore and Anchialine Ponds

As mentioned previously, impacts to the coastal and anchialine ponds will be generated from the marine excavation activities; increased public usage of the pond areas; increased sediment loading during marine excavation and dredging activities; increased nutrient loading due to the maintenance of newly landscaped areas; possible introduction of oily discharges from boat motors operating in the marina; and increased salinity due to the interruption of

groundwater flows. Based on studies conducted at other similar coastal and anchialine ponds, impacts from increased human activity and/or landscaped area maintenance appear to be minimal.

In addition, several ponds will be located within the proposed residential lots. The filling or management of these ponds should be discussed.

A complete pond survey of the project would be performed as part of the EIS field studies.

Natural Hazards

The dredging, shoreline alterations and marina could change the present tsunami and coastal flood hazard zone patterns. The extent of the potential changes should be adequately studied, especially in terms of the height of the proposed fill or terracing and structural implications with regards to flood hazard and tsunami zones. Secondary impacts may be generated by the proposed marina in the area of additional emergency services. The applicant proposes to connect the marina area to the county coastal hazard emergency siren warning system and marina operators would coordinate emergency management procedures with the Civil Defense Agency.

Archaeological and Cultural Resources

As a result of previous archaeological reconnaissance surveys performed for both Mauna Lani Resort and the Ritz-Carlton Hotel, approximately twenty sites of varying significance within the project boundaries have been located and recorded. However, a complete detailed survey would be conducted as part of the EIS field studies in order to know the physical impact of the project on the sites. Thus, a mitigation program can be developed following a significance assessment.

X. DETERMINATION OF SIGNIFICANCE

The proposed project has the potential of significantly altering the environment. Therefore, it is determined that the preparation of a Supplemental Environmental Impact Statement is warranted. To assist in the determination of the above described impacts, the studies listed below have been used to provide background data:

1. Belt Collins & Associates. Final Environmental Impact Statement, The Ritz-Carlton Mauna Lani, Mauna Lani Resort, South Kohala, Hawaii. July 1987.
2. Belt Collins & Associates. Final Environmental Impact Statement Revised Master Plan for Mauna Lani Resort, South Kohala, Hawaii. June 1985.
3. Belt Collins & Associates. Engineering Evaluation of Ocean and Shoreline Conditions at the Ritz-Carlton Hotel Site, Pauoa Bay, South Kohala, Hawaii. December 1986.
4. Community Resources, Inc. Preliminary Summary of Socio-Economic Impacts From Ritz-Carlton and South Kohala Resort Projects. March 1987.
5. Dollar, S. J. Baseline Assessment of the Marine Environment at Pauoa Bay, South Kohala, Hawaii. October 1986.

6. Kirch, P.V. Marine Exploitation in Prehistoric Hawai'i: Archaeological Investigations at Kalahuioua'a Hawaii Island. Pacific Anthropological Records No. 29. Department of Anthropology, B.P. Bishop Museum, Honolulu. May 1979.

The reasons supporting this determination, which are based on the significance criteria in Section 11-200-12 of the Environmental Quality Commission EIS Regulations, are as follows:

1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;
2. Curtails the range of beneficial uses of the environment;
3. Substantially affects a rare, threatened or endangered species, or its habitat;
4. Detrimentally affects air or water quality or ambient noise levels; and
5. Affects an environmentally sensitive area such as a flood hazard area, tsunami zone and coastal waters.

The following areas should receive further study in the Supplemental EIS:

1. Impact of proposed dredging, filling and terracing on flood hazard and tsunami zones and resulting structural (building) implications.
2. Impact of resort residential project on anchialine and nearshore ponds and subsequent management by private individuals.
3. Impact to existing on- and offshore recreational activities.

XI. PARTIES TO BE CONSULTED IN THE PREPARATION OF THE EIS

Federal Agencies

Department of Army, Army Corps of Engineers, Honolulu District
Department of Commerce, National Marine Fisheries Service
Department of Agriculture, Soil Conservation Service
Department of Interior, Fish and Wildlife Service
Department of Interior, Geological Survey, Water Resources Division
Department of Interior, National Park Service
Department of Transportation, U.S. Coast Guard

State Agencies

Department of Accounting and General Services
Department of Agriculture
Department of Business and Economic Development
Department of Budget and Finance
Department of Education
Department of Hawaiian Home Lands
Department of Health
Department of Land and Natural Resources
Department of Transportation
Office of Environmental Quality Control
Office of Hawaiian Affairs
Office of State Planning
Housing Finance and Development Corporation
University of Hawaii Environmental Center
University of Hawaii Water Resources Research Center

State Legislators

Senator Andrew Levin
Senator Richard Matsuura
Senator Malama Solomon
Representative Jerry Chang
Representative Harvey Tajiri
Representative Wayne Metcalf
Representative Dwight Takamine
Representative Virginia Isbell
Representative Mike O'Kieffe

Hawaii County

Office of the Mayor
Civil Defense Agency
Fire Department
Department of Parks and Recreation
Department of Public Works
Department of Research and Development
Department of Water Supply
Hawaii Redevelopment Agency
Office of Housing and Community Development
Police Department

Hawaii County Council

Russell S. Kokubun, Chairman
Takashi Domingo
Helene H. Hale

Lorraine R. Inouye

Merle K. Lai, Vice Chairwoman

Robert H, Makuakane

Harry S. Ruddle

Spencer K. Schutte

Stephen K. Yamashiro

Public Utilities

Hawaiian Telephone Company

Hawaii Electric Light Company

Gasco, Inc., Hawaii Division

Community Organizations and Other Public Interest Groups

Alu Like

American Lung Association

Big Island Chamber of Commerce

Big Island Business Council

Board of Realtors - Island of Hawaii

Hawaii Island Economic Development Board

Hawaii Hotel Association

Hawaii Visitors Bureau - Big Island Chapter

Hawaii Leeward Planning Conference

Hawaii Conference Foundation

Hawaii Audubon Society

Kona Chamber of Commerce

Kohala Chamber of Commerce

Life of the Land

Moku Loa Group, Hawaii Chapter Sierra Club

Native Hawaiian Legal Corporation

Na Ala Hele

Portuguese Chamber of Commerce

Puako Community Association

Waimea-Kawaihae Community Association

XII. LIST OF EXHIBITS

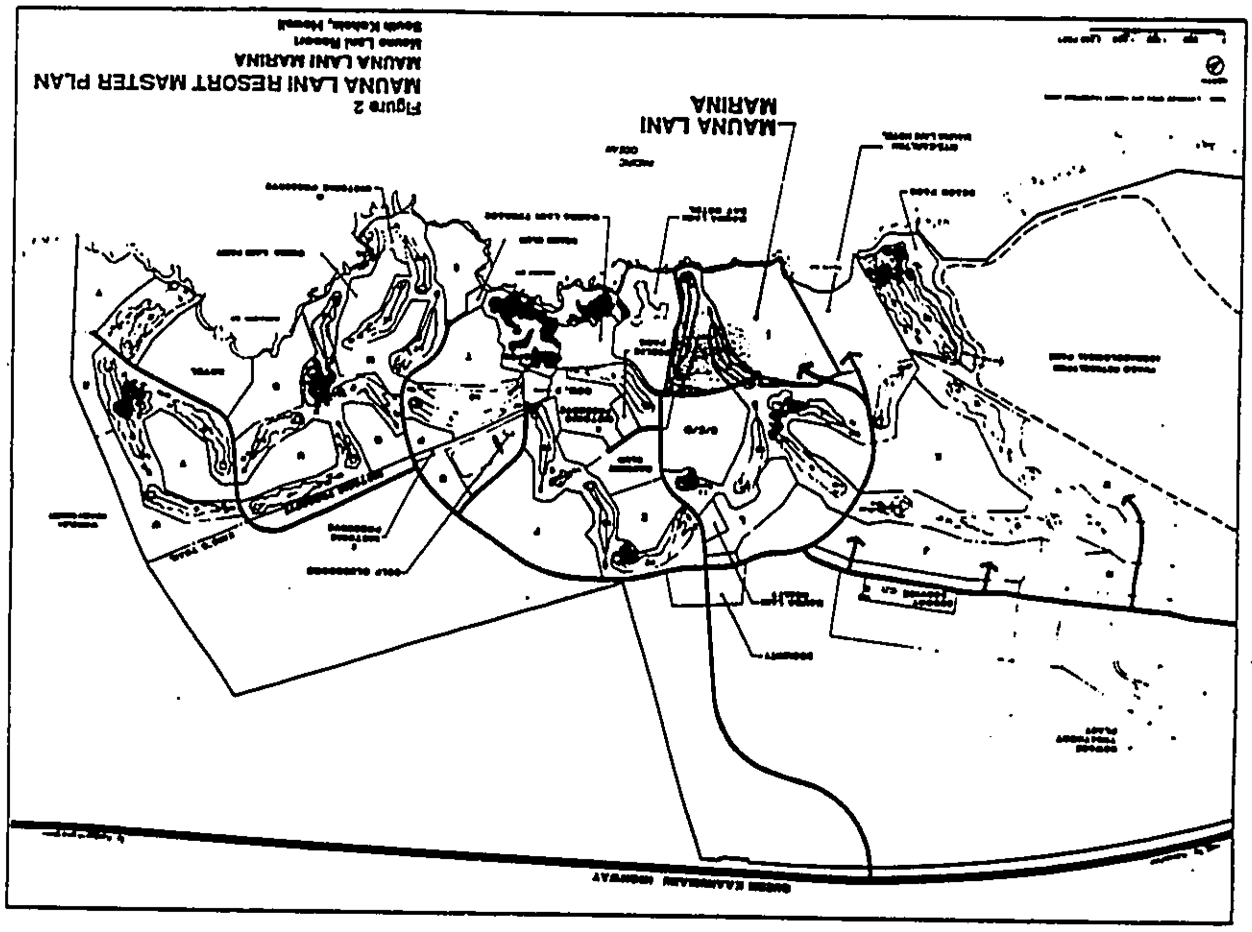


Figure 2
MAUNA LANI RESORT MASTER PLAN
MAUNA LANI MARINA
Mauna Lani Resort
South Kohala, Hawaii

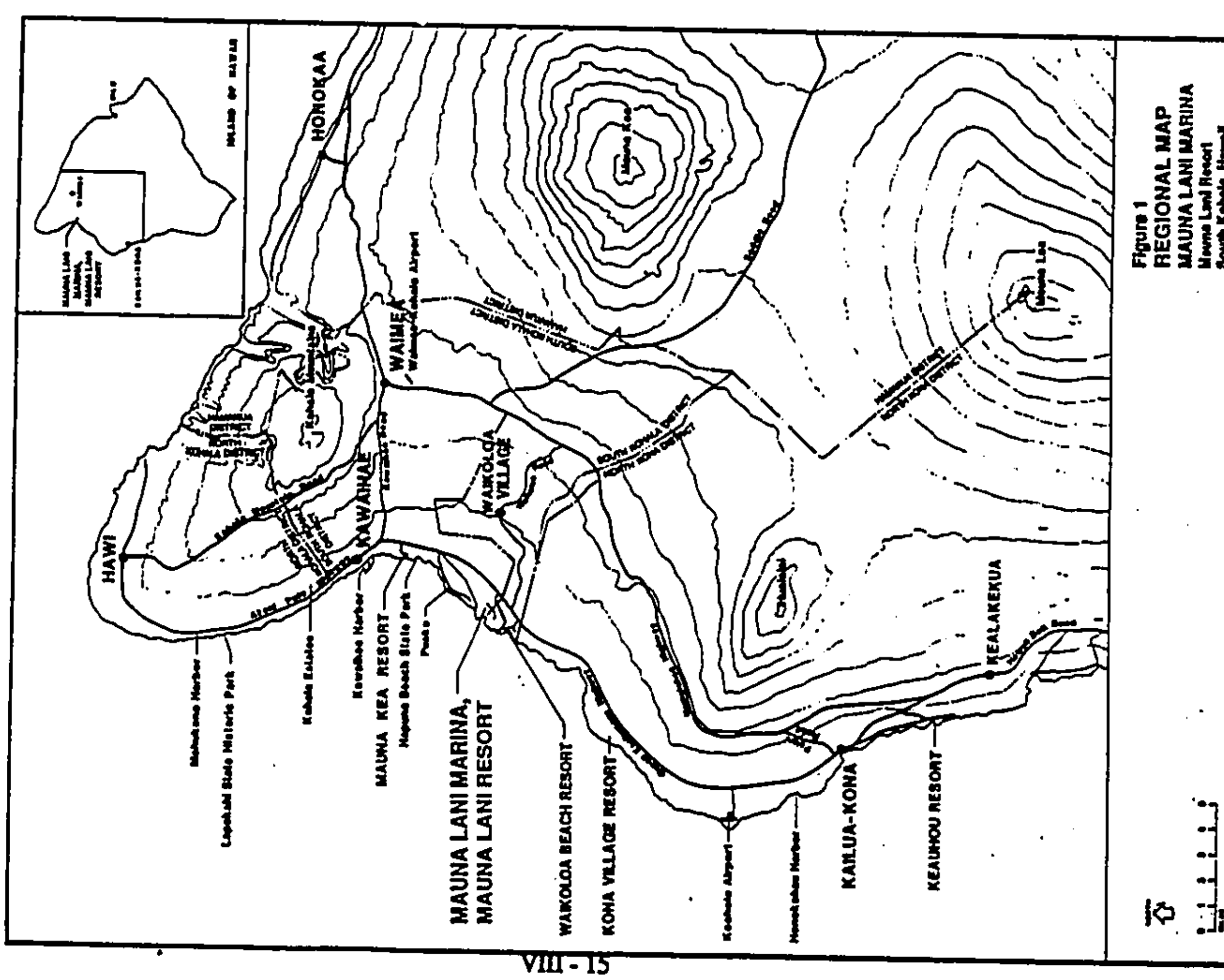


Figure 1
REGIONAL MAP
MAUNA LANI MARINA
Mauna Lani Resort
South Kohala, Hawaii

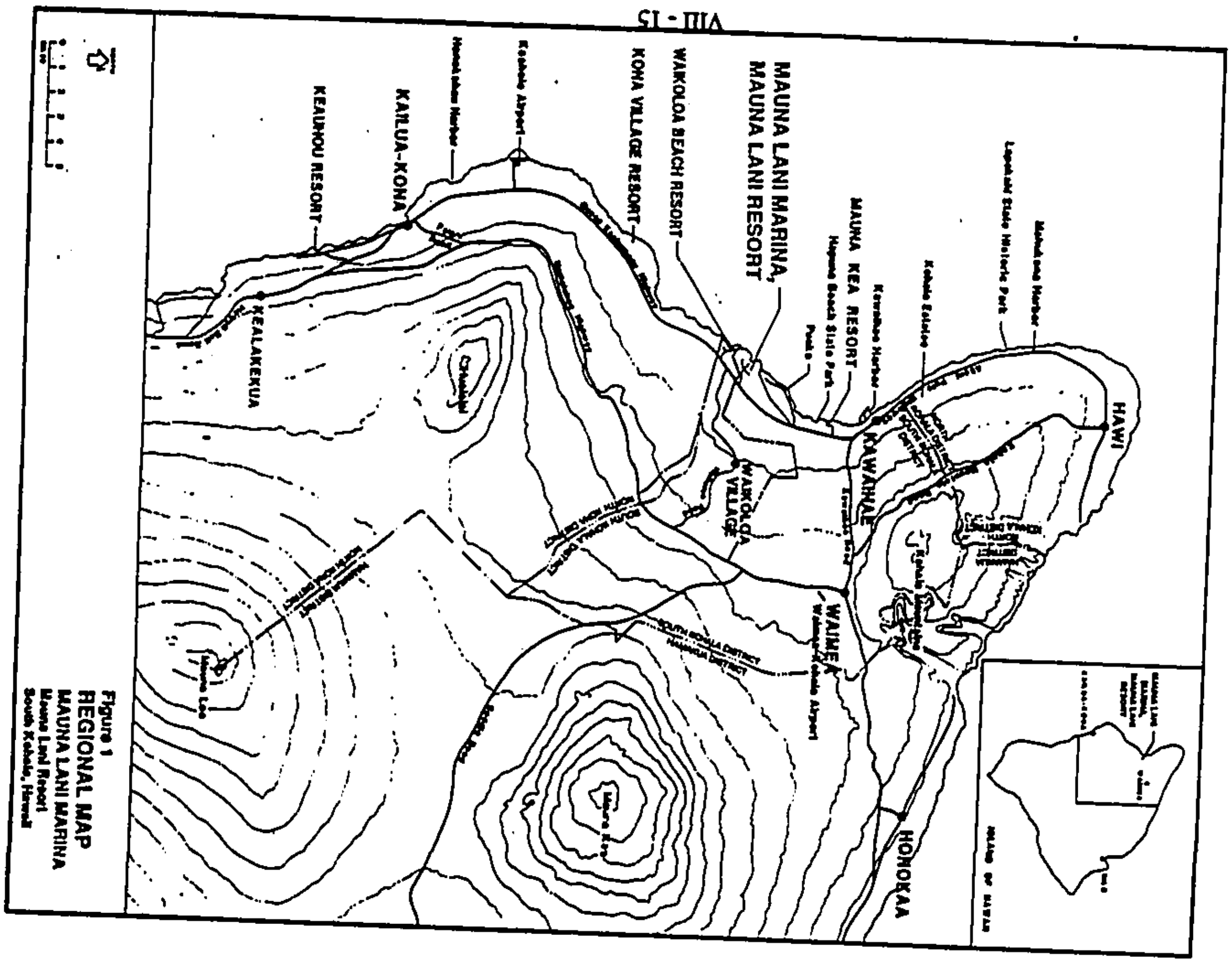


Figure 1
REGIONAL MAP
MAUNA LANI MARINA
Mauna Lani Resort
South Kohala, Hawaii

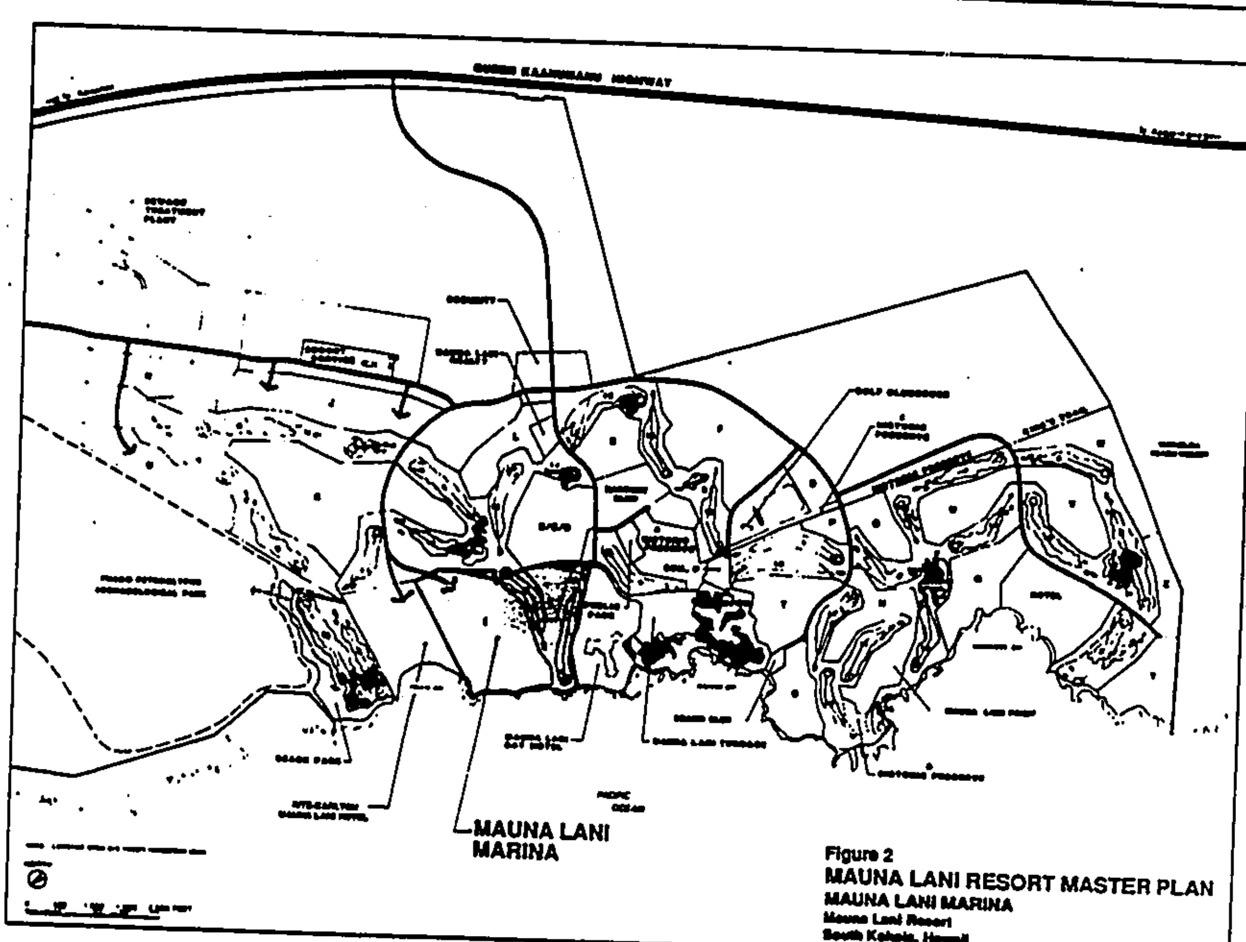
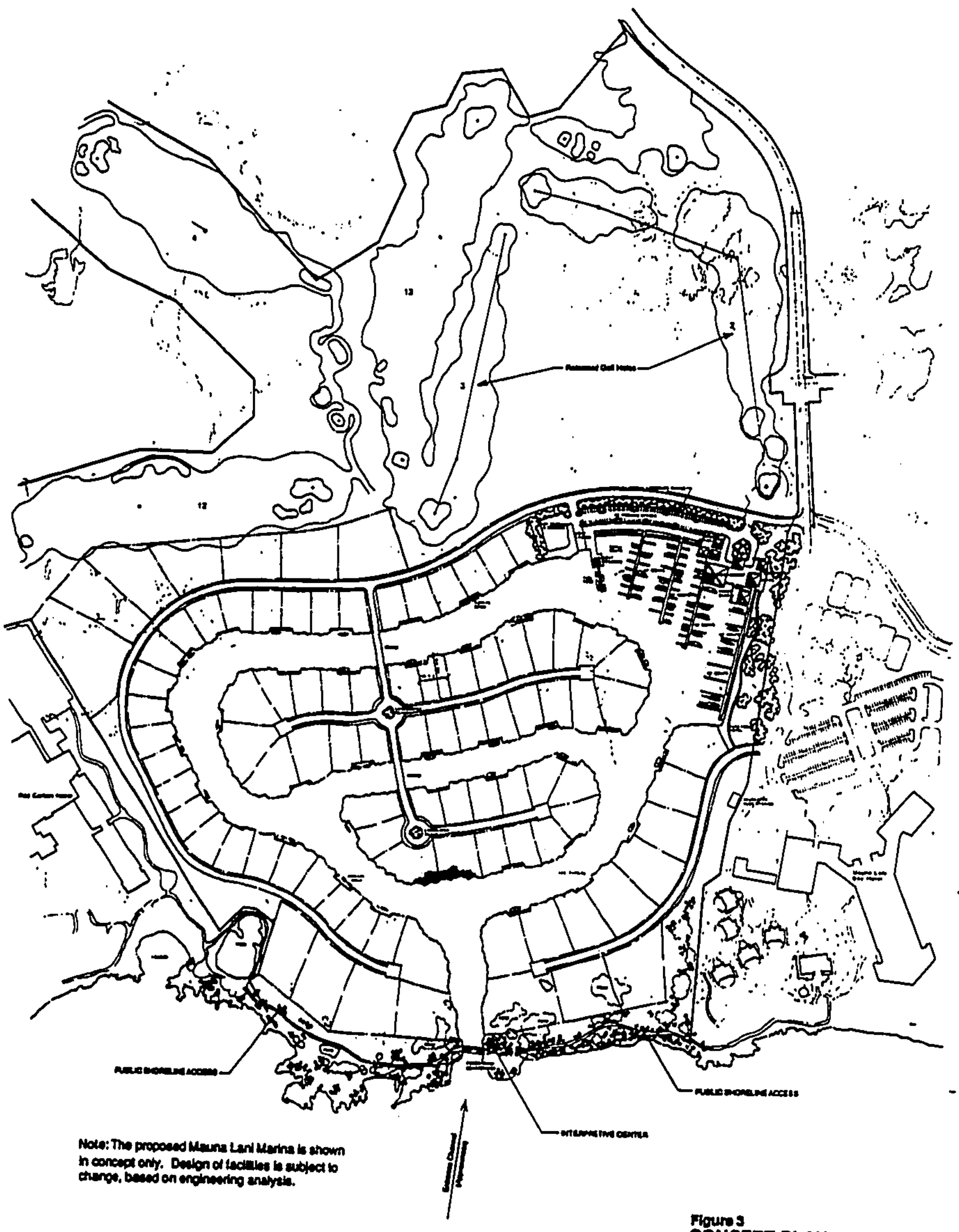


Figure 2
MAUNA LANI RESORT MASTER PLAN
MAUNA LANI MARINA
Mauna Lani Resort
South Kohala, Hawaii



Note: The proposed Mauna Lani Marina is shown in concept only. Design of facilities is subject to change, based on engineering analysis.

Figure 3
CONCEPT PLAN
MAUNA LANI MARINA
Mauna Lani Resort
South Kohala, Hawaii
ROMA Design Group
Belt Collins & Associates
January 1989

#1

RECEIVED
APR 11 1989
BELT, COLLINS & ASSOCIATES

HOUSE OF REPRESENTATIVES
THE FIFTEENTH LEGISLATURE
STATE OF HAWAII
STATE CAPITOL
HONOLULU, HAWAII 96813

April 10, 1989

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

I acknowledge the receipt of your letter asking me to comment on the proposed residential/ marina project on 88 acres of land at the existing Mauna Lani Resort.

Although I have no comment at this time, I thank you for providing me the opportunity to comment on this matter.

With warm personal regards.

Sincerely,

WAYNE METCALF
Hawaii State Representative
Third District

WM:mn

#2

RECEIVED
APR 10 1989
BELT, COLLINS & ASSOCIATES

April 4, 1989

Belt Collins & Associates
680 Ala Moana Blvd St 200
Honolulu Hawaii 96813

Gentlemen:

We request being a consulted party to the EIS preparation notice for the Mauna Lani Marina.

Yours truly,

Jerry Rothstein, Coordinator
Public Access Shoreline Hawaii (PASH)
PO Box 1544, Kailua-Kona Hawaii 96745

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-769 (849.11)

Mr. Jerry Rothstein, Coordinator
Public Access Shoreline Hawaii (PASH)
P.O. Box 1544
Kailua-Kona, Hawaii 96745

Dear Mr. Rothstein:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your April 4, 1989 request to become a consulted party to the preparation of a Supplemental EIS for the proposed Mauna Lani Marina project. Enclosed is a copy of the Supplemental EIS Preparation Notice for your review. A copy of the Draft EIS will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

Attachment

Sunrise, Mt. McKinley — Ansel Adams

SIERRA CLUB
LEGAL DEFENSE FUND, INC.
212 Merchant Street, Suite 202 Honolulu, Hawaii 96813 (808) 599-2436
FAX (808) 521-6841

HAWAII OFFICE
Arnold L. Lum
Michael R. Sherwood
Staff Attorneys
Marjorie F. Y. Ziegler
Resource Analyst

Other Offices
SAN FRANCISCO OFFICE
2044 Fillmore Street
San Francisco, CA 94115
(415) 567-6100
ROCKY MOUNTAIN OFFICE
1600 Broadway St.
Suite 1600
Denver, CO 80202
(303) 863-9898
WASHINGTON, DC OFFICE
1516 P Street, N.W.
Suite 200
Washington, DC 20005
(202) 667-4500
ALASKA OFFICE
325 Fourth Street
Juneau, AK 99801
(907) 586-2751
NORTHWEST OFFICE
216 First Avenue, South
Suite 330
Seattle, WA 98104
(206) 343-7340

RECEIVED #3
APR 13 1989
BELT, COLLINS & ASSOCIATES

April 11, 1989

Belt, Collins & Associates
680 Ala Moana Blvd. Suite 200
Honolulu, Hawai'i 96813

Re: Environmental Assessment and Notice of Preparation of an EIS for the Mauna Lani Marina Project, South Kohala, Hawai'i

To Whom It May Concern:

The Sierra Club Legal Defense Fund would like to request a copy of the Environmental Assessment for the above-referenced project and in addition, would like to be made a consulted party. Thank you very much.

Sincerely,

Marjorie F.Y. Ziegler

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 26, 1989
89-783 (849.11)

Ms. Marjorie F.Y. Ziegler
Sierra Club Legal Defense Fund, Inc.
212 Merchant Street, Suite 202
Honolulu, Hawaii 96813

Dear Ms. Ziegler:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your April 11, 1989 request to become a consulted party to the preparation of a Supplemental EIS for the proposed Mauna Lani Marina project. Enclosed is a copy of the Supplemental EIS Preparation Notice for your review. A copy of the Draft EIS will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

Enclosure

RECEIVED #4
APR 14 1989
BELT, COLLINS & ASSOCIATES

HAWAII REDEVELOPMENT AGENCY
COUNTY OF HAWAII
35 WAILUKU DRIVE • HILO, HAWAII 96720 • PHONE (808) 935-0023

April 13, 1989

Ms. Anne L. Mapes
c/o Belt Collins & Associates
680 Ala Moana Blvd.
Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

Supplemental Environmental Impact Statement (EIS) Preparation Notice
Proposed Mauna Lani Marina, Mauna Lani Resort, Hawaii

Reference your letter of April 3, 1989, subject as above.

This Agency has no comments to submit for preparation of the Mauna Lani Marina EIS. The jurisdiction and responsibility of the HRA is limited to the Hilo area.

Thank you for considering the Agency in your review process.

Very truly yours,

GORDON H. NOBRIGA
Manager

GHN/dd

BCA
BELT COLLINS & ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-771 (849.11)

Mr. H. William Sewake, Manager
Department of Water Supply
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Sewake:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of April 12, 1989 in response to the Supplemental EIS Preparation Notice for the above project. Your concerns will be addressed in the Draft EIS. A copy of the document will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

APR 14 1989
BELT, COLLINS & ASSOCIATES
#5

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720

April 12, 1989

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, HI 96813

SUPPLEMENTAL EIS PREPARATION NOTICE
PROPOSED MAUNA LANI MARINA
TAX MAP KEY 6-8-22: 1, 3, AND 9

Thank you for the opportunity to review the subject document.

The document should include a detailed discussion of the domestic water demands of the project. Mauna Lani Resort's water allocation from the Lalamilo Water System and current water usages for completed and ongoing projects should be noted. Improvements to the Lalamilo Water System, including storage and pipeline, must be constructed. The necessary improvements are currently being discussed with your engineers.

H. William Sewake
Manager

QA

... Water brings progress...

HARRY S. RUDDLE
Councilman

COUNTY COUNCIL
County of Hawaii
Hawaii County Building
25 Aupuni Street
Hilo, Hawaii 96720

#6
RECEIVED
APR 18 1989
BELT, COLLINS & ASSOCIATES

April 17, 1989

Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes,

Thank you for your thoughtful letter of April 3, 1989, supplying me with the information regarding the Proposed Manua Lani Marina, Mauna Lani Resort, Hawaii.

I will definitely review your information carefully, and place it in an active file until council begins deliberations on this issue.

Again mahalo for your thoughtfulness. If I can be of any assistance to you please contact me at my office, 961-8265.

Sincerely,

Harry S. Ruddle
Councilman

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES
DIVISION OF PUBLIC WORKS
P. O. BOX 119, HONOLULU, HAWAII 96810

#7
RECEIVED
APR 18 1989
BELT, COLLINS & ASSOCIATES

COMPTROLLER
DEPUTY COMPTROLLER

LETTER NO. (P)1318.9

APR 14 1989

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard
Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Subject: Proposed Mauna Lani Marina
Supplemental EIS Preparation Notice

Thank you for the opportunity to review the subject document. We have no comments to offer.

Should there be any questions, please have your staff contact Mr. Cedric Takamoto of the Planning Branch at 548-7192.

Very truly yours,

TEUANE TOMINAGA
State Public Works Engineer

CT:jnt
cc: OEQC

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

RECEIVED #8
APR 18 1989
BELT, COLLINS & ASSOCIATES

REPLY TO ATTENTION OF

April 17, 1989

Operations Branch

Ms. Ann L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

We have reviewed the Supplemental Environmental Impact Statement (EIS) Preparation Notice, Proposed Mauna Lani Marina, Mauna Lani Resort, Hawaii and have the following comments to offer:

a. A Department of the Army (DA) permit will be required for the construction of the marina entrance channel, any protective structures, installation of docks or piers within the marina, and for any filling of anchialine ponds or fishponds on the project site. The permit may also cover future maintenance dredging requirements and any temporary fill or causeways built in the water during construction.

b. We note that the preparation notice has addressed the need to provide more information and analysis of the effect of the project on the marine environment and the nearshore and anchialine pond system. Pond filling for residential or non water-dependent purposes must be fully evaluated in terms of practicable alternatives, in accordance with Section 404(b)(1) of the Clean Water Act. Guidance on this analysis is enclosed for your use.

c. The presence of endangered species in the marine environment will require consultation with the National Marine Fisheries Service (NMFS) under Section 7 of the Endangered Species Act. In preparation for this consultation which will be initiated during the DA permit process, the applicant should gather all pertinent scientific and commercially available information on the species' use and habitat conditions in the vicinity of the project area. This information is necessary for the assessment of project impacts on

the species and their critical habitat. Early informal consultation with NMFS is also encouraged to determine specific requirements for an adequate determination of effect.

d. In conjunction with the detailed archaeological survey to be conducted for the EIS, the archaeological consultant should evaluate each site that meets National Register criteria for effect. Assessment of the effect (no effect, no adverse effect, adverse effect) for these sites will facilitate the consultation required under Section 106 of the National Historic Preservation Act of 1966. Finally, we strongly recommend that preservation be fully considered for important sites or sites with interpretive or educational potential, prior to the development of mitigation plans.

We hope these suggestions are helpful in your development of the environmental document. You may contact the Operations Branch at 438-9258 if you have additional questions.

Sincerely,

Stanley T. Arakaki
Stanley T. Arakaki
Chief, Operations Branch
Construction-Operations Division

Enclosure

BCA
BELT COLLINS
& ASSOCIATES

Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-772 (849.11)

Mr. Stanley T. Arakaki
Chief, Operations Branch
Construction-Operations Division
Department of the Army
U.S. Army Engineer District, Honolulu
Ft. Shafter, Hawaii 96858-5440

Dear Mr. Arakaki:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of April 17, 1989 in response to the Supplemental EIS Preparation Notice for the above project. The concerns outlined in your letter will be addressed in the Draft EIS, a copy of which will be sent to you when it becomes available. Also, we shall be submitting shortly to you the necessary Department of the Army permit applications for the construction of the marine entrance channel, installation of docks and piers, and maintenance dredging.

Sincerely,

Anne L. Mapes

ALM:lf

RECEIVED
APR 30 1989
BELT, COLLINS & ASSOCIATES

#9

STATE OF HAWAII
DEPARTMENT OF BUSINESS AND ECONOMIC DEVELOPMENT
HOUSING FINANCE AND DEVELOPMENT CORPORATION
P. O. BOX 29360
HONOLULU, HAWAII 96820-1760

IN REPLY REFER TO:

89:PLNG/1305B jt

April 17, 1989

Ms. Anne L. Mapes,
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Re: Supplemental Environmental Impact Statement Notice and Environmental Assessment for the Proposed Mauna Lani Marina Project

We have reviewed the subject report and offer the following comments.

The draft Supplemental EIS should address the housing implications of the proposed project. For example, how many housing units will be required to accommodate employment stemming from the project? And, if applicable, how will this housing need be mitigated? Also, what is the proposed range of sales prices for the 90 to 140 residential house lots that are proposed for development?

Thank you for the opportunity to comment.

Sincerely,

JOSEPH K. CONANT
Executive Director

cc: Department of Business and Economic Development

PUAKO COMMUNITY ASSOCIATION
P.O. BOX 44345
KAWAIHAE, HAWAII
April 19, 1989

RECEIVED #10
APR 20 1989
BELT, COLLINS & ASSOCIATES

Belt Collins & Associates
680 Ala Moana Blvd.
Honolulu, Hawaii 96813
Attn: Anne Mapes

Aloha:

The Puako Community Association is in receipt of the Supplemental Environmental Impact Statement Preparation Notice for the Proposed Mauna Lani Marina. We thank you for including us in the distribution.

The Association does wish to be a consulted party in this proceeding. Our community is immediately north of the proposed marina and will be substantially affected by all excavation (especially including blasting) seaward and at the marina entrance. We are particularly concerned with all impacts to the marine environment, including the creation of sediment, the effect on marine life and endangered species, and on short and long-term effects on ocean recreation. Another area of particular interest is the maintenance and management of public access.

We look forward to further communication with you.

Very truly yours,

Richard Schulze, President
Puako Community Association

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-773 (849.11)

Mr. Joseph K. Conant
Executive Director
Housing Finance and Development Corporation
State of Hawaii
P.O. Box 29360
Honolulu, Hawaii 96820-1760

Dear Mr. Conant:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of April 17, 1989 in response to the Supplemental EIS Preparation Notice for the above project. Your concerns regarding housing will be addressed in the Draft EIS, a copy of which will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BLLTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-774 (849.11)

Mr. Richard Schulze, President
Puako Community Association
P.O. Box 44345
Kawaihae, Hawaii 96743

Dear Mr. Schulze:

Supplemental Environmental Impact Statement (EIS)
<u>Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii</u>

Thank you for your comments of April 20, 1989 in response to the Supplemental EIS Preparation Notice for the above project and your request to become a consulted party. Your concerns regarding potential impacts to the marine environment and public access will be addressed in the Draft EIS. A copy of the report will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

LIFE OF THE LAND

RECEIVED #11
APR 21 1989
BELT, COLLINS & ASSOCIATES

April 19, 1989

Ms. Anne Mapes
Belt Collins & Associates
680 Ala Moana Blvd., suite 200
Honolulu, HI 96813

Dear Ms. Mapes;

Thanks for your letter of April 3, requesting that Life of the Land participate in the Supplemental EIS preparation for the proposed marina at the Mauna Lani Resort. We would like to officially become a "consulted party", and we offer the following comments for your use in preparing the EIS.

1) Chapter 343 and the Rules and Regulations governing EIS preparation require a thorough study of alternatives. To that end you should investigate alternative locations for the marina project within the Mauna Lani Resort, specifically those which would have a lesser impact on the nearshore marine environment. You should also evaluate the alternative of no marina.

2) On page 19 of the EIS prep notice, one finds three areas listed which should receive further study in the Supplemental EIS. Not mentionned is impact to the coastal marine ecosystem. Nor is mention made of impact to the coastal and anchialine pond system from the construction of the marina. The body of the prep notice clearly acknowledges such impacts, so I presume that the omission on page 19 doesn't indicate a lack of need for such studies.

3) Since the project is located where an excellent reef structure is found in the 15' to 75' depth zone, there is naturally abundant marine life present. This specific area is very familiar to me personally, since I frequently dived here in the 1971 to 1973 period when I lived at Puako. Further inshore there are several hundred feet of shallow shelf which I presume are valuable habitat for invertebrates as well as the young of many fish species. I think it is imperative for your marine work to be thorough and broad-based. The rather narrow meth dology of S. Dollar's work in other EIS's in West Hawaii is not sufficient in my judgement. I would be glad to further discuss my views on this subject.

We anticipate an excellent Supplemental EIS and thank you for the opportunity to participate.

Sincerely,

Bill Graham,
Big Island Chapter

cc: Duane Kanuha

19 Niolopa Place, Honolulu, Hawaii 96817. Tel. 595-3903

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BLLTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-775 (849.11)

Mr. Bill Graham
Big Island Chapter
Life of the Land
19 Niolopa Place
Honolulu, Hawaii 96817

Dear Mr. Graham:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of April 19, 1989 in response to the Supplemental EIS Preparation Notice for the above project and your request to become a consulted party. The concerns outlined in your letter will be addressed in the Draft EIS. For your information, various ocean related studies are being performed for the EIS, including a marine survey.

A copy of the Draft EIS will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

DEPARTMENT OF PUBLIC WORKS
COUNTY OF HAWAII • 25 AUPUNI STREET • HILO HAWAII 96720 • TELEPHONE (808) 961-8321

BERNARD K. AKANA
Mayor
HUGH Y. ONO
Chief Engineer
BRUCE C. McCLURE
Deputy Chief Engineer

RECEIVED
APR 21 1989
BELT, COLLINS & ASSOCIATES

#12

April 19, 1989

MS ANNE L MAPES
BELT COLLINS & ASSOCIATES
680 ALA MOANA BLVD SUITE 200
HONOLULU HI 96813

SUBJECT: SUPPLEMENTAL EIS PREPARATION NOTICE
MAUNA LANI MARINA
South Kohala, Hawaii
TMK: 6-8-22: Por. of 1, 3 and 9

We have reviewed the subject document and we have the following comments:

1. This is an unusual subdivision. Variance will have to be obtained for such items as the cul-de-sac length, the number of lots in a cul-de-sac, etc.

2. How is public access assured if the access at the shoreline is by draw bridge?

3. Where is the legal shoreline after the marina is constructed?

4. The project is in a coastal high hazard area. Determine the changes in the V-zone (with accompanying flood heights).

for
ROBERT K. YAMABU, Division Chief
Engineering Division

DHM/acs

cc: Planning Dept.

BELT COLLINS
& ASSOCIATES

Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: (8) 1174 8474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-776 (049.11)

Mr. Robert K. Yanabu, Division Chief
Engineering Division
Department of Public Works
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Yanabu:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of April 19, 1989 in response to the Supplemental EIS Preparation Notice for the above project. The concerns outlined in your letter will be addressed in the Draft EIS, a copy of which will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

---

for the people...for the ocean...

TORCH

The Ocean Recreation Council of Hawaii

STATE ADDRESS:
P.O. Box 1809
Kailua, HI 96734

COUNTY CHAPTER ADDRESSES:
Kauai
229 Aina Lani Pl.
Kapaa, HI 96746

Oahu
P.O. Box 26131
Honolulu, HI 96825

Maui
1573 N. Alaniu Place
Kihei, HI 96753

Hawaii
P.O. Box 5306
Kailua-Kona, HI 96745

RECEIVED #13
APR 21 1989
BELT, COLLINS & ASSOCIATES

Belt, Collins & Associates
680 Ala Moana Boulevard
Suite 200
Honolulu, HI 96813

19 April 1989

Gentlemen,

The Big Island chapter of The Ocean Recreation Council of Hawaii (TORCH) request that we be added to the consulted parties list for the Mauna Lani EIS preparation process.

BI TORCH represents approximately seventy five ocean users, both commercial and recreational, in the Kailua-Kona and Kohala area. We are part of a four chapter statewide organization concerned with resolving user conflicts involving the ocean resources and the wise use and management of those resources.

Thank you for this opportunity to participate.

Best regards,

Tina Clothier, BI Rep.

for the people...for the ocean...
TORCH
The Ocean Recreation Council of Hawaii

Tina Clothier
Big Island President

P.O. Box 5306
Kailua-Kona, Hawaii 96745
329-7585

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-777 (849.11)

Ms. Tina Clothier
Big Island President
TORCH
P.O. Box 5306
Kailua-Kona, Hawaii 96745

Dear Ms. Clothier:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your April 19, 1989 request for TORCH to become a consulted party to the preparation of a Supplemental EIS for the proposed Mauna Lani Marina project. Enclosed is a copy of the Supplemental EIS Preparation Notice for your review. A copy of the Draft EIS will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

Enclosure

---

*14

RECEIVED
APR 24 1989
BELT, COLLINS & ASSOCIATES

STATE OF HAWAII
DEPARTMENT OF EDUCATION
P. O. BOX 2360
HONOLULU, HAWAII 96804

OFFICE OF THE SUPERINTENDENT

April 14, 1989

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

SUBJECT: Supplemental Environmental Impact Statement (EIS) Preparation Notice. Proposed Mauna Lani Marina, Mauna Lani Resort, Hawaii

Our review of your proposed marina project which includes 90 to 140 residential house lots will have a negligible effect on the area's public schools.

Thank you for the opportunity to comment.

Sincerely,

Charles T. Toguchi
Superintendent

CTT:jl

cc: Mr. E. Imai
Dr. A. Garson

AN AFFIRMATIVE ACTION AND EQUAL OPPORTUNITY EMPLOYER

#15

United States Department of the Interior

GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
677 Ala Moana Boulevard, Suite 415
Honolulu, Hawaii 96813

April 18, 1989

RECEIVED
APR 24 1989
BELT, COLLINS & ASSOCIATES

Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Subject: Supplemental Environmental Impact Statement (EIS) Preparation Notice, Proposed Mauna Lani Marina, Mauna Lani Resort, Hawaii

We have reviewed the subject Environmental Impact Statement Preparation Notice, and have no comments.

Thank you for allowing us to review the EIS notice.

Sincerely,

William Meyer
District Chief

RECEIVED #16
APR 24 1989
BELT, COLLINS & ASSOCIATES

OFFICE OF STATE PLANNING

Office of the Governor

STATE CAPITOL, HONOLULU, HAWAII 96813 TELEPHONE: (808) 548-3893

JOHN WAIHEE, Governor

Ref. No. P-9365

April 20, 1989

Ms. Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Subject: Supplemental EIS Preparation Notice for the Mauna Lani Marina, South Kohala, Hawaii

We have reviewed the subject document and offer the following comments.

Coastal Zone Management Concerns

The SEIS should describe the project's compliance with the objectives and policies of the Hawaii Coastal Zone Management (CZM) Program. The marina will require extensive inland excavation and shoreline alteration. We are particularly concerned about: 1) potential impacts upon ground and marina water quality (i.e., due to increased runoff of sediments, pesticides, and fertilizers; poor circulation of internal waters; discharge and accidental spill of fuel and oil; release of biocides from antifoulant vessel paints; and direct flow of surface runoff into marine waters), 2) degradation of anchialine pools and coral reefs, 3) adverse impacts upon endangered species, 4) loss of historic sites, 5) erosion along adjacent shorelines, 6) obstruction of coastal views to and along the shoreline, 7) provision of public access (i.e., pedestrian, vessel and vehicular), and 8) conflicts with existing recreational activities. We are also concerned that development of the marina may alter existing flood hazards patterns and may threaten areas outside the existing hazard area, such as those lots that will face the marina entrance channel.

If a Federal permit, license, or financial assistance is required, a CZM Federal consistency determination must be submitted to our office for concurrence.

Land Use Concerns

The draft supplemental environmental impact statement should discuss how the proposed marina and other uses, which are the subject of this action, affect the overall master plan for the resort and the proposed land uses for other adjacent and as yet undeveloped lands in the resort. In reviewing

Figure 2, we note that at least two holes of a golf course will be displaced by the marina project. Other Mauna Lani plans in our files indicate that at least two hotel sites, a commercial area and some multi-family residential uses will be similarly displaced by the marina project. The following questions should be addressed:

(a) How has the master plan for the resort been changed?

(b) How will changes in the project area affect the proposed land uses elsewhere in the resort?

(c) Will the proposed land use changes in the marina area likely to result in the need to develop other lands currently not in the master plan?

(d) Is this marina proposal, which will result in significantly lower densities at this site than previously proposed, part of an overall strategy to lower densities throughout the resort? What are the implications of such a strategy?

(e) How will the proposed changes affect the commitments made by the applicant to the County and to the State Land Use Commission concerning the resort? How will the proposed changes affect the applicant's compliance with conditions of approval imposed by the County and the State Land Use Commission?

Thank you for the opportunity to comment.

Sincerely,

Harold S. Masumoto
Director

cc: Operations Branch
U.S. Army Corps of Engineers

Planning Department
County of Hawaii

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

April 25, 1989
89-778 (849.11)

Mr. Harold S. Masumoto, Director
Office of State Planning
State Capitol
Honolulu, Hawaii 96813

Dear Mr. Masumoto:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Marina, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of April 20, 1989 in response to the Supplemental EIS Preparation Notice for the above project. The concerns outlined in your letter will be addressed in the Draft EIS. Also, in conjunction with our submittal of the necessary Department of the Army permit applications, we shall be seeking from you a CZM Federal consistency determination.

A copy of the Draft EIS will be sent to you when it becomes available.

Sincerely,

Anne L. Mapes

ALM:lf

STATE OF HAWAII
DEPARTMENT OF BUDGET AND FINANCE
STATE CAPITOL
P.O. BOX 150
HONOLULU, HAWAII

RECEIVED
APR 26 1989
BELT, COLLINS & ASSOCIATES

417

April 21, 1989

Ms. Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Thank you for the opportunity to comment on your Supplemental Environmental Impact Statement for the proposed Mauna Lani Marina at the Mauna Lani Resort, Hawaii.

Review of your environmental impact statement indicates that the recommendations in your report appear reasonable. The Department of Budget and Finance has no comments with respect to your proposed project. Once again, thank you for the opportunity to comment on your report.

Sincerely,

for YUKIO TAKEMOTO

RECEIVED #17
APR 27 1989
BELT, COLLINS & ASSOCIATES

Office of the Mayor

BERNARD K. AKANA
Mayor

April 21, 1989

Ms. Anne Mapes
Belt, Collins & Associates
680 Ala Moana Boulevard
Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

Re: Supplemental Environmental Impact Statement Preparation Notice
Proposed Mauna Lani Marina

Thank you for the opportunity to provide comments on the preparation notice for the Mauna Lani Marina EIS. We will be coordinating our response through the Planning Department of the County of Hawaii.

Should you have any concerns in the meantime, please do not hesitate to contact my office or the Planning Department.

Aloha,

Bernard K. Akana
MAYOR

cc: Planning Department

County of Hawaii • 25 Aupuni Street • Hilo, Hawaii 96720

JOHN WAIHEE
GOVERNOR

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
Honolulu, Hawaii 96814-2512

YUKIO KITAGAWA
CHAIRPERSON, BOARD OF AGRICULTURE

SUZANNE [illegible]
DEPUTY TO THE CHAIRPERSON

RECEIVED #19
APR 27 1989
BELT, COLLINS & ASSOCIATES

Mailing Address:
P. O. Box 22159
Honolulu, Hawaii 96822-0159

April 21, 1989

Belt Collins and Associates
680 Ala Moana Boulevard
Suite 200
Honolulu, Hawaii 96813
Attention: Ms. Anne L. Mapes

Dear Ms. Mapes:

Subject: Supplemental Environmental Impact Statement Preparation Notice (SEISPN)
Proposed Mauna Lani Marina
Mauna Lani Resort, Inc.
TMK: 6-8-22: por. 1, 3, 9 South Kohala, Hawaii
Area: 88 acres

The Department of Agriculture has reviewed the subject document and has no comments to offer.

Thank you for the opportunity to comment.

Sincerely,

YUKIO KITAGAWA
Chairperson, Board of Agriculture

cc: OEQC

RECEIVED #20
MAY 3 1989
BELT, COLLINS & ASSOCIATES

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

April 21, 1989
PN:0071

Belt, Collins and Associate
680 Ala Moana Boulevard
Suite 200
Honolulu, Hawaii 96813

Dear Sir:

Preparation Notice (PN)
Environmental Impact Statement (EIS)
Mauna Lani Marina
South Kohala, Hawaii

The above referenced document proposes the construction of an 88-acre marina located at Pauoa Bay. The proposed project will include 90-140 residential house lots, approximately 175 boat slips, and other amenities.

This review was conducted with the assistance of Charles Mader and George Curtis, Joint Institute of Marine and Atmospheric Research; Richard Brock, Sea Grant; and C. Anna Ulaszewski, Environmental Center.

The following issues have been identified by our reviewers for further consideration in the preparation of the Draft EIS:

General Comments

This project will have some impacts, both long and short term, on ambient air quality, and electric, water, and sewage service; however, these impacts have not been addressed by the PN. Considering the magnitude of the project and the potential significance of the impacts, they should be addressed in the Draft EIS.

Nearshore and Anchialine Ponds (page 10)

As part of the pond survey that will be conducted for the Draft EIS, the present status and rehabilitation potential of each pond should be considered. Also, the Draft EIS should discuss how the anticipated changes in groundwater hydrology will affect the ponds.

Marine Environment (page 11)

The PN acknowledges the fact that green turtles, hawksbill turtles, and humpback whales inhabit the water off the coast. These creatures are either endangered or threatened; however, there is no discussion about the DIRECT and INDIRECT impacts this project will have on them. It is imperative that this subject be addressed at length, and any mitigating measures which can be taken to protect these animals should be considered and included in the Draft EIS.

Reef and food fish are "expected" to inhabit the off-shore area; however, the PN does not discuss the impact on these fish. The Draft EIS should discuss the impacts on the fish themselves, as well as the impacts on the fish as a resource for subsistence and sports fishing.

Natural Hazards - Tsunamis (page 13)

The effect of a tsunami or storm surge on the proposed marina needs to be investigated to a greater extent. There may be serious swell, as well as tsunami problems unless the design of the marina and its entrance are carefully modeled using currently available, numerical modeling techniques.

The marina will change the tsunami hazard zones since the new "shoreline" will start at the back of the harbor. A tsunami may activate the proposed harbor and cause large wave oscillations, or a trough may dewater the harbor. These effects need to be considered and numerically modeled and studied using scale hydraulic models.

In regards to storm surge, it might be of some interest that during the 1982 Hurricane, the Natural Energy Laboratory of Hawaii at Ke'ahole experienced several waves larger than originally predicted for a tsunami. We feel this is significant, and the effects of a storm surge, as well as tsunamis should be taken into consideration.

Summary of Major Impacts and Mitigation Measures (page 14)

The impacts of this project should be discussed in terms of short and long-term impacts. It is difficult to discern from the PN which are which.

Marine Environment (page 14)

According to this document, the water along the new "shoreline" of the marina is expected to become more saline due the disruption of groundwater flows. One other water quality concern should be taken into consideration. It is possible, given the present design of the marina, that water at the back of the marina will become stagnant. The marina should be designed in such a way that water circulation is maximized.

This PN did touch on many issues which will be addressed in the Draft EIS; however, we feel that the issues identified in this review warrant further development. It is important that Draft EIS consider all consequences, "both primary and secondary, and the cumulative as well as the short and long-term effects of the [proposed] action" (Chapter 200 of Title 11, DOH Administrative Rules).

Thank you for the opportunity to comment on this document. We hope our comments will be helpful in preparing the Draft Environmental Impact Statement.

Yours truly,

John Harrison
Environmental Coordinator

cc: OEQC
Planning Commission, County of Hawaii
L. Stephen Lau
George Curtis
Charles Mader
Richard Brock
C. Anna Ulaszewski

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

November 27, 1989
89-2161

Mr. John Harrison
Environmental Coordinator
University of Hawaii at Manoa
Environmental Center
2550 Campus Road, Crawford 317
Honolulu, Hawaii 96822

Dear Mr. Harrison:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Cove, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of April 21, 1989 in response to the Supplemental EIS Preparation Notice for the proposed Mauna Lani Cove project (formerly the Mauna Lani Marina).

Potential impacts on the environment, including the areas of concern you identified, will be addressed in the Draft EIS. Also, specific studies of the marine and pond environment, natural hazards such as tsunamis, and endangered marine species, have been completed and will be included as appendices to the EIS document.

The Draft EIS will be available next month and a copy of the report will be sent to you for review and comment.

Sincerely,

Anne L. Mapes

ALM:lf

Bernard K. Akana
Mayor
Larry Tanimoto
Director
George Yoshida
Deputy Director

Department of Parks and Recreation
25 Aupuni Street, Rm. 210 • Hilo, Hawaii 96720 • (808) 96[illegible]

RECEIVED
MAY [illegible] 1989
BELT COLLINS & ASSOCIATES

May 1, 1989

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

Subject: Supplemental EIS Preparation Notice for Proposed Marina, Mauna Lani Resort, South Kohala, Hawaii

Dear Ms. Mapes:

We have reviewed the supplemental report and have no comments or objections on the proposed project as it relates to our jurisdiction and responsibility.

Shoreline access appears to be adequately provided for through the proposed lateral pedestrian shoreline pathway.

Thank you for the opportunity to be included in the review process.

Sincerely,

Larry Tanimoto
Director

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813

RECEIVED
MAY 4 - 1989
BELT, COLLINS & ASSOCIATES

EDWARD Y. HIRATA
DIRECTOR

DEPUTY DIRECTORS
JOHN K. UCHIMA
DAN T. KOCHI
JEANNE K. SCHULTZ

IN REPLY REFER TO:

April 26, 1989

HAR-EP 3881

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Supplemental EIS Preparation Notice
Proposed Mauna Lani Marina

Thank you for the opportunity to review the subject supplemental EIS preparation notice.

We have no objection. The drawbridge over the entrance channel should provide the required public access along the shoreline. Please keep us informed on the type of bridge that will be provided.

Very truly yours,

Edward Y. Hirata
Director of Transportation

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
LIBERT K. LANDGRAF
MANABU TAGOMORI
RUSSELL N. FUKUMOTO

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

RECEIVED
MAY 10 1989
BELT, COLLINS & ASSOCIATES

REF: OCEA-sor

MAY 9 1989

FILE NO.: 89-558
DOC. NO.: 5636E

Ms. Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

SUBJECT: Supplemental E.I.S. Preparation Notice
Proposed Mauna Lani Marina, Mauna Lani Resort, Hawaii
TMK: 6-8-22: portions of 1, 3 and 9

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the materials you submitted and have the following comments.

Our Department's Aquatic Resources Division suggests that the forthcoming EIS discuss in detail potential short-term impacts (related to marina construction such as blasting, sedimentation and turbidity) and long-term effects (related to marina operation such as oil spills, waste disposition, and so forth). Among other topics, the discussion should cover:

1. use effects on existing public activities along the shoreline and in the nearshore waters;

2. drainage effects (erosion, disposition of runoff and possibile contamination of anchialine ponds, marina and coastal waters);

3. wastewater effects (disposition, nutrient loading of ground or marina waters);

4. potential impact to and mitigation measures for endangered and threatened species; and

5. detailed description of public benefits and amenities that would occur from the developer's use of State submerged land at channel entrance.

The EIS should project impacts, propose specific means of averting or minimizing adverse effects to benthic organisms and other aquatic life, and suggest possible mitigation or compensation for unavoidable damage to natural resource values.

The Division of Forestry and Wildlife comments that based on the preliminary description of the project there are specific issues and topics that need further elaboration:

1. Project effects on existing public access;

2. Project effects on indigenous bird species;

3. Project effects on existing anchialine ponds and associated fauna;

4. Project effects on Hawaiian hoary bat; and

5. Project effects on threatened green turtle and endangered hawkbill turtle and humpback whale.

The Historic Sites Section notes that given the extensive alteration of the land in the area, we believe that the project will have "no effect" on significant historic sites.

Please feel free to call me or Roy Schaefer of our Office of Conservation and Environmental Affairs, at 548-7837, if you have any questions.

Very truly yours,

WILLIAM W. PATY

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

November 28, 1989
89-2175 (849.11)

Mr. William W. Paty
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Cove, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of May 9, 1989 in response to the Supplemental EIS Preparation Notice for the proposed Mauna Lani Cove project (formerly the Mauna Lani Marina).

The concerns identified by the Department's Aquatic Resources Division and Division of Forestry and Wildlife will be addressed in the EIS. Various specialized studies have been completed for the EIS. These include, among others, reports on the anchialine ponds and marine environment, green sea turtles, and the humpback whale; all of the reports will be included in the EIS as appendices. Also, the public benefits associated with the project will be fully described.

The Draft EIS will be available next month and a copy of the report will be sent to you for review and comment.

Sincerely,

Anne L. Mapes

ALM:lf

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
300 S. Ferry Street
Terminal Island, CA 90731

RECEIVED
MAY 15 1989
BELT, COLLINS & ASSOCIATES

May 10, 1989 F/SWR13:JJN

Ms. Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Blvd. Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

NOAA Fisheries has received the Supplemental Environmental Impact Statement (EIS) Preparation Notice for the proposed Mauna Lani Marina, Mauna Lani Resort, South Kohala, Island of Hawaii. The document was sent to the wrong office, consequently these comments from our review of the document are coming to you at this late date.

It is our understanding that Mauna Lani Resort, Inc. proposes to develop a residential/marina project on 88 acres of land at the existing Mauna Lani Resort. The marina project would include 90 to 140 residential house lots and approximately 175 boat slips. Presently the marina is in the conceptual stage. It would be excavated inland of the shoreline with an entrance channel dredged to connect the marina with coastal waters. The entrance channel would be approximately 150 feet wide, 18 feet deep and 600 feet long. Blasting may be required to excavate the marina channels should ripping alone be determined to be too time consuming and cost prohibitive. Since the marina project was not specifically described or assessed in the two earlier EIS's prepared for Mauna Lani Resort, the proposed marina development will require a supplemental EIS.

NOAA Fisheries is concerned over the rapid increase in coastal development along the Kona Coast of the Island of Hawaii, and the potential cumulative impacts it may have on the pristine marine environment and coral reef habitat for which the area is so well known. Of particular concern are the proposals for blasting and dredging in nearshore waters (i.e., Hawaiian Riviera Resort, Natural Energy Laboratory of Hawaii, Hawaiian Ocean Science and Technology Park, Hyatt Waikoloa Resort, Kohana-iki Resort and the Mauna Lani Resort). We feel there is a critical need for master planning in the area, especially to consolidate small boat harbors and marinas in order to reduce the necessity to blast and dredge entrance channels through the nearshore reef platform.

A biologist from our Pacific Area Office has conducted qualitative site surveys of the nearshore marine environment fronting the proposed Mauna Lani marina. A rich and diverse marine ecosystem occurs in the area and is fairly typical of the Kona Coast of Hawaii.

We understand that a marine environmental baseline survey which will detail marine biota and water chemistry is underway at the site and the results will be included in the EIS. The survey should also detail the existing use of these coastal waters by commercial and recreational fishermen, the dive charter industry, and other water oriented activities.

Several threatened and endangered species which fall under the jurisdiction of NOAA Fisheries utilize the Mauna Lani area to varying degrees. Specifically these are the endangered humpback whale (Megaptera novaeangliae), the endangered hawksbill turtle (Eretmochelys imbricata), and the threatened green turtle (Chelonia mydas). A statement is made on page 12 of the Preparation Notice that the area is now known as a hawksbill turtle resting, breeding, and aggregating area. This statement needs to be substantiated or clarified. Consultation under Section 7 of the Endangered Species Act of 1973 should be initiated with NOAA Fisheries and our Biological Opinion made part of the Final EIS.

The EIS should contain a section on alternatives to the proposed marina. This would include alternative sites on the applicant's property such as the expansion of the existing boat basin in Makaiwa Bay, consolidating the marina with existing or proposed small boat harbors in other areas along the Kona coast, and the no action alternative.

We appreciate the opportunity to comment on the proposed project at this early, pre-EIS stage. Please contact John Naughton, Pacific Islands Environmental Coordinator in our Pacific Area Office (955-8831), with any questions concerning these comments and for further coordination on the proposed Mauna Lani Marina project.

Sincerely yours,

Rodney R McInnis
for E.C. Fullerton
Regional Director

cc: F/SWR13, Naughton
EPA, Region 9 (E-4)
FWS, Honolulu
CZM Program, Hawaii
Hawaii State Div. of Aquatic Resources
TORCH, Hawaii

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

November 27, 1989
89-2162

Mr. E.C. Fullerton, Regional Director
National Marine Fisheries Service
U.S. Department of Commerce
Southwest Region
300 S. Ferry Street
Terminal Island, California 90731

Dear Mr. Fullerton:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Cove, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of May 10, 1989 in response to the Supplemental EIS Preparation Notice for the proposed Mauna Lani Cove project (formerly the Mauna Lani Marina).

The concerns you have identified will be addressed in the EIS. Specifically, two reports on endangered marine species will be included in the document as appendices. As to your suggested alternatives to the proposed project, we have included those which might reasonably attain the objectives of the applicant.

The Draft EIS will be available next month and a copy of the report will be sent to you for review and comment.

Sincerely,

Anne L. Mapes

ALM:lf

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. BOX 50004
HONOLULU, HAWAII
96850

RECEIVED
MAY 17 1989
BELT, COLLINS & ASSOCIATES

May 12, 1989

#25

Ms. Ann L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Ste. 200
Honolulu, HI 96813

Dear Ms. Mapes:

Subject: Supplemental Environmental Impact Statement (SEIS),
Preparation Notice, Proposed Mauna Lani Marina,
Mauna Lani Resort, Hawaii.

Per your request, the above-mentioned document has been reviewed. We offer the following comments for your consideration:

It is highly recommended that throughout the construction of the marina, the installation and use of anti-silt screens and a water quality monitoring system be used. It would be impossible to evaluate water quality during and after construction without this system. It should also be retained after construction as there will undoubtedly be some degradation of the marina waters from oil leaks, discharges, and other forms of pollution associated with marina development and use.

There is no reference in the preparation notice regarding sewage treatment or waste disposal. This topic should be covered since the soils mapped in this area are not recommended for construction, use of cesspools, or other types of leaching fields.

A degradation and loss of anchialine ponds has been noted in the other recently completed developments in the area. This loss resulted from the filling in of ponds during development, indirect sources such as nutrient overloading from recently landscaped areas, sediment discharge from construction activities, oil discharges from boats operating in the area, and salinity changes due to interrupted groundwater flows. The net result has been a physical loss of shoreline habitat values for marine wildlife and organisms. The proposed EIS should discuss such effects as related from the proposed development.

The document should also describe the expected effect of surface runoff during construction and discuss the measures that will be taken to reduce potential water quality degradation from erosion and sedimentation during construction. Thank you for the opportunity to comment on this proposal.

Sincerely,

WARREN M. LEE
State Conservationist

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

November 27, 1989
89-2171 (849.11)

Mr. Warren M. Lee
State Conservationist
U.S. Department of Agriculture
Soil Conservation Service
P.O. Box 50004
Honolulu, Hawaii 96850

Dear Mr. Lee:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Cove, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of May 12, 1989 in response to the Supplemental EIS Preparation Notice for the proposed Mauna Lani Cove project (formerly the Mauna Lani Marina).

The concerns you have identified will be addressed in the EIS. In particular, potential impacts due to the project on marine life and organisms are addressed in studies prepared specifically for the EIS; the reports are included as appendices to the EIS.

The Draft EIS will be available next month and a copy of the report will be sent to you for review and comment.

Sincerely,

Anne L. Mapes

ALM:lf

RECEIVED
MAY 24 1989
BELT COLLINS & ASSOCIATES

#26

BERNARD K. AKANA
MAYOR

HAWAII COUNTY FIRE DEPARTMENT
466 KINOOLE STREET • HILO, HAWAII 96720

THOMAS J. BELLO
FIRE CHIEF

EDWARD BUMATAY
DEPUTY FIRE CHIEF

May 22, 1989

Ms. Anne L. Mapes
Belt, Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Subject: Supplemental EIS Preparation Notice -
Proposed Mauna Lani Marina, Mauna Lani Resort, Hawaii

Upon review of your Supplemental EIS Preparation Notice for the proposed Mauna Lani Marina, we wish to submit the following comments:

(1) Roadways to be constructed in accordance with County of Hawaii standards with a minimum of 40 feet turning radius.

(2) Fire hydrants with fire flow requirements in accordance with Table No. 16, Water System Standards, Department of Water Supply, County of Hawaii.

Thank you for giving us the opportunity to submit our comments.

Very truly yours,

THOMAS J. BELLO
FIRE CHIEF

TJB/mo

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BLLTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

November 27, 1989
89-2163

Mr. Richard K. Paglinawan, Administrator
Office of Hawaiian Affairs
State of Hawaii
1600 Kapiolani Blvd., Suite 1500
Honolulu, Hawaii 96814

Dear Mr. Paglinawan:

Supplemental Environmental Impact Statement (EIS)
Mauna Lani Cove, Mauna Lani Resort, South Kohala, Hawaii

Thank you for your comments of June 23, 1989 in response to the Supplemental EIS Preparation Notice for the proposed Mauna Lani Cove project (formerly the Mauna Lani Marina).

Field work for an archaeological survey of the project site has been completed and the results are reported in the archaeological inventory survey report. This report will be included in the EIS as an appendix.

The Draft EIS will be available next month and a copy of the report will be sent to you for review and comment.

Sincerely,

Anne L. Mapes

ALM:lf

RECEIVED
JUN 28 1989
BELT, COLLINS & ASSOCIATES

#37

STATE OF HAWAII
OFFICE OF HAWAIIAN AFFAIRS
1600 KAPIOLANI BLVD., SUITE 1500
HONOLULU, HAWAII 96814
(808) [illegible]
(808) [illegible]

June 23, 1989

C-L89-0069

Ms. Anne L. Mapes, Planner
Belt Collins & Associates
680 Ala Moana Blvd. #200
Honolulu, Hawaii 96813

SUBJECT: Supp. EISPN: Proposed Mauna Lani Marina, Hawai'i

Dear Ms. Mapes:

Thank you for your letter of April 3, 1989, and for the opportunity to comment.

The project area is known to be rich in archaeological resources. Previous archaeological surveys have already located a number of archaeological sites within the boundaries of the marina project area. A complete, comprehensive archaeological survey should be conducted, and a copy of the survey report should be sent to our office for review and comment.

Sincerely,

Richard K. Paglinawan
Administrator

RKP:EN:klr

CHAPTER NINE

CHAPTER IX

AGENCIES, ORGANIZATIONS AND PERSONS WHO RECEIVED A COPY OF THE DRAFT EIS, WRITTEN COMMENTS RECEIVED DURING PUBLIC REVIEW PERIOD AND RESPONSES

1. DRAFT SUPPLEMENTAL EIS

The Draft Supplemental EIS was officially submitted to the Office of Environmental Quality Control (OEQC) on December 5, 1989 and notice of its availability published in the OEQC Bulletin on December 8 and 23, 1989 and January 8 and 23, 1990. The official date for receipt of comments was January 22, 1990, which was extended by the applicant to February 5, 1990 to accommodate additional public review. All comments received as a result of the 60-day public review period, and responses thereto, are included in this Chapter.

DEPARTMENT OF PUBLIC WORKS
COUNTY OF HAWAII
HILO, HAWAII

RECEIVED
JAN 9 1990
BELT, COLLINS & ASSOCIATES

Memorandum

DATE January 5, 1990

TO : PLANNING DEPARTMENT

FROM : ROBERT K. YANABU, Division Chief, Engineering Division

SUBJECT: MAUNA LANI COVE DRAFT EIS
South Kohala, Hawaii

We have reviewed the subject document and our comments are as follows:

1. The lands along the shoreline are in VE and AE flood zones.

2. When warranted a grade separated structure should be constructed at the Queen Kaahumanu Highway instead of the additional access as proposed in the EIS.

DEM:so

cc: Department of Transportation, Highways Division, Hilo
Mauna Lani Resort, Inc.
O.E.Q.C.
Belt, Collins & Associates
Engineering

(1)

BELT COLLINS & ASSOCIATES
Engineering • Planning
Landscape Architecture

February 16, 1990
90-367 (849.11)

Mr. Robert K. Yanabu, Division Chief
Engineering Division
Department of Public Works
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Yanabu:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your Memorandum of January 5, 1990 to Mr. Duane Kanuha, Director, Planning Department, regarding the subject project and Supplemental Draft Environmental Impact Statement. The following is provided in response to your letter.

1. The flood zone designations of the proposed project lands are described in Chapter IV, Section 2.3 of the Draft Supplemental EIS.

2. As indicated in Chapter IV, Section 6.1.1, Mauna Lani Resort has been discussing future Queen Kaahumanu Highway improvements with the State Department of Transportation. These talks will continue as use of the resort facilities continues to grow. Please note that the State Department of Transportation did not have any comments on the Draft Supplemental EIS.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Very truly yours,

Anne L. Mapes

GC:AM:lf

cc Director, County of Hawaii Planning Department

(2A)

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
465 SOUTH KING STREET, ROOM 104
HONOLULU, HAWAII 96813

RECEIVED
JAN 17 1990
BELT, COLLINS & ASSOCIATES

MARVIN T. MIURA, Ph.D
DIRECTOR

TELEPHONE NO.
548-6915

January 12, 1990

Duane Kanuha, Director
Hawaii County Planning Department
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Kanuha:

Subject: Comments on Mauna Lani Cove EIS

We have reviewed this EIS and offer the following comments for your consideration:

- There are several large anchialine ponds in the Waikoloa area which will be impacted by the proposed marina. Anchialine ponds contain rare and unique fauna that need to be protected.

  First of all, the mouth of the proposed marina is close to several of the ponds. It is likely that they will be adversely impacted or damaged during the construction of the marina.

  Secondly, there are homes that will be sited adjacent to these anchialine ponds. These homes seem to be situated so as to make the ponds a backyard amenity. Homes should not be located close to the anchialine ponds.

  Finally, water from the marina may infiltrate and travel through the porous lava formation to the anchialine ponds, adversely affecting them.

(2B)

- The marina has a very narrow opening to the sea, making tidal flushing of the marina waters difficult. The proposal to use a flushing reservoir, although novel, may not work. The volume of water in the reservoir relative to that in the marina is small and thus the discharge of stagnant water into the ocean will also be small. The manner in which the water will be discharged into the marina will be comparable to trying to flush the marina with a fire hose. For this reason, the proposed flushing reservoir is likely to fail. Additionally, the configuration of the marina will work against this manner of flushing. Any improvement in the water quality of the marina will be due to dilution of the marina water with the flush water, which will be minimal.

  The Hydraulic Model Study prepared by Hydro Research Science shows that no circulatory pattern resulted in most of their tests and flow velocities were improved or enhanced under certain conditions, but still relatively small.

- The houses along the marina should not have cesspools. The EIS states that a pump station at the landing will be connected to an existing private wastewater treatment plant, but does not say whether the homes will be hooked up to it. We recommend that these homes be sewered.

  Boat owners should not be allowed to live on their boats, and boat owners should not be allowed to discharge their wastes into the marina.

- All blasting, both for the marina and the channel, should not be allowed during the humpback migratory season. Blasting in the water should be preceded by an area reconnaissance to ensure that turtles are not in the blast vicinity. The first few charges should be kept small, primarily to scare turtles and fish from the blast zone.

- The median home value at Mauna Lani Cove will be $2.25 million, far above what most Hawaii residents will be able to afford.

  According to the market study conducted by Ming Chew Associates for the 1985 EIS, the projected demand in 1990 was 25 homes, in 1995 50 homes, and in 2000 70 to 90 homes. The projected prices for fee-simple houses and lots ranged from $600,000 to $1 million in 1984 dollars. The number and prices of the proposed homes are greater than those projected in the 1985 study.

Thank you for providing us the opportunity to comment on this EIS.

Sincerely,

Marvin T. Miura, Ph.D.
Director, Office of Environmental Quality Control

Roy Sakamoto
Environmental Technical Specialist

cc: Anne L. Mapes, Belt Collins & Assoc.

(2C)

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 16, 1990
90-366 (849.11)

Dr. Marvin Miura, Director
Mr. Roy Sakamoto, Environmental Technical Specialist
Office of Environmental Quality Control
State of Hawaii
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Dr. Miura and Mr. Sakamoto:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your letter of January 12, 1990 to Mr. Duane Kanuha, Director, County of Hawaii Planning Department, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your comments.

1. Mauna Lani recognizes the importance and value of both its anchialine and fishpond systems. Many Kalahuipua'a anchialine ponds have been successfully restored, cleaned and maintained (and some created) as part of the resort's ongoing program of coastal pond management.

   The proposed project will be located near two anchialine ponds in the entrance channel area. Both of these ponds are currently in a state of prolonged senescence and will be cleaned and restored to a healthier condition, capable of supporting typical fauna of anchialine pond systems. As are all ponds at Mauna Lani Resort, these ponds will be protected and serve as educational and aesthetic features of the resort.

   Based on scientific studies conducted in Hawaii and on the U.S. Mainland, marinas that are well managed and maintained have been found to be non-polluting. A rigorous management plan, properly enforced, can ensure long-term environmental protection. Mauna Lani's management plan will include specific measures to control point and nonpoint source pollution, with the goal of meeting and exceeding applicable State water quality standards.

   During construction, precautionary measures will be taken (use of barriers, etc.) to minimize temporary impacts on the ponds. Given these short-term and long-term measures, we do not foresee any adverse impacts to the ponds or coastal nearshore waters as a result of the proposed project.

   Homes will not be situated in close proximity to any ponds, which will not serve as backyard amenities. Rather, the restored ponds will be integral parts of a shoreline greenbelt.

By definition, anchialine ponds are pools with no surface connection with the sea, containing salt or brackish water, which fluctuates with the tides. Water in the marina, which opens into the ocean, will be very similar to ocean water, and hence would have a similar impact on the ponds.

2. As part of the overall engineering and planning for the proposed project, we have had professional coastal engineers conduct hydraulic modeling studies to determine the flushing characteristics of the Cove and to develop supplemental measures should natural tidal flushing, groundwater efflux and nearshore current patterns not provide the degree of flushing required to maintain acceptable water quality. As a result of these studies, a flushing reservoir, as noted in the Draft Supplemental EIS, will be constructed immediately inland of the Cove. Water from the reservoir, which will also serve as a golf course feature, will be pumped into the Cove as necessary to maintain acceptable water quality standards.

3. The homes and other facilities to be constructed as part of the proposed project will be connected to the existing Mauna Lani Resort sewage collection, treatment and disposal system. None of the homes will have cesspools. Similarly, in compliance with federal and state environmental protection regulations, boats will not be allowed to flush sewage into the Cove and a pump-out station will be provided for the boaters. Mauna Lani Resort, Inc. does not intend to allow permanent live-aboards in the Cove.

4. As noted in the Draft Supplemental EIS, blasting for the proposed entrance channel will be limited to the summer months. The entrance channel construction period is estimated to require approximately two months. Further, as noted in the Draft Supplemental EIS, visual reconnaissance surveys will be conducted prior to blasting and during dredging activities to assure that there are no turtles in the blasting/construction area. Charges will be sized to crack the underlying pahoehoe lava for subsequent dredging by a barge mounted backhoe or clamshell dredge.

5. The market study for Mauna Lani Resort was conducted by Ming Chew Associates five years ago when Hawaii's economy was soft and in recession. It is obvious that land and construction costs in Hawaii have increased during the past five years. Furthermore, the study has been updated by more current market demand data and analysis, particularly pertaining to a new product (houselot with boat dock), to arrive at the projected cost of the Cove's residential lots and homes.

Mauna Lani acknowledges that these lots and homes will be out of reach for most Hawaii residents. It must be noted, however, that Mauna Lani is the only Big Island resort developer in the past two decades that has responded to the need for affordable housing by planning, designing, and building affordable homes for Hawaii residents. Completed to date are 19 units (Noelani I) and 24 units (Noelani II) in Waimea, and 216 units (La'ilani) at Kealakele, Kona. These units are now held and managed by the State. Mauna Lani and its sister companies

(Pan Pacific Development and Pan Pacific Construction) continue to seek new projects to help bring affordable units on the market for Hawaii residents.

Thank you for your comments and participation in the Supplemental Draft EIS review process. Your letter and this response will be appended to the Final EIS.

Sincerely,

Anne L. Mapes

GC:AM:FD:lf

cc Director, County of Hawaii Planning Department

3A

RECEIVED
JAN 22 1990
BELT, COLLINS & ASSOCIATES

Jan. 17, 1990

3B

Planners:

This is meant to be recorded as a comment on the Environmental Impact Statement being prepared in response to the proposed project on the grounds and in the ocean fronting the Mauna Lani Bay Resort. We feel that this project will have negative physical, social and biological impact upon the area in question.

Biological Impact-

The Destruction of Living Reef Itself. The Island of Hawaii, being the youngest island in the Hawaiian Chain, is mostly rough rock coastline, with a scattering of small beaches. In only a few cases have reef systems begun to establish themselves here. These systems are...

Honokahau

Kona Village

Fronting the Mauna Lani Resort

Kawaihae- Which has been dredged and is suffering from sedimentation resulting from this dredging.

The reef fronting the Mauna Lani Bay Resort is rare on the Big Island.

It has been known since the early part of this century that sedimentation (such as that associated with dredging a channel for the proposed Marina) can negatively affect the health of a reef and that heavy enough insult will actually kill it.[1] Later on, a link between Ciguatera and the growth of a blue green algae which colonizes a reef immediately after disturbance was noticed. It is notable that the area in question for this project is an area already beset with an outbreak of this toxin, possibly (and logically) resulting from the many insults heaped upon this area's fledgling reef system by the current spasm of shoreline construction and associated shoreline interventions.

Effects of this intrusion upon the shoreline in general-

There has been no mention of what the effect a channel such as this might have upon nearby beaches such as Pauoa Bay, or even Hapuna Beach. The effects of interventions such as this upon littoral currents and the pattern changes this might induce are anyone's guess. We would like to see the matter thoroughly studied before any such interventions occur. The example of the radical degeneration of the beach and water quality from the Kahala Hilton Hotel to Black Point, on Oahu, after the installation of a dredged swimming area and groins should serve as a red flag of warning.

Destruction of Culturally Preferred Foods and an Income supplement for our people-

These few reef systems on the Big Island are viewed as a large natural refrigerator, with food waiting for the harvest, by many cultures. The destruction of reef habitats should be viewed as if someone went into your home and stole your refrigerator. You would be angry, and so will those people who depend upon these reefs as food sources, income supplements (by saving money on food) and places to practice their traditional cultures. It can be said that Hawaiians practicing their culture are an endangered species threatened by loss of habitat.

The area affected directly by the dredging of a channel is considered "prime squidding grounds." This refers to the He'e, or octopus, hunted by local divers on the shallows of this specific area.

Destruction of the surf spot "Peaks"-

As portrayed at the recent public meeting, held here on the Big Island, the Marina Channel will run straight through the middle of a unique local surf spot named "Peaks."[2] This was discovered when the question was asked, "Well just where is the channel going?" The result was that the path of the channel was briefly traced

[1] Charles Howard Edmondson, Waikiki, 1910-1911.

[2] "Peaks" was called "Browns" at an earlier time, and was recorded on the Statewide Comprehensive Outdoor Recreation Plan revision of 1978. The site was recorded on the Surf site survey conducted by Marshall, Kaplan, Gahne, Kahn and Yamamoto. An original of the report is still in the possession of John Kelly, 4117 Black Point road, Honolulu Hawaii, Phone: 735-0547.

IX - 5

with fingers upon a large blown up photograph of the area. The channel, as drawn, ran straight through the middle of a large triangle of whitewater left behind by the waves peeling off at "Peaks." Official personnel at the meeting seemed surprised.

It is worth noting that surf itself is a very variable feature of the seascape. What was a spot packed with thirty or more surfers can in half an hour, with a switch of the wind, be vacant. Swell direction and size can also completely change the location of the surfing area. What may be the takeoff zone on a smaller day might be engulfed on larger days when the takeoff zone might moves hundreds of yards seaward. Indeed, the spot can appear entirely differently as size causes the waves to break over shoals at differing depths. Swell direction can have an equally important role in the fluid location of a surfing area.

Another factor is that we, as individuals, have only seen a very limited snapshot of what the sea is capable of. For instance, the last time Waikiki was truly big was in 1952. We have grown to manhood without ever seeing a South swell of that size.

This spot is unique in many ways...

-It breaks on a South swell, as well as West and Northwest swells, the only spot in this area to do so. As such it is...

-the only all year spot North of Keahole.

-One of the few spots on the Big Island situated in such a way that the whitewater backs off before hitting rocks or any other danger.

Because of all the above...

- On the many calmer days it is an ideal spot for children and beginning surfers to develop their skills in a safe environment. There would be no people if there were no nurseries to raise babies in. Likewise, there would be no surfers if there were not nurseries for them to begin surfing in. A spot does not have to be Pipeline to be of great value to the surfing community.

- It is one of a very few spots on the Big Island where the ancient Hawaiian sport of outrigger canoe surfing can be practiced, and the only consistent spot.[3]

[3] Bayfront in Hilo, Spencer Park and Kawaihae Breakwater are the others. All of them break infrequently.

Surfing-

Trends in the growth of the surfing population seem to indicate that the population is growing at a rate of up to 4 times that of the population in general.[4] On the Big Island this growth in surfing population is set in an area of relative scarcity of surf. The Big Island has an average of .9 Surfing Areas per shoreline mile, as opposed to the average of all of the other islands of 2.9 per shoreline mile.[5] Each of the 150 recorded surfing sites on the Island of Hawaii thus takes on increased importance when one considers the impending population increase, especially on the West shore.

It must have been with this in mind that a Senate Resolution in 1970 was passed declaring surfing areas to be recognized as public recreational resources and stating that as such they should be protected.

Summary-

We would like to see the problems of the general populations health and the social impact of loss of food sources, cultural degradation through loss of habitat for traditional activities, degradation of the shoreline and loss of public recreational resources addressed.

The cumulative impact of this and other projects along the West Coast may eventually lead to a change in the attitudes of local residents toward tourists and hotels, in general. This can become a major factor in hotel marketability, as the ambiance of the area degenerates into purse snatching, car break-in's and general bitterness evident in other parts of this State.

It is worth noting that, until now, Mauna Lani has been one of the better citizens of this area. Unlike the Hyatt project, which crudely destroyed anchialine ponds (in which organisms spotted only one other place on the face of Earth have been reported, and in which the most common organism is recognized to be so rare

[4] Surf Parameters Study

[5] SCORP Revision, Statewide Inventory of Surf Spots, Marshall, Kaplan, Gahne, Kahn and Yamamoto, 1971.

that it should be on the endangered species list[a] the Mauna Lani has been an example of subtlety. The fishponds were preserved, instead of destroyed. A curator was hired, and the ponds were used to show off the reef life to all visitors. This project represents a distressing change of approach to the environment.

Harbors and Marinas should be the business of the State Government. Allowing any individual with shoreline property to dredge through and ruin public resources for private profit sets a very worrying precedent.

Leif (Keone) Lindsey   Michael Moriarty   David Tompkins

[a] See the Environmental Impact statement for the Hyatt project.

3E

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 16, 1990
90-370 (849.11)

Save Our Surf/Big Island
P.O. Box 1102
Kapaau, Hawaii 96755

Attention: Messrs. Leif Lindsey, Michael Moriarty and David Tompkins

Gentlemen:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement

Thank you for your letter of January 17, 1990 to the Hawaii County Planning Department, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. The Destruction of Living Reef Itself

As noted in the Draft Supplemental EIS (see Chapter IV, Section 3.3.2.7) a number of scientific studies regarding colonization and recolonization of coral reefs have been conducted in Hawaii and other tropical and subtropical regions. These studies have shown that coral reefs colonize and recolonize new and/or disturbed areas almost as soon as conditions are favorable, that is, when conditions of the substrate are such that larvae can settle. Factors inhibiting the establishment of flourishing coral reefs in Hawaii include the natural efflux of large quantities of groundwater along the coastline, storm waves and heavy surge actions. As indicated in the Draft Supplemental EIS and marine survey conducted specifically for the EIS, the living corals on the shallow reef terrace fronting Mauna Lani Resort is limited in size and species diversity. Coral cover in the reef platform near the Mauna Lani Cove entrance channel varies from 5 to 28 percent. There will be no dredging beyond the reef dropoff, where coral cover increases to between 49 and 86 percent.

The coral species found are typical of Hawaii (Porites lobata, Porites compressa, Pocillopora meandrina, Montipora verrucosa, etc.). As indicated in the Draft Supplemental EIS, sedimentation can negatively affect corals and other sessile organisms if the sediment load is deposited faster than the organisms are able to naturally remove the sediment. Based on the analyses performed for the proposed project and the type of material to be dredged--pahoehoe lava--it is expected that sedimentation loading as a result of dredging activities would be minimal as compared to the dredging at Kawaihae Harbor which was accomplished in coralline limestone materials without any environmental protection measures.

The mechanisms by which the ciguatera occurs are poorly understood. A link between coral disturbance, caused by a number of factors including anchor dragging, has been shown as one possible cause. However, ciguatera poisoning has also occurred in the absence of man-induced coral reef disturbance. As part of the environmental protection measures to be undertaken by Mauna Lani Resort, a ciguatera monitoring program will be conducted prior to and following the entrance channel dredging. Should ciguatera be found to occur, appropriate measures will be taken.

2. Effects of This Intrusion Upon The Shoreline In General

With regard to the effect of the entrance channel on nearby beaches, it is unlikely that the proposed project would have any effect on those beaches due to the prevailing current flow which is to the southwest. The littoral transport, wave and current studies conducted for the proposed project indicate that the proposed project is not expected to have any adverse effect on existing adjacent beaches. Please refer to the studies "Nearshore Wave and Current Measurements for Mauna Lani Resort", "Coastal Processes Investigations", and "Deepwater Wave Climate Summary", conducted by Sea Engineering, Inc.

3. Destruction of Culturally Preferred Foods and an Income Supplement for Our People

As indicated in the Draft Supplemental EIS, based on the results of the marine survey that was conducted specifically for the proposed project, the proposed project is expected to have positive effects on the biota of the project area by increasing habitat opportunities for sessile organisms that serve as the food supply for many of the fish found in the area. It is also noted that neither squid nor octopus were sighted during the marine survey of the proposed channel area. The bays fronting the Mauna Lani Bay Hotel and other Kalahuipua'a nearshore areas are favorite octopus grounds for some local fishermen with adept "squid eyes". With proper mitigation of construction impacts and rigorous management of water quality within the inland channels, there should be little or no impact on he'e grounds.

4. Destruction of The Surf Spot "Peaks"

Mauna Lani Resort is cognizant of the popular surfing area called "Peaks," which fronts the 11th hole and the Mauna Lani Bay Hotel. Having had an avid surfer on-staff involved in the location of the proposed channel, Mauna Lani was careful to avoid "Peaks" in locating the channel, which is over 1,000 feet north of the surf site. Consistent with the objectives of such organizations as the Surfrider Foundation, Mauna Lani will consult with its engineers to encourage a design that creates, rather than diminishes, a surf break.

The proposed entrance channel has been located to avoid large outcroppings of rocks and there are no large outcroppings of coral that would give rise to a particularly good surfing spot. Our review of the "Statewide Ocean Recreation

Plan (SCORP) 1971", has indicated that there are several surfing locations along the Kohala coast, although SCORP 1971 does not provide specific names for most of the spots. Similarly, "The Beaches of The Big Island" notes that during the winter months, when high surf often forms on the offshore reef, surfers find suitable waves at a number of breaks between Pauoa Bay and Makaiwa Bay. The proposed project will not affect the offshore reef.

Further, it is in Mauna Lani Resort's best interest to protect the ocean recreation spots off the resort, for both the use of its guests as well as for its employees and the residents of the Big Island. The Resort has shown by its actions to improve beach access, protection of the anchialine ponds and other natural features within the resort boundaries, as well as its preservation of archaeological and cultural features within the resort, that it is truly cognizant of the need to protect the natural and cultural environmental features of the resort area.

5. Summary

Mauna Lani Resort began its development with a specific philosophy on community relations because of the very concerns you raise about local attitudes toward development. Under the leadership of Kenneth Francis Brown, Mauna Lani still pursues its objectives of community consciousness and the importance of addressing socioeconomic issues, such as affordable housing, public access, lateral shoreline access, historic preservation, child care and education, and environmental protection. Mauna Lani, as a company, believes that "quality of life" can only be achieved by balancing social, environmental, and economic programs and values.

It was not long ago that access to these privately held oceanfront properties was impossible unless one knew the owner personally. Partnerships with the State, County, and private landowners have insured a policy of access to the ocean and shoreline for all people. These partnerships are essential for all workable efforts to improve the island's socioeconomic climate.

The social impact assessments that have been conducted specifically for Mauna Lani Resort projects (Mauna Lani Bay Hotel and Ritz-Carlton at Mauna Lani) coupled with those performed for other projects in West Hawaii, have identified several areas of potential social impacts, including increased crime. Appropriate mitigation measures have been taken by Mauna Lani Resort, other resort developers, the County and State to minimize potential adverse effects. The Mauna Lani area has been identified as one of the resort destination areas in West Hawaii and development is proceeding in compliance with stated County and State goals and objectives established in the Hawaii State Plan, State Tourism Functional Plan and West Hawaii Regional Plan.

Mauna Lani Resort is proud of its efforts in restoring, creating and protecting the natural and archaeological features found within the resort boundaries. These features include the anchialine ponds that have been and will be restored to their natural beauty. The proposed project has been designed to add another water-

February 16, 1990
90-370 (849.11)

oriented amenity to the resort that will both be a positive natural environmental factor as well as positive visual element. As indicated in the Draft Supplemental EIS, the State has increased the size of Honokohau Harbor and has put forth preliminary plans for constructing a small boat harbor at Kawaihae. However, neither the Federal nor State monies for design or construction are presently available and the timing of the Kawaihae project is speculative at this time. The proposed Mauna Lani Cove will assist the State in providing much needed small boat moorings in the West Hawaii region with no direct costs to the public.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes
Anne L. Mapes

GC:AM:FD:lf

cc Director, County of Hawaii Planning Department

(4)

Civil Defense Agency

Bernard K. Akana
Mayor

34-A Rainbow Drive • Hilo, Hawaii 96720 • (808) 935-0031 • Fax (808) 935-6460

RECEIVED
JAN 23 1990
BELT, COLLINS & ASSOCIATES

04520

January 18, 1990

TO: Duane Kanuha, Planning Director

FROM: Harry Kim, Administrator, HCDA H.K.

SUBJECT: Draft Mauna Lani Environmental Impact Statement

The project is located in an earthquake, tsunami and tropical cyclone impact area. The project enhances the damages and threats of tsunami waves and tropical cyclone waves for the area by creating a waterway for damaging waves.

The proposed project creates a problem of safety for all residents, employees and guests during tropical cyclones, tsunami episodes and earthquakes. If the project is approved, it is recommended that the resort be required to develop a warning, evacuation and securement plan that meets with Civil Defense procedures. The plan should be reviewed and approved prior to occupancy of any berth or residence in the area potentially affected by tsunami waves or tropical cyclone's effects.

Other specific areas of concern:

1. The limited vehicle access to the project area (ingress-egress).
2. Loss of two acres of naturally-occurring shoreline reef.
3. Loss of 125 linear feet of natural shoreline.
4. Loss of 28 acres of land.
5. Where will the shoreline be established at with the construction of the marina?

js

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-378 (849.11)

Mr. Harry Kim, Administrator
County of Hawaii
Civil Defense Agency
34-A Rainbow Drive
Hilo, Hawaii 96720

Dear Mr. Kim:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your Memorandum of January 18, 1990 to Mr. Duane Kanuha, Director, Planning Department, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your memorandum.

1. As noted in the Draft Supplemental EIS, all structures planned at the proposed project will be constructed above the historical high water level. The islands to be created in the center of the Cove will be a minimum of 8 feet above mean high water and habitable floor elevations will be a minimum of 10 feet above mean high water. The base flood elevation has been determined by the U.S. Army Corps of Engineers to be 8 feet.

2. Mauna Lani currently has a flood/tsunami evacuation plan that has been developed in collaboration with your agency. This plan would be revised to include the proposed project. In addition, the existing resort-wide tsunami warning system would be extended to cover all areas of the proposed project. These measures are expected to provide sufficient warning and evacuation plans in the event of a natural disaster.

3. Vehicle access to/from the project would be designed in compliance with applicable County of Hawaii codes and standards.

4. The two acres of nearshore reef terrace that will be lost will be replaced by the entrance channel walls and the 23 acres of interior estuarine habitat. The loss of 125 linear feet of natural shoreline will be replaced by a pedestrian bridge across the channel and the waterfront perimeter of the inner Cove, which will be open to the public.

5. The land area for the project site is currently zoned for another hotel. The proposed project would result in less dense use of the project lands while providing a needed small boat marina and associated facilities.

6. Based on past practices of the State Department of Land and Natural Resources (DLNR), it is expected that the certified shoreline (as of September 1989) will remain in its present location. The inland, newly created shoreline of the Cove will remain as private property. However, a final determination by DLNR is pending.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your memorandum and this response will be appended to the Final Supplemental EIS.

Very truly yours,

Anne L. Mapes

GC:AM:lf

cc Hawaii County Planning Director

LIFE OF THE LAND

RECEIVED (5) JAN 23 1990 BELT COLLINS & ASSOCIATES

January 21, 1990

Hawaii County Planning Commission
C/O Duane Kanuha, Director
Hawaii County Planning Department
25 Aupuni Street
Hilo, Hawaii 96720

Gentlemen:

Subject: Draft EIS for Mauna Lani Cove

There are three points which need clarification in the Final EIS.

1. How often and how long on a typical weekday and a typical weekend will public longshore access be interrupted by raising of the proposed bridge across the proposed marina entrance channel?

Public shoreline access will not be "enhanced" by raising of the proposed bridge, contrary to statements made in the Draft EIS.

2. What fees will be charged to the general public to moor vessels and to launch boats in the proposed marina?

Public demand for moorings and launching ramps is not going to be satisfied with facilities which only out-of-state millionaires can afford.

3. Are Gambierdiscus toxicus present in the gut of kole or on leaves of red-brown algae in the area where offshore dredging is proposed?

According to Dr. Hokama of the U.H. Department of Pathology, if either condition is true, then dredging of the proposed marina entrance channel will result in proliferation of this organism and the amount of ciguatera toxin in various marine species. Dr. Hokama indicated that inland dredging will not increase the risk of ciguatera poisoning, but offshore dredging in an area where Gambierdiscus are present can create a health risk to persons who consume marine species from the affected area. Apparently this has been the case at Waianae Boat Harbor, Barbers Point Harbor, and the Reef Runway circulation channel on Oahu. Since the entire Kona Coast has a history of ciguatera poisoning, the discussion of health risks posed by the proposed marina needs scientific treatment. The cursory self-serving discussion in the Draft EIS will not withstand critical scrutiny.

Sincerely,

DT for

Corinna Ching
President

19 Niolopa Place, Honolulu, Hawaii 96817. Tel. 595-3903

BELT COLLINS & ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-377 (849.11)

Ms. Corrine Ching, President
Life of The Land
19 Niolopa Place
Honolulu, Hawaii 96817

Dear Ms. Ching:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your letter of January 21, 1990 to the Hawaii County Planning Commission, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. The pedestrian bridge is being designed to allow a minimum 14-foot vertical clearance, which is sufficient height to allow passage of most power boats. The bridge would be raised only for high-masted sailboats and high power boats.

   It is estimated that the duration of longshore access interruption on any given day (week or weekend) would not exceed one hour per day. It is likely that openings would occur in early morning and late afternoon. Management may require that opening occurs only at set times, requiring boats to form a queue.

   Mauna Lani continues to be a demonstration project for Na Ala Hele. Continuous lateral access along the shoreline has always been a priority; hence, the bridge will be operated and managed with particular sensitivity to the importance of pedestrian access. The term "enhanced" was used only in reference to new features (whale watch, operator's loft) that will be added to the shoreline and to the improvements within the shoreline greenbelt to make lateral access safer.

   Overall, public shoreline access will be improved through the addition of two mauka-makai public access routes to the shoreline, as well as access around the inland channels. Mauna Lani continues to work with PASH on a community-responsive access plan.

2. The fees charged to the general public for transient mooring and launching have not been determined. However, they are expected to be competitive with those of other similar high service facilities. Mauna Lani does not intend to gauge the general public and does not intend to use pricing as a mechanism to keep its facilities underutilized.

3. Please refer to the discussion on Gamblerdiscus toxicus in Appendix F. It can exist as an epiphyte on algae and within organisms such as kole (surgeon fish), palani (surgeon fish), uhu (parrotfish) and others that feed directly on the algae or coral reefs upon which the algae grows.

Dr. Hokama, the expert on this subject, has often emphasized that while increased incidences of Gamblerdiscus toxicus have been implicated with initial colonization of substrata bared by dredging, the definitive cause and effect relationships between environmental alteration and toxic outbreaks have not been elucidated. Outbreaks have occurred with or without environmental alteration and environmental alteration has occurred with or without outbreaks.

We are not aware of ciguatera poisoning outbreaks associated with the Barbers Point Deep Draft Harbor, the Reef Runway construction, West Beach (Ko Olina), or Honokohau Harbor.

We are very much concerned about the incidence of toxic outbreaks in the Kona-Kohala area. If our discussion came across as "cursory" and "self-serving", it certainly was not intended to be. Mauna Lani does not take this issue lightly. We have studied the problem to understand it better and are investigating ways to best address the problem and to minimize the problem's potential.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes
Anne L. Mapes

FD:GC:AM:lf

cc Hawaii County Planning Director

(6A)

RECEIVED
JAN 25 1990
BELT, COLLINS & ASSOCIATES

928 Mokulua Drive
Kailua HI 96734

Jan. 21, 1990

Hawaii County Planning Commission
c/o Duane Kanuha, Director
Hawaii County Planning Department
25 Aupuni Street
Hilo HI 96720

Dear Sirs:

I wish to comment on the Draft Environmental Impact Statement for Mauna Lani Cove.

1. Scope of Project.

This is a substantial project, one that will permanently alter the coastal topography. I do not believe that the county should consider it, or any other proposed development, on a piecemeal fashion, but should hold off approving any plan until an overall approach to coastal development in the Kohala region is in place. Only in this fashion can the cumulative environmental impacts of these developments be considered -- and those cumulative impacts are far and away the most substantial, even though they may not or cannot be addressed in individual environmental impact statements.

The DEIS speaks frequently of "adding a new water-related dimension" to the resort and of fostering development of a "pleasure-boating based industry" in West Hawaii. I am concerned that, given the alterations to the natural landscape required to support these goals, perhaps they are goals that, ultimately, are incompatible with the goal of keeping the natural environment of the Kohala coast intact. I would urge the county planning commission to consider this in evaluating the adequacy of this draft environmental impact statement.

2. Whales.

Although the DEIS says that no whales should be disturbed by the proposed marina, if indeed the boat traffic in the area is increased by another two hundred fifty pleasure boats, the whales that frequent the deep waters off the Kohala coast cannot help but be disturbed. The humpback whales are very sensitive to human activity; I believe much greater consideration should be given to this environmental impact than the DEIS now provides.

(6B)

3. Endemic Plants.

The DEIS anticipates disturbance of the habitat for the pololei fern, a Category 1 candidate endangered species. To mitigate this, the developers say "the pololei fern will be relocated and incorporated into the landscape planting." But the fern requires a rather long dry season, during which, to quote the DEIS, "they die back with only the underground stems surviving until the next rainy season." I would like the developers to state exactly what is known about the propagation of this species and, further, to specify exactly what landscaping plan it has that will ensure the thriving of this fern. The mitigation measures described for the pololei fern are not sufficient.

4. Anchialine Ponds.

I would like to ask whether the anticipated changes in groundwater flow will affect anchialine ponds. The mitigation measures that are described in the DEIS do not take this admitted "potential resultant alteration" into account at all. I believe that if the anchialine pond systems are to be preserved, more will be required than simply cleaning them out. An improved mitigation plan should be included in the final EIS.

5. Cove Chemistry.

The DEIS does not do justice to the unique combination of nutrients, biocides and other contaminants that may be expected to be found in the cove in some quantities. Because of the close proximity of golf courses, the nutrient load will be substantial -- perhaps more than the anticipated "grazing zooplankton community" can handle. The result could well be foul-smelling, intractable "blooms" of algae. The references to Honokohau Harbor and Barbers Point basin do not answer concerns about the Mauna Lani cove, since enough differences exist among these examples to make comparisons unhelpful.

Not enough attention is paid to anti-fouling paints. Because this will be a residential marina, one can expect the boats to stay in the cove for long periods. When this occurs, the effect of organotin compounds on shellfish and other marine animals is aggravated. Given the relative small size of the Mauna Lani marina, one might expect the impact of organotin compounds to be even more exaggerated. I do not accept the DEIS statement that "it appears that ... antifouling paints ... will [not] significantly contribute toxic substances to the cove or offshore waters."

The DEIS refers to these as "unresolved issues" (page I-8) -- though it doesn't like the term, and would rather call them "potential impacts" that will have to remain undefined until the project is constructed. I strongly urge the planning commission to hesitate giving approval to any EIS that would subject the environment to such a dangerous experiment. Rather, more serious consideration should be required of the developers to these aspects of the proposed project, and the final EIS should indicate better what the likely outcome will be, and what mitigation measures will be taken to offset them.

6. The "Natural" Setting.

I don't believe there is much about the proposed project that is "natural," and so I take exception to the developers' frequent invocation of this term in describing Mauna Lani Cove. In fact, they seem to have an aversion to the real natural setting, which at one point is disparagingly described as "dry, scrub, lava land." In the artists' depictions of the planned residential areas, I see nothing that could distinguish the site from a resort in the Caribbean or other tropical destination. In the final EIS, I would urge the developers to be mindful that what they are proposing is frankly artificial. It may be nicely landscaped, but it is a far cry from what nature has placed on the setting. This may seem like a nitpicking complaint, but I do believe that the language and, by corollary, its users are diminished when we don't call things by their rightful names -- even (especially) in environmental impact statements.

Sincerely,

Patricia Tummons

Patricia Tummons

cc: Office of Environmental Quality Control
Belt Collins & Associates

6c

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-379 (849.11)

Ms. Patricia Tummons
928 Mokulua Drive
Kailua, Oahu, Hawaii 96734

Dear Ms. Tummons:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your letter of January 21, 1990 to Hawaii County Planning Commission, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. Scope of Project

The proposed Mauna Lani Cove project is part of the overall Mauna Lani Resort which currently has been zoned and land use planned as a destination resort area. The resort and proposed project are in keeping with the Hawaii State Plan, various State Functional Plans, Hawaii County General Plan and recently completed West Hawaii Regional Plan. Present zoning for the lands on which the proposed project would be constructed are zoned for another hotel. The West Hawaii Regional Plan, prepared by the Office of State Planning with significant input from numerous federal, state and county governmental agencies, as well as numerous private groups and individuals, has assessed the overall impact of the resort nodes identified within the plan. Additional regional planning does not appear necessary at this time.

The proposed project will alter the present visual character of the site. It is expected that the resulting visual character will be more aesthetically pleasing to most than the present dry, scrub lava land. The above noted West Hawaii Regional Plan notes that there are several areas along the West Hawaii Coast that will remain in the present natural condition and the state administration is working on the purchase of several miles of West Hawaii coastal strand that would be preserved in its present natural condition and serve as a public park resource.

2. Whales

Existing federal and state rules and regulations regarding protection of endangered and threatened species, along with consistent enforcement of those rules and regulations, will provide the degree of whale and green turtle protection required. In addition, Mauna Lani Resort is in the process of developing a marina management plan that will emphasize environmental protection and conservation. The Cove rules and regulations will be strictly enforced and appropriate actions taken against those who violate those rules and regulations.

3. Endemic Plants

The pololei fern exists in the hot, dry Kohala coast by being able to die back during long, dry spells. It survives well without those long dry spells and, based on information provided by our consulting botanist, is easily and successfully relocated to wetter conditions. The fern will be incorporated into the overall resort landscaping. As noted in the Draft Supplemental EIS, the fern is found throughout Hawaii and may not be as rare as previously thought.

4. Anchialine Ponds

The proposed project includes the cleaning and restoration of the anchialine ponds that may be affected by the proposed project. Given that the organisms inhabiting the ponds are euryhaline, no adverse impacts are expected as a result of the proposed project. Protection of the ponds will be afforded via the existing Mauna Lani environmental protection plan program. It is noted that it is in the best interests of Mauna Lani Resort to maintain the anchialine ponds and other natural features of the resort to reflect the world class setting that the resort provides.

5. Cove Chemistry

Several scientific studies both in Hawaii and on the Mainland U.S. have shown that golf courses do not significantly contribute to nutrient loading of nearby coastal or aquatic ecosystems. In Hawaii, and especially along the West Coast, high nutrient groundwater efflux is known to contribute significant quantities of nutrients to the nearshore waters. These nutrients, which serve as food to algae, are rapidly mixed with nutrient poor offshore waters via wave, wind and current actions. The Cove is being designed to promote flushing of the Cove waters such that appropriate state water quality standards are maintained.

Antifouling paints on boats within the Cove will be those approved for sale and use by the U.S. Environmental Protection Agency. As noted in the Draft Supplemental EIS, studies in Hawaii and the Mainland U.S. indicate that well-managed marinas are generally non-polluting. Given the measures that are being taken with the design and management of Mauna Lani Cove, we would expect that the Cove will also be non-polluting. All applicable state and federal water quality and environmental protection rules and regulations will be complied with during the construction and operation of the Cove.

6. The "Natural" Setting

The term "dry, scrub, lava land" is used as an ecosystem descriptive term and carries no value judgement. The Cove project is being designed and planned to be another amenity, in keeping with the overall resort design, available to the residents and guests of Mauna Lani Resort.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

GC:AM:lf

cc Duane Kanuha

JOHN WAIHEE
GOVERNOR

RECEIVED
JAN 24 1990
BELT, COLLINS & ASSOCIATES

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813

EDWARD Y. HIRATA
DIRECTOR

DEPUTY DIRECTORS
RONALD N. HIRANO
DAN T. KOCHI
JEANNE K. SCHULTZ
CALVIN M. TSUDA

IN REPLY REFER TO:

(7)

January 18, 1990

HAR-EP 2178

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Boulevard, Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

Draft EIS
Proposed Mauna Lani Marina

Thank you for the opportunity to review the subject draft EIS.

We have no comment or objection on the proposed project.

Very truly yours,

Edward Y. Hirata
Director of Transportation

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-380 (849.11)

Mr. Edward Y. Hirata, Director
Department of Transportation
State of Hawaii
869 Punchbowl Street
Honolulu, Hawaii 96813

Dear Mr. Hirata:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your letter of January 18, 1990 regarding the subject project and Draft Supplemental Environmental Impact Statement. We appreciate your participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

AM:lf

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
300 S. Ferry Street
Terminal Island, CA 90731

(8A)

January 26, 1990 F/SWR13:JJN

Ms. Anne L. Mapes
Belt Collins and Associates
680 Ala Moana Blvd. Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

The National Marine Fisheries Service (NMFS) has received a copy of the Draft Supplemental Environmental Impact Statement (EIS), Mauna Lani Cove, Mauna Lani Resort, South Kohala, Hawaii. We have reviewed pertinent portions of the document and offer the following comments for your consideration.

The Draft EIS appears to be fairly complete and contains much useful information, particularly in the reports appended to the document. However, presently we do not have the time or manpower necessary to review the EIS in detail. Instead we will utilize the document in our detailed review of the Federal permit application (Corps of Engineers permit) for the project, as is mandated under the Fish and Wildlife Coordination Act. We understand an application has been submitted to the Corps and a public notice will be available shortly from the Corps for agency and public review.

As stated in our letter to you dated May 10, 1989 responding to the EIS Preparation Notice (included in Chapter VIII, pages 38-39 of the subject EIS), NMFS has major concerns over the rapid increase in coastal development along the Kona Coast of the island of Hawaii. Our concerns center on the potential cumulative impacts from coastal development on the pristine marine environment and coral reef habitat for which Kona is so well known. Considering the magnitude of the proposed project and the potential adverse impacts on the coastal environment, NMFS feels that a number of issues raised in the draft EIS warrant further consideration and development.

Under the section entitled Necessary Approvals and Permits there is no mention of Section 7 Consultation under the Endangered Species Act, as specified in our letter of May 10, 1989. Consultation will have to be conducted prior to obtaining the Corps of Engineers permit(s). Corps permits may be required under Section 404 of the Clean Water Act as well as Section 10 of the River and Harbor Act.

(8B)

There are several facets of the proposed project which we feel need to be further discussed and analyzed. These include the impacts of blasting and dredging the entrance channel, the quality of the waters within the Cove inner channels and offshore waters, and the impacts on coastal waters from mechanically pumping water to flush out inland water areas of the Cove. These issues cannot "...remain undefined until the project is constructed" as stated in the draft EIS. In addition we understand there is a proposed major change in the Cove flushing system which is not included in the draft EIS.

NMFS is presently in the final stage of implementing a National mitigation policy for loss of estuarine and marine habitats. It is a top priority of the agency to take all possible measures to conserve these habitats through avoiding, minimizing, and if necessary, compensating for loss of habitat resulting from legitimate water dependent projects. The applicant has not provided any form of mitigation to compensate for the unavoidable loss of approximately 2.5 acres of nearshore coral reef habitat from construction of the Cove entrance channel should the project be permitted. Mitigation appropriate for this loss, in the form of habitat restoration, enhancement, or creation of habitat (e.g. construction of an artificial reef) should be included in the scope of the project.

In light of the concerns specified above and the magnitude of the proposed project, NMFS recommends that a scoping meeting be held prior to finalizing the EIS. The meeting would most appropriately be coordinated by the Corps of Engineers and should include the developer and his consultants, all State and Federal reviewing agencies, and appropriate public organizations. Please contact Mr. John Naughton of our Pacific Area Office in Honolulu (808-955-8831) concerning the recommended meeting and/or to clarify or elaborate on these comments.

Sincerely yours,

E.C. Fullerton
E.C. Fullerton
Regional Director

cc: P/SWR13, Naughton
Corps of Engineers, Hon. District
EPA, Region 9 (W-7-2)
FWS, Honolulu
Hawaii CZM Program
Hawaii State Div. of Aquatic Resources
Environmental Center, Univ. of HI
TORCH, Hawaii

(8C)

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-381 (849.11)

Mr. E.C. Fullerton, Regional Director
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Region
300 South Ferry Street
Terminal Island, California 90731

Dear Mr. Fullerton:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your January 26, 1990 letter regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your comments.

1. We understand your concerns relative to the increase in coastal development along the Kona and Kohala coast of the island of Hawaii. As one of the original destination resorts along the coast Mauna Lani has expended considerable time and effort to assure that subsequent developments are environmentally compatible and in keeping with the land use plans, policies and controls of both the State and County of Hawaii. To this end, Mauna Lani has developed and successfully implemented several environmental protection measures. These include the restoration and continued maintenance of Hawaiian fishponds and anchialine ponds, the restoration and maintenance of archaeological preserves and public educational programs regarding the environmentally sensitive area in which Mauna Lani does business. It is in the resort's best long-term interests to promote environmental protection and awareness and, as noted in the Draft Supplemental EIS, it would continue and expand those programs to the proposed Mauna Lani Cove project.

   With regard to your comment regarding the pristine nature of the marine environment and coral reef habitat, the entire Kohala coastline is subjected to numerous natural environmental stresses that are part of the overall ecological balance of the area. For example, it has been estimated that the natural groundwater efflux along the coastline varies from three to seven million gallons per day per mile of coastline. This efflux tends to limit coral growth and the establishment of large coral colonies and bottom coverage in the nearshore areas. Similarly, man-induced pressures, such as the collection of fish by tropical fish collectors, has severely reduced populations of reef fish as has increased shore fishing. Based on the studies that have been conducted for the proposed and previous Mauna Lani projects, the nearshore coastal waters fronting the resort are less than spectacular with coral cover ranging from 5 to 28 percent on the shallow reef terrace, and 5 to 9 percent within the channel proper, that would be dredged for the entrance channel. Similarly, reef fish and invertebrate species densities and diversity are low, most likely due to the less than favorable physical environment caused by heavy surge and nearshore wave action. These conditions are fairly typical along the entire Mauna Lani Resort coastline, as has been described in the several scientific studies conducted for and by the resort.

Beyond the nearshore reef drop-off, where there will be no dredging, coral cover increases to between 49 to 86 percent. To prevent sedimentation of these richer coral areas, a boom system will be used to control fugitive turbidity generated by dredging in the nearshore shelf.

2. Consultation under the Endangered Species Act will be added to the Final Supplemental EIS list of approvals and permits required for the proposed project.

3. The Final Supplemental EIS will contain an expanded description of the blasting methods and techniques to be used during the construction of the entrance channel. As noted in the Draft Supplemental EIS, natural and/or induced currents will be utilized to maintain the water quality of the marina interior channels, in compliance with applicable state water quality standards. Natural wave and current actions are expected to assist in the maintenance of offshore water quality standards. Based on scientific studies conducted in Hawaii and on the Mainland U.S., as noted in the Draft Supplemental EIS, well-managed marinas are generally considered to be non-polluting. As such, we do not foresee any significant adverse impacts to either the coastal water or habitat quality as a result of the construction of the proposed project. Further, additional information, including results of a hydraulic model study performed specifically to address the issue of marina flushing, will be included in the Final Supplemental EIS. As indicated in the Draft Supplemental EIS, two methods of assuring flushing of the Cove are being considered. The first is to rely on natural flushing resulting from the efflux of groundwaters into the cove, tidal flushing and the existing nearshore current patterns. The second includes the construction of a saltwater flushing reservoir just inland of the Cove that would serve as a water feature to the golf course and provide water that would be pumped as necessary into the Cove to aid in flushing. Based on the model studies performed, use of the reservoir would most likely be required to aid flushing. However, it has generally been found that the groundwater efflux along the Kohala coast is greater than that predicted, which may reduce the need to utilize the flushing reservoir. An ongoing water quality monitoring program during the operation of the Cove will dictate the degree of aided flushing required. Please refer to the studies on "Water Quality and Exchange Characteristics of Mauna Lani Cove" prepared by OCEES International, which will be included in the Final EIS.

4. We understand that the National Marine Fisheries Service (NMFS) national policy for loss of estuarine and marine habitats is part of the overall Environmental Protection Agency's (EPA) National Coastal and Marine Policy. We have reviewed the EPA policy, as it applies to the proposed project, and believe that the proposed project is in compliance with the goals of that policy. The

applicability of EPA's policy to the proposed project will be included in the Final Supplemental EIS. With regard to habitat replacement, studies in Hawaii have indicated that the dredged entrance channel walls may provide better habitat than that presently found offshore of the proposed project. The walls would not be subjected to the heavy surge and wave action currently experienced by the natural shoreline and nearshore reef environment, consequently providing better habitat opportunities for sessile and settling organisms. This in turn is expected to lead to greater food supplies for motile organisms. Similarly, the interior portions of the Cove will provide about 23 acres of estuarine habitat that does not presently exist. We believe that these features will offset the 2.5 acres of sparsely populated reef habitat that will be lost.

5. The subject of a scoping meeting between the affected federal, state and county agencies has been discussed with the Corps of Engineers, Pacific Ocean Division. It is an excellent idea. It is our understanding that such a meeting would be held in conjunction with the Department of Army Permit application that has been filed.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

GC:AM:FD:lf

cc Director, Office of Environmental Quality Control
Director, County of Hawaii Planning Department

RECEIVED
FEB 2 1990
BELT, COLLINS & ASSOCIATES

Kona Conservation Group
C/O
Douglas L. Blake
73-4504 Kohanaiki Rd.
Box 10
Kailua-Kona, HI. 96740

January 20, 1990

Ms. Anne Mapes
Belt,Collins and Associates
680 Ala Moana BLVD.
Suite 200
Honolulu,Hawaii 96813

Dear Ms. Mapes

Regarding the findings of impact as noted in the Draft Environmental Impact Statement (E.I.S.) for the proposed Mauna Lani Cove residential/resort marina in South Kohala which was prepared by your company,the members of the Kona Conservation Group would like to submit a few comments and suggestions and pose a few questions that we request to be addressed in the follow-up studies to this draft E.I.S.

Not building the hotel on the site in favor of this proposed marina,desireable in some ways,will however result in a change of density for this area developmental node and may well increase efforts to later add off-setting additional density elsewhere encouraging other spot-zoning in this node and elsewhere.

The proposed marina will add to fishing pressures upon already strained offshore fishing stocks.In light of the State plans to build in expansion a 350 slip public marina located just 8 miles north of Kalahuipuaa,we feel that the proposed subject marina will have too large of a later cumulative impact to be justified.

The potential and likelihood of affecting the offshore area in a manner distructive to the currently invaluable surfing areas on effected reefs directly offshore of the site is for unknown reasons unaddressed in this impact study.Surfing is not mentioned in this study.Therfore we request that any future studies include long-term investigation into the serious potential for adverse impact and distruction of the currently existing surfing breaks which are located directly in front and to the sides of the proposed entrance channel to this tentatively"planned" marina.

We thank you for this opportunity to comment upon this E.I.S. and look forward to your specific replies as regards our concerns.Please contact our organization for further information and assistance.We look forward to receiving your replies.

Sincerely,

Douglas L. Blake
Douglas L. Blake
President
Kona Conservation Group
Kailua-Kona Hawaii
phone
C/O
325-9950

cc. Conservation Council for Hawaii
cc. Hawaii County Planning Commission
cc. Hawaii County Planning Dept.
cc.State of Hawaii,Dept. of Land and Natural Resources
cc. Save Our Surf
cc. The Surfrider Foundation
cc. Public Access Shoreline Hawaii(PASH)
cc. Hawaii Sierra Club
cc. U.S. Army Corps of Engineers
cc. Environmental Protection Agency
cc. West Hawaii Today
cc. Hawaii Tribune Herald

(9)

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-382 (849.11)

Mr. Douglas L. Blake, President
Kona Conservation Group
73-4504 Kohanaiki Road
Box 10
Kailua-Kona, Hawaii 96740

Dear Mr. Blake:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your January 20, 1990 letter regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. As indicated in the Draft Supplemental EIS, the proposed project will lower the use density of the proposed Mauna Lani Cove project lands. Future development plans for Mauna Lani Resort are shown on Figure II-2, Master Plan, Mauna Lani Resort. In compliance with the West Hawaii Regional Plan and County General Plan designation as a major resort destination, future resort facilities would be sized and located to serve the overall resort area. The 3,000 resort unit limit established in the General Plan for major resorts will not be exceeded within the boundaries of the entire resort. Also, the limit on the number of residential units (3,182) specified for the resort in an approved 1979 SMA amendment would remain unchanged. Development will occur in a planned, orderly manner; there will be no "spot-zoning." Mauna Lani's focus has been to reduce overall densities and is not seeking to offset densities elsewhere.

2. It is not clear that offshore fishing stocks are strained or what the causes may be. Mauna Lani does not intend to allow large volume commercial fishing vessels to operate out of the facility. Only limited sports fishing charters will be allowed. However, in light of the state's relatively unclear plans regarding a small boat harbor at Kawaihae and the timing of such facilities, Mauna Lani Cove will provide in-the-water mooring facilities for those who now must trailer their boats to/from ocean recreation activities. It is not certain that denial of additional mooring and launching facilities would necessarily lead to increases in sport fishery stocks. We note that neither federal or state monies to construct the small boat facilities at Kawaihae have been appropriated and state monies will most likely not be requested until a substantial portion of the federal construction activities have been completed. It is our understanding that, at this time, a federal construction period has not been established, given the lack of funds as well as the need to initiate and complete federal environmental documentation for the project.

3. The Draft Supplemental EIS notes that the offshore areas fronting Mauna Lani Resort are used for a variety of ocean recreation activities; however, surfing will be addressed in the Final Supplemental EIS. Based on our review of pertinent documents, such as Hawaii Statewide Comprehensive Outdoor Recreation Plan (SCORP), no specific surfing sites are identified immediately seaward of the proposed project and informal surveys by Mauna Lani Resort outdoor recreation personnel have not identified particularly popular surfing sites in the proposed entrance channel area. The one popular area is "Peaks", which is about 1200 feet away from the channel area and fronting the 11th hole and the Mauna Lani Bay Hotel. As such, the proposed project is not expected to affect surfing at "Peaks".

   We note that basic physical oceanographic principles dictate that those areas that are favored surfing locations are not good locations for marina or harbor entrance channels; that is, for an area to be a good surfing location, offshore rock or coral reefs that rise fairly quickly are required. As such, a marina or harbor entrance channel, if possible, would be located outside those quickly shoaling areas to reduce entrance channel construction costs. Based on the hydraulic modeling, current and wave studies conducted for the proposed project, the surfing breaks located to the sides of the channel are not expected to be affected by the proposed channel. Mauna Lani will consult with its engineers to study the possibility of a surf break that can be generated by the channel cut.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your memorandum and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

GC:AM:FD:lf

cc Duane Kanuha

(10 A)

RECEIVED
FEB 6 1990
BELT, COLLINS & ASSOCIATES

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
Keith W. Ahue
MANABU TAGOMORI
RUSSELL N. FUKUMOTO

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

REF:OCEA-VIN

File No.: HA-2275
Doc. No.: 7368E

FEB 2 1990

Mr. Duane Kanuha, Director
Department of Planning
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Kanuha:

SUBJECT: Departmental Review of Draft EIS for Mauna Lani Cove, South Kohala, Hawaii

We have completed our departmental review of the subject Draft EIS for Mauna Lani Cove and offer the following comments for your consideration.

We find that the subject DEIS should contain a more detailed description and evaluation on the method to create the proposed access channel, particularly in regards to proposed construction (including blasting) techniques. Additionally, more information and assessment is required on the proposed method to transport and store dredged material and the alternatives of compensation for the spoil.

The DEIS should contain a thorough inventory and impact assessment of potential fishery (vertebrates/invertebrates) resources in the offshore area (i.e. octopus, lobster, spawning fish, etc.)

Additional information and assessment is also required relative to on-shore and offshore recreational activities in the area (i.e. fishing, surfing, kayaking, snorkeling, etc.)

The EIS and CDUA must be amended to include additional lands uses for required navigational aids (i. e. buoys, channel markers, etc.)

Our Historic Preservation Program highlights that pages IV-35 to -38 covers historic preservation review. We recently reviewed the PHRI archaeological inventory survey report. We agreed that all historic sites are likely to have been found, totalling 18, and that these sites are significant solely for their information content. However, contrary to the statement in the Draft EIS (p. IV-38), we disagreed that 17 of the 18 sites need no further

(10 B)

work, or in our terms are "no longer significant". We believe that 8 sites still contain some significant information and need mitigation and that 10 can be considered "no longer significant".

Thus, at this point, significance evaluations and general mitigation commitments have still not been agreed upon under the historic preservation review process. Mauna Lani and our Historic Preservation Program office are in consultation and will be rapidly resolving these concerns. Again, we do agree that archaeological data recovery will be an appropriate mitigation measure; it is simply the specific tasks that need resolution.

Finally, review comments submitted by the Division of Forestry and Wildlife identify that the developer should be aware of the following problems:

1. Nene are grazers and will undoubtedly congregate on fairways and greens to feed. This activity will create obstructions for golfers and may prevent the developer from using pesticides and other chemicals for grass maintenace.

2. Nene are considered an endangered species under State and Federal laws. As such, it is unlawful for any person to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect or to attempt to engage in any such conduct.

Thank you for the opportunity to provide comments on this document. Should you have any questions, please feel free to contact assigned staff planner, Ed Henry at the Office of Conservation and Environmental Affairs (548-7837).

Very truly yours,

WILLIAM W. PATY

cc: Anne Mapes
Belt Collins and Associates

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-384 (849.11)

Dept. of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Attention: Mr. William Paty, Director

Gentlemen:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your letter of February 2, 1990 to Mr. Duane Kanuha, Director, Hawaii County Planning Department, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. Per your request, additional information regarding the access channel construction methods and techniques will be included in the Final Supplemental EIS. Additional information regarding the size and placement of blasting charges will be provided as will additional information regarding the expected results of blasting.

   Also, per your request, additional information regarding the transport of dredged spoil material will be provided in the Final Supplemental EIS. As presently proposed, the materials will be dredged by a barge mounted backhoe or clamshell dredge, loaded onto a transport barge and stockpiled at Kawaihae Harbor prior to transport back to Mauna Lani and disposal on Mauna Lani lands designated for such disposal. By the time the materials are transported back to Mauna Lani, they are expected to have lost, through drainage and evaporation, all but a minor amount of the water associated with the dredged material. We do not anticipate any drainage problems enroute during the transportation between Kawaihae and Mauna Lani. Should the materials be too wet for truck transport, we will allow the materials additional drainage and drying time prior to transport.

   When consulted, DLNR Land Management staff suggested that Mauna Lani submit a proposal to buy the dredged materials at waste rates. Such a proposal will be forthcoming.

2. The Draft Supplemental EIS contains a thorough marine survey (Appendix F), green turtle impact assessment (Appendix J) and impact assessment relative to humpback whales (Appendix K). Per your request, additional information relative to the recreational aspects of the proposed project area will be included in the Final Supplemental EIS.

3. Per your request, the Final Supplemental EIS and CDUA will be amended to include the land uses required for navigational aids.

4. We appreciate your cooperation in the development of the specific tasks required to accomplish the archaeological data recovery mitigation plan.

5. We are unaware of any Nene inhabiting the Mauna Lani or West Hawaii coastal area. However, based on the avifauna and feral mammal survey conducted for the proposed project, as well as our past experience, we realize that Pacific Golden Plover congregate on the golf course and other open landscaped areas of the resort. The fertilizers and biocides used on the golf course are approved by the U.S. EPA and State Department of Health for golf course application. Mauna Lani's Cove management plan will require use of rapid root uptake fertilizers and include guidelines that control introduction of phosphate and nitrates into ecosystems. Since its opening in 1983, Mauna Lani Resort has not experienced any incidences of harm to either the terrestrial or aquatic wildlife inhabiting the resort area and does not anticipate any as a result of future resort operations and maintenances practices.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

GC:AM:FD:lf

cc Duane Kanuha

(11A)

RECEIVED
FEB 6 1990
BELT, COLLINS & ASSOCIATES

Planning Department
25 Aupuni Street, Rm. 109 • Hilo, Hawaii 96720 • (808) 961-8288

Bernard K. Akana
Mayor
Duane Kanuha
Director
William L. Moore
Deputy Director

February 5, 1990

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

Draft Supplemental Environmental Impact Statement
MAUNA LANI COVE

We have reviewed the subject Draft SEIS and would preface our comments by stating that the SEIS will be utilized as a support document for the various applications, County and State permits, variance and rezoning applications currently filed with this office and the State Department of Land and Natural Resources. The documentation, analysis, conclusions and factual accuracy should be comprehensive and complete for decision-making purposes. With this in mind, the following comments are provided:

DESCRIPTION OF PROPOSED PROJECT

1. Page I-9: The layout of the proposed residential subdivision may also require a variance or a Planned Unit Development because of the length of the cul-de-sac and the number of lots it will serve.

2. It is unclear as to the exact number or breakdown of residential lots or units being proposed. Page I-3 states 90 to 140 residential lots or units, but it is different on Page II-18, 105 units and Page IV-44, i.e. 75 to 90 single family houselots.

3. The document needs to clarify if the area of the proposed clustered single family detached units will be subdivided. Figure II-2 (Master Plan) appears to be proposed lots, however Figure II-3 (Concept Plan) does not show this. Are the interior channelways considered to be one lot and what are the plans for ownership?

4. Mauna Lani Resort hopes to balance private and public benefits derived from the project. Since one of the criteria in granting the shoreline setback variance is the finding that the variance would be in the public interest, direct public benefits should be discussed and clarified in the SEIS.

(11B)

5. More details need to be provided for two amenities- the flushing reservoir (some details are discussed in other sections of the SEIS but should also be included in the project description) and the fuel storage tanks. No description is provided as to where the storage tanks will be located, the capacity of the tanks, etc. and no discussion on the potential leakage and impacts to surrounding coastal and anchialine pond waters. Also, what sort of mitigation measures are available?

6. The project would include 10 public transient moorings. How long a term is transient? Approximately what rate would the fee be for public/private moorings and for service to and from the parking area to the boat launching area?

7. It is unclear as to the exact number and breakdown of vessel capacity being proposed. Page II-18 states 110 vessels: 80 for Mauna Lani residents, 10 for commercial uses and the remaining for transient facilities, 10 of which will be transient moorings. The document further states a total capacity of 250 vessels inclusive of the residential moorings. Page IV-47 states 185 boat slips, 75 are private mooring floats.

8. The survey on the demand for the marina should be discussed further.

ALTERNATIVES

9. Other on-property locations should be considered and discussed in the document. While the proposed location may be the best alternative, given what land remains vacant for Mauna Lani, the alternatives should be discussed and reasons why this site was chosen should be detailed.

10. The "no-action" or "no-project" alternative should be discussed separately from the development for a hotel site.

PHYSICAL ENVIRONMENT

11. The SEIS should include the salinity levels at the Puako Shaft. It should also describe the salinity contours for the groundwater in the area so that monitoring in the future can be done against some baseline.

12. If brackish water is used for irrigation of landscaping and the golf-course, what is the salinity tolerance for plants? When can it be determined that fresh water needs to be added or wells moved?

(11C)

13. Appendix F discusses a water quality monitoring program at Honokohau Harbor. However, the Draft SEIS does not clearly establish that the proposed configuration of the planned project does result in a circulation and turnover pattern similar to or better than that at Honokohau Harbor. Page IV-5 provides a summary of anticipated effects and states that the computer simulation results will be available for the Final SEIS. The Draft SEIS should have provided the model and the model reviewed and analyzed so that more study could be made if necessary.

14. FIRM Map designations should be shown as an overlay on the project site plan. The SEIS should give a detailed analysis of the existing flooding inundation areas, existing natural contours, finished contours and anticipated finished grade. Maps showing this would aid in the visual evaluation. The hydraulic model should hypothesize new FIRM Map designations on the site plan overlay.

15. The hydraulic model (Appendix B) does not incorporate model hurricane storm findings in Appendix I, which project 30' wave height at 12.0 seconds. This is considerably greater than 17' wave height at 9 seconds used for storm waves/tsunamis.

16. Historically, storm waves anticipated to cause most damage comes from the south and southwest (Kona storms) but the wave disturbance and harbor modeling tests show waves generated from the northwest. This needs to be clarified. How valid is this in assessing maximum damage, wave height generated within the harbor, etc. (see also Appendix B and C).

17. During storms and tsunamis, emergency services (civil defense, public works, coast guard) will be activated. What is the current evacuation plan? Are the current roadway systems adequate to service evacuation? The tsunami warnings time lapse is not applicable to locally generated tsunamis. This potential should be discussed also.

18. As part of the mitigation measure, the SEIS should include as an appendix a list of plants likely to be utilized for landscaping.

NATURAL ENVIRONMENT

19. A map showing the present location of the pololei fern should be included in Chapter IV.

20. The fish survey did not examine the inshore reef community, nor did it attempt to identify other organisms that might be present such as gastropods, eels, etc. Discussion on the use of this area

(11D)

by fishermen and the impacts upon these resources as food should be included.

21. A baseline count of Gambierdiscus should be conducted of the proposed project site since Appendix F concludes "there is no reason to expect a priori that construction at the Mauna Lani Cove site will cause incidences of ciguatera." Any studies conducted along the west Hawaii coastline should also be included in the SEIS.

22. When will the engineering study mentioned in Appendix F be conducted to determine if volcanic cinder exists? If this situation exists, what are the impacts or proposed mitigation, if any?

23. What is proposed to prevent rapid loss of sand during marine construction as concluded in Appendix G?

24. The conceptual plan shows anchialine ponds being subdivided out of the residential lots. Several anchialine pond parcels are proposed to be zoned RS-15. How will these ponds be managed and by whom?

HISTORICAL RESOURCES

25. The SEIS has identified one disposal site for the fill. An archaeological reconnaissance survey of this area should be included in the Final SEIS.

26. The Keanapou Pond adjacent to the proposed residential lots is proposed for preservation in conjunction with the Ritz-Carlton hotel development. The SEIS did not discuss this nor any impacts on the pond and the mitigation measures, if any.

SOCIOECONOMIC FACTORS

27. Page IV-39 notes that 30% of the construction workers are anticipated to be from the Big Island and presumably the other 70% from Oahu. What sort of housing arrangements would be made?

28. The fiscal impact study does not specifically add up all of the cost areas for the County, e.g. general government, public safety, road maintenance, etc. but rather states for many of these items that the impacts would be negligible. An itemized cost along the categories discussed should be made and calculated on a per capita basis even for those items that appear small.

INFRASTRUCTURE

29. In the traffic analysis, it is unclear as to how the

(11E)

projected traffic growth of 15% is derived from the Ritz-Carlton Final EIS, and less clear as to how it is used in concluding with the projections on Figure 3. Although the traffic study discusses alternatives, the SEIS did not provide any mitigation measures.

30. The Ritz-Carlton Final EIS (Figure IV-11) reflects a roadway which branches off into the project site. The SEIS did not address the alternative use or status of this roadway system.

31. The SEIS states that construction of a second access road to the project would alleviate predicted queuing at Mauna Lani Drive intersection. When and where is this second access likely to be put in place?

32. Page IV-47 states "Because there is a lack of parking space around The Cove, Cove employees would assist boat owners with the launching operations and then park their vehicles and trailers at a site away from The Cove." The concept plan does not show the location of the boat-trailer parking area nor discussion of the area was addressed in the SEIS.

33. Page IV-52 states that the estimated demand for potable water requirements is 0.26mgd. How was this figure derived and is it based on historical usage at Mauna Lani? Breakdown between residential, commercial and industrial uses should be shown.

34. We assume that the brackish water system will be used for the common area landscape irrigation. Will this also be tied into the residential lots being planned or is domestic water also likely to be used by individual homeowners for their own landscaping?

RECREATION AND PUBLIC ACCESS

35. There is no assessment or analysis of existing on- and off-shore recreational resources/activities. What will be displaced and what mitigation measures are proposed, if any? Potential water traffic in relationship to off-shore recreational activities such as surfing, windsurfing, snorkeling, etc. should be addressed in the Final SEIS.

36. Public access is shown to be around the basin in front of residential lots but between private boat docks. Who owns the residential dock? Has the private/public interaction been analyzed? Is the proposed public pedestrian basin access safe in the event of high wave action? What means of pedestrian evacuation are proposed as there is no outlet between the residential lots?

(11F)

37. The Final SEIS will be a support document to the SMA application and as such it should include a map showing the shoreline park and landscaped area near the anchialine ponds. Consideration of mauka/makai access to the shoreline within the project should also be included.

LAND USE PLANS

38. Page II-18 states that the proposed zoning for the residential lots/units are RM-3 and RM-10. However, Figure V-2 (Page V-28) reflects RM-3 and RS-15. Figure V-2 also shows that the Open zone on the south side appears to traverse over the parcel boundary into the Bungalow site.

39. The Office of State Planning comments (letter dated April 20, 1989) requested information on how specific conditions of the Land Use Commission approval would be met due to the change in the project. Specific discussion on this should be included.

40. Detailed discussion of the public benefit to the use of submerged lands (State owned) as well as submerged land issues and requirements of the DLNR should also be provided in the SEIS.

OTHER COMMENTS

41. The analysis of the overall impact needs to be better documented. For example, Appendix F refers to a monitoring program at Honokohau Harbor by the U.S. Army Corps of Engineers (1983), coral communities at Kawaihae Deep Draft Harbor (ORCA 1978), sediment stress by Johannes (1975), Dodge and Vaisnys (1977), Bak (1978) and toxicity monitoring (S.E.A. Ltd.). Studies/analyses which have been used to reach significant conclusions should be included in the SEIS.

42. The Final SEIS should state that a certified shoreline survey has been approved by the BLNR.

43. Page I-1: It is the Planning Department, and not Mauna Lani, who makes the determination that a SEIS is required.

44. Page I-5 states that the pedestrian bridge is proposed to be 6 feet wide, but Page IV-43 states 5 feet wide.

45. Page IV-7 states that the tsunami historic data registered wave height at 10 feet, but Page III-3 states 12 feet.

Thank you for the opportunity to review and comment on the Draft SEIS for the proposed Mauna Lani Cove development.

Sincerely,

DUANE KANUHA
Planning Director

ak
xc: Mauna Lani Resort, Inc.
OEQC

(11G)

BCA
BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-385 (849.11)

Mr. Duane Kanuha, Director
Planning Department
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Kanuha:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your February 5, 1990 letter regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

Description of Proposed Project

1. The Final Supplemental EIS will be revised to indicate that a variance or Planned Unit Development may be required because of the length of the cul-de-sac and the number of units it will serve.

2. The Final EIS will be revised to eliminate any confusion regarding the number of lots to be developed and the planned use of those lots.

3. The Final Supplemental EIS will be revised to clarify the areas to be subdivided. Similarly, based on past State Department of Land and Natural Resource practices, the channel areas will remain as the property of Mauna Lani Resort, Inc. Further discussion with your staff will be conducted to determine if all channels will be one or more lots. Your assistance with this question will be appreciated.

4. Additional discussion regarding the public benefits to be realized from the proposed project will be included in the Final Supplemental EIS.

5. Per your request, additional information relative to the flushing reservoir and boat fuel storage tanks will be included in the Project Description section of the Final Supplemental EIS. Installation of the tanks will be in compliance with applicable U.S. EPA and State Departments of Health and Transportation. This information will be included in the final Supplemental EIS.

6. The State Department of Transportation, Harbors Division, defines transient vessels as those visiting the state for a period of less than ninety days and temporary moorings as visits of up to three days. Transient slips would be used by vessels for terms of one day, one week or a month. Although specific rates and fees have not been determined, fees, rates and definitions used by the state will

be used as guidelines by Mauna Lani Resort and modified as applicable to comparable private marinas, taking into consideration that state fees are publicly subsidized.

7. The numbers of vessels and moorings to be provided will be clarified in the Final Supplemental EIS. The completed Cove will have the capacity for 250 vessels. There will be a total of 185 boat slips, including 75 private mooring floats adjacent to the houselots fronting the Cove channels. However, with the ability to tie more than one vessel to some of the slips, the total capacity is increased to 250 vessels.

8. Per your request, additional demand survey information will be included in the Final Supplemental EIS. We are also seeking similar information developed by the state for Honokohau and Kawaihae Harbors. If obtained, this information will also be included.

Alternatives

9. Those feasible alternatives that would allow the stated objectives of the proposed project to be met are included in the discussion provided in Chapter III of the Draft Supplemental EIS. These on-property sites will be discussed in the Final EIS. In selecting the proposed site, Mauna Lani considered Honokaape Bay and other areas in close proximity to the chosen site. Topography and other environmental conditions (such as bathymetry, low coral diversity and cover, and elevation) were critical factors in the overall evaluation of sites.

10. In this particular instance, the "No-Action" alternative equates to the development of another hotel. As such, the two must be addressed as one.

Physical Environment

11. The salinity levels at the Puako Shaft will be included in the Final Supplemental EIS if that information is available. Similarly, groundwater salinity contours will be provided if available.

12. Non-potable water will be used to irrigate the golf course and potable water used to irrigate resort common landscape areas. The latter is required due to the need to maintain the resort landscaping in a manner befitting the remainder of the resort. The golf course turf can generally withstand salinity levels between 400 and 1,000 parts per thousand, i.e., two to five times the generally accepted level for potable water.

13. A water quality monitoring program will be conducted prior to, during and following construction of the Cove to assure that state water quality standards both inside and outside the Cove are maintained. A draft of the proposed water quality monitoring program will be included in the Final Supplemental EIS. Prior to construction, concurrence with the program will be obtained from the U.S. Army Corps of Engineers, State Departments of Health and Land and Natural

Resources and your department. The final results of the computer simulation studies as well as updated circulation and water quality results will be included in the Final Supplemental EIS. Please note that as a result of our initial modeling, additional studies were conducted and minor modifications to the interior of the Cove are being contemplated to expedite flushing of the Cove.

14. A separate map delineating the FIRM map designations within the project boundaries will be included in the final Supplemental EIS.

15. The hydraulic model did incorporate model hurricane storm findings. Test 4 of the wave disturbance tests utilized waves with significant heights of 23.6 ft. and periods of 11 seconds (see Pages B-18 and B-23 of Appendix B). According to the data compiled in Appendix I (see page I-9, Table 5), the worst hurricane storm since 1947 had hindcasted significant wave heights of 22.5 ft. and periods of 12 seconds (Hurricane Dot - 1959). Again, according to Appendix I, the severe Kona storm of January 1980 had hindcasted significant wave heights of 17 ft. with 9 second periods (see Page I-2 of Appendix I). The model hurricane storm referred to is a worst case scenario, which assumes that the hurricane passes very near to the west coast of Hawaii and the project site. As Appendix I states, it is more likely that the storm would pass some distance from the island; thus, the wave heights would be lower. The 23.6 ft. wave heights tested on the hydraulic model are quite conservative and the data clearly indicates that the higher wave heights do not indicate a trend toward increased wave disturbance in the development (see Page B-25, Table 3 in Appendix B). Indeed, the wave heights generated in the development are all very low considering the severity of the offshore waves tested.

16. The direction of wave attack for the disturbance tests was chosen based on the direction which would allow the waves to most easily enter the development. Waves approaching perpendicular to the shoreline cause the most disturbance; therefore, that was the direction chosen. The Kona waves will be heavily refracted as they approach the project site; therefore, may not be any more likely to cause disturbance as very severe North Pacific swell or severe local hurricane waves that might approach from the northwest. Again, the wave direction chosen is the worst case, whether it results from refracted Kona waves, North Pacific swell, or hurricane waves.

17. Mauna Lani currently has an emergency evacuation plan that was developed in collaboration with the County Civil Defense Agency. The plan will be extended to the Cove and surrounding houselots. In addition, the resort tsunami warning system will be extended to cover the proposed project area. The present evacuation plan leads guests and residents out of the coastal area via Mauna Lani Drive, which is more than adequate to handle increased population levels resulting from the proposed project. In addition, all roads and habitable structures are and will be above the historical high water level.

18. A list of plants typically used within the resort will be included in the Final Supplemental EIS.

Natural Environment

19. Per your request, a map showing the location of the pololei fern will be included within the text of the Final Supplemental EIS. A map showing the location of the fern is included in Appendix D (see page D-5) of the Draft Supplemental EIS.

20. As shown on Figure 1 of Appendix F (page F-15), the marine survey conducted specifically for the proposed project covered the area from about one-foot deep along the shoreline out to a depth of over 40 feet. Further, a complete listing of the fish, coral and invertebrate species sighted during the survey are included in the various tables included in Appendix F and listed in Chapter IV, Section 3.3.2. Use of this area by fishermen will be addressed in the Final EIS.

21. In conjunction with the environmental monitoring program, before construction, counts of Gambierdiscus will be conducted for comparison with during and after construction population level counts. Studies that have been conducted with regard to the incidence of ciguatera in West Hawaii will be identified in the Final Supplemental EIS along with the latest State Department of Health information.

22. Soil borings to determine the type of material that will be excavated will be conducted as part of the construction contract. If as is presently suspected, pahoehoe lava underlies the project site, little if any siltation resulting from excavation activities is expected. This is because pahoehoe lava does not contain the "fines" that cause siltation problems such as those encountered in the dredging of coralline limestone materials. The experiences of dredging Honokohau Harbor are instructive in this regard and will be included in the Final Supplemental EIS.

23. The rapid loss of sand referred to in Appendix G is caused by a loss of vegetative cover. Therefore to prevent further loss of sand, revegetation of areas that would be cleared of naturally occurring vegetation would be accomplished. It is expected that the vegetative cover of the project area will be greater than that found at present at the conclusion of the project.

24. All anchialine ponds within the resort boundaries will be managed by Mauna Lani Resort. Mauna Lani has years of success in anchialine pond restoration and management.

Historical Resources

25. An archaeological reconnaissance survey of the Mauna Lani Resort lands, including the area to be used as the dredged spoil material disposal site, was conducted by the Bishop Museum. No archaeological sites were found in the proposed disposal area. Please refer to the Mauna Lani Resort Revised Master Plan EIS (June 1985) for a map showing the location of archaeological sites at the Resort (Figure IV-5).

26. The proposed project is not expected to affect the Keanapou Pond which has been cleaned and restored as part of the Ritz-Carlton at Mauna Lani project. However, for completeness, this information will be included in the Final Supplemental EIS.

Socioeconomic Factors

27. Housing arrangements for off-island construction workers will be the responsibility of the construction contractor. A similar arrangement has been approved by the County for the construction of the Ritz-Carlton Mauna Lani project.

28. More detail, as requested, will be included in the Final Supplemental EIS.

Infrastructure

29. Traffic study methodology and proposed mitigation measures will be clarified in the Final Supplemental EIS.

30. Figure IV-11 of the Draft Supplemental EIS is in error and will be corrected in the Final Supplemental EIS. The short roadway branch will not be constructed and will be deleted from the figure.

31. The second access roadway would be located north of the existing Mauna Lani Drive/Queen Kaahumanu Highway intersection and sufficiently removed from that intersection to assure the safe and efficient flow of traffic.

32. The boat/trailer parking area would be located mauka of the Cove project in the resort services area near the present Mauna Lani Resort Administration buildings. The parking area will be discussed in the Final Supplemental EIS.

33. Potable water requirements for the proposed project have been derived using standard civil engineering formulas in compliance with County Department of Public Works requirements. A breakdown according to various usage areas will be included in the final Supplemental EIS. This breakdown will necessarily be speculative, given the present unknown nature and sizes of the types commercial activities that might be located within the proposed project.

34. Brackish water will be used for irrigation of the golf course. As noted previously, because of the lack of salt tolerance by most landscape plants, potable water will be used for landscaping purposes.

Recreation and Public Access

35. Present on-shore activities are limited to shore fishermen and resort guests/residents walking along the beach. Offshore activities include surfing and diving. The channel dredging should not affect popular surfing spots. However,

project engineers will investigate possible engineering design of the cut to encourage the surf break. Popular diving areas will not be affected.

36. Docks located in front of houselots will be owned by the individual property owner. A public easement will cross each lot to allow public access around the Cove. As noted previously, the present resort evacuation plan will be revised to include the Cove and associated houselots. Public access/evacuation routes will be provided in compliance with applicable state and county requirements.

37. The shoreline park and landscaped area near the anchialine ponds is shown on Figure II-2 as Holoholokai Beach Park at Mauna Lani and as the shoreline "green belt" fronting Mauna Lani Cove. Mauka-makai access is provided throughout the Cove via the accessway around the perimeter of the channels. Mauna Lani is consulting with PASH regarding access solutions.

Land Use

38. Discrepancies regarding zoning designations will be corrected in the Final Supplemental EIS.

39. Additional information relative to the Office of State Planning April 20, 1989 letter will be included in the Final Supplemental EIS.

40. Additional information regarding public benefits to be realized from the proposed project will be included in the Final Supplemental EIS.

Other Comments

41. In keeping with accepted EIS preparation practices and federal and state rules and regulations, informational sources are referenced as appropriate. All references listed in the Draft Supplemental EIS and Appendices thereto, are available at most public and/or university libraries. To include all of these references as attachments to the EIS itself would result in an unnecessarily cumbersome and unwieldy document.

42. The Certified Shoreline, as approved by the BLNR, is shown of Figure II-3 of the Draft Supplemental EIS.

43. The wording regarding the determination for the Supplemental EIS will be corrected in the Final Supplemental EIS to reflect that it was the County Planning Department's decision.

44 and 45. Inconsistencies throughout the Draft Supplemental EIS will be corrected in the Final Supplemental EIS.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

GC:AM:FD:JG:lf

RECEIVED
FEB 8 1990
BELT, COLLINS & ASSOCIATES

(12A)

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

February 1, 1990
RE:0547

Mr. Duane Kanuha, Director
Hawaii Planning Commission
Planning Department
County of Hawai'i
25 Aupuni Street
Hilo, Hawai'i 96720

Dear Mr. Kanuha:

Supplemental Draft Environmental Impact Statement (EIS)
Mauna Lani Resort
(Mauna Lani Cove Project)
Alahuipua'a, South Kohala, Hawai'i

The above cited Supplemental Draft EIS for the development of a channel and inland marina/luxury residential complex on an 88-acre waterfront parcel in South Kohala, Hawaii has been reviewed with the assistance of Michael Graves, Anthropology; Yoshitsugi Hokama, Pathology; Jacquelin Miller and Robert Irwin, Environmental Center.

In general, we are pleased with the quality of the document and the extent of the environmental planning it conveys. We note particularly: 1) the inclusion of a sewage pump-out facility for the marina (the first of its kind on the Big-Island), 2) the decision to suspend blasting during peak hump-back whale occurrence months and, 3) the provision of public access to the shoreline. However, our reviewers have noted several inadequacies which we list below.

<u>Subsurface Hydrology Model Studies</u>

The most conspicuous deficiency is the incomplete documentation of model data pertaining to ground water patterns at the site of the proposed project. The document mentions two computer models simulating anticipated hydrological impacts which are to be released in the Final EIS:

(12B)

Page IV-5.

> "One model is a two-dimensional plan view which simulates changes to ground water flowlines and quantifies the discharge rate into the marina itself. Another model is a two-dimensional vertical section which has been used primarily to anticipate the movement of sea water inland. Computer simulation results will be available for the final draft."

Inclusion of incomplete or preliminary data in a Draft EIS was addressed specifically by the Environmental Council's Declaratory Ruling 87-1:

> "...the Environmental Council finds that the inclusion of any such incomplete report in a draft environmental impact statement compromises the intent of Chapter 343 HRS [Sec. 343-1] and the EIS Rules (Sec. 11-200-15(e)) and 17(g)) by denying both public and private agencies and individuals the opportunity for a thorough review of the proposed action and its potential impacts."

Also of particular relevance here is EIS Rule (11-200-17(i)):

> "It should be realized that several actions, in particular those that involve the construction of public facilities or structures (e.g. highways, airports sewer systems, water resource projects etc.) may well stimulate or induce secondary effects. These secondary effects may be equally important as, or more important than, primary effects, and shall be thoroughly discussed to fully describe the probable impact of the proposed action on the environment." (emphasis ours).

These data are crucial to a comprehensive public review of the applicant's proposal and should have been released at the draft stage of the review process. The preliminary "summary of anticipated effects" anticipates some potentially significant problems with the project as a whole. As suggested by the inclusion of the sewage pump-out facility and the marina flushing reservoir in the development plans, it is clearly the developers' intent to create a marina that is as free from problems of pollution and stagnation as possible. Yet, at this stage in the planning process, it is unclear what quantity of fresh water will be emptying into the marina and what effect these newly discharged groundwaters will have on the greater circulation patterns and flushing rates of various sections of the marina. These important factors have been only tentatively modeled by the study presented in Appendix B.

(12C)

Among the probable impacts outlined in the "GROUNDWATER, HYDROLOGY, SURFACE WATER AND DRAINAGE" subchapter of chapter four is the following: "the contrast in density between groundwater and seawater will tend to create vertical stratification; and the nutrient load of influent groundwater may cause a biological response."(p. IV-5, emphasis ours). Further quantification of both the nutrient load of influent waters and their rate of discharge into the marina must be provided before biological impacts can be adequately anticipated and reviewed. Potentially, these impacts could be far ranging and could affect sea-water quality beyond the marina itself.

Equally important is the second model assessing saltwater intrusion into the coastal groundwater. In view of local anchialine pools and plans to draw well water from coastal wells, quantification of this intrusion is essential.

Anchialine Pools

Anchialine pool ecosystems are a diminishing natural resource in Hawai'i, and conservation of this unique habitat should be encouraged. Better descriptions of affected pools and anticipated impacts are needed:

Page IV-16.

> "The shoreline area of the project site contains several anchialine and old fish ponds. There are five major ponds ... and several smaller ponds..."(The maps provided do not clearly delineate each pond or link pond locations with pond descriptions.)

Page IV-17.

> "The biota of the two ponds that could be affected..."(Emphasis ours: it is unclear which two ponds are being referred to here. How are the other ponds known to be safe from the possibility of being altered?)

We suggest that the applicant include a more detailed map which clearly delineates each pool and superimposes the planned project site. In addition, a detailed inventory of basin morphology and the biota presently inhabiting each pool is needed. Inclusion of an historical perspective (i.e. what others found in these pools in the past) would reflect biotic degradation that may have occurred since the pools were first studied in the early 1970's.

Sea water intrusion resulting from marina construction is likely to significantly raise salinity in the pools. What kind of biotic changes might be expected with a change in salinity from 5-7 parts per thousand to perhaps 25-30 parts per thousand?

The Revised Supplemental EIS also should address possible interruption of lateral migration of anchialine species due to alteration of mauka lava

(12D)

habitat. (Anchialine red shrimp and other small species migrate through interstices in the subsurface lava.)

The Supplemental Draft EIS mentions improving the pools by dredging out accumulated sediments. This is probably a good way to slow down senescence. However, we would recommend that the applicant consider not "dredging" the pools but rather clearing them by hand methods. Mechanical dredging may do more damage than good; we know that the traditional Hawaiian hand clearing methods produced good results in these fragile ecosystems.

Potential Ciguatera Fish Poisoning

Coastal dredging and construction have been implicated in blooms of Gambierdiscus toxicus, the dinoflagellate responsible for ciguatera poisoning. Proactive risk management through establishment of the following measures would minimize the potential health hazards:

1. Conduct a baseline (pre-development) survey of G. toxicus in the area.

2. Examine intestinal smears and flesh assays of herbivores (Ctenochaetus strigosus, or Nohe, for example) and piscivores (e.g. Caranx sp., or Ulua) to see if the toxin is present in a significant number of fish. A sample size of at least 150-200 of each species is advised, as only a relatively small number of individuals are likely to be carrying the toxin at a given time.

3. Repeat the survey as outlined above for several 6 month periods after the development has occurred. If, at any point in the study concentrations of G.toxicus are significant and the number of fish carrying ciguatoxin climbs towards 50-60 percent or more, a significant public health risk exists and a warning to the general public should be issued.

By conducting these surveys and responding appropriately to their results, Mauna Lani Resort, Inc. would provide a precedent for ciguatera fish poisoning risk management in Hawai'i.

We appreciate the opportunity to comment on this document and hope our comments will prove useful in the preparation of a more complete draft document.

Yours truly,

John T. Harrison, Ph.D.
Environmental Coordinator

cc: OEQC
Mauna Lani Resort ✓
L. Stephen Lau
Richard Brock
Michael Graves
Yoshitsugi Hokama
Robert Kai Irwin

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
849-11/90-391

University of Hawaii at Manoa
Environmental Center
Crawford Hall 317, 2550 Campus Road
Honolulu, Hawaii 96822

Attention: Dr. John Harrison,
Environmental Coordinator

Gentlemen:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement

Thank you for your letter of February 1, 1990 to Mr. Duane Kanuha, Director, Hawaii Planning Department, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. Subsurface Hydrology Model Studies

We appreciate your concern regarding groundwater patterns and potential seawater intrusion into groundwater supplies inland of the proposed project. Mauna Lani shares that concern, which is one of the reasons that consultants are continuing to conduct computer simulations and model tests, not only of the potential groundwater/seawater question, but also investigations regarding maintenance of acceptable water quality within the proposed Mauna Lani Cove. As a result of the complete studies included in the Draft Supplemental EIS, the concept of the flushing reservoir was developed and has been studied in greater detail since publication of the Draft Supplemental EIS. We note that the studies included in the Draft Supplemental EIS were complete and the reports included as appendices are final reports describing the results of the studies conducted.

We are cognizant of the Environmental Council's rulings regarding the inclusion of draft reports in Draft EIS's and note that it is our understanding that the specific reference in your letter was to a ruling regarding a draft archaeological survey report. The final reports included in the Draft Supplemental EIS for Mauna Lani Cove are not considered to be draft or incomplete. The fact that those reports have led to additional investigations serves to indicate Mauna Lani's concern regarding enhancement of the marine and terrestrial environment surrounding Mauna Lani Resort specifically and Hawaii in general.

The quantity of groundwater that would be pumped into the Cove to aid natural flushing will depend on the degree of natural flushing occurring at any given time. Observations along the West Hawaii coast have indicated that, at times, the natural efflux of groundwater is greater than that which has been predicted. Should this be the case at Mauna Lani, it is possible that pumping flushing reservoir waters may not be required to maintain water quality that meets state standards. Based on the studies included in the

Draft Supplemental EIS and those conducted subsequent to publication of the Draft, pumping water from the reservoir would assure that acceptable water quality standards are maintained.

With regard to surface hydrology, groundwater quality and potential impacts, we note that the long-term studies in West Hawaii and elsewhere regarding increased nutrient loading have indicated that although increases in nutrient loading do occur as a result of natural inland processes as well as man-induced processes, there do not appear to be any significant adverse impacts to marine biota and/or water quality. Further, given that the water quality of the proposed Cove will be maintained to meet state water quality standards, we would not anticipate significant impacts to the waters outside the proposed Cove.

As shown on Figure IV-2, potential seawater intrusion is not expected to reach inland far enough to affect Mauna Lani Resort's or its neighbors' non-potable water wells. The extent (quantity and distance inland) of seawater intrusion will depend on many factors, including amount of upland rainfall, tidal height ranges, etc.

2. Anchialine Pools .

The location of the existing anchialine ponds relative to the overall project is shown in Figure II-3. The present and historical biota of the ponds is described in Appendix F, page F-5. The Final Supplemental EIS will include a drawing that more clearly delineates the ponds. As noted in the Draft Supplemental EIS, the ponds that may be affected by the proposed project are in various stages of senescence due to infilling by windblown sand, vegetation and detritus. As with other anchialine ponds within Mauna Lani Resort, the ponds will be cleaned of the accumulated debris, restored and maintained. Restoration and cleaning of the ponds would be done by hand. The dredging referred to in the Draft Supplemental EIS is that required for the Cove entrance channel. Mauna Lani Resort views the ponds as a natural asset that should be protected and maintained for the benefit of the organisms inhabiting those ponds as well as for the education and enjoyment of residents and visitors to the resort and Hawaii.

Given that the organisms inhabiting the ponds are euryhaline, increased salinity levels in the ponds, should they occur, are not expected to significantly affect the pond organisms. Similarly, given that the ponds that may be most affected by the proposed project are presently in an advanced stage of senescence, we would expect lateral migration opportunities to increase once those ponds are restored. Per your request, additional information regarding potential impacts of the proposed project on the ponds will be included in the Final Supplemental EIS.

3. Potential Ciguatera Fish Poisoning

We agree that a pre-construction baseline survey for Gambierdiscus toxicus should be conducted and will conduct that survey. We would, however, note that although Acanthurid fish represent about 52 percent of the individual fish observed during the marine survey conducted for the proposed project, a total of 493 individual

Ctenochaetus strigosus were observed. To catch 150 to 200 of these individuals may pose a far greater impact on the species than detecting ciguatera would on the population of the Big Island. We will be contracting with qualified biologists for the conduct of the pre-construction survey and will select and collect macroalgae and fish species in sufficient quantities to detect the presence of Gambierdiscus toxicus. Similar sampling and analyses will be conducted during the two to four-month offshore construction period. Results of the analyses will be reported to the State Department of Health. The testing to be performed would be similar to that which has been done as part of the Ko Olina project on Oahu. We note that previous harbor dredging projects on the Big Island have not been correlated with increased incidences of ciguatera. Perhaps the need for long-term studies following construction of the proposed project should be more closely examined since such studies could have the effect of substantially decreasing the population levels of a significant component of the nearshore biota.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely yours,

Anne L. Mapes

GC:AM:gk

cc Hawaii County Planning Director

Belt Collins & Assoc., Ann Mapes
Mauna Lani Resort, Francine Duncan
Hawaii County Planning Dept.
Hawaii County Planning Commission
Dept. of Land & Natural Resources (DLNR)
Dept. of Business & Economic Development (DBED)
US Army Corp of Engineers

Re: PUBLIC ACCESS SHORELINE HAWAII ("PASH") INPUT INTO THE DRAFT ENVIRONMENTAL IMPACT STATEMENT (EIS) FOR THE "MAUNA LANI COVE" RESIDENTIAL MARINA AT THE MAUNA LANI RESORT

Dear Ms.Mapes, Ms.Duncan, and approving government agencies,

BACKGROUND

As a result of the "Public Notice" of shoreline certification applications and PASH's mission to inspect all proposed pending shoreline certifications on Hawaiiisland, and pursuant to Ch.13-222 "Rules for shoreline certification", PASH first inspected the Mauna Lani Cove shoreline area during the spring of '89, and numerous times thereafter.

In the public interest and with the cooperation of the Mauna Lani Resort administrative office, PASH has had direct first hand knowledge of and on-site experience with the Mauna Lani Cove shoreland. As such, PASH makes the following well considered recommendations from its "on-site/public interest" perspective.

IRRETRIEVABLE LOSS & OTHER ADVERSE IMPACTS

The proposed Mauna Lani residential marina entails the irretrievable loss of 2 acres of existing shoreline reef consisting of an excavated offshore channel 150' wide, 625' long and 18' deep as well as 150' of existing natural shore. While this marine area is not extraordinary neither is it any less representative of marine environment at that depth.

Also the excavation is likely to have an adverse impact on some of the nearby coral reefs to the north and south of the channel entrance as well. With exceptionally good marina management green turtle and whale harassment could be minimized.

UNIQUE OPPORTUNITY FOR GREAT PUBLIC BENEFIT

However, PASH does not oppose this development because we believe that there is a unique opportunity at the proposed Mauna Lani Cove residential marina development for a meaningful community contribution with great public benefit that could offset this loss.

EXPANSION OF PUBLIC RECREATIONAL RESOURCES AT "SHORELAND ENCLAVE" ON BOTH SIDES OF MARINA CHANNEL ENTRANCE

PASH respectfully requests that Mauna Lani Resort give the following requests for the expansion of public recreational resources and other concerns at the proposed Mauna Lani Cove its most favorable consideration:

- that the area from the certifed shoreline mauka to the distinctive lava outcropping that occurs from 200-400' ~~makai~~ mauka of the shoreline be open to public use. This shoreland area enclave situated on both sides of the proposed marina channel is generally sandy and shaded with ponds throughout whereas the raised land mauka of it is generally pahoehoe lava with [illegible]

(3A)

- that this naturally defined shoreland enclave be developed and maintained by Mauna Lani to provide various basic, passive, public recreational amenities such as picnic tables, informational signs, trails, composting toilets etc.

- that a reasonable setback for residential development from this enclave be required.

- that in addition to the planned 1/2 mile and 1 mile long public pedestrian walkways from the parking area to the shoreland enclave, there be public vehicular access along the roadway from the parking area to both residential cul de sacs nearest the shoreland enclave, with a drive-in drop-off point and a pedestrian easement from these two cul de sacs to the shoreland enclave in order that "family use" be encouraged. Families can be conveniently dropped off near the shore so that only the driver has to walk the long distance from the parking area back to the shore.

Reference is made to figure II-3 on page II-5 in the "Mauna Lani Cove" EIS titled "Concept Plan". Attached to this EIS submittal is an altered figure II-3 indicating PASH's "Proposed Easements" and realignment of the shoreland enclave at "Mauna Lani Park".

- that the amount of planned public parking near the marina commercial activities be doubled by utilizing the vacant land across the road since 100 parking stalls, while sufficient for the planned 100 marina slips and commercial activities, is not sufficient for increased public use of the shoreland enclave.

that an option to this parking and access plan is to provide a 50 stall parking area on each side of the channel situated on one or more of the makai house lots that abut the channel or the enclave, with pedestrain access to the enclave.

- that a public easement for the shoreland enclave, parking stalls, and vehicular and/or pedestrian access thereto be recorded with the Bureau of Conveyance.

SURF SITE(S)

It has been reported to PASH by 2 surfers that the excavation of the marina submerged channel is going to severly impact certain surf sites. Such destruction is opposed by PASH since it believes that surf spots are "public parks" and that except for exceptional cases and with the consensus of the surfing community, no such naturally occurring public recreational facilty should be destroyed or degraded for private gain unless it can be replaced by a superior man-made facility in a nearby area of minimal marine impact.

Since there is no mention of surfing sites in the draft EIS PASH requests that an additional study be made identifying existing surfing spots and a determination of the impact of the proposed marina development on such sites.

Should a negative impact be determined then we request that one or the other of the following measures be taken:
1. relocate boat channel entrance to eliminate impact on the surf site(s) or,
2. replace affected surf site(s) with equivilant or better man-made surf site(s).

PASH and its resources welcome the opportunity to work with Mauna Lani on the surfing issue. Detailed information on man-made surf sites will be forwarded.

(3B)

SIX MORE REQUESTS:

In addition to developing the shoreland enclave as an enhanced public recreational resource with better parking & access thereto, and dealing with surf site impacts, PASH respectfully requests that Mauna Lani Resort give the following six (6) requests its most favorable consideration:

CIGUETERA POISONING STUDY

1. Mauna Lani Resort does a comprehensive study of ciguetera poisoning in Hawaii & elsewhere as it could affect fishermen and their families who catch and eat the fish that swim the Mauna Lani Resort coast. Ciguetera, a toxin created by algea attracted to excavated coral reefs, contaminate fish that feed on this algea which in turn can kill humans who eat the fish. It is not sufficient to minimize the ciguetera threat by saying that it also occurs where there is no disturbance.

MARINA MANAGEMENT PLAN

2. Mauna Lani Resort hold public informational hearings on the marina management plan in order to develop and enforce measures which protect the marine environment both inside and outside the marina. This management plan must be no less than exemplary in its establishment and its enforcement in order to minimize harassment of whales, green turtles and other sea life and the potential for marine pollution.

MARINE MONITORING PROGRAM

3. Mauna Lani Resort monitor the marine environment in perpetuity submitting its reports to the appropriate government agency(s) in order that the remaining marine environment never degrades.

"ORGANIC" GROUNDS MAINTENANCE PROGRAM

4. Mauna Lani Resort develop a grounds maintenance program within its 2.97 miles of coastal resort bounding its 3,200 acres of land that shall be 100% devoid of the use of toxic material so that inevitable ocean runoff will not have any long term detrimental effect on the remaining marine environment nor on any possible underground fresh water. Mauna Lani Resort could develop "organic" standards for resort grounds keeping that would enhance both the coastal land and marine environment of Hawaii and beyond. Such non-toxic technology and practices do exist. PASH and its resources welcome the opportunity to work with Mauna Lani on this issue.

THREE MILES OF LATERAL SHORELINE ACCESS

5. Mauna Lani Resort implement in its totality and without delay the public shoreline lateral access planned along the 3 miles of coastal resort so that the Mauna Lani Resort can be an accessible public recreational resource along its entire shore.

PUBLIC FIELD TRIP

6. Mauna Lani Resort and PASH conduct a joint public field trip to the shoreland enclave area in order that greater public understanding may ensue.

(13c)

ENDORSEMENT

PASH can endorse development of the Mauna Lani Cove residentail marina to the extent that the Mauna Lani Resort adopts PASH's eight (8) public interest recommendations. PASH and its resources welcomes the opportunity of working together with Mauna Lani Resort to implement these recommendations.

(13D)

COMMENDATION ON HIGH QUALITY OF EIS

Finally, PASH commends the Mauna Lani Resort for the high standards of the EIS document itself. It is unparalleled in the State of Hawaii for its clarity and its completeness. The easy to read style of writing, the layout, and the 18 separate studies that comprise the technical material (plus the requested 19th & 20th study on surfing sites and ciguetera) is commendable. This EIS is a real planning document not just a planning hurdle to get through. The Mauna Lani Cove draft EIS fulfills the intent of the law not just the letter of the law and is a model for other coastal developments in Hawaii.

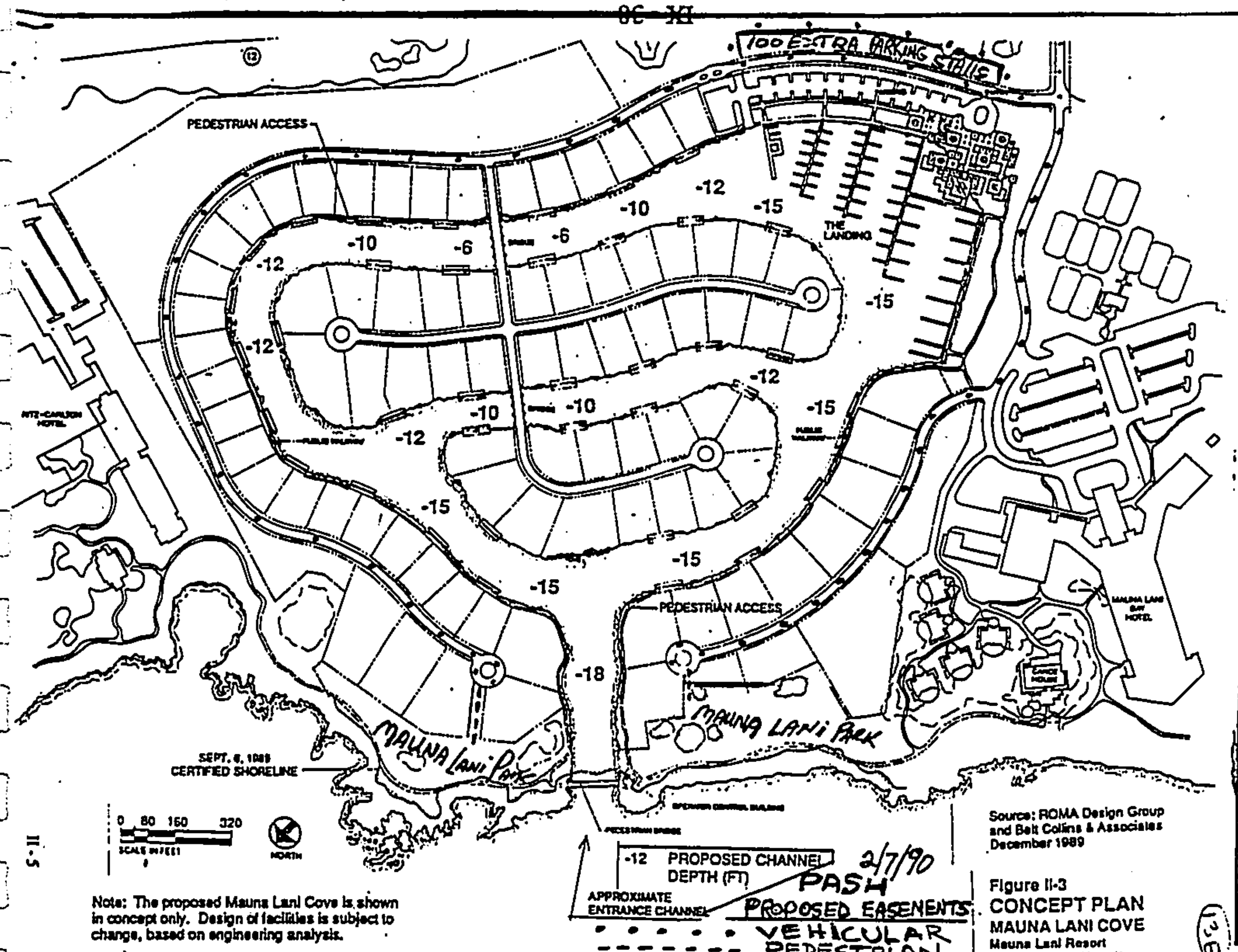
ON-SITE INSPECTION BY GOVERNMENT AGENCIES

This letter is also addressed to approving government agencies in the hope that it will result in on-site inspections of the proposed shoreland enclave as part of the permit review process.

Yours for a better way,

Jerry Rothstein

Jerry Rothstein, coordinator
Public Access Shoreline Hawaii(PASH)
PO Box 1544 Kailua-Kona Hawaii 96745
329-1560



Note: The proposed Mauna Lani Cove is shown in concept only. Design of facilities is subject to change, based on engineering analysis.

Source: ROMA Design Group and Belt Collins & Associates December 1989

Figure II-3
CONCEPT PLAN
MAUNA LANI COVE
Mauna Lani Resort
South Kohala, Hawaii

13E

BELT COLLINS & ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-383 (849.11)

Mr. Jerry Rothstein, Coordinator
Public Access Shoreline Hawaii (PASH)
P.O. Box 1544
Kailua-Kona, Hawaii 96745

Dear Mr. Rothstein:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your February 7, 1990 letter to me and Ms. Francine Duncan, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. Irretrievable Loss and Other Adverse Impacts

The proposed Mauna Lani Cove project will entail the dredging of a 150-foot wide, 625-foot long, 18-foot deep channel through the nearshore shallow reef terrace. As indicated in the Draft Supplemental EIS and Appendix F thereto, as well as your letter, this reef terrace is immature and supportive of limited coral. Based on the project consultants' experiences and with similar projects in Hawaii and elsewhere in the Pacific, the channel walls are expected to provide habitat that is at least as good as that which will be dredged. Further, the interior of the Cove will provide about 28 acres of estuarine habitat that does not presently exist, further adding to the marine habitat opportunities in West Hawaii.

We do not anticipate any adverse effects to adjacent reef areas as a result of the dredging or Cove operations. The subsurface materials to be dredged are thought to be pahoehoe lava which contains few if any fine sedimentary materials that might cause siltation over and above that which corals and other sessile organisms are able to naturally remove. Appropriate measures will be taken, including the use of containment devices to minimize turbidity beyond the channel area. Also a jack-up barge system will be used to minimize activities that cause turbidity and destruction.

As noted in the Draft Supplemental EIS, the Cove will be managed by an experienced harbor master and all users of the Cove will be provided informational materials regarding the need to protect all marine organisms, especially those that are endangered or threatened. Further, this information will identify the federal and state environmental protection laws and penalties for infractions of those laws.

2. Unique Opportunity for Great Public Benefit

We agree that the proposed project will provide a much needed marina facility in West Hawaii that will serve the general public as well as residents and guests of Mauna Lani Resort. As indicated above, there will be a net gain in available marine habitat, not a loss.

As you are aware, public access to areas makai of the certified shoreline are guaranteed by state laws. As indicated in the Draft Supplemental EIS, this access will be maintained and improved by the proposed project. Further, the shoreline area up to about 150 feet mauka of the certified shoreline, and all anchialine ponds, will be maintained as open space and as a greenbelt area for general public use. Educational signs and displays will be provided where appropriate. Mauna Lani will consider passive recreational amenities that will be consistent with the natural aesthetic characteristics of the coastline.

Residential setbacks in compliance with County rules and regulations will be maintained. No home will be allowed directly on the beach. Individual homeowners will be required to follow stringent design guidelines which emphasize maintenance of the natural setting and increased landscaping to improve the overall visual character of the area.

We appreciate your positive suggestion regarding a drive-in drop-off at the end of the cul-de-sacs on either side of the entrance channel with pedestrian access to the beach from the cul-de-sacs. We are seriously considering your proposal as well as the possibility of providing public access from the cul-de-sacs to the promenade around the perimeter of the Cove. Your suggestions are positive contributions to the planning process.

As Mauna Lani finalizes plans for the Landing, it will consider your suggestion that we double, or at least add substantially, to the parking area. It agrees that more parking may be necessary.

Public accessways will be appropriately recorded.

3. Surf Sites

Surfing sites will be addressed in the Final Supplemental EIS.

We are aware that there are several surfing spots offshore of Mauna Lani Resort and that, depending of swell direction, time of day, etc. the attractiveness of these spots changes during any given day. The popular site closest to the proposed channel is "Peaks", which fronts the 11th hole and the Mauna Lani Bay Hotel and is about 1200 feet away from the channel. Our detailed bathymetric investigations, as well as our interviews of local watersport enthusiasts and review of state recreation resource documents (such as Hawaii Statewide Ocean Recreation Plan, 1971) have indicated that the proposed entrance channel is outside present favored surfing spots. While our analyses indicate that the proposed channel is not expected to affect nearby surfing and/or fishing/diving spots, we will consult with our engineers to encourage a better surf break. We note that good surfing spots generally are caused by a shoaling rock or coral reef outcrop. As such, we have avoided such outcrops because of the increased amount of dredging that would be required.

However, Mauna Lani Resort also welcomes the opportunity to work with PASH on the surfing issue and looks forward to receiving detailed information on man-made surf sites.

4. <u>Ciguatera Monitoring Study</u>

Although ciguatera poisoning has not been correlated with other harbor construction in West Hawaii, we do propose to conduct a pre-, during and post-construction monitoring program. This program will be similar to the ongoing Ko Olina program on Oahu.

5. <u>Marina Management Plan</u>

A Mauna Lani Cove management plan is currently being formulated and will be in effect prior to opening of the facilities. The plan is generally based on existing State Department of Transportation, Harbors Division small boat harbor rules and regulations and is intended to be more rigorous. There will be an emphasis on marine conservation and protection measures with federal and state environmental protection measures and penalties for violation of those measures identified in the plan. As previously noted, administration of the Cove will be by a qualified harbor master and all users of the Cove will be required to abide by the Cove rules and regulations. Enforcement of those rules and regulations will be strict.

6. <u>Marine Monitoring Program</u>

As indicated in the Draft Supplemental EIS, a marine biological and water quality monitoring program will be conducted during construction of the facilities. Should Cove operations, following completion of construction, appear to be affecting the nearshore environment, additional monitoring will be conducted as necessary. In general, well maintained small boat marinas are non-polluting. Mauna Lani hopes to be the model via a rigorous management plan.

Mauna Lani sees the need for continuous monitoring in order to establish trends and red-flag potential problems. Although too premature to announce, Mauna Lani is seeking a new program that will focus on the long-term baseline monitoring of the West Hawaii coastline.

7. <u>"Organic" Grounds Maintenance Program</u>

Mauna Lani Resort presently adheres to an environmental protection plan that assures protection of sensitive environmental conditions in and around the resort. Mauna Lani Cove's management plan will mandate use of rapid uptake fertilizer landscape maintenance by only one qualified company, prohibition of certain toxic materials, and prohibition of point and nonpoint source of pollution. Based on Mauna Lani's almost ten-years of operational experiences, it can be said that environmental conditions within and adjacent to Mauna Lani Resort have been improved rather than degraded since initiation of resort operations.

8. <u>Three Miles of Lateral Shoreline Access</u>

The entire shoreline fronting Mauna Lani Resort is presently open to the general public as required by state law. Mauna Lani remains a demonstration project for Na Ala Hele. Public mauka-makai access is assured through the central public park and will be enhanced when the beach park to the north is completed.

9. <u>Public Field Trip</u>

The suggestion is an excellent one. Mauna Lani Resort has made several presentations of its plans to the general public during public informational meetings and public hearings, as well as separate presentations to County and State agencies and will continue to make these presentations as requested. Such a site visit should be coordinated with Mauna Lani at a time convenient for your PASH members and anyone else interested in this project.

10. <u>Endorsement</u>

As noted previously, Mauna Lani is studying your proposals regarding public access via the cul-de-sacs within the residential portion of the proposed project, as well as your request for additional parking. In addition, the ciguatera and water quality monitoring programs suggested in your letter will be performed, as noted above, prior to, during and following construction of the proposed Cove project. You and your organization are to be complimented in proposing positive measures that would allow the proposed project to move forward. These partnerships will ensure a better future for Hawaii. Lastly, Mauna Lani also appreciates your comments regarding the quality of the Draft Supplemental EIS. Mauna Lani has always upheld the principle that special interest groups and quality developers share the same mission: protection of quality of life. The future of Hawaii depends on our ability to work together toward common goals.

February 20, 1990
90-383 (849.11)

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

GC:FD:AM:lf

cc Duane Kanuha

Planning Department
25 Aupuni Street, Rm. 109 • Hilo, Hawaii 96720 • (808) 961-8288

Bernard K. Akana
Mayor
Duane Kanuha
Director
William L. Moore
Deputy Director

RECEIVED
BELT, COLLINS & ASSOCIATES

(14)

February 9, 1990

Ms. Anne L. Mapes
Belt Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, HI 96813

Dear Ms. Mapes:

Draft SEIS - Mauna Lani Cove

Transmitted herewith are comments for your appropriate action. These comments should be incorporated in the final SEIS as they were received or postmarked on February 5, 1990.

Sincerely,

William L. Moore

for DUANE KANUHA
Planning Director

AK:lm

Enclosures

(15A)

Sunrise, Mt. McKinley   Ansel Adams

RECEIVED
FEB 1? '90
BELT, COLLINS & ASSOCIATES

SIERRA CLUB LEGAL DEFENSE FUND, INC.

212 Merchant Street, Suite 202   Honolulu, Hawaii 96813   (808) 599-2436
FAX (808) 521-6841

HAWAII OFFICE

Arnold L. Lum
Michael R. Sherwood
Staff Attorneys

Marjorie F. Y. Ziegler
Resource Analyst

Other Offices

SAN FRANCISCO OFFICE
2044 Fillmore Street
San Francisco, CA 94115
(415) 567-6100

ROCKY MOUNTAIN OFFICE
1600 Broadway St.
Suite 1600
Denver, CO 80202
(303) 863-9898

WASHINGTON, DC OFFICE
1516 P Street, N.W.
Suite 200
Washington, DC 20005
(202) 667-4500

ALASKA OFFICE
325 Fourth Street
Juneau, AK 99801
(907) 586-2751

NORTHWEST OFFICE
216 First Avenue, South
Suite 330
Seattle, WA 98104
(206) 343-7340

February 5, 1990

Duane Kanuha, Director
Hawai`i County Planning Department
25 Aupuni Street
Hilo, Hawai`i 96720

<u>Re: Mauna Lani Cove Draft Environmental Impact Statement</u>

Dear Mr. Kanuha:

The Sierra Club Legal Defense Fund submits these comments on behalf of the Sierra Club, which will submit separate comments.

Although the DEIS addresses the impact of the proposed Mauna Lani Cove on native species and ecosystems, albeit from a developer's point of view, the Sierra Club remains concerned with the potential adverse impacts caused by the project to endangered humpback whales, threatened and endangered sea turtles, and anchialine ponds and their associated biota. These impacts include actual harm to species and their habitat, as well as siltation and other forms of degradation of nearshore waters and anchialine ponds.

The project scheduled should be modified to avoid blasting marina channels between November and May, when humpback whales calve, nurse, and breed in Hawaiian waters. In addition, every effort should be made to clear the site of sea turtles before blasting occurs. Will the National Marine Fisheries Service be on the site during the blasting activity to assume this responsibility? The developer should also be required to monitor anchialine ponds in the project area, beginning with the collection of baseline water quality and population data for anchialine pond organisms. Although monitoring is currently being conducted for those ponds still remaining at `Anaeho`omalu, pond

(15B)

complexes in different locations vary and may not be affected by blasting, land development, and landscaping in the same way. Consequently, it is important to monitor each pond complex that may be affected by land and water uses.

Finally, the Sierra Club recommends that native taxa of plants be used in landscaping within the project area, especially in areas adjacent to the anchialine ponds. The Club also suggests that no chemicals (fertilizers and pesticides) be used in these areas. The Sierra Club appreciates the opportunity to comment.

Sincerely,

Marjorie F.Y. Ziegler

Marjorie F.Y. Ziegler
Resource Analyst
Sierra Club Legal Defense Fund

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-387 (849.11)

Ms. Marjorie F.Y. Ziegler
Resource Analyst
Sierra Club Legal Defense Fund, Inc.
212 Merchant Street, Suite 202
Honolulu, Hawaii 96813

Dear Ms. Ziegler:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your letter of February 5, 1990 to Mr. Duane Kanuha, Hawaii County Planning Department, regarding the subject project and Draft Supplemental Environmental Impact Statement. The following is provided in response to your letter.

1. Impact on Endangered Threatened Species and Anchialine Ponds

Each of the items raised in your letter has been thoroughly discussed in the Draft Supplemental EIS. Blasting of channels will be performed during the summer months when humpback whales are outside Hawaiian waters; visual reconnaissance surveys of the areas to be blasted will be conducted prior to blasting to ensure that turtles are not in the blast area; and the anchialine ponds that may be affected by the proposed project will be cleaned, restored and maintained by Mauna Lani Resort, Inc. as part of their overall resort pond management program. The presence of National Marine Fisheries Service personnel during offshore construction activities is a decision that must be made by NMFS; however, Mauna Lani encourages any effort to minimize adverse impacts on endangered species in these waters. Further, complete baseline water quality and biotic community surveys of the offshore and anchialine ponds have been conducted and included in the Draft Supplemental EIS. Please be aware that the existing condition of such ponds can range from advanced stages of senescence to healthy ponds with opae'ula and other components. The ponds in question are in senescence and require restoration.

2. Landscaping

Native landscaping is and will be used by Mauna Lani Resort to the extent possible, both in the project area and around the anchialine ponds. Such usage is part of the overall landscaping plan for the resort. Fertilizers and biocides used by Mauna Lani Resort are those approved by the U.S. EPA and State Department of Health. Mauna Lani's Cove management plan will require use of rapid root uptake fertilizers and include guidelines that control introduction of phosphate and nitrates into ecosystems.

Thank you for your comments and participation in the Draft Supplemental EIS review process. Your letter and this response will be appended to the Final Supplemental EIS.

Sincerely,

Anne L. Mapes

GC:FD:AM:lf

cc Duane Kanuha

Office of Housing and Community Development
50 Wailuku Drive • Hilo, Hawaii 96720 • (808) 961-8379 • Fax (808) 935-4725

Bernard K. Akana
Mayor
A. Scott Leithead
Housing Administrator

February 5, 1990

RECEIVED
FEB 1? ?
BELT, COLLINS & ASSOCIATES

MEMORANDUM

TO: Duane Kanuha, Director
Planning Department

FROM: A. Scott Leithead
Administrator

SUBJECT: Mauna Lani Draft Environmental Impact Statement
Change of Zone Application

This is in response to your request, by letter dated January 2, 1990, for comments on the Mauna Lani Cove Draft EIS which includes the proposed Change of Zones from Open to RH-3 (6.18 acres), Open to RS-15 (13.51 acres), RH-3 to RS-15 (3.26 acres), V-1.25 to RH-3 (9.36 acres), V-1.25 to RS-156 (37.02 acres) and Open to CV-10 (2.76 acres).

Having completed both the La'ilani and Noelani II housing projects, the employee housing requirement imposed by the County has been deemed fully satisfied and discharged for Mauna Lani Resort's present development scenario, which includes a maximum of 1,450 additional hotel resort units and a maximum of 450 resort residential units within the area covered under State Land Use Boundary Amendment No. A84-583.

Therefore, the credit received by MLR against their affordable housing requirements should be reduced, upon completion of the above mentioned projects, by the appropriate number of additional resort residential units developed.

If you have any questions, please feel free to contact Brian Nishimura of this office.

EQUAL HOUSING OPPORTUNITY

(16)

BELT COLLINS & ASSOCIATES
Engineering • Planning
Landscape Architecture

February 20, 1990
90-388 (849.11)

Mr. A. Scott Leithead, Administrator
Office of Housing & Community Dev.
County of Hawaii
50 Wailuku Drive
Hilo, Hawaii 96720

Dear Mr. Leithead:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your Memorandum of February 5, 1990, to Mr. Duane Kanuha, Director, Planning Department, regarding the subject project and Draft Supplemental Environmental Impact Statement.

Mauna Lani appreciates the cooperative effort with the County and State in creating attractive, livable affordable units at Noelani, Waimea, and La'ilani, Kealakehe. These are clear examples of productive partnerships.

Sincerely,

Anne L. Mapes

FD:lf

cc Duane Kanuha

RECEIVED
FEB 28 1990
BELT, COLLINS & ASSOCIATES

February 8, 1990

Ms. Anne Mapes
BELT COLLINS & ASSOCIATES
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

Dear Ms. Mapes:

RE: Proposed Mauna Lani Cove, Kohala Coast, Hawaii

I am writing this letter to comment on the draft environmental impact statement on the proposed Mauna Lani Cove project.

I have run boats on the Kawaihae-Kohala coastline since 1947, and over these forty three years I've developed an intimate knowledge of the ocean conditions in this region. As ocean conditions can change very rapidly here, there is a great need for safe harbor. If a boater is caught in inclement weather and treacherous ocean conditions off the Kohala-Kawaihae coast his options in finding safety are limited. It's a good three hours to Honokohau Harbor, and Kawaihae Harbor itself is not safe under inclement surge and windy conditions. In the recent February 7 storm, two pleasure craft at Kawaihae Harbor ended up on the breakwater rocks. In 60 mph winds, tugs must be brought in even for the large commercial ships.

The proposed Mauna Lani Cove project will be ideally located to provide that safe harbor. The resort's offer of the Cove as safe harbor is an important public benefit that should not be taken lightly.

When the Kohala-Kona Coast area was earmarked as one of Hawaii's tourist destinations, it was clear that ocean recreation would become a significant part of that growth industry. It is shortsighted thinking that encourages quality tourism without the venues for ocean recreation. Mauna Lani has made tremendous commitments over the years to create a quality development, including several successful shoreline improvements. These improvements have enhanced the shoreline for both guests and the general public, and have demonstrated that such shoreline work can be done with minimal short term impacts and no long term impact.

In the past seven years that we've operated ocean craft out of Makaiwa Bay at Mauna Lani, we have rescued several boats in distress and saved lives. The safe harbor at Mauna Lani Cove would be a big plus in helping to avoid such problems.

We are greatly concerned about adverse environmental impacts on coastal waters in this area. Having seen what is possible in balancing costs and benefits of a project, and seeing how work in lava can be done with minimal impact on ocean waters, we are confident that Mauna Lani can do a good job with Mauna Lani Cove. If done right, with the jackup barge and booms in the summer months as Mauna Lani is proposing, the environmental effects should be minimal. Also, if the channel itself is engineered right, the channel can help the surf break for surfers who frequent Peaks (in front of the Mauna Lani Bay Hotel) and Pauoa Bay.

As we have been taking dive tours out on excursions to experience the spectacular diving sites along the three miles of Mauna Lani shoreline over these years, we can attest that the channel area selected will not displace any popular diving sites and does not threaten the sites we regard as irreplaceable.

Thank you for consideration of my comments.

Sincerely,

Francis H. Ruddle

Francis Ruddle
Corporate Vice President
Kamuela Leisure Company

BELT COLLINS
& ASSOCIATES
Engineering • Planning
Landscape Architecture

680 Ala Moana Blvd., Suite 200, Honolulu, Hawaii 96813
Phone: (808) 521-5361, Telex: BELTH 7430474, Fax: (808) 538-7819
Hawaii • Singapore • Australia • Hong Kong • Saipan

October 12, 1990
90-2146/849.1100

Mr. Francis Ruddle
Kamuela Leisure Company
P. O. Box 651
Kamuela, Hawaii 96743

Dear Mr. Ruddle:

Mauna Lani Cove
Draft Supplemental Environmental Impact Statement (EIS)

Thank you for your February 8, 1990 letter regarding the subject project and Draft Supplemental Impact Statement.

We appreciate your support for the project and find your comments (those of a long-time ocean observer and user in the project area) most useful.

Sincerely,

Anne L. Mapes

Anne L. Mapes

cc: Ms. Francine Duncan, Mauna Lani Resort, Inc.

APPENDICES

APPENDICES

A. Economic and Fiscal Impact Analysis, Mauna Lani Cove, Natelson-Levander-Whitney, Inc., November 1989, Revised March 1990

B. Hydraulic Model Study of the Mauna Lani Cove, Dr. A.B. Rudavsky & Adrian W.K. Law, September 1989

C. Tsunami Wave Modeling for Mauna Lani Cove, Mader Consulting Co., October 1989

D. Botanical Survey, Mauna Lani Marina, Mauna Lani Resort, Island of Hawai'i, Char & Associates, April 1989

E. Survey of the Avifauna and Feral Mammals at Mauna Lani Marina, South Kohala, Hawaii, Phillip L. Bruner, March 30, 1989

F. Preliminary Assessment of the Marine and Pond Environments in the Vicinity of the Proposed Mauna Lani Cove, South Kohala, Hawaii, Marine Research Consultants, Revised October 3, 1989

G. Coastal Processes Investigations, Mauna Lani Resort, North Kona, Island of Hawaii, Sea Engineering, Inc., October 1989

H. Nearshore Wave and Current Measurements for the Mauna Lani Resort, North Kona, Hawaii, Final Data Report, October 1989

I. Deepwater Wave Climate Summary for the Mauna Lani Resort, Island of Hawaii, Sea Engineering, Inc., April 1989

J. Green Turtles (Chelonia mydas) at Mauna Lani Resort, South Kohala, Hawaii: An Analysis of Impacts With the Development of a Small Boat Marina, Richard E. Brock, Ph.D., October 1989

K. Impacts Assessment for the Mauna Lani Cove Development with Regard to Humpback Whales, AECOS, Inc., November 1989

L. Archaeological Inventory Survey, Mauna Lani Cove Project Area, Mauna Lani Resort, Paul H. Rosendahl, Ph.D., Inc., November 1989

M. Traffic Impact Study, Mauna Lani Cove, South Kohala, Hawaii, Belt Collins & Associates, October 1989

APPENDICES (Continued)

N. Air Quality Impact Analysis, Mauna Lani Cove, South Kohala, Hawaii, James Morrow, November 1989

O. Noise Study for Mauna Lani Cove, South Kohala, Hawaii, Yoichi Ebisu, November 1989.

P. Mauna Lani Cove Ocean Monitoring Program (Draft). February 1990.

Q. Mauna Lani Cove Management and Operations Rules and Regulations (Draft). February 1990.

R. Groundwater Impact Assessment, Mauna Lani Marina. March 1990. Belt Collins & Associates and Mackie Martin & Associates.

S. Water Quality and Exchange Characteristics of Mauna Lani Cove. OCEES International, Inc. December 1989 and Addenda, January 1990 and October 1990.

T. Mauna Lani Cove Development, Modeling of Effluent Plumes in Ocean Receiving Waters Due to Dredging Operations and Normal Water Discharges From the Operating Marina and Inland Waterways. Edward K. Noda & Associates. September 1990.

U. Ciguatera Monitoring Results. Letter Report from Dr. Y. Hokama, University of Hawaii, John A. Burns School of Medicine, Department of Pathology. September 1990.

APPENDIX A

ECONOMIC AND FISCAL IMPACT ANALYSIS
MAUNA LANI COVE

ECONOMIC AND FISCAL IMPACT ANALYSIS

MAUNA LANI COVE

November 1989

Revised March 1990

Prepared for:

Belt Collins & Associates

Prepared by:

Natelson·Levander·Whitney, Inc.
10960 Wilshire Boulevard
Suite 222
Los Angeles, California 90024
(213) 478-5016

TABLE OF CONTENTS

INTRODUCTION

The following report summarizes the economic and fiscal impacts which are likely to result with the implementation of the proposed Mauna Lani Cove. The analysis is presented in two major sections. The first section reviews the development program with respect to its probable economic impacts, which are defined in this report as effects on the private sector economy. The second section analyzes the development program with respect to its probable fiscal impacts, which are defined in this report as the effects on the public sector economy embodied in the governments of the County and State of Hawaii.

SUMMARY OF FINDINGS

General Characteristics, Island of Hawaii

The Island of Hawaii is the largest of the Hawaiian Islands with 4,034 square miles of land area or nearly 63 percent of the State total. After several years of slow growth tourism has established itself as a major economic factor. Total planned projects according to the Hawaii Visitors Bureau call for development of 20,904 hotel units and 22,910 condominium units. These figures may be somewhat optimistic but they demonstrate the enormous potential for the Island of Hawaii.

Project Characteristics

The proposed development program consists of 90 to 140 residential units oriented around a 175- to 250-boat marina with direct ocean access. The minimum unit value --including the combination of the lot and completed house -- will likely exceed $1.25 million. The median home value will likely approach $2.25 million. Total residential development value based on 140 residential units is $315 million.

The preliminary size distribution for boats in the marina should be as follows:

Size	Percent
24' and Under	42.5%
25' - 29'	21.9
30' - 39'	21.9
40' - 49'	5.5
50' and Over	8.2
Total	100.0%

These sizes are based upon surveys of existing Mauna Lani homeowners with respect to their interest in boating activities at the resort.

Economic Impacts

Beginning in 1990 the planned marina will generate short-term employment for infrastructure work. The construction period of approximately nine months will require 230 workers.

Residential unit construction will begin in the third quarter of 1990 and will generate 54 workers on a full-time basis from 1990 through 1996.

At full development permanent employment at the Mauna Lani Cove should approach 85 to 90 persons as delineated below:

Employment Source	Number Employed
Marina	7
Boating Operations	57 - 62
Restaurant/Retail	15
Maid Service	6
Total	85 - 90

Fiscal Impacts

The projected public costs and revenues engendered by the program are examined for both the County of Hawaii and State of Hawaii, the two entities that provide local municipal governmental services to the South Kohala district. The costs to the County will be minimal and are projected at approximately $85 thousand and will be more than offset by the projected $2.7 million in anticipated revenues. Costs to the State will also be minimal and should be more than offset by the $173 thousand generated from general excise taxes.

REVIEW OF ECONOMIC IMPACTS

The chapter summarizes the economic impact of the proposed marina at the Mauna Lani Resort. The analysis first examines the general characteristics and socioeconomic conditions with regard to the Island of Hawaii, in general, then examines the general characteristics and socioeconomic conditions with regard to the Primary Study Area in more detail. The section concludes with an examination of the specific economic impacts related to the Mauna Lani Cove, including population projections, employment projections, income projections, and visitor expenditures.

ISLAND OF HAWAII

Socioeconomic Conditions

General Characteristics

The Island of Hawaii, hereinafter referred to as the Big Island, is the largest of the Hawaiian Islands. According to the Hawaii Department of Business and Economic Development (DBED), in 1980 the Big Island contained 4,034 square miles of land area or nearly 63 percent of the State total.

The settlement of the Big Island has been strongly influenced by five large shield volcanos (Mauna Loa, Mauna Kea, Kohala, Kilauea, and Hualalai) which create a very diversified climate. The windward side of the Big Island is wet, with rain exceeding 300 inches per year in some areas. The leeward side of the Big Island is mostly dry, with some locations considered to be approaching desert conditions while experiencing rainfall averaging under eight inches annually.

Because of the favorable climate, agricultural lands on the windward side of the Big Island have been used for sugar production. The deep water harbor at Hilo has historically made this area the primary center of population. Hilo also became the primary port for the shipment of sugar to the West Coast, and flourished as well as the seat of county government and a center for tourism.

The dry climate of the leeward side of the Big Island was ideal for ranching activities, resulting in the growth of Parker Ranch and other holdings centered around Waimea. Ranching has played a major role in the area and is responsible for growth in the Waimea area. To the south, coffee production historically was a major influence in the development of the Kona region; more recently, this area has been strongly influenced by the tourist industry and fishing and oceanographic activities.

The U.S. Census Bureau reported that the Big Island's resident population was 92,053 persons in 1980. The Hawaii County Department of Research and Development (DRD) estimate that the population had increased to 117,461 persons by 1988, which represented nearly a 28 percent increase over the eight year period. The DBED projects that by the year 2005 the Big Island's population will reach 180,500 persons, thus nearly doubling its 1980 population in 25 years.

The Hawaii State Department of Labor and Industrial Relations (DLIR) reported that the civilian labor force had seen increases in the number of people employed and decreases in the percentage of people unemployed during the 1980s. The U.S. Census Bureau reported that in 1980 civilian employment numbered 41,006 persons with a 7.0 percent unemployment rate. The DLIR reported that in 1987 civilian employment had increased to 51,050 persons with only a 5.7 percent unemployment rate. Recent growth in the construction industry has undoubtedly resulted in a further lowering of the unemployment rate as of mid-1989.

Economic Sector Analysis

The following paragraphs briefly review the major economic sectors in the Big Island which provide the context for development of the Mauna Lani Cove.

Tourism

After years of slow growth tourism has established itself as a major economic factor on the Big Island. The future for tourism on the Big Island appears to be strongly positive as evidenced by the recent opening of the Hyatt Regency Waikoloa as well as numerous planned projects for the Kohala and Kona coastal areas. According to the Hawaii Visitors Bureau (HVB) Visitor Plant Inventory, February 1988, the existing visitor plant totalled 8,823 units spread between 6,469 hotel units and 2,354 condominium units. According to HVB the Big Island has the most planned hotel and condominium projects of all the Hawaiian Islands. Total announced projects call for development of an additional 20,904 hotel units and 22,910 condominium units. These figures may be somewhat optimistic, but they demonstrate the enormous current interest in the expansion of Big Island tourism.

Another indicator of the growing strength of tourism on the Big Island has been the increase in visitor expenditures. The HVB estimated that 1987 visitor expenditures totalled $381.8 million, more than double the 1980 figure of $187.6 million. After allowance for inflation, the net real growth in tourist spending has averaged 10.7 percent annually over the most recent seven-year period for which data are available.

The annual number of visitors has also increased during the 1980s. In 1981 672.7 thousand Westbound tourists reached the Big Island. In 1988 it is estimated that 787.9 thousand Westbound tourists visited the Big Island. This represents a growth in tourist visitation of 2.3 percent annually over the period of investigation.

Sugar

The closing of sugar mills such as the Puna Sugar Company in September of 1984 has resulted in a decrease in the Big Island's production of sugar and slight reductions in agricultural employment. The DBED reported that in 1984 the Big Island produced 3.4 million tons of unprocessed cane. By 1987 that figure had decreased to just under 2.6 million tons of unprocessed cane.

Diversified Agriculture

The reduction in the production of sugar has resulted in efforts to increase the production of diversified crops. An example of this redirection can be seen in the production of Macadamia nuts, which has increased from 37.5 million pounds in 1984 to 41.3 million pounds in 1987.

Ranching

The number of livestock operations on the Big Island has remained relatively constant since 1984 although the number of cattle operations did decrease somewhat from 395 operations in 1984 to 380 operations in 1987. This decrease was offset by the volume of cattle marketing which increased from 20.9 million pounds in 1984 to over 25.9 million pounds in 1987.

High Technology

The importance of high technology on the Big Island has increased, as evidenced by the expansion of observatories atop Mauna Kea and support facilities in Waimea and Hilo. In addition, the Natural Energy Laboratory of Hawaii (NELH) has pushed forward on the commercialization of aquaculture projects. Successful operations are also moving or expanding into the Hawaii Ocean Science Technology (HOST) Park located at Keahole Point.

Demographic and Housing Data

Table 1 presents the historic population growth for the Big Island compared to the State of Hawaii. The Big Island has experienced significant population growth in the 1970s and 1980s following a nearly dormant period in the decade of the 1960s. As a consequence, the Big Island has reversed a trend where it represented a declining percentage of the State's total population, and has increased its total share of State residents from a low of 8.25 percent in 1970 to 10.57 percent in 1987. As of mid-1987, the most recent date for which comprehensive data are available, the Big Island held 114,400 of the State's 1,082,500 residents.

Between 1970 and 1987 the population on the Big Island increased from 63.5 thousand persons to 114.4 thousand persons, an 80 percent increase. The annual percentage growth rate for population over that same period was 3.5 percent. In comparison, the annual percentage growth rate for the State of Hawaii from 1970 to 1987 was only 2.0 percent.

Table 2 presents recent trends in the number of households and the average household size. Household size is a measure of the average number of persons living in an occupied dwelling unit within a market area. Household size has been declining steadily on the Big Island since 1960. The average household size in 1980 was 3.09 persons per occupied dwelling unit, a reduction of 14.4 percent from the 3.61 persons per unit recorded in 1960. The DBED estimated that the figure had decreased to 3.08 persons in 1987, the most recent date for which data are available. This decline is consistent with national patterns, and reflects socioeconomic trends towards smaller families, fewer families as a percent of total households, and delays in family formation.

Table 1
HISTORIC POPULATION TRENDS
STATE OF HAWAII AND COUNTY OF HAWAII
1960 TO 1987
(Rounded to Nearest Hundred)

Area	1960	1970	Net Change, 1960 - 1970 Number	Annual Percent
State of Hawaii	632,800	769,900	137,100	2.0%
County of Hawaii	61,300	63,500	2,200	0.4%
County as Percent of State	9.69%	8.25%	1.60%	

Area	1970	1980	Net Change, 1970 - 1980 Number	Annual Percent
State of Hawaii	769,900	964,700	194,800	2.3%
County of Hawaii	63,500	92,100	28,600	3.8%
County as Percent of State	8.25%	9.55%	14.68%	

Area	1980	1987	Net Change, 1980 - 1987 Number	Annual Percent
State of Hawaii	964,700	1,082,500	117,800	2.3%
County of Hawaii	92,100	114,400	22,300	3.1%
County as Percent of State	9.55%	10.57%	18.93%	

Sources: Department of Business and Economic Development (DBED);
Natelson Levander Whitney, Inc. (NLW).

Note: Figures are for April 1 of Year noted except 1987, which was taken on July 1.

Table 2
TRENDS IN AVERAGE HOUSEHOLD SIZE AS MEASURED
BY AVERAGE PERSONS PER OCCUPIED UNIT
COUNTY OF HAWAII
1970, 1980, 1987

County of Hawaii

Year	Number of Households	Persons Per Household	Net Change Number	Annual Percent
1970	17,260	3.61		
1980	29,237	3.09	(0.52)	(1.54)
1987	37,150	3.08	(0.01)	(0.06)

Sources: U.S. Census 1970, 1980; DBED; NLW.

Consistent with population growth and the decline in household size, the number of households has increased significantly on the Big Island. In 1960 there were 17,260 households; that figure more than doubled by 1985, when the number of households totalled 34,900. By 1987, the estimated number of households in the Big Island approached 37,150.

Presented in Appendix I to this report are detailed demographic and housing data from the U.S. Census Bureau for the years 1970 and 1980. The information is presented for the Big Island as well as for the individual districts and/or census tracts that are used to delineate the primary study area. Presented below are some of the highlights from the census reports covering that period:

- The ethnic composition changed on the Big Island as the percentage of Hawaiians increased from 12.3 to 18.8 percent, the percentage of Caucasians increased from 28.8 to 35.0 percent, and the percentage of Japanese decreased from 37.5 to 26.6 percent.
- The percentage of population with a college education increased from 7.5 percent to 15.2 percent.
- The percentage of families living below the poverty level increased from 9.7 percent to 10.3 percent.
- The civilian labor force increased from 25.9 thousand persons to over 41.0 thousand persons.
- The total year round housing units increased from 18,939 units to 33,954 units.

PRIMARY STUDY AREA

Socioeconomic Conditions

Definition

The Primary Study Area (PSA) consists of the district of North Kona and the districts of North and South Kohala. North Kona is coterminous with Census Tracts 215 and 216. North Kohala is coterminous with Census Tract 217 and South Kohala is coterminous with Census Tract 218. The PSA is depicted in Figure 1.

General Characteristics

North Kohala until recently was dominated by economic activities related to sugar cane production. The area, comprised of the six towns of Hawi, Kapaau, Halaula, Makapala, Halawa, and Niulii, in the past had hosted numerous sugar mills, the last of which closed in 1975. North Kohala is characterized by its ethnically varied population, a result of the waves of immigrants that were brought in to cultivate the sugar cane grown in the local area.

South Kohala consists of both the high plains of the Kohala mountain foothills and the dry coastal area which includes the residential communities of Puako, Kawaihae Village, and Waikoloa Village. The area is dominated by Parker Ranch which consists of 223,000 owned and leased acres of land. The area represents a relatively homogeneous community with the exception of descendants of Paniolos (Spanish Cowboys) which were originally brought to the ranch by its founder. Recently, there has been an influx of second home owners, young professionals and resort workers who prefer the cooler climate and unique setting offered by the town of Waimea.

North Kona was strongly influenced by ranching activities and coffee production through most of this century. However, with the instability of the international coffee market and the introduction of jet service to the islands, the Kona coastline began to host numerous visitors. This trend has continued, and the area has become a resort destination which is the dominant tourist center on the island.

The U.S. Census Bureau reported that the PSA had a population of 21,604 persons in 1980. North Kona accounted for 63.6 percent of the total with 13,748 persons, while North Kohala totalled 3,249 persons and South Kohala totalled 4,607 persons. The DRD estimated that the 1988 population of the PSA had increased to 32,736 persons, nearly a 52 percent increase over the 1980 figure. North Kona experienced significant growth as the population reached 21,484 persons, a 56.3 percent increase over the 1980 figure. Similarly, South Kohala also grew rapidly, as the population reached 7,562 persons, a 64.1 percent increase since 1980. In contrast, North Kohala achieved more modest 13.5 percent growth, with its population reaching 3,690 persons during the same period.

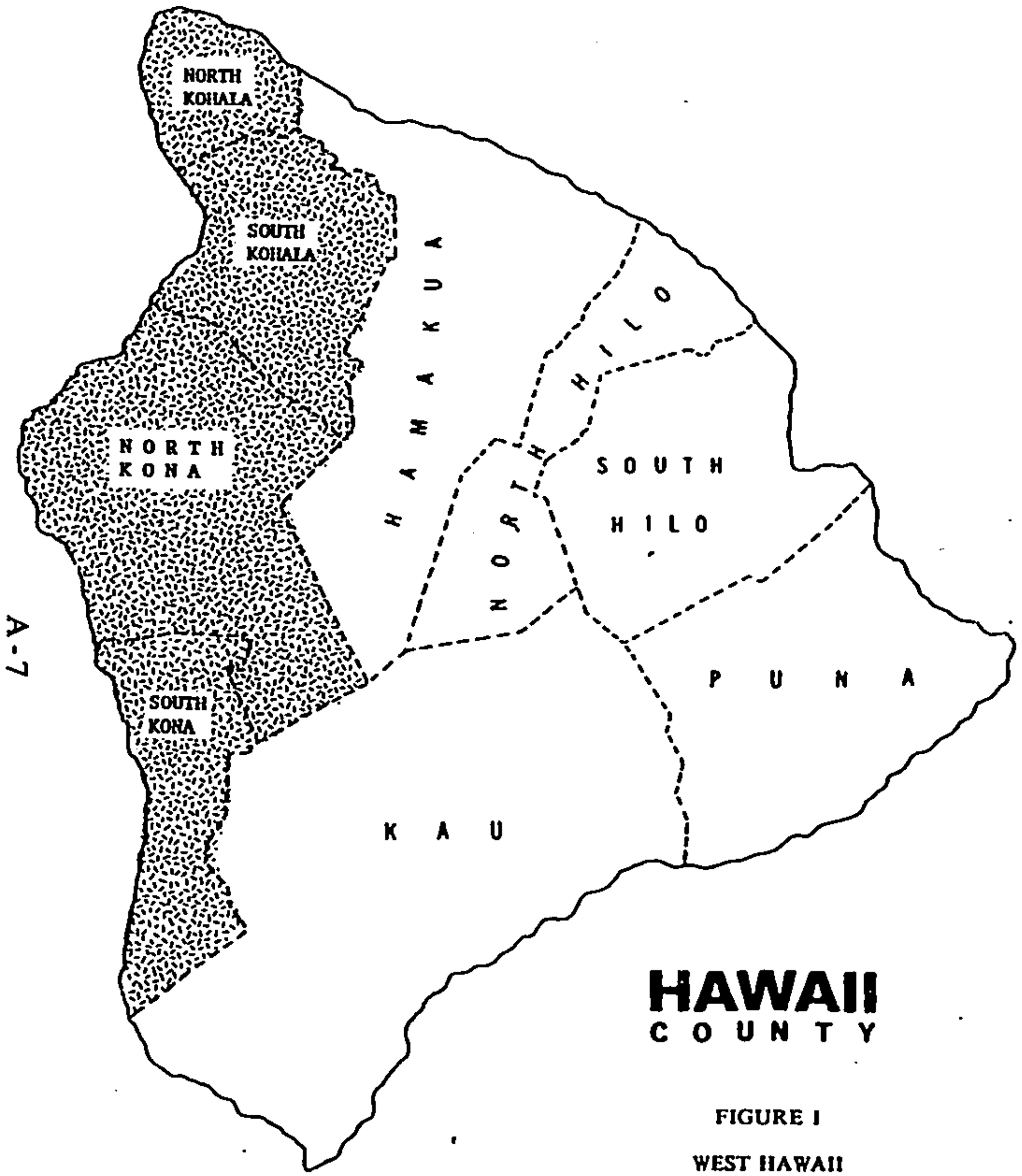


FIGURE I

WEST HAWAII
MARKET AREA

Economic Sector Analysis, PSA

The following paragraphs briefly review the major economic sectors in the PSA.

Tourism

Since the 1960s tourism has played an increasingly important role in the local economy of the PSA. Resort development began in North Kona, and has spread more recently to the South Kohala area. Several master planned resorts have been developed in the area. The resorts include the following:

South Kohala	North Kona
Mauna Kea	Kailua-Kona
Mauna Lani	Kona at Keauhou
Waikoloa Beach Resort	Kona Village

The North Kona/South Kohala coastal area has emerged as the new center of the tourist industry on the Big Island, replacing Hilo as the dominant focus for visitor activity. According to the HVB Visitor Plant Inventory, February 1988, the visitor plant inventory for the PSA accounted for 7,429 visitor units or 84.2 percent of the Big Island total.

Sugar

Overall, sugar production in the PSA has decreased recently. North Kohala originally developed as a sugar production and processing area until the last mill closed in 1975. Since that time the area has experienced significant population losses and relatively high unemployment rates. The area is now supported primarily by small scale agricultural and retail activities.

Diversified Agriculture

Diversified agriculture has played an important role in the economic development of the PSA. Coffee production served as North Kona's primary export economic base for many years; however, international market fluctuations have recently reduced its role. The production of Macadamia nuts has increased in such areas as North Kohala, while the production of vegetable crops such as celery, cabbages, and lettuce, has increased in the area around Waimea.

Ranching

Although tourism has passed cattle operations as the leading economic activity in South Kohala, ranching continues to play an important economic role in the area, led by the Parker Ranch headquartered in Waimea. In addition to ranching and tourism, South Kohala is supported by vegetable crops, truck farming, retail establishments and second home industries.

High Technology

High technology industries in the PSA include the support facilities for the observatories on Mauna Kea, the Natural Energy Laboratory of Hawaii (NELH) and the Hawaii Ocean Science Technology (HOST) Park located at Keahole Point.

Shipping

Shipping plays an important role in the PSA. Kawaihae Harbor is a deep water harbor located in South Kohala. In 1985, the harbor handled 493 million tons of cargo according to the Hawaii State Department of Transportation. The harbor receives and ships general cargo, bulk sugar, molasses, lava cinders, petroleum products, and bulk fertilizers.

Construction

The release of lands by the Parker Ranch has resulted in the development of numerous residential subdivisions in Waimea. The availability of Hawaiian Homestead lands has also resulted in increased construction. More recently, the construction of visitor plants such as the Hyatt Regency Waikoloa has resulted in significant employment increases within that sector of the economy, and further fueled the demand for residential units in the PSA.

Demographic and Housing Data

Table 3 presents the historic population and housing unit growth as well as the average household size for the three judicial districts which comprise the PSA. As was previously mentioned the North Kona and South Kohala districts grew substantially from 1970 to 1980 while North Kohala actually decreased in population during the same period. The U.S. Census Bureau reports that in 1970 North Kohala represented nearly 32 percent of the PSA's population while North Kona represented 46 percent and South Kohala represented 22 percent. In 1980, the North Kohala area represented only 15 percent of the population while North Kona represented nearly 64 percent and South Kohala 21 percent. The annual percentage change in population over the 10-year period for North Kona was 11 percent while South Kohala grew at an annual rate of 7 percent. In contrast, North Kohala's population decreased at an annual negative rate of 0.23 percent.

Table 3 also presents the trends in the average household size in the PSA. Household size is a measure of the average number of persons living in an occupied dwelling unit in a given market area. Following Big Island and national trends, the PSA has experienced significant decreases in the average household size. The most pronounced decreases have occurred in the North Kohala district where the average household size has decreased from 3.75 persons to 3.16 persons per household. The North Kona district decreased from 3.36 persons to 2.92 persons per household, while South Kohala decreased from 3.51 persons to 3.07 persons per household.

Table 3
COMPARATIVE POPULATION, HOUSING GROWTH AND HOUSEHOLD SIZE
PRIMARY STUDY AREA
1970 TO 1980

			Net Increase, 1970 to 1980	
North Kohala	1970	1980	Number	Annual Percent
Population	3,326	3,249	(77)	-0.23%
Housing Units	941	1,121	180	1.77%
Household Size	3.75	3.16	(0.59)	-1.70%
Pop. as % of Primary Study Area	31.77%	15.04%		
South Kohala				
Population	2,310	4,607	2,297	7.15%
Housing Units	798	1,959	1,161	9.40%
Household Size	3.51	3.07	(0.44)	-1.33%
Pop. as % of Primary Study Area	22.07%	21.32%		
North Kona				
Population	4,832	13,748	8,916	11.02%
Housing Units	1,975	6,894	4,919	13.32%
Household Size	3.36	2.92	(0.44)	-1.39%
Pop. as % of Primary Study Area	46.16%	63.64%		

Sources: Hawaii County Department of Research & Development; MLW.

Finally, Table 3 shows the change in the number of housing units in the PSA. The total number of housing units increased from 3,714 units in 1970 to 9,974 units in 1980, more than doubling the previous figure. The most significant increase came in North Kona which more than tripled its 1970 unit count from 1,975 to 6,894 units. In comparison, North Kohala added an additional 180 units while South Kohala added 1,161 units.

Presented below are some of the highlights from the census reports for the PSA.

- The percentage of Caucasians and Hawaiians increased while the percentage of Japanese decreased.
- The percentage of people with a college education increased.
- The percentage of people living below the poverty level decreased in North Kona and South Kohala while the percentage rose in North Kohala.

These reports are presented in the Appendix to this report.

MAUNA LANI COVE ECONOMIC IMPACTS

Residential Development Summary

The proposed development program consists of 90 to 140 residential units oriented around 175- to 250-boat marina with direct ocean access. Present configurations indicate that the ultimate design will probably yield 140 residential units.

The minimum unit value -- including the combination of the lot and completed house --will likely exceed $1.25 million. The anticipated price range is $1.25 million to $5.0 million, with the median home value approaching $2.25 million. Total residential development value based on the current program is projected at $315.0 million as expressed in 1989 dollars.

Unit absorption is projected to begin in 1991 at a rate of 15 to 20 units per year. At these rates buildout of the project could take from 4.5 to 9.0 years. A residential absorption schedule for each scenario is delineated in Table 4.

Marina Development Summary

The current plan for the 88-acre project provides for 250 boats, with 75 slips at the residential sites, 65 additional moorings resulting from rafting and varying boat sizes, and 110 slips at "The Landing" boat basin. The preliminary size distribution for boats in the marina is presented below. These figures are based on market survey responses obtained from Mauna Lani owners who have expressed interest in berthing facilities at the resort.

Size	Percent
24' and Under	42.5
25' - 29'	21.9
30' - 39'	21.9
40' - 49'	5.5
50' and Over	8.2
TOTAL	100.0%

Of the 110 slips in "The Landing" boat basin, it is anticipated that 80 would be available for Mauna Lani resident use. Of the remaining berths, ten slips would be allocated for commercial uses (charter fishing boats, tour boats, etc.) and twenty slips would serve as transient facilities for boaters visiting the resort on a short-term basis. At least ten of these moorings will be available for public use.

The marina will provide the following facilities:

- A boat launching area with related parking for automobiles with boat trailers;
- A dry storage area for smaller boats;

Table 4
MAUNA LANI RESORT
RESIDENTIAL ABSORPTION SCHEDULE

ABSORPTION BY YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
@ 92 Units	0	0	20	20	20	20	12	0	0	0	0	0	92
@ 90 Units	0	0	20	20	20	20	10	0	0	0	0	0	90
@ 140 Units	0	0	20	20	20	20	20	20	20	0	0	0	140

Source: NLW.

- Limited retail facilities, including a "general store" to provide food, ice, and limited chandlery;
- Marina facilities, including a dockmaster's office, laundry, restroom/locker areas and other support space;
- A waterfront restaurant with adequate meeting space for a Mauna Lani-sponsored yacht club; and
- Parking sufficient to accommodate boatowners, marina visitors, retail facilities visitors, and commercial boat passengers and crews.

Resident Population Projections

The following paragraphs describe the occupancy characteristics and resultant resident population projections for the Mauna Lani Cove. The occupancy characteristics are based on information provided by the following resorts:

- Mauna Lani;
- Mauna Kea;
- Waikoloa Beach Resort; and
- Waikoloa Village.

Occupancy Characteristics

In the early stages of development full-time resident occupancy will be minimal, and is projected at only 5.0 percent of the total units. Over time the resident population will age, and a greater number of homeowners should elect to use their unit as a permanent, full-time residence. The full-time resident population is projected to ultimately reach 10.0 percent as shown in Table 5(a).

On an annual basis, occupancy rates at the marina residential units -- including both homeowners and visitors -- should increase from 55.0 percent in the early stages of the project to 62.5 percent by the year 2000. These trends will reflect the "maturing" of the population and their increasing propensity to use their unit at the resort on a full-time basis. Occupancy characteristics are shown in Table 5(b).

Average party size will vary between full-time residents and part-time visitors. Based on current activity in the area full-time residents should average 2.0 persons while part-time guest occupancies should will average 3.5 persons.

Population Impact

The average daily population in the marina residential community, exclusive of housekeeping assistance, should range between 197 and 306 persons, depending ultimately upon the number of units constructed. These projections are shown in Table 6(a). During the peak periods from December

Table 5 (a)
MAUNA LANI RESORT
FULL TIME RESIDENT OCCUPANCY (As Percent Of Total Units)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	----	----	----	----	----	----	----	----	----	----	----	----
FULL TIME RESIDENT OCCUPANCY												
@ 92 Units	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
@ 90 Units	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
@ 140 Units	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%

Table 5 (b)
MAUNA LANI RESORT
AVERAGE ANNUAL OCCUPANCY

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	----	----	----	----	----	----	----	----	----	----	----	----
AVERAGE ANNUAL OCCUPANCY												
@ 92 Units			55.0%	55.0%	57.5%	57.5%	57.5%	60.0%	60.0%	60.0%	60.0%	62.5%
@ 90 Units			55.0%	55.0%	57.5%	57.5%	57.5%	60.0%	60.0%	60.0%	60.0%	62.5%
@ 140 Units			55.0%	55.0%	57.5%	57.5%	57.5%	60.0%	60.0%	60.0%	60.0%	62.5%

Source: BLW.

Table 6 (a)
MAUNA LANI RESORT
AVERAGE DAILY POPULATION

Average Party 3.5

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	----	----	----	----	----	----	----	----	----	----	----	----
AVERAGE DAILY POPULATION												
@ 92 Units	0	0	39	77	121	161	185	193	193	193	193	201
@ 90 Units	0	0	39	77	121	161	181	189	189	189	189	197
@ 140 Units	0	0	39	77	121	161	201	252	294	294	294	308

Table 6 (b)
MAUNA LANI RESORT
PEAK PERIOD POPULATION

Peak Period Occupancy: 90.0%

Peak Period: Selected Dates, December Through March

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	----	----	----	----	----	----	----	----	----	----	----	----
PEAK PERIOD POPULATION												
@ 92 Units	0	0	63	126	189	252	290	290	290	290	290	290
@ 90 Units	0	0	63	126	189	252	284	284	284	284	284	284
@ 140 Units	0	0	63	126	189	252	315	378	441	441	441	441

Table 6 (c)
MAUNA LANI RESORT
FULL TIME RESIDENT POPULATION

Average Party 2.0

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	----	----	----	----	----	----	----	----	----	----	----	----
FULL TIME RESIDENT POPULATION												
@ 92 Units	0	0	2	4	6	8	9	11	13	15	17	18
@ 90 Units	0	0	2	4	6	8	9	11	13	14	16	18
@ 140 Units	0	0	2	4	6	8	10	14	20	22	25	28

Source BLW

through March the population should increase to a typical range of between 284 and 441 persons. During these periods many people in this population will be visitors who are guests of the homeowners. Peak period population projections are shown in Table 6(b).

Reflective of the low percentage of full-time occupancies, the population for full-time residents should range from 18 to 28 persons at completion of development as depicted in Table 6(c).

Age Distribution of Homeowners

The median age of marina community heads-of-household should approach 55 years. The anticipated age distribution of the resident population is projected as follows:

Age Level	Percent
Under 45	10.0%
45 - 54	35.0
55 - 64	35.0
65 and Over	20.0
TOTAL	100.0%

Income Characteristics of Households

The median annual income for households should approach $445,000, while the average annual household income should be well over $500,000. The projected distribution of households by income levels is presented below:

Income Level		Percent
Under $100,000		2.5%
$100,000 - 249,999		20.0
$250,000 - 500,000		35.0
Over $500,000		42.5
	TOTAL	100.0%

Direct Employment Impacts - Construction Period

Infrastructure Construction

Beginning in 1990 the planned marina will generate short-term employment for infrastructure work. The planned marina will require that nearly 1.5 million cubic yards of dirt be moved. Assuming a normal time schedule for construction, the infrastructure work should be completed in nine months. Employment projections and requirements for the proposed marina are based on this time schedule. The total employment requirement is projected at 269,000 man hours. This figure includes 28,000 man hours for the construction of the small buildings such as the restaurant and the retail

facilities. The peak number of employees required during the construction period should approach 230 workers. Approximately 30 percent of this total, or 69 persons, should be retained from the existing Big Island resident population. The remaining 70 percent, or 160 men, most likely will be imported from Oahu. The distribution by type of employee is as follows:

PEAK PERIOD CONSTRUCTION EMPLOYMENT DISTRIBUTION

Employee	Number
Administrative Staff	10
Operators	107
Carpenters	47
Laborers	51
Electricians/Other	15
TOTAL	230

Source: Hawaiian Dredging & Construction Company estimate, May 1989.

Residential Unit Construction

Beginning in the third quarter of 1990 the planned marina would generate short-term employment for the construction of residential units. As presented in Table 7 the construction of each residential unit would require 2.7 persons on a full-time basis, with the average construction period per unit requiring approximately one year. Given the relatively low anticipated rate of absorption it is very likely that the local labor market can supply the necessary construction work force. Using the 140 unit scenario, it is projected that the marina program will require an annual work force of 54 full-time employees from 1990 through 1996.

Direct Employment Impacts -- Operational Period

Marina

Based on comparable facilities, employment at the marina facility would number seven persons and include the following:

- Harbormaster/Marina Manager;
- Secretary;
- Maintenance/Clean-Up Personnel (2); and
- Dock Assistants (3).

Security for the marina will be provided by the Marina Association. It is assumed that marina facility employees will come from Hawaii County.

Table 7
MAUNA LANI RESORT
DIRECT EMPLOYMENT FOR SINGLE
FAMILY UNIT CONSTRUCTION

Full-Time Equivalent Jobs Per Year 2.7 Persons

Average Construction Period Per Unit 1.0 Year

DEVELOPMENT	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
@ 92 Units	0	54	54	54	54	32	0	0	0	0	0	0
@ 90 Units	0	54	54	54	54	27	0	0	0	0	0	0
@ 140 Units	0	54	54	54	54	54	54	54	0	0	0	0

Source: MLU.

Boating Operations

Employees will be generated by commercial boat operations as well as by larger yachts that require full-time crews. The current plan allows for 10 commercial boats to be harbored at the marina. It is projected that these commercial boats in total will generate the equivalent of 15 to 20 full-time employees. The distribution of boats over 50' in the marina is projected to be 8.2 percent or 21 boats. This analysis assumes that boats over 50' require full-time crews of at least two persons. It is projected that at buildout full-time crews will generate 42 employees. The combined employment from commercial boats and large yachts should approach 57 to 62 persons.

Restaurant/Retail

Additional employment would be generated from the operating requirements of the restaurant and the general store at the marina. The total employment generated by these two facilities should account for about 15 persons. The restaurant would generate 11 employees distributed as follows: 1 manager; one host; four waiters; two busboys; three cooks/helpers. The retail store would generate four employees, with one manager, two cashiers, and one fuel attendant.

Maid Services

Finally, a maid service should be provided exclusively for the use of marina residents, generating six employees on a full-time basis. It should also noted that, given the anticipated unit values, some residents may prefer to have full-time staff at their residences.

Total Permanent Employment

Summarizing the various employment components, the total persons employed at Mauna Lani Cove should approach 85 to 90 persons, as developed below:

Employment Source	Number Employed
Marina	7
Boating Operations	57 - 62
Restaurant/Retail	15
Maid Service	6
Total	85 - 90

Visitor Expenditures

The projected average daily visitor population and annual visitor days for the proposed marina is presented in Table 8. As was previously noted the average daily visitor population is projected to increase from 39 persons in 1991 to 306 persons in 2000. The annual visitor days is projected to rise from just over 14,050 to nearly 111,800 days.

Table 8
MAUNA LANI RESORT
VISITOR EXPENDITURE ASSUMPTIONS
(Based on 140 Units Built)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
A. Average Daily Visitor Population	0	0	39	77	121	161	201	252	294	294	294	306
B. Annual Visitor Days	0	0	14,053	28,105	44,074	58,765	73,456	91,980	107,310	107,310	107,310	111,781
C. Visitor Expenditures Per Day,												
Westbound Visitors	$150	$150	$150	$150	$150	$150	$150	$150	$150	$150	$150	$150
Eastbound Visitors	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200
D. Visitor Distribution												
Westbound	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Eastbound	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
E. Visitor Retail Expenditures As Percent of Total Expenditures	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%

Retail Category	Percent of Retail Demand
Eating and Drinking	48.0%
Convenience Goods (Food and Drug/Sundries)	12.0%
Apparel/General Merchandise	17.5%
Specialty (Gifts, etc.)	22.5%
Total	100.0%

Source: Hawaii Visitors Bureau; MLW.

Table 8 also presents the expenditure characteristics of visitors as reflected in the percentage distribution of purchases by retail category. Adjusting for different spending habits of Westbound versus Eastbound tourists the average daily visitor expenditure was conservatively estimated at $150.00 per day for Westbound visitors and $200.00 per day for Eastbound visitors. These figures represent all goods and services, including accommodations, retail purchases, transportation, and other services. Expressed in constant dollars, these figures are forecasted to remain constant. The projected distribution of visitors is 80 percent Westbound and 20 percent Eastbound.

Based upon visitor expenditure patterns developed from Hawaii Visitors Bureau data, visitor retail expenditures are estimated to be 35 percent of their total expenditures. The largest percentage of visitor expenditures for a particular retail category is the 48 percent allocation to Eating and Drinking, followed by Specialty Retail purchases at 22.5 percent, Apparel/General Merchandise at 17.5 percent and Convenience Goods at 12 percent.

Projected visitor demand for retail goods is shown in Table 9. Expressed in 1989 constant dollars, residents and marina visitors are projected to spend $787 thousand in 1991 and $6.3 million by 2000.

Table 9
MAUNA LANI RESORT
PROJECTED VISITOR DEMAND FOR RETAIL GOODS
1989 TO 2000
(In Thousands of 1989 Dollars)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Eating and Drinking												
Westbound	$0	$0	$283	$567	$889	$1,185	$1,481	$1,854	$2,163	$2,163	$2,163	$2,254
Eastbound	$0	$0	$94	$189	$296	$395	$494	$618	$721	$721	$721	$751
Convenience Goods (Food and Drug/Sundries)												
Westbound	$0	$0	$71	$142	$222	$296	$370	$464	$541	$541	$541	$563
Eastbound	$0	$0	$24	$47	$74	$99	$123	$155	$180	$180	$180	$188
Apparel/General Merchandise												
Westbound	$0	$0	$103	$207	$324	$432	$540	$676	$789	$789	$789	$822
Eastbound	$0	$0	$34	$69	$108	$144	$180	$225	$263	$263	$263	$274
Specialty (Gifts, etc.)												
Westbound	$0	$0	$133	$266	$416	$555	$694	$869	$1,014	$1,014	$1,014	$1,056
Eastbound	$0	$0	$44	$89	$139	$185	$231	$290	$338	$338	$338	$352
Total Visitor Expenditures	$0	$0	$787	$1,374	$2,468	$3,291	$4,114	$5,151	$6,009	$6,009	$6,009	$6,260

Source: MLW.

MAUNA LANI COVE FISCAL IMPACTS

The following section examines the fiscal impacts of the proposed Mauna Lani Cove development program upon the public sector. The projected public costs and revenues engendered by the program are examined for both the County of Hawaii and the State of Hawaii, the two entities that provide local municipal governmental services to the South Kohala district. The basic methodology employed is that of a case study wherein public sector cost and revenuse study wherein public sector cost and revenue categories are examined within the specific local context of the proposed development.

Fiscal Impact on the County of Hawaii

The County of Hawaii would normally provide the following major services to Mauna Lani Cove residents and businesses: General Government; Sanitation; Public Safety; Health and Welfare; Road Maintenance and Repair; Culture and Recreation; and Retirement and Pensions. The total general fund budget for fiscal year 1987-1988 indicates that the County was scheduled to spend $77.2 million or $675 per capita[1] on various governmental services supported by the General Fund. These monies are distributed by major category as follows:

Budget Category	FY 1987-88 Allocation (in Millions)
General Government	$11.2
Sanitation	2.8
Public Safety	26.0
Health/Welfare/Education	3.1
Road Maintenance and Repair	5.5
Culture and Recreation	6.4
Retirement and Pensions	6.4
Other (Debt Service, Health Fund, Miscellaneous)	15.8
TOTAL	$77.2

Sources: County of Hawaii; Natelson-Levander-Whitney, Inc.

The major expenditure areas are examined below with specific reference to the proposed marina impacts.

General Government

General Government consists of salaries and overhead expenditures for the executive and legislative branches of government as well as major departments such as Finance, Planning and Zoning, Law, and Public Works. During the pre-development and development phases the project will undergo zoning and building review procedures, thus incur costs in this governmental sector. These costs will be of a transitory nature, and will

[1]Based upon an estimated population of 114,400 persons for the County.

be largely offset by governmental charges for current services in the form of application/permit fees and other processing charges. They are not considered to be long term recurring costs to County Government. The incremental costs associated with the proposed development are projected at $30.0 thousand.

Public Safety

Three major cost areas within this service category are police protection; fire protection; and other protection, including civil defense and prosecuting attorney.

Police Protection. Police protection for the South Kohala area is currently provided from the Waimea Station. It is unlikely that the development will impact the need for the deployment of additional police personnel in the area. Security for the marina will be provided by the proposed Marina Association. In addition, the existing Mauna Lani Resort has security personnel which operate on a resort-wide basis to provide necessary back-up assistance.

Fire Protection. The existing fire station at South Kohala has a primary service radius which includes the lands encompassing the Mauna Lani Cove development program. Existing levels of capital facilities and manpower are sufficient to service the projected development without significant impact on operations. As a consequence there should not be a significant cost impact in this public protection category.

Other Protection. Other protection includes the cost of civil defense, liquor control, and the prosecuting attorney's office. At present the annual cost for these categories stands at $2.5 million or $21.83 per capita. Assuming that this figure accurately portrays costs for this service to residents in the Mauna Lani Cove area, at full development full-time new resident homeowners would require expenditure approaching $6.7 thousand as measured in 1988 constant dollars.

Road Maintenance and Repair

Road maintenance and repair together with street lighting and signalization is normally financed from a separate Highway Fund. However, the Mauna Lani Resort intends to construct all major and minor streets to and within the development. The Mauna Lani Resort also plans to maintain and repair these streets privately. Therefore, it is projected that there will be no significant public fiscal impact from the Mauna Lani Cove on internal roadway maintenance, though the residents and visitors will have a minor cost impact emanating from their use of the regional and local roadways located outside the resort. These costs are projected at $14.7 thousand.

Sanitation and Waste Removal

The Mauna Lani Resort currently has its own privately-owned and -maintained sewer treatment plant with a capacity of 0.76 mgd (million gallons per day). Of that capacity the resort utilizes only 0.13 mgd each day at present. The sewer treatment plant has sufficient capacity to support the new development and in the future will be required to provide for any

additional required capacity. There would thus be a minimal cost impact in this category from the proposed marina development program. These costs are projected at $7.5 thousand.

Health, Welfare and Education

The primary expenditures for these functions relate to welfare/recreation activities for the elderly and maintenance of cemeteries. It is unlikely that the marina development will generate significant fiscal impact in this sector. However, on a per capita basis the costs are projected at $8.3 thousand.

Culture and Recreation *Culture and Recreation*

The primary expenditures associated with this function are for park maintenance, recreation services, and administration. Given the fact that Mauna Lani Resort provides its own recreational opportunities the proposed development will not generate significant fiscal impacts on this sector except for minor costs associated with residents visiting local County facilities off the resort. These costs are projected at $17.1 thousand.

Cost Summary

The Mauna Lani Cove is anticipated to have minimal financial impacts on the sectors examined. Projected in 1988 constant dollars, incremental public costs associated with the proposed development are projected at approximately $85 thousand on an annual basis.

County Revenues

Public sector revenues generated by the proposed marina development which will accrue to the County General Fund include property taxes and licenses and permits. Public sector revenues accruing to the Highway Fund which can offset roadway construction and maintenance requirements include public utility franchise taxes, fuel taxes, and licenses for street use. These revenue sources are reviewed and projected for the Mauna Lani Cove program below.

Property Taxes

Property tax generation by the proposed marina is projected to reach $2.68 million at buildout, derived from application of current County tax rate of $8.50 per $1,000 value of land and building to an anticipated total development valuation of $315 million[2]. These monies would be available to the General Fund for use as an offset to necessary public expenditures made on behalf of marina residents and businesses.

[2]The valuation expressed here covers only the residential component; the marina commercial and boating facilities would generate additional property tax base.

Business Licenses/Non-Business Licenses and Permits

Revenues from licenses and permits for FY 1987-88 were $3.7 million for the County, representing a per capita figure of $32.61. Because of the small scale of commercial development at the marina, the revenues generated will be minimal, and are projected to reach $10.0 thousand.

Highway Fund Revenues

Monies channeled to the Highway Fund are provided by three major sources: public utility franchise tax; fuel tax; and licenses and permits related to street use. These three sources combined are expected to provide $8.0 million to the Highway Fund in 1987-88, or $70 per capita. The Mauna Lani Cove activities are projected to generate funds to this source at approximately 20 percent of the current County per capita figure or $14 per capita. Total revenues to the Highway Fund should reach $4.3 thousand at the completion of the development, based on the average daily population of 306 persons.

Revenue Summary. Public revenues generated for the County of Hawaii General Fund and Highway Fund by the Mauna Lani Cove are projected to reach $2.7 million upon completion. The revenues are summarized by source below:

COUNTY REVENUES UPON COMPLETION
MAUNA LANI MARINA DEVELOPMENT PROGRAM
(in Thousands of 1989 Constant Dollars)

Revenue Source	Annual Revenue
Property Taxes	$ 2,680.0
Licenses and Permits	$ 10.0
Public Utility Franchise Tax, Street Use Licenses/Permits, and Fuel Tax	$ 4.3
TOTAL	$ 2,694.3

These revenues should more than offset the projected increase in County expenditures required by the development of $85 thousand, and should provide a substantial revenue surplus for use in other areas on the Big Island.

Fiscal Impact on the State of Hawaii

The State of Hawaii provides the following services to local residents which could be directly impacted by the proposed development: education; highways; hospitals; and health/sanitation.

Education

Due to the high land values and resort-type setting, it is unlikely that many of the residents will have children living at the residences on a permanent basis and attending local public schools. The development is

thus unlikely to generate any financial impact in this sector.

Highways

Given its small scale, the marina development will have little impact on the existing highway system.

Hospital/Health and Sanitation

Medical services are provided to the area by two state-operated hospitals - - Kohala Hospital and Honoka'a Hospital. It is unlikely that additional hospital capacity will be required because of the development.

State Harbors Division/Coast Guard

The State Harbors Division has indicated that development of the Mauna Lani Cove would not likely impact employment other than what has already been planned. In fact, development of the marina would somewhat release pressure for expanding the Honokahau Harbor.

State Revenues. Recurring revenues generated to be State of Hawaii by the development will include monies from the following major sources:

- General Excise tax revenue from various businesses such as the restaurant and the retail/fuel facility; and
- Personal and corporate income tax collected from persons and businesses residing in the development.

While it is beyond the scope of this study to project income taxes emanating from the development, general excise taxes are projected to reach $173 thousand on an annual basis, as developed below:

	Square Feet	Sales per Square Foot	Total Sales	Taxes @ 4.167 Percent
Restaurant	7,000	$375	$2,625,000	$109,384
General Store	1,500	350	1,525,000	63,547
	8,500		$3,150,000	$172,931

When combined with state income taxes these anticipated revenues should be sufficient to offset state expenditures required locally to service the development.

APPENDIX

Total Population and Demographic Breakdowns: County of Hawaii, and Primary and Secondary Study Areas, 1970 and 1980

	COUNTY OF HAWAII 1970	COUNTY OF HAWAII 1980	SOUTH KOHALA (C.T. 217) 1970	SOUTH KOHALA (C.T. 217) 1980	NORTH KOHALA (C.T. 218) 1970	NORTH KOHALA (C.T. 218) 1980	NORTH KONA (C.T. 215-216) 1970	NORTH KONA (C.T. 215-216) 1980	SOUTH KONA (C.T. 213-214) 1970	SOUTH KONA (C.T. 213-214) 1980	HONOKAA-KUKUIHAELE (C.T. 219) 1970	HONOKAA-KUKUIHAELE (C.T. 219) 1980
TOTAL POPULATION	63,468	92,053	2,310	4,607	3,326	3,249	4,832	13,748	4,004	5,914	2,829	3,287
ETHNICITY*	%	%	%	%	%	%	%	%	%	%	%	%
Caucasian	28.8	35.0	39.2	46.5	25.6	27.8	44.0	53.8	17.7	30.0	36.9	37.9
Japanese	37.5	26.6	24.4	14.6	23.8	16.1	23.1	11.8	39.6	27.5	30.0	24.9
Chinese	2.9	1.7	1.3	1.4	4.3	1.0	3.7	1.6	0.8	0.8	2.7	1.9
Filipino	16.5	13.9	6.6	5.6	29.2	24.0	8.4	7.2	26.2	13.0	21.8	21.9
Hawaiian	12.3	18.8	26.4	28.5	15.3	24.7	19.3	22.1	14.7	23.5	7.1	12.2
Other	2.0	4.1	2.0	3.4	1.7	6.4	1.5	3.5	1.0	5.2	1.4	1.9
AGE												
Less than 5 yr.	8.6	9.1	9.3	10.2	10.0	9.2	9.1	9.1	9.0	9.8	7.6	9.4
5 - 17 yr.	27.8	21.5	28.3	23.6	29.4	22.9	27.0	20.3	29.8	20.7	27.1	22.3
18 - 64 yr.	54.4	59.2	56.1	58.6	51.1	54.4	55.7	63.9	48.9	58.8	55.0	54.5
65 or more yr.	9.2	10.2	6.4	7.7	9.5	13.6	8.2	6.7	12.4	10.6	10.3	13.8
Median age (yr.)	28.9	29.4	28.1	29.3	27.3	31.9	28.6	28.9	29.7	29.7	31.6	32.2
PLACE OF BIRTH*	%	%	%	%	%	%	%	%	%	%	%	%
Hawaii	NC	70.5	NC	64.9	NC	75.6	NC	54.4	NC	71.2	NC	77.2
Other U.S.**	NC	20.0	NC	30.4	NC	13.6	NC	39.9	NC	20.8	NC	9.5
Foreign country	NC	9.4	NC	4.7	NC	10.8	NC	5.7	NC	7.8	NC	13.3
RESIDENCE 5 YRS. AGO (people aged 5+)												
Same house	62.5	52.9	45.6	50.7	49.9	68.9	51.1	38.8	56.1	57.4	64.7	68.3
Same island	NC	24.9	NC	17.3	NC	12.1	NC	28.1	NC	22.9	NC	16.5
Different island	NC	8.1	NC	14.9	NC	4.4	NC	7.0	NC	6.5	NC	8.9
Different state	NC	11.1	NC	16.4	NC	11.6	NC	23.1	NC	10.7	NC	4.3
Different country	NC	3.1	NC	0.7	NC	3.1	NC	3.0	NC	1.2	NC	2.0
EDUCATION* (selected—people aged 25+)												
0-8 years only	37.2	20.1	24.1	8.6	44.2	29.0	28.9	8.0	26.1	23.6	45.7	30.3
Hi school only	31.6	35.5	34.2	37.0	30.0	39.0	66.0	40.9	21.9	33.8	27.5	35.7
College, 4+ yr.	7.5	15.2	13.1	20.7	5.9	8.1	8.8	18.8	6.4	12.4	5.3	9.8

Notes: *Figures based on 15% sample; hence, numbers represent estimate.
**Including persons born in U.S. territories, and persons born abroad or at sea to American parent/s.

"NC" = 1970 categories or bases "Not Comparable" to 1980 (1970 Census kept a "non-response" category, while 1980 Census allocated non-responses to other categories shown).

Sources: U.S. Bureau of the Census, 1970 Census of Population and Housing--Census Tracts--Honolulu, Hawaii, PHC(1)-88; 1980 Summary Tape Files 1-A and 3-A; State of Hawaii, 1973, Community Profiles for Hawaii.

APPENDIX

Total Population and Demographic Breakdowns: County of Hawaii, and Primary and Secondary Study Areas, 1970 and 1980

	COUNTY OF HAWAII		SOUTH KOHALA (C.T. 217)		NORTH KOHALA (C.T. 218)		NORTH KONA (C.T. 215-216)		SOUTH KONA (C.T. 213-214)		HONOKAA-KUKUIHAELE (C.T. 219)	
	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980
TOTAL POPULATION	63,468	92,053	2,310	4,607	3,326	3,249	4,832	13,748	4,004	5,914	2,829	3,287
ETHNICITY*	%	%	%	%	%	%	%	%	%	%	%	%
Caucasian	28.8	35.0	39.2	46.5	25.6	27.8	44.0	53.8	17.7	30.0	36.9	37.9
Japanese	37.5	26.6	24.4	14.6	23.8	16.1	23.1	11.8	39.6	27.5	30.0	24.9
Chinese	2.9	1.7	1.3	1.4	4.3	1.0	3.7	1.6	0.8	0.8	2.7	1.9
Filipino	16.5	13.9	6.6	5.6	29.2	24.0	8.4	7.2	26.2	13.0	21.8	21.9
Hawaiian	12.3	18.8	26.4	28.5	15.3	24.7	19.3	22.1	14.7	23.5	7.1	12.2
Other	2.0	4.1	2.0	3.4	1.7	6.4	1.5	3.5	1.0	5.2	1.4	1.9
AGE												
Less than 5 yr.	8.6	9.1	9.3	10.2	10.0	9.2	9.1	9.1	9.0	9.8	7.6	9.4
5 - 17 yr.	27.8	21.5	28.3	23.6	29.4	22.9	27.0	20.3	29.8	20.7	27.1	22.3
18 - 64 yr.	54.4	59.2	56.1	58.6	51.1	54.4	55.7	63.9	48.9	58.8	55.0	54.5
65 or more yr.	9.2	10.2	6.4	7.7	9.5	13.6	8.2	6.7	12.4	10.6	10.3	13.8
Median age (yr.)	28.9	29.4	28.1	29.3	27.3	31.9	28.6	28.9	29.7	29.7	31.6	32.2
PLACE OF BIRTH*	%	%	%	%	%	%	%	%	%	%	%	%
Hawaii	NC	70.5	NC	64.9	NC	75.6	NC	54.4	NC	71.2	NC	77.2
Other U.S.**	NC	20.0	NC	30.4	NC	13.6	NC	39.9	NC	20.8	NC	9.5
Foreign country	NC	9.4	NC	4.7	NC	10.8	NC	5.7	NC	7.8	NC	13.3
RESIDENCE 5 YRS. AGO (people aged 5+)												
Same house	62.5	52.9	45.6	50.7	49.9	48.9	51.1	38.8	56.1	57.4	66.2	48.3
Same island	NC	24.9	NC	17.3	NC	12.1	NC	28.1	NC	22.9	NC	16.5
Different island	NC	8.1	NC	14.9	NC	4.4	NC	7.0	NC	6.5	NC	8.9
Different state	NC	11.1	NC	16.4	NC	11.6	NC	23.1	NC	10.7	NC	4.3
Different country	NC	3.1	NC	0.7	NC	3.1	NC	3.0	NC	1.2	NC	2.0
EDUCATION* (selected-people aged 25+)												
0-8 years only	37.2	20.1	24.1	8.6	44.2	29.0	28.9	8.0	26.1	23.6	45.7	30.3
Hi school only	31.6	35.5	34.2	37.0	30.0	39.0	66.0	40.9	21.9	33.8	27.5	35.7
College, 4+ yr.	7.5	15.2	13.1	20.7	5.9	8.1	8.8	18.8	6.4	12.4	5.3	9.8

Notes: *Figures based on 15% sample; hence, numbers represent estimate.
**Including persons born in U.S. territories, and persons born abroad or at sea to American parent/s.

"NC" = 1970 categories or bases "Not Comparable" to 1980 (1970 Census kept a "non-response" category, while 1980 Census allocated non-responses to other categories shown).

Sources: U.S. Bureau of the Census, 1970 Census of Population and Housing--Census Tracts--Honolulu, Hawaii, PHC(1)-88; 1980 Summary Tape Files 1-A and 3-A; State of Hawaii, 1973, Community Profiles for Hawaii.

Housing Stock and Characteristics: County of Hawaii, and Primary and Secondary Study Areas, 1970 and 1980

	COUNTY OF HAWAII		SOUTH KOHALA (C.T. 217)		NORTH KOHALA (C.T. 218)		NORTH KONA (C.T. 215-216)		SOUTH KONA (C.T. 213-214)		HONOKAA-KUKUIHAELE (C.T. 219)	
	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980
TOTAL YEAR-ROUND HOUSING UNITS	18,939	33,954	798	1,959	941	1,121	1,975	6,894	1,131	2,052	880	1,114
	%	%	%	%	%	%	%	%	%	%	%	%
vacant (total)	9.0	13.9	18.5	24.3	6.6	8.8	27.4	33.3	6.4	9.7	8.1	6.5
vacant for sale	0.6	1.3	0.1	2.9	0.7	0.3	3.2	3.2	0.0	2.9	X.X	0.1
vacant for rent	2.0	5.5	1.9	4.1	1.1	1.8	8.3	18.9	0.3	2.1	X.X	1.1
TOTAL YEAR-ROUND OCCUPIED UNITS	17,260	29,237	650	1,483	879	1,022	1,431	4,602	1,059	1,853	809	1,042
TENURE	%	%	%	%	%	%	%	%	%	%	%	%
owner-occupied	56.9	60.6	48.8	59.3	66.6	67.7	44.7	55.1	36.9	52.7	59.7	64.3
renter-occupied	43.1	39.4	51.2	40.7	33.4	32.2	55.3	44.9	63.1	47.3	40.3	35.7
SELECTED CONDITIONS												
lacking some or all plumbing	17.1	6.4	15.4	2.0	17.6	7.3	26.3	7.3	35.8	28.4	17.4	7.9
1.51 or more persons/room	6.5	5.0	8.2	5.3	9.7	3.1	14.1	6.1	13.1	10.1	4.2	4.6
PERSONS/HOUSEHOLD	3.61	3.09	3.51	3.07	3.75	3.16	3.36	2.92	3.71	3.14	3.4	3.1
1980 MEDIAN RENT (renter-occupied)		$223		$307		$153		$331		$200		$128
1980 MEDIAN VALUE* (owner-occupied)		$70,300		$95,700		$64,200		$114,000		$102,600		$60,600

Notes: * Median values are for non-condominium housing units.

Sources: U.S. Bureau of the Census, 1970 Census of Population and Housing--Census Tracts--Honolulu, Hawaii, PHC(1)-88; 1980 Summary Tape File 1-A; State of Hawaii, 1973, Community Profiles for Hawaii.

Family Characteristics and Income Levels: County of Hawaii, and Primary and Secondary Study Areas, 1970 and 1980

	COUNTY OF HAWAII		SOUTH KOHALA (C.T. 217)		NORTH KOHALA (C.T. 218)		NORTH KONA (C.T. 215-216)		SOUTH KONA (C.T. 213-214)		HONOKAA-KUKUIHAELE (C.T. 219)	
	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980
POPULATION IN FAMILIES	N/A	81,728	N/A	4,114	N/A	2,961	N/A	11,543	N/A	5,235	N/A	3,042
as % of total population	N/A	88.8%	N/A	89.3%	N/A	91.1%	N/A	84.0%	N/A	88.5%	N/A	92.4%
NUMBER OF FAMILIES	14,533	22,825	533	1,204	741	826	1,131	3,339	848	1,378	654	862
HEAD	%	%	%	%	%	%	%	%	%	%	%	%
Husband/wife	87.1	82.1	90.1	79.7	88.0	84.0	87.4	84.0	88.3	83.4	87.8	91.1
Male only	5.2	5.2	3.6	7.6	6.7	6.2	4.1	4.7	4.4	6.1	7.3	2.4
Female only	7.7	12.7	6.4	12.7	5.3	9.8	8.5	11.4	7.3	10.5	4.9	6.5
WITH OWN CHILDREN UNDER 18	57.4	52.7	63.2	51.6	58.0	52.2	53.4	54.4	59.3	51.5	56.4	48.5
Female head	4.0	7.4	4.5	9.1	2.2	5.9	5.0	4.8	3.5	5.4	3.1	4.3
BELOW POVERTY LEVEL	9.7	10.3	11.8	5.7	10.5	12.2	13.0	8.0	17.3	9.8	10.4	9.4
1980 MEDIAN FAMILY INCOME		$19,132		$17,924		$15,7194		$21,100		$19,128		$19,107

Notes: All figures (except "Population in Families") based on 15% sample; hence, numbers represent estimates.
"N/A" = "Not Available" in published form. However, other published 1970 and 1980 census data lead to the conclusion that families generally comprised a smaller percentage of Hawaii's 1970 population than of the 1980 total.

Sources: U.S. Bureau of the Census, 1970 Census of Population and Housing--Census Tracts--Honolulu, Hawaii, PHC(1)-88; 1980 Summary Tape File 3-A; State of Hawaii, 1973, Community Profiles for Hawaii.

Labor Force Size and Characteristics: County of Hawaii, and Primary and Secondary Study Areas, 1970 and 1980

	COUNTY OF HAWAII		SOUTH KOHALA (C.T. 217)		NORTH KOHALA (C.T. 218)		NORTH KONA (C.T. 215-216)		SOUTH KONA (C.T. 213-214)		HONOKAA-KUKUIHAELE (C.T. 219)	
	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980
POTENTIAL LABOR FORCE (aged 16+)	43,075	67,205	1,446	3,290	2,240	2,286	3,632	10,115	2,629	4,265	2,092	2,418
	%	%	%	%	%	%	%	%	%	%	%	%
not in lab. force	39.5	38.7	34.2	35.9	38.4	39.8	44.3	27.8	41.6	33.8	40.6	46.7
armed forces	0.4	0.3	0.0	0.0	1.1	1.0	0.0	0.1	0.0	0.0	0.2	0.0
civil. lab. force	60.1	61.0	65.8	64.1	60.5	59.3	55.7	72.1	58.4	66.2	59.2	53.3
CIVILIAN LABOR FORCE	25,889	41,006	951	2,110	1,355	1,355	2,022	7,293	1,535	2,823	1,238	1,289
% unemployed	2.7	7.0	4.1	6.3	1.9	9.2	4.8	5.2	2.3	5.7	1.9	5.4
TOTAL EMPLOYED CIVIL. LAB. FORCE	25,180	38,150	912	1,978	1,330	1,230	1,925	6,913	1,500	2,662	1,215	1,220
OCCUPATION	%	%	%	%	%	%	%	%	%	%	%	%
service	16.3	16.5	15.9	18.0	25.9	34.2	19.3	21.5	16.0	17.3	19.5	11.2
manager./profes.	NC	20.0	NC	20.6	NC	15.2	NC	21.2	NC	13.6	NC	12.5
technical, sales & adminis.	NC	26.1	NC	19.2	NC	13.7	NC	28.2	NC	24.8	NC	18.9
farm/fish/forest	NC	10.3	NC	14.0	NC	14.2	NC	7.1	NC	19.5	NC	12.6
precision, craft, repair	NC	12.7	NC	16.5	NC	9.7	NC	12.1	NC	14.8	NC	17.5
operators, fabricators, laborers	NC	14.4	NC	11.8	NC	12.9	NC	9.9	NC	10.0	NC	27.3
INDUSTRY (selected)												
agric., forest, fish, mining	12.5	11.2	N/A	16.8	N/A	8.1	N/A	6.2	N/A	19.4	N/A	16.2
construction	10.6	9.1	13.6	12.3	7.6	5.0	23.6	11.2	20.4	14.3	9.9	8.0
manufacturing	15.0	8.3	2.3	5.1	29.3	8.1	1.0	1.9	3.2	1.2	26.4	29.4
retail trade	14.8	17.5	15.9	13.8	2.9	7.0	13.1	23.6	8.9	18.4	10.3	13.8
financial, insur., real estate	2.8	5.7	3.5	7.6	1.1	2.3	4.0	8.6	3.8	4.5	0.4	1.2
personal, entert. & recreat. serv.	11.2	10.9	N/A	16.0	N/A	31.4	N/A	20.7	N/A	15.2	N/A	6.6
health, educ, & professional	14.1	16.7	13.9	14.8	14.7	20.5	7.8	11.4	18.3	13.1	6.9	7.1
public adminis.	6.5	7.3	3.1	2.1	5.5	8.1	4.2	2.7	3.7	4.8	8.6	5.3
COMMUTE TO WORK:												
45 minutes + (%)	N/A	6.0	N/A	13.9	N/A	22.6	N/A	4.8	N/A	6.8	N/A	13.4
mean travel (min.)	N/A	16.5	N/A	21.7	N/A	24.1	N/A	16.4	N/A	20.6	N/A	17.6

Notes: All figures based on 15% sample; hence, numbers represent estimates.
"N/A" = "Not Available" in published form. "NC" = 1970 categories or bases "Not Comparable" to 1980 Census.

Sources: U.S. Bureau of the Census, 1970 Census of Population and Housing--Census Tracts--Honolulu, Hawaii, PHC(1)-88; 1980 Summary Tape File 3-A; State of Hawaii, 1973, Community Profiles for Hawaii.

APPENDIX B

HYDRAULIC MODEL STUDY OF THE MAUNA LANI COVE

Project Report HRS - 192-89
Project 1424

HYDRAULIC MODEL STUDY OF THE MAUNA LANI COVE

Prepared for
Peratrovich, Nottingham & Drage

by
Dr. A. B. Rudavsky &
Adrian W. K. Law

September 1989

HYDRO RESEARCH SCIENCE Inc.
3334 VICTOR COURT • SANTA CLARA, CA 95054-2316 • 408 - 988-1027

Project Report HRS - 192-89
Project 1424

HYDRAULIC MODEL STUDY OF THE MAUNA LANI COVE

Prepared for
Peratrovich, Nottingham & Drage

by
Dr. A. B. Rudavsky &
Adrian W. K. Law

September 1989

PREFACE

Model investigation for hydraulic assessment and experimental evaluation of the Mauna Lani Cove on the island of Hawaii, was requested by Peratrovich, Nottingham & Drage, Inc. to be performed by Hydro Research Science (HRS, Inc.), Santa Clara, California. The extent of the model study, its execution, and associated administrative procedures were discussed via written and telephonic correspondence in November 1988. HRS submitted a proposal for this model study on November 29, 1988. The letter agreement for engineering services (work order) of the proposed study was signed on April 24, 1989. An additional agreement for an edited and narrated video was signed on June 26, 1989. Finally, an additional agreement on the modification and extension of physical modeling for the waves, pump and reservoir tests was also signed on June 26, 1989.

The study was divided into four phases: Stage 1 - construction of the hydraulic model, Stage 2 - hydraulic testing of the design and the introduction of modifications found necessary by model tests, Stage 3 - numerical study of the design under storm surge and average tides, Stage 4 - a comprehensive report and an edited and narrated video of the study. The first stage of the model investigation was completed in May 1989, the second and third stages were completed in August 1989, and the fourth stage was finished in September 1989.

During the course of the model construction and model investigation, the experimental setup was visited on many occasions by representatives from several parties involved in the Mauna Lani Cove project. Visitors to the HRS facilities included:

From Peratrovich, Nottingham & Drage:

- Jeff Gilman
- Robert Miller

From Mauna Lani Resort:

- Marcia Stevens
- Francine Duncan
- Tom Yamamoto
- Leilani Hino
- Michael Gomes

From Belt Collins & Associates:

- Joe Vierra

The purpose of the various visits was to discuss test results, develop revisions and plans, and correlate test results with the engineering work concurrently performed by Peratrovich, Nottingham & Drage.

The construction of the model and subsequent investigations were conducted under the direct supervision of Dr. A. B. Rudavsky. The layout, construction, modifications, and subsequent model investigation were conducted by personnel of Hydro Research Science, Santa Clara, California.

Although the name of this project is Mauna Lani Cove, for convenience sake, the word 'marina' is used throughout this report to designate not only the marina (or yacht club), but the entire complex of the entrance and interior channels.

SUMMARY

Part I of this report describes the physical hydraulic model, the test program and test results of the Mauna Lani Marina on the Island of Hawaii performed by HRS for Peratrovich, Nottingham and Drage. Comprehensive hydraulic model studies were performed to (1) assess the flow pattern inside the marina under the combination of wave and tide action, and with or without the mechanical pumping and reservoir flushing scheme, and (2) to identify the wave disturbance characteristics inside the marina.

An undistorted physical model of scale 1:75 was constructed to analyze and verify the aforementioned objectives. The model encompassed the marina and an area of the offshore topography approximately 1600 ft along the coastline and 1900 ft offshore, adjacent to the marina entrance. Both wave motion and tidal change in water surface elevation were simulated in the model.

The test program was divided into three phases: Phase I, base tests; Phase II, developmental tests; Phase III, verification tests. The specific tests associated with each of these phases are identified in Table 2.

Phase I, base tests, identified the hydraulic performance of the preliminary design configuration of the marina.

Phase II, developmental tests, consisted of the following subdivisions of model testing:

(i) Geometric Configuration Tests

The geometric configuration tests, examined the change in the flow pattern inside the marina by altering the geometric boundaries. These tests focused primarily upon the improvement in the hydraulic circulation by simple geometric change to the marina configuration. Two different configurations were tested and the results were demonstrated to the representatives of Peratrovich, Nottingham & Drage and Mauna Lani Resort.

(ii) Wave Tests

The wave tests verified the wave disturbance characteristics of the preliminary design configuration. Four tests with incoming offshore waves of different wave height/period combinations were performed. The corresponding wave response at different locations inside the marina was recorded.

(iii) Pump Tests

The pump tests investigated the flow pattern inside the marina with a pumping scheme of varying discharges and intake/outlet locations. These tests aimed at examining hydraulic circulation improvement by the mechanical means of pumping discharge. Nine tests of different arrangement were performed. The flow patterns inside the marina were recorded and demonstrated to Client.

(iv) Reservoir Tests

The reservoir tests studied the flow pattern during the discharge of water from an uphill reservoir into the marina. Eight tests of different discharge volumes and outlet configurations were performed during the ebb tide. The resulting flow pattern was recorded. The aim of release of reservoir water was to increase the net mass exchange between the marina and the ocean and to displace water in the area of sluggish flow.

Phase III, verification tests, verified the hydraulic performance of the arrangement selected by Client under the influence of both the wave motion and the tidal action. Three tests were performed with an average tide and different incoming wave heights and periods. Each test was carried out to a duration of three and one-half tide cycles, with velocity measurements inside the marina taken throughout the test duration.

An edited and narrated video was prepared at the end of the testing program to describe the study.

In Part II, the numerical model study, the flow patterns inside the marina under average tide and under storm surge conditions were simulated using a two-dimensional tidal circulation numerical model (the TEA model). Two simulations were run, one for the average tide and the other for the storm surge. Results of the simulations were described in detail in the report.

Table of Contents

List of Tables

LIST OF PHOTOS

LIST OF FIGURES

Part II: NUMERICAL MODEL STUDY

1.0 INTRODUCTION

1.1 GENERAL

1.1.1 SCOPE AND OBJECTIVE

Part I of this report, from Section 1 to 4, describes the construction, test sequence, and test results of the Mauna Lani Marina hydraulic model studies for Peratrovich, Nottingham & Drage (PN&D).

The model investigations were conducted: (1) to verify the effectiveness in enhancing the hydraulic circulation with the different proposed designs, and (2) to examine the wave disturbance characteristics inside the marina. Client established the following specific objectives for the model studies:

- Observe and record the general flow patterns for the various configurations of the marina under the action of both wave and tide, with and without the pump discharge and the reservoir flushing scheme
- Record the wave disturbance characteristics inside the marina with different incoming offshore waves
- Maintain close liaison with Client during the course of the investigation to ensure that the designs tested are acceptable according to non-hydraulic considerations

1.1.2 CONTENTS

Part I of this report consists of four major parts:

- 1.0 Introduction
- 2.0 The Model
- 3.0 Description of Tests and Results
- 4.0 Illustrative Materials

1.1.3 Sources of Information

General information about the project area and the marina under study was supplied to HRS by PN&D. HRS also compiled a list of references and reviewed reports prepared by other consultants. These materials were used extensively for the design and construction of the models, for the development of the testing program, and for the narrative and illustrations included in this report. A partial listing of reference materials is presented at the end of the report.

1.2 DESCRIPTION OF THE PROJECT

1.2.1 LAYOUT AND ITS PURPOSE

The Mauna Lani Marina will be part of the development of the Mauna Lani Resort at the island of Hawaii. The marina will provide moorage for pleasure craft in the vicinity of the project site. The level of wave protection afforded and inner harbor water quality posed the two most critical factors in the marina's design. A circulatory flow pattern inside the marina is in general desirable for water quality considerations, since the mixing of the tidal prism with the marina will be optimized. This particular hydraulic model study evaluated the wave protection ability of the marina and provided the preliminary results of flow patterns to allow the design engineers to address the water quality issue.

1.2.2 PRINCIPAL ELEMENTS OF THE PROJECT

The project in an overall view for the purposes of this report can be considered to consist of the following engineering design elements: the configuration of the channels inside the Mauna Lani Marina, the dredged offshore entrance to the Marina, the offshore topography adjacent to the entrance, the tide condition at the project site, and the offshore wave climate. The current HRS study involved all aforementioned elements to investigate their interactive effects on the circulation pattern and wave disturbance characteristics inside the Marina.

1.2.3 COMPONENT PARTS MODELED

Key elements of the Mauna Lani Marina that were selected for hydraulic model assessment and experimental development of their designs are the configuration of the waterways of the Marina, the offshore dredged entrance to the Marina, and the offshore topography adjacent to the entrance; an area of approximately 1900 ft along the coastline and 1600 ft offshore. These elements must be considered in modeling in order to simulate the hydraulic and hydrologic environmental behavior of the model proper.

1.2.4 TIDE CONDITIONS INVESTIGATED

The tide condition to be investigated was determined by PN&D based on the analysis of past information in the vicinity of the project site. The selected average tide condition for experimentation was that the water surface elevation rose from 0 ft MLLW to 2 ft MLLW in 6.25 hours during flood tide and dropped from 2 ft MLLW to 0 ft MLLW in 6.25 hours during ebb tide. This average tidal change in water surface elevation for the model tests is shown in Figure 4. The tidal elevation changes were modeled as linear segments rather than the sinusoidal shape due to equipment limitations.

1.2.5 WAVE CONDITIONS INVESTIGATED

The offshore wave conditions to be investigated were also selected by PN&D in consultation with HRS based on the review of past studies in the offshore wave climate near the project site. The waves varied in different tests, and ranged from 0 to 25 ft in wave height, and 6 to 15 seconds in wave period. Incoming waves approached from approximately the Northwest, roughly parallel to orientaion of the dredged offshore entrance.

1.2.6 STRUCTURAL DESIGN DATA

Data pertinent to the preliminary design of the marina, especially the geometric configuration, the bottom bathymetry of the channels inside the Marina, the shape of the side banks of the channels, and the orientation of the offshore dredged channel, were indicated in Figures 1 and 2.

1.3 NEED FOR MODEL INVESTIGATION

1.3.1 LIMITATION OF ANALYTICAL APPROACH

The complex geometrical configuration of the marina and the offshore topography, with the combined effect of tide and wave motion, pose unique problems that are not completely susceptible to theoretical analysis. A number of uncertainties inherent in solely analytical determinations had to be confirmed by model studies if reliable predictions of the suitability of the individual designs of the various elements were to be made with confidence.

1.3.2 AREAS OF CONCERN

The main elements of concern in the model study were:

- the generation of circulatory flow pattern in the marina
- the reduction of areas of no flow in the channels
- the achievement of reduced wave disturbance in the mooring area of the marina

1.3.3 MODEL STUDIES MANDATORY

Confirmation and possible refinement of the proposed solutions to the above problems by means of hydraulic model tests were imperative. Only through the

effective use of a physical model could these problems be solved with confidence. The complex interaction of the topography and the tide and wave motion precludes a purely theoretical analysis in this study.

2.0 THE MODEL

2.1 MODEL SETUP

2.1.1 KEY ELEMENTS OF MODEL SETUP

An undistorted model of model to prototype scale 1:75 was constructed to address the aforementioned areas of concern. The models were built to be flexible enough to make the components readily modifiable if the need arose for major revisions to the model structure. The experimental setup consisted of three main parts:

- The Physical Model
- Auxiliary Equipment
- Instrumentation

Overall views of the model with auxiliary equipment and instrumentation, during construction and after completion, are shown in Photographs 1 through 7.

2.1.2 PHYSICAL MODEL

As indicated in Photographs 3 to 5, the physical model of the Mauna Lani Marina encompassed the marina itself and the offshore topography (approximately 1900 ft along the coastline and 1600 ft offshore) of immediate vicinity to the entrance. The overall structure was made of cement blocks, wood and concrete. The curvilinear perimeters of the marina were first outlined by the cement blocks. Gravel was then used to fill the space between the blocks. Finally, wood blocks and concrete were placed on top of the cement blocks to reproduce the cross-sectional geometry of the channels. Special sealants coated the top of the model topography to ensure that the model was waterproof.

The following assumptions and component characteristics enabled HRS to simulate the model geometry approximately:

- Depth Contours Inside the Marina: The bottom bathmetry map inside the marina was supplied by PN&D through fax communication. Discrete regions of bottom elevations -18, -15, -12, -10 and -6 ft MLLW were identified. Transition from one region to the other was assumed to occur linearly in 50 ft prototype.
- Offshore Topography: The offshore topography surrounding the entrance was constructed according to the Client drawing of the prototype offshore bathymetry map. The width of the modeled coastline was about 1900 ft prototype with the entrance located near the middle. From the coastline, the model topography was extended offshore down to an elevation of -60

ft MLLW. Then a one- to-one slope was assumed to continue the topography to a platform of elevation -118 ft MLLW, which was the approximate depth of the model basin. The wave maker was placed on the platform to generate the desirable waves. The generated waves at this platform can be considered as deep water waves in most of the tests being performed.

- Offshore Entrance Channel: The orientation, depth and width of the offshore entrance channel was supplied by PN & D through fax communication. A one-to-one side channel slope was assumed to transit the channel geometry smoothly to the surrounding topography. A transition length of about 25 ft prototype was also assumed to smoothly merge the offshore entrance channel to the marina's entrance.
- Marina's Channel Side Slope: According to the fax communication by PN & D on the preliminary design of the marina's channel geometry, the side slope of the channel is four to one up to an elevation of +4ft MLLW. However, this four to one steep slope would behave similarly to a vertical wall in terms of wave reflection characteristics. After a brief discussion between HRS and Client, it was decided to approximate the steep slope by means of vertical walls in the model. The cross-section profile of the marina's channels in the model is shown in Figure 3.
- Marina Periphery: The preliminary design of the marina was supplied by PN & D and shown in Figure 2. Simplification of the channels' boundaries had to be made for model construction purposes due to the highly irregular nature of the boundaries as seen in the figure. The construction method chosen was to set up a grid system in the model. The grid system represented a 200 ft by 200 ft grid in the prototype along the north-south and east- west directions. The boundary of the marina was first outlined on the grids, with smoothening as deemed necessary. Cement blocks of model width 15 in were then placed along the outline to optimize the matching of the curvilinear boundaries. Wood blocks were then placed on top of the cement blocks to simulate the channels' side bank. The spaces between the cement blocks were then filled with gravel. Finally concrete was poured on top of the gravel and between the wood blocks to reproduce the bottom bathymetry.

2.1.3 AUXILIARY EQUIPMENT

The actual model components were augmented by auxiliary equipment: a sump to store water, a centrifugal pump to circulate the water between the model and the sump to simulate the tide, a system of discharge valves to regulate the flow to reproduce the desirable changes in water surface elevation, and a plunging wave maker to generate the offshore waves.

2.1.4 INSTRUMENTATION

HRS has a variety of instrumentation for accurately monitoring and recording hydraulic phenomena. HRS instruments used for this model study included:

- A microcomputer for monitoring and recording test results
- Point gages for measuring water surface elevations to within 0.001 of a foot (model)
- Metal scales for measuring water depth with an accuracy of .02 inches
- Dye probe together with stop watches to measure velocity with an accuracy of 0.012 feet per second(prototype)
- Precalibrated orifice plates to produce orifice flow inside pipelines. A differential pressure measured across an orifice plate indicates flow rate
- Flow rotameters to measure low flow rates in small diameter tubing
- Dye meters to release opaque color into the water to tint the flow for observation

2.2 MODELING LAWS

2.2.1 SIMILITUDE RELATIONSHIPS

The similitude relationships between the model and the prototype for this type of model are based on the Froude Law. The resulting mathematical relationships between the basic hydraulic quantities of the model and the prototype are summarized in Table 1 for the undistorted model.

2.2.2 SYMBOLS IN THE REPORT

In this report (p) indicates the prototype values, (m) applies to model values, and subscript (r) signifies the ratio of model to prototype. Unless otherwise designated or self-evident, the quantities given in this report refer to the prototype. Model data have been transferred to prototype equivalences by the scale relationships listed above.

2.3 INTERPRETATION OF MODEL RESULTS

2.3.1 SIMILARITY LIMITATIONS

Similarity between the model and the prototype was obtained in accordance with the Froude Law which assumes gravity as the dominant force. Since complete dynamic similitude and accurate reproduction of some properties of the prototype materials are not possible, some limitations must be imposed on the model results.

2.3.2 ROUGHNESS CONSIDERATIONS

Since it is not feasible to reproduce the prototype roughness of rock in the concrete surfaced model at this scale, a slight decrease in conveyance efficiency of the model can result. A slight variation from the theoretical model roughness will have no significant effect on the performance of the flow in the model proper.

2.3.3 ACCURACY IN VELOCITY MEASUREMENTS

The velocity profile at any channel section inside the marina was typically complex and of a 3-dimensional nature. The velocities recorded and indicated in the result drawings only represented the average cross-sectional velocities from visual observation. Due to the method of measurement, the maximum accuracy of the velocity recordings was approximately within 0.012 feet per second prototype.

2.3.4 TURBULENCE CONSIDERATION

The original concept of investigating the effect of the combinations of waves and tidal action called for the necessity of an undistorted model. However, practical considerations limit the feasible model size and hence the range of model scale to be chosen. The compromised scale 1:75 prototype to model chosen in this study renders the flow characteristic inside the marina to range from laminar to transition to turbulence. This model flow characteristic would differ from the generally turbulent nature in the prototype, the major effects of which will be increasing the resistance for flow conveyance and affecting the cross-sectional velocity distribution profiles. The results observed in the present model study should be viewed as the conservative evaluation of the prototype behavior.

2.3.5 WATER QUALITY CONSIDERATIONS

This model is intended solely to evaluate the hydraulic performance of the marina under different hydraulic conditions. No environmental assessment on the water quality can be attempted based on the modeling results alone, since the consideration of water quality will in fact depend mainly on the mixing characteristic of the water from different sources, the quality of the water from the individual source, and the ecological environment of the prototype site location. Detailed assessment of the water quality should involve the consideration of all the above factors and is beyond the scope of work of the current project.

3.0 TESTS AND RESULTS

3.1 SCOPE OF THE EXPERIMENTAL PROGRAM

3.1.1 PURPOSE OF THE MODEL STUDY

The general purpose of the model study was to evaluate the hydraulic performance of the marina under different hydraulic conditions and different geometrical configurations. It was the function of the experimental program to provide the Client with the hydraulic characteristics of the marina which will then assist the Client in improving the preliminary design.

3.1.2 AREAS OF CONCERN

Tests were conducted to analyze the hydraulic conditions in the following areas of concern:

- Wave Disturbance - The wave disturbance at the mooring area under the action of the offshore storm waves poses one of the major parameters for the design of the marina configuration. Excessive wave height may induce damage to boating facilities, difficulties in navigation and discomfort of boat passengers.
- Flow Pattern - Flow pattern inside the marina represents the general hydraulic characteristics for the configuration and should be understood for the preliminary assessment of its hydraulic performance. Waves inside the marina can superimpose on the tidal current and contribute to the net flow pattern. The combination of waves with different magnitudes and periods with the tidal current would need to be investigated in order to evaluate the hydraulic characteristics of the marina under realistic conditions.
- Area of No Flow - Areas without significant water movement have a generally higher potential in producing faulty water which is environmentally undesirable. The criteria for the minimum water velocity required to prevent the formation of faulty water will very much depend on the local ecological environment. The velocity measurements from this model study can provide the preliminary information for addressing this issue.
- Circulation - The formation of circulatory flow patterns inside the marina is, in general, beneficial for the mixing of the tidal prism with the marina's water. The flow pattern observed during the testing can therefore provide the preliminary evaluation as to the effectiveness of the configuration in enhancing the exchange of water between the marina and the ocean. The

mixing characteristics and the quantitative exchange can, however, be evaluated only by investigating the mixing pattern between the two types of water. The tidal prism was estimated to be approximately 15 %.

3.1.3 LIAISON WITH CLIENT

Liaison was maintained with PN&D engineers through telephonic communications, fax information of preliminary test results, draft video tape of the testing, written communications, and meetings at HRS facilities. Modeling methodology and design ...ifications were based on a plan of study developed by HRS and approved b... ...on selection of specific design alternatives and the extent of s... ...consultation with HRS.

Is Client qualified to make sound judgements on engineering facts?

3.1.4 OV... ...AM

The exp... ...ate the comparative improvement in... ...nfigurations of the marina under differen... ...of the experimental program, three distinct phases ...

- Phase I - Base Tests

Tests were first conducted to investigate the hydraulic performance of the preliminary design configuration of the marina.

- Phase II - Developmental Tests

Developmental tests experimentally evaluated the hydraulic performance of different design alternatives. The following scope of testing was performed:

(A) Geometric Configuration Tests: Subsequent to the base test, the preliminary design configuration was modified twice and the hydraulic performance of the modifications was recorded and compared with the base configuration. The aim of this phase was to attempt to improve the hydraulic performance of the marina by adjusting its geometrical shape.

(B) Wave Disturbance Tests: Tests were performed to evaluate the effectiveness of the preliminary design configuration in sheltering against the offshore storm waves. Waves of different magnitudes and periods were generated off shore, and the corresponding induced waves were measured at different locations inside the marina.

(C) Pump Tests: The aim of these tests was to investigate the effectiveness of using mechanical pumping to enhance the hydraulic circulation inside the marina.

Different inlet and outlet configurations with different pumping discharges were tested. Flow pattern was recorded for every test for comparison purposes.

(D) Reservoir Tests: Flushing arrangement using water from a reservoir uphill of the marina was tested in this phase. Different combinations of outlet configurations, total volumes of discharged water and discharge durations were investigated. Flow pattern inside the marina was identified during the discharge duration. Boundaries of the observed plume from the flushing discharge were sketched at the end of the tide cycle. The aim of the reservoir tests was to study the flow pattern during the release of the reservoir water.

- Phase III - Verification Tests

After the two different phases of tests discussed above, a final configuration of the marina was selected by Client. The flushing arrangement with the reservoir water was determined to be the auxiliary condition to improve the flow pattern inside the marina. In this testing phase, the selected configuration was further tested with a combination of tide and wave conditions to document its performance under realistic conditions. In addition, the individual test duration was extended to three-and-one- half tide cycles to observe features with long period occurrence.

The above three phases completed the scope of work for HRS's testing program. The testing procedures and results for different tests will be discussed in detail in the following sections.

3.2 TEST PROCEDURES

3.2.1 TESTING SEQUENCE

Tests of a particular modification of the marina consisted of reproducing the selected hydraulic conditions and then recording the flow patterns, current velocities, and directions of flow in the strategic locations. The only exception was in the wave tests of testing Phase II, during which attention was concentrated on the wave disturbance characteristics inside the marina, and hence only the wave heights at different locations were measured. In the reservoir test in testing Phase II and testing Phase III, the observed boundaries of the plume of discharged reservoir water were also sketched at the end of the tide cycle.

3.2.2 ASSESSMENT OF FLOW PATTERNS

The test results of the different configurations and arrangements were carefully recorded and are described and summarized in this report in graphic and tabular form. Operational and maintenance conditions were also simulated.

mixing characteristics and the quantitative exchange can, however, be evaluated only by investigating the mixing pattern between the two types of water. The tidal prism was estimated to be approximately 15 %.

3.1.3 LIAISON WITH CLIENT

Liaison was maintained with PN&D engineers through telephonic communications, fax information of preliminary test results, draft video tape of the testing, written communications, and meetings at HRS facilities. Modeling methodology and design modifications were based on a plan of study developed by HRS and approved by Client. Decisions on selection of specific design alternatives and the extent of some tests were made by Client in consultation with HRS.

3.1.4 OVERALL VIEW OF EXPERIMENTAL PROGRAM

The experimental program was designed to evaluate the comparative improvement in hydraulic performance between various configurations of the marina under different hydraulic conditions. During the course of the experimental program, three distinct phases of testings can be identified:

- Phase I - Base Tests

Tests were first conducted to investigate the hydraulic performance of the preliminary design configuration of the marina.

- Phase II - Developmental Tests

Developmental tests experimentally evaluated the hydraulic performance of different design alternatives. The following scope of testing was performed:

(A) Geometric Configuration Tests: Subsequent to the base test, the preliminary design configuration was modified twice and the hydraulic performance of the modifications was recorded and compared with the base configuration. The aim of this phase was to attempt to improve the hydraulic performance of the marina by adjusting its geometrical shape.

(B) Wave Disturbance Tests: Tests were performed to evaluate the effectiveness of the preliminary design configuration in sheltering against the offshore storm waves. Waves of different magnitudes and periods were generated off shore, and the corresponding induced waves were measured at different locations inside the marina.

(C) Pump Tests: The aim of these tests was to investigate the effectiveness of using mechanical pumping to enhance the hydraulic circulation inside the marina.

Different inlet and outlet configurations with different pumping discharges were tested. Flow pattern was recorded for every test for comparison purposes.

(D) Reservoir Tests: Flushing arrangement using water from a reservoir uphill of the marina was tested in this phase. Different combinations of outlet configurations, total volumes of discharged water and discharge durations were investigated. Flow pattern inside the marina was identified during the discharge duration. Boundaries of the observed plume from the flushing discharge were sketched at the end of the tide cycle. The aim of the reservoir tests was to study the flow pattern during the release of the reservoir water.

- Phase III - Verification Tests

After the two different phases of tests discussed above, a final configuration of the marina was selected by Client. The flushing arrangement with the reservoir water was determined to be the auxiliary condition to improve the flow pattern inside the marina. In this testing phase, the selected configuration was further tested with a combination of tide and wave conditions to document its performance under realistic conditions. In addition, the individual test duration was extended to three-and-one- half tide cycles to observe features with long period occurrence.

The above three phases completed the scope of work for HRS's testing program. The testing procedures and results for different tests will be discussed in detail in the following sections.

3.2 TEST PROCEDURES

3.2.1 TESTING SEQUENCE

Tests of a particular modification of the marina consisted of reproducing the selected hydraulic conditions and then recording the flow patterns, current velocities, and directions of flow in the strategic locations. The only exception was in the wave tests of testing Phase II, during which attention was concentrated on the wave disturbance characteristics inside the marina, and hence only the wave heights at different locations were measured. In the reservoir test in testing Phase II and testing Phase III, the observed boundaries of the plume of discharged reservoir water were also sketched at the end of the tide cycle.

3.2.2 ASSESSMENT OF FLOW PATTERNS

The test results of the different configurations and arrangements were carefully recorded and are described and summarized in this report in graphic and tabular form. Operational and maintenance conditions were also simulated.

3.2.3 VELOCITY ANALYSIS

Visual observations of flow patterns of velocity at various strategic locations were used to evaluate the hydraulic efficiency of the various configurations tested. The strategic locations for velocity measurement were selected by Client prior to the beginning of the tests.

Different techniques were introduced for velocity measurement and visualization purposes in the testing program. The most timesaving technique was a dye line or a sequence of dye lines released along the desired study area, which provided instantaneous visualization of velocity distributions and flow patterns. A scale of 1 inch intervals was drawn along the center line of the channels inside the marina. By measuring the distance the dye patch traveled in a specific time interval, the average velocity at that particular section was then recorded.

3.2.4 OBSERVATION OF THE PLUME BOUNDARIES FOR THE DISCHARGE RESERVOIR WATER

In the reservoir tests in testing Phases II and III, flushing arrangements using the uphill reservoir water were simulated. The intruding reservoir water was colored with blue color to distinguish it from the clear marina water. Once the dyed reservoir water was released into the marina, mixing of the dyed water with the marina water occurred instantaneously. The observable plume boundaries of the reservoir water were sketched at the end of each tide cycle.

3.2.5 WAVE MEASUREMENTS

In the wave tests in testing phase II, wave disturbances at six different locations were measured with different incoming offshore waves. The measurement of the wave period was performed by averaging the measured time of 10 waves. The individual wave period for the 10 waves was almost exactly the same. The averaging process were performed only to minimize the measurement error. The wave heights were measured using two electronic wave gages and four point gages. The two electronic wave gages were located at the offshore and the entrance to the marina as seen in Figure 1. The electronic gages were calibrated both before and after every test for accuracy. Signals from the electronic gages were collected by means of computerized data acquisition. The signals were then converted to the wave profile with the results of the calibration. Point gages were employed in the other locations of the marina to directly measure the wave heights. The gage readings of both the crest and the trough of the waves were recorded.

With the correction for the surface tension, the wave height could then be computed.

3.2.5 PRESENTATION OF DATA

The experimental data are presented in terms of descriptions of flow conditions supported by photographic and video documentation and in terms of computed and measured velocity magnitudes and directions. In graphical summaries, the velocities are expressed in prototype values. Schematic presentations of eddy patterns, stagnation area, and the reservoir plume boundaries were used in this experimental program to supplement the photographic records.

3.2.6 SUBDIVISION OF EXPERIMENTAL PROGRAM

The presentation of test data in this report follows the chronological order of the experimental program. Each of the following major phases of the model study and its inherent problems are considered in turn and all tests conducted therein are described in detail:

- Phase I - Base Tests
- Phase II - Developmental Tests
- Phase III - Verification Tests

3.3 PHASE I: BASE TESTS

3.3.1 SCOPE OF BASE TEST

Base tests, or tests of the conceptual design, were first conducted to establish a base for comparison and to indicate the extent and direction of the model program. The original design of the modeled marina used throughout this test series was described in Section 1.2. The general layout of the modeled structure and the nomenclature are given in Figure 1.

3.3.2 HYDRAULIC CONDITIONS INVESTIGATED

The hydraulic conditions investigated in this testing phase consisted of the average tide. During the flood tide, the water surface elevation rose uniformly from 0 ft MLLW to 2 ft MLLW in 6.25 hours. During the ebb tide, the water surface elevation dropped uniformly from 2 ft MLLW to 0 ft MLLW in 6.25 hours. A typical tidal change in water surface elevation for the physical model testing is illustrated in Figure 4.

3.3.3 BASE TEST: TEST 1

The test results indicated that the hydraulic performance of the preliminary conceptual design was not totally satisfactory to the Client. During both the flood and ebb tide, motionless areas were observed along the back channel and in the mooring area. Flow velocities inside the marina away from the turning basin were slow. No circulatory flow pattern resulted. Figures 5 and 6 show the observed flow pattern.

3.4 PHASE II: DEVELOPMENTAL TESTS

The developmental tests were based upon indications developed and conclusions reached during the base tests of the proposed design. The plan was to concentrate on the geometric configuration of the marina in order to reduce or eliminate the areas of no water flow and improve the general circulation characteristics of the marina.

3.4.1 GEOMETRIC CONFIGURATION TESTS

3.4.1.1 Scope of Geometric Configuration Tests

The scope of the tests was to investigate the enhancement of hydraulic circulation inside the marina by adjusting the configuration of the channels. The geometry of the preliminary marina design was revised twice and the modified geometries were tested. The geometric configuration of the two modifications are shown in Figure 7 and 8.

3.4.1.2 Hydraulic Conditions Investigated

The hydraulic conditions investigated in these tests consisted of the average tide similar to the hydraulic conditions in the base test described in section 3.3.2.

3.4.1.3 Geometric Configuration Test 1 and 2

Results of the two geometric configuration tests are described in this section.

Test 1 - Base test observations indicated that the mooring area was a potential area of no flow. In this test, a large portion of the mooring area was blocked off to attempt to improve the flow condition. The configuration was tested with the flood tide only. Improvement of flow velocities was observed at the middle and back channel, although a portion of the back channel remained motionless. No circulatory flow pattern was observed. The flow pattern is illustrated in Figure 7.

Test 2 - In this test, the middle channel in the preliminary design configuration was rotated 90 degrees. The purpose of the test was to provide an easier path for the water to flow to the back channel, thus reducing or eliminating the area of no flow. The configuration was tested for both the flood and ebb tide. The results are illustrated in Figures 8 and 9. General improvement in the magnitude of flow velocities was recorded. Water movement was observed in part of the mooring area. A motionless area was still recorded in portions of the back channel. No net circulatory flow pattern was observed.

3.4.1.4 Assessment of Geometric Configuration Test Findings

The results of the two tests showed that geometric rearrangement of the marina configuration was unable to improve the hydraulic performance to the extent of eliminating all areas of no flow and generating a circulatory flow pattern. After a meeting at the HRS facility, Client decided to retain the original preliminary design of the marina configuration, and to investigate a mechanical pumping discharge and flushing arrangement to improve hydraulic performance. A revised schedule for four types of tests was then drafted and implemented. The description and results of these tests is shown below.

3.4.2 WAVE DISTURBANCE TESTS

3.4.2.1 Scope of Wave Disturbance Tests

The wave disturbance characteristics of the preliminary design were investigated in this series of tests. The aim of these tests was to evaluate the wave response at strategic locations in the marina due to the action of offshore waves of varying wave heights and periods. The locations of wave measurements are indicated in Figure 1. Four wave tests were performed, as described below.

3.4.2.2 Hydraulic Conditions

All wave tests were conducted with the water surface elevation of +1 ft MLLW. This elevation was the mean water level of the average tide condition investigated in the previous tests. Waves are generated from the Northwest. The offshore wave heights and periods were measured offshore at a bottom elevation -118.13ft MLLW. The characteristics of the offshore waves for the four different wave tests were:

- Test 1: wave height 4.4 ft, wave period 15 seconds
- Test 2: wave height 6.5 ft, wave period 6 seconds
- Test 3: wave height 17.3 ft, wave period 9 seconds

- Test 4: wave height 23.6 ft, wave period 11 seconds

3.4.2.3 Wave Disturbance Tests 1,2,3,4

The results of the four wave tests are tabulated in Table 3. The wave profiles measured by the electronic gages offshore and at the marina entrance for Test 3 are shown in Figure 10. The results demonstrated that the marina configuration provided effective shelter against wave action. The response ratios of the wave height at the mooring area compared to the offshore wave height were typically less than 10%. The longer period offshore waves (approximately 10 to 15 seconds) typically generated greater excitation inside the marina than the shorter period waves (approximately 6 to 10 seconds). Visual observation showed that the offshore entrance channel together with the surrounding topography significantly refracted and diffracted the incoming waves and substantially reduced the wave height at the entrance. This effect was especially prominent for the shorter period incoming waves. In Tests 1 and 2, wave shoaling was observed along the coastline adjacent to the entrance, however, wave breaking was not observed along the entrance channel. The large wave heights generated in Tests 3 and 4 caused significant wave breaking both along the coastline and near the beginning of the offshore entrance channel. In addition, significant wave setups were recorded with the higher incoming storm wave, as observed in the table summary.

3.4.2.4 Assessment of Wave Test Findings

The result of this test phase demonstrated that the marina configuration was satisfactory for wave protection in the mooring area.

3.4.3 PUMP TESTS

3.4.3.1 Scope of Pump Tests

The base test results gave cause for concern over the water quality in certain locations due to the presence of regions of sluggish velocities. The aim of the pump tests was to attempt to improve the hydraulic performance by employing a mechanical means of pumping discharge. The function of the pumping system was to transfer water from one part of the marina to the other. Circulatory flow patterns could be generated inside the marina by properly selecting the intake and outlet locations and by optimizing the pumping discharge rates. Nine pump tests were performed. The configurations of the nine different tests were the combinations of three intake locations, two outlet arrangements and two pumping discharge rates. The three intake locations and the two outlet arrangements were illustrated in Figure 11.

3.4.3.2 Hydraulic Conditions

All pump tests were performed with the average tide throughout one complete tide cycle. The average tide is similar to that in the base test described in section 3.3.2. A key hydraulic condition unique to this test phase was the pumping discharge rate. The pumping rates for individual test were:

- Tests 1, 2, 3,7, and 8 - Pumping rate: 50 cfs
- Tests 4, 5, 6, and 9 - Pumping rate: 25 cfs

3.3.4.3 Pump Test Results

Tests 1 and 4 - Tests 1 and 4 used a similar intake/outlet combination: intake location 1 and outlet arrangement 1. The only difference was the rate of pumping discharge. In both tests, water was pumped from the corner of the back channel and discharged into the mooring area. The results showed that the magnitude of flow velocities in the marina was generally improved. A large eddy was observed in the mooring area. In Test 1 with higher discharge, the eddy extended significantly into the back channel. A stagnant area was recorded along the middle channel during flood tide. The flow pattern of both tests did not result in net circulatory movement. The resulting flow pattern for the flood tide of Test 1 is illustrated in Figure 12.

Tests 2 and 5 - Tests 2 and 5 used a similar intake/outlet combination: intake location 2 and outlet arrangement 1. The only difference was the pumping discharge rate. In both tests, water was pumped from the middle channel and discharged into the mooring area. The results showed that the magnitude of flow velocities in the marina was again generally improved, especially along the middle channel. The improvement was more significant in Test 2 (due to the higher pumping rate) than in Test 5. A large eddy was observed in the mooring area. No stagnant area was recorded. Both tests did not produce a circulatory flow pattern.

Tests 3 and 6 - Tests 3 and 6 used a similar intake/outlet combination: intake location 3 and outlet arrangement 1. The only difference was the pumping discharge rate. In both tests, water was pumped from the turning basin and discharged into the mooring area. Results showed that the magnitude of flow velocities in the marina was generally improved. The improvement was more prominent in Test 3 (due to the higher pumping rate) than Test 6. A large eddy was observed in the mooring area. No stagnant area was recorded. Circulatory flow pattern was generated in the flood tide of Test 3. However, the circulation did not occur at the ebb tide of Test 3 or during either the flood or ebb tide of Test 6.

Test 7 - In Test 7, water was pumped from the middle channel and discharged into the mooring area similar to Test 2, but the outlet was adjusted to arrangement 2. In this outlet arrangement, all six of the discharge ports were aligned along the rear of the mooring area, directing the discharge momentum towards the south channels. The purpose was to utilize the discharge momentum to generate a circulatory flow pattern. The results indicated that the magnitudes of the flow velocities had improved slightly in the ebb tide and more significantly in the flood tide. A large eddy was still observed in the mooring area, but the strength of the eddy was smaller than in any of the previous pump tests. No stagnant area was recorded. No circulatory flow pattern was generated.

Tests 8 anc ... intake/outlet combination: intake
location 3 ε ... nce was the rate of pumping
discharge. ... turning basin and discharged
into the mc ... arrangement adjusted similar
to Test 7. ... tion, results indicated that the
hydraulic ... ondition without the pumping
scheme. I ... caused significantly increased
flow velo ... large eddy was still observed
in the mc ... was less in comparison to the
previous ... A circulatory flow pattern was
generated during both the floo... result for the ebb tide of Test 8
is illustrated in Figure 13.

Report states that resort uses 2 mg/day for golf courses & landscape from 3 wells. Estimated flow of 2-6 mg/day. It appears that using pumps to flush system may over tax ground flow

3.4.3.4 Assessment of Pump Test Findings

Conclusively, the pumping scheme enhanced the magnitude of flow velocities in the marina. The arrangement in Pump Test 8 demonstrated the best result obtained among the nine pump tests, with a circulatory pattern occurring in both the flood and ebb tide.

3.4.4 RESERVOIR TESTS

3.4.4.1 Scope of Reservoir Tests

A flushing arrangement using water located in a reservoir above the marina was investigated during this test phase. The purpose was to create an additional exchange of water between the marina and the ocean by injecting reservoir water into the marina, thereby 'flushing' the water from the marina into the ocean. The aim of this test phase was to investigate the flow patterns resulting from different combinations of discharge locations, volumes and durations. Eight tests were performed. The different discharge arrangements are illustrated in Figure 14. Note

that the difference in water density between the intruded water and the marina water was not modeled.

3.4.4.2 Hydraulic Conditions

All reservoir tests were performed with the average tide condition as described in Section 3.3.2. The tests were conducted only with the ebb tide, because only during the ebb tide could the injected reservoir water increase the exchange of water through the entrance.

A key hydraulic condition unique to this testing phase was the rate of discharge of the reservoir water. The rate of discharge was related to the available volume of the reservoir water and the duration of discharge. The specific conditions for individual tests are listed as follows:

- Test 1 : discharge volume 650,000 cu. ft., duration 6.25 hours
- Test 2 : discharge volume 650,000 cu. ft., duration 3.0 hours
- Test 3 : discharge volume 650,000 cu. ft., duration 2.0 hours
- Test 4 : discharge volume 650,000 cu. ft., duration 6.25 hours
- Test 5 : discharge volume 650,000 cu. ft., duration 2.0 hours
- Test 6 : discharge volume 325,000 cu. ft., duration 6.25 hours
- Test 7 : discharge volume 325,000 cu. ft., duration 2.0 hours
- Test 8 : discharge volume 400,000 cu. ft., duration 6.25 hours

In the tests where the discharge duration was less than the time interval for the ebb tide, the discharge was programmed to occur during the middle of the ebb tide.

3.4.4.3 Reservoir Tests

Results of the eight reservoir tests are described in this section.

Tests 1, 2 and 3 - Tests 1, 2 and 3 had the same outlet configuration. In all three tests, water was discharged directly into the mooring area. The discharge pipes were aligned along the back of the mooring area. The three tests differed only in the duration of discharge. The resulting flow patterns of the three tests were similar, as illustrated in Figures 15, 16 and 17. The discharge reservoir water pushed the flow from the mooring area directly toward the turning basin and the marina entrance. Simultaneously, water flowed along the back channel into the mooring area. The magnitude of the velocities improved significantly during the discharge.

Test 7 - In Test 7, water was pumped from the middle channel and discharged into the mooring area similar to Test 2, but the outlet was adjusted to arrangement 2. In this outlet arrangement, all six of the discharge ports were aligned along the rear of the mooring area, directing the discharge momentum towards the south channels. The purpose was to utilize the discharge momentum to generate a circulatory flow pattern. The results indicated that the magnitudes of the flow velocities had improved slightly in the ebb tide and more significantly in the flood tide. A large eddy was still observed in the mooring area, but the strength of the eddy was smaller than in any of the previous pump tests. No stagnant area was recorded. No circulatory flow pattern was generated.

Tests 8 and 9 - Tests 8 and 9 used a similar intake/outlet combination: intake location 3 and outlet arrangement 2. The only difference was the rate of pumping discharge. In both tests, water was pumped from the turning basin and discharged into the mooring area similar to Test 3, with the outlet arrangement adjusted similar to Test 7. In Test 9, the lower discharge rate condition, results indicated that the hydraulic performance was similar to the base condition without the pumping scheme. However, in Test 8 the higher discharges caused significantly increased flow velocities during both the flood and ebb tide. A large eddy was still observed in the mooring area, but the strength of the eddy was less in comparison to the previous tests. No stagnant area was recorded. A circulatory flow pattern was generated during both the flood and ebb tide. The result for the ebb tide of Test 8 is illustrated in Figure 13.

3.4.3.4 Assessment of Pump Test Findings

Conclusively, the pumping scheme enhanced the magnitude of flow velocities in the marina. The arrangement in Pump Test 8 demonstrated the best result obtained among the nine pump tests, with a circulatory pattern occurring in both the flood and ebb tide.

3.4.4 RESERVOIR TESTS

3.4.4.1 Scope of Reservoir Tests

A flushing arrangement using water located in a reservoir above the marina was investigated during this test phase. The purpose was to create an additional exchange of water between the marina and the ocean by injecting reservoir water into the marina, thereby 'flushing' the water from the marina into the ocean. The aim of this test phase was to investigate the flow patterns resulting from different combinations of discharge locations, volumes and durations. Eight tests were performed. The different discharge arrangements are illustrated in Figure 14. Note

that the difference in water density between the intruded water and the marina water was not modeled.

3.4.4.2 Hydraulic Conditions

All reservoir tests were performed with the average tide condition as described in Section 3.3.2. The tests were conducted only with the ebb tide, because only during the ebb tide could the injected reservoir water increase the exchange of water through the entrance.

A key hydraulic condition unique to this testing phase was the rate of discharge of the reservoir water. The rate of discharge was related to the available volume of the reservoir water and the duration of discharge. The specific conditions for individual tests are listed as follows:

- Test 1 : discharge volume 650,000 cu. ft., duration 6.25 hours
- Test 2 : discharge volume 650,000 cu. ft., duration 3.0 hours
- Test 3 : discharge volume 650,000 cu. ft., duration 2.0 hours
- Test 4 : discharge volume 650,000 cu. ft., duration 6.25 hours
- Test 5 : discharge volume 650,000 cu. ft., duration 2.0 hours
- Test 6 : discharge volume 325,000 cu. ft., duration 6.25 hours
- Test 7 : discharge volume 325,000 cu. ft., duration 2.0 hours
- Test 8 : discharge volume 400,000 cu. ft., duration 6.25 hours

In the tests where the discharge duration was less than the time interval for the ebb tide, the discharge was programmed to occur during the middle of the ebb tide.

3.4.4.3 Reservoir Tests

Results of the eight reservoir tests are described in this section.

Tests 1, 2 and 3 - Tests 1, 2 and 3 had the same outlet configuration. In all three tests, water was discharged directly into the mooring area. The discharge pipes were aligned along the back of the mooring area. The three tests differed only in the duration of discharge. The resulting flow patterns of the three tests were similar, as illustrated in Figures 15, 16 and 17. The discharge reservoir water pushed the flow from the mooring area directly toward the turning basin and the marina entrance. Simultaneously, water flowed along the back channel into the mooring area. The magnitude of the velocities improved significantly during the discharge.

and more improvement was noticed as the discharge duration became smaller. No motionless areas were observed in any of the three tests during the discharge duration. The observable reservoir water plume boundaries at the end of the ebb tide were similar in all three tests. The plume boundaries extended from the mooring area, along the south channel and up to the turning basin.

Tests 4 and 5 - Tests 4 and 5 had the same outlet configuration. In both tests, 60% of the reservoir water was discharged into the mooring area, while the remaining 40% was injected into the opposite corner of the back channel. The only difference in the two tests was the discharge duration. Test 5 had a shorter duration than Test 4. The resulting flow patterns of the two tests during the discharge duration were similar, except that the flow direction in the middle channel was reversed. Velocity magnitudes were generally enhanced in the marina during the discharge duration, with a greater increase during Test 5. The observed reservoir water plume limits were similar in the two tests. The plume occupied the mooring area and the corner of the back channel. A motionless area was observed at the mooring area. The results are illustrated in Figures 18 and 19.

Tests 6 and 7 - Tests 6 and 7 had the same outlet configuration, similar to Tests 4 and 5. Tests 6 and 7 varied in that Test 7 had a shorter discharge duration. The resulting flow patterns of the two tests during the discharge duration were similar, except that the flow direction in the middle channel was reversed. Marina flow velocities were generally greater during discharge, with the flow in Test 7 exhibiting a higher velocity than during Test 6. The observed reservoir water plume limits were also similar, with the plume occupying the mooring area and the most of the back channel. A motionless area was observed at the mooring area. The results are illustrated in Figures 20 and 21.

Test 8 - In Test 8, the outlet configuration was further modified. The perimeter of the mooring area was made smooth to reduce the resistance to hydraulic conveyance due to the sharp corners. The number of discharge pipes had increased from five, as in the previous tests, to seven. This was done in order to reduce the discharge momentum at the pipe outlet to prevent any navigation problems. The seven pipe outlets were aligned in such a way that the discharge momentum was directed towards the south channel. The resulting flow pattern showed that the discharge reservoir water pushed the flow from the mooring area directly toward the turning basin. In addition, water flowed along the back channel into the mooring area. The magnitudes of the velocities improved significantly during the discharge. No motionless areas were observed during the discharge duration. A circulatory flow pattern was generated in the channels. The observable reservoir water plume limit at the end of the ebb tide extended from the mooring area, along the side channel, and up to the turning basin. The result is illustrated in Figure 22.

3.4.4.4 Assessment of Reservoir Tests Findings

The release of reservoir water into the marina enhanced the magnitude of flow velocities during the discharge duration, with better improvement for shorter discharge duration. The resulting flow patterns and plume boundaries were sensitive to the discharge arrangement and the discharge volume, but less sensitive to the discharge duration. Theoretically, the higher the discharge volume, the greater the increase in the mass exchange at the entrance between the marina and ocean. However, due to site constraints, the available volume of the reservoir was limited to 400,000 cu. ft.. With this confinement in volume, Test 8 demonstrated the best results among the eight tests in terms of the improvement of flow velocities.

3.5 PHASE V: VERIFICATION TESTS

3.5.1 SCOPE OF VERIFICATION TESTS

After the completion of the base and developmental tests, a meeting was again held at the HRS facility to discuss the test results. A final configuration was selected by Client, with the auxiliary condition of the reservoir flushing arrangement to improve the hydraulic performance. The final configuration was similar to the setup as in reservoir Test 8, with the perimeter of the mooring area further adjusted due to the site constraint and to optimize hydraulic characteristics. Similar flushing arrangement as that in Reservoir Test 8 was also selected. The final configuration is illustrated in Figure 23.

In the verification tests, the final configuration and the flushing arrangement were carefully tested with the combination of wave and tide motion. The objective of the tests was to document in detail the hydraulic performance of the final configuration under realistic situations of both wave and tide action. The test duration was extended to three-and-one-half tide cycles to evaluate the hydraulic features during a realistic time interval.

3.5.2 HYDRAULIC CONDITIONS

All verification tests were performed under the average tide conditions for three-and-one-half cycles. The average tide conditions were similar to those in the base test as described in Section 3.3.2. The tests began with an ebb tide (termed pre-ebb tide), and with the release of reservoir water during this pre-ebb tide into the marina. The discharge volume of the reservoir water was selected to be 400,000 cu. ft.. The discharge duration was 6.25 hours, the entire interval of an ebb tide. The pre-ebb tide was then followed by three complete tide cycles, during which the reservoir water plume boundaries and the velocities at strategic locations were continuously monitored.

The three verification tests differed in the characteristics of the offshore wave conditions. The wave characteristics for individual tests were:

- Test 1 - No offshore waves
- Test 2 - Offshore wave height 3 ft., wave period 6 seccnds
- Test 3 - Offshore wave height 2 ft., wave period 12 seconds

The wave conditions represented the normal wave climate offshore of the project site. Combinations of the normal tide and wave climate reproduced the realistic conditions at the project site.

3.5.3 VERIFICATION TESTS

Results of the Verification Tests 1, 2 and 3 are discussed in this section.

Test 1 - The test results are illustrated in Figures 24 to 30. During the pre-ebb tide, with the release of the reservoir water, a circulatory flow pattern was established in the marina. In the following three complete tide cycles, the flow patterns were similar to that of the preliminary design configuration. However, the flow velocities along the back channel appeared to be slightly improved due to the adjustment of the perimeter in the mooring area. The evolution of the plume of reservoir water was surprising as indicated in the illustrated test results. During the three tide cycles following the pre-ebb tide, the plume extended along the back channel and followed the waterways until it passed the turning basin into the entrance. The original arm of the plume, which extended into the south channel of the mooring area due to the discharge momentum during the ebb tide, actually retreated back into the mooring area instead of progressing towards the entrance. The observations made throughout the duration of the test demonstrated the necessity of extended test duration in the verification tests.

Test 2 - The effect of short period offshore waves was investigated in this test. The result is illustrated in sequence in Figures 31 to 37. Both the flow patterns and the evolution of the plume boundaries were similar to Test 1. The exception was that during the pre-ebb tide, the circulatory flow pattern was not established. The similarity in test results between Tests 1 and 2 were most likely due to the fact that the short period wave was not able to penetrate into the marina to produce a significant effect in the flow patterns.

Test 3 - As opposed to Test 2, the effect of relatively longer period offshore waves was investigated in this test. The test results are illustrated in sequence in Figures

38 to 44. Visual observation indicated more offshore wave energy was able to penetrate the marina. However, due to the small wave height, it was not able to produce a prominent effect. As such, the test results of Test 3 were similar to those of Test 2.

Conclusively, both the evolution of the plume of reservoir water and the flow patterns were similar throughout the three verification tests, except during the pre-ebb tide when the reservoir water was released. This indicated that the normal wave climate at the project site would not significantly affect the hydraulic performance of the marina.

3.6 CONCLUSION

3.6.1 DATA PRESENTATION

The selected general configurations of the marina and the various pumping and flushing arrangements were discussed with Client throughout the duration of the investigations, and partial submissions of preliminary test data were made as the study progressed. This report confirms the test results and structural dimensions and presents relevant experimental data compiled during the course of the study.

The figures and photographs illustrating the results of the model investigation are indexed at the beginning of this report and presented in the following section. A video cassette containing unedited footage corresponding to the first two phases of the test program was submitted to Client. An edited and narrated video briefly describing the entire study was also prepared and is submitted to Client with this report.

3.6.2 SUMMARY OF CONCLUSIONS

The final configuration of the marina with the flushing arrangement of the reservoir water represented the optimized solution with the project's constraints, the available testing results and the limitations of the model investigation as previously described. The current study reviewed the following important conclusions:

The preliminary design configuration of the marina provides good protection against wave action in the mooring area. Since the final configuration was very similar to the preliminary design except for the change of the mooring area's perimeter, the result of the wave protection from the preliminary design should be applicable to the final configuration.

A simple alteration of the geometry of the marina is not likely to produce satisfactory hydraulic performance in the marina.

A mechanical pumping arrangement with properly located intake/outlet configuration can generate a circulatory flow pattern inside the marina.

A flushing arrangement using reservoir water can induce additional mass exchange between the marina and the ocean. The discharge configuration, if properly arranged, can improve the flow velocities inside the marina during the discharge duration. It can also ensure that local regions of the marina which have a tendency toward slow velocities receive regular infusions of fresh water, thus improving local water quality.

4.0 ILLUSTRATIVE MATERIAL

TABLE 2 - SUMMARY OF EXPERIMENTAL RESULTS

TEST SERIES	TEST NUMBER	TEST CONDITIONS ·	INTAKE/ OUTLET TYPE	EXPERIMENTAL RESULTS	REFERENCES
Base	Base Test #1	Average Tide: Flood and Ebb Tide	None	No circulatory flow pattern; stagnant along the back channel and at the mooring area	Figure 5 - 6
Developmental	Geometric Configuration Test #1	Average Tide: Flood Tide Only	None	Eliminating the mooring area enhanced the general velocities. No circulatory flow pattern generated; stagnant area observed in portion of back channel.	Figure 7
Developmental	Geometric Configuration Test #2	Average Tide: Flood and Ebb Tide	None	Rotating the middle channel 90° enhanced the general flow velocities; stagnant area observed at portion of back channel and mooring area. No circulating flow pattern was generated.	Figure 8 - 9
Developmental	Wave Disturbance Test #1 - 4	Different wave conditions; see Section 3.4.2.2	None	Good wave protection at the mooring area.	Table 3
Developmental	Pump Test #1	Average Tide: Flood and Ebb Tide Pump Discharge 50 cfs	Pump Intake 1 Pump Outlet 1	Velocities improved due to the pumping. No circulatory flow pattern resulted	Figure 10
Developmental	Pump Test #2	Average Tide: Flood and Ebb Tide Pump Discharge 50 cfs	Pump Intake 2 Pump Outlet 1	Velocities improved due to the pumping. No circulatory flow pattern resulted.	
Developmental	Pump Test #3	Average Tide: Flood and Ebb Tide Pump Discharge 50 cfs	Pump Intake 3 Pump Outlet 1	Velocities improved due to the pumping. Circulatory flow pattern generated during the flood tide but not the ebb tide.	

TABLE 1

HYDRAULIC MODEL STUDY OF MAUNA LANI MARINA

HYDRAULIC SIMILITUDE RELATIONSHIPS BETWEEN MODEL AND PROTOTYPE

Dimension	Ratio of Model to Prototype	Scale Relationships
Length	$L_r = L_m/L_p$	1: 75
Area	$A_r = (L_r)^2$	1: 5625
Time	$T_r = (L_r)^{1/2}$	1: 8.66
Velocity	$V_r = (L_r)^{1/2}$	1: 8.66
Discharge	$Q_r = (L_r)^{5/2}$	1: 48714
Roughness	$n_r = (L_r)^{1/6}$	1: 2.05

The above scale relationships were used to transfer quantitatively the discharge, depth of flow, and the velocity of flow from the model to the prototype.

TABLE 2 - SUMMARY OF EXPERIMENTAL RESULTS (con't)

TEST SERIES	TEST NUMBER	TEST CONDITIONS	INTAKE/ OUTLET TYPE	EXPERIMENTAL RESULTS	REFERENCES
Developmental	Pump Test #4	Average Tide: Flood and Ebb Tide Pump Discharge 25 cfs	Pump Intake 1 Pump Outlet 1	Velocities improved due to the pumping. No circulatory flow pattern resulted.	
Developmental	Pump Test #5	Average Tide: Flood and Ebb Tide Pump Discharge 25 cfs	Pump Intake 2 Pump Outlet 1	Velocities improved due to the pumping. No circulatory flow pattern resulted.	
Developmental	Pump Test #6	Average Tide: Flood and Ebb Tide Pump Discharge 25 cfs	Pump Intake 3 Pump Outlet 1	Velocities improved due to the pumping. No circulatory flow pattern resulted.	
Developmental	Pump Test #7	Average Tide: Flood and Ebb Tide Pump Discharge 50 cfs	Pump Intake 2 Pump Outlet 2	Velocities improved due to the pumping. No circulatory flow pattern resulted.	
Developmental	Pump Test #8	Average Tide: Flood and Ebb Tide Pump Discharge 50 cfs	Pump Intake 3 Pump Outlet 2	Velocities improved due to the pumping. Circulatory flow pattern generated during both the flood and ebb tide.	Figure 11
Developmental	Pump Test #9	Average Tide: Flood and Ebb Tide Pump Discharge 25 cfs	Pump Intake 3 Pump Outlet 2	Flow pattern similar to base test. No circulatory flow pattern resulted.	
Developmental	Reservoir Test #1	Average Tide: Ebb Tide Only Reservoir Capacity 650,000cu ft Discharge duration 6.25 hr 100% discharged into mooring area	Reservoir Outlet 1	Flow velocities improved during the discharge. No circulatory flow pattern resulted.	Figure 12

TABLE 2 - SUMMARY OF EXPERIMENTAL RESULTS (con't)

TEST SERIES	TEST NUMBER	TEST CONDITIONS	INTAKE/ OUTLET TYPE	EXPERIMENTAL RESULTS	REFERENCES
Developmental	Reservoir Test #2	Average Tide: Ebb Tide Only Reservoir Capacity 650,000cu ft Discharge duration 3 hr; 100% discharged into mooring area	Reservoir Outlet 1	Flow velocities enhanced during the discharge duration. No circulatory flow pattern resulted.	Figure 16
Developmental	Reservoir Test #3	Average Tide: Ebb Tide Only Reservoir Capacity 650,000cu ft Discharge duration 2 hr; 100% discharged into mooring area	Reservoir Outlet 1	Flow velocities enhanced during the discharge duration. No circulatory flow pattern resulted.	Figure 17
Developmental	Reservoir Test #4	Average Tide: Ebb Tide Only Reservoir Capacity 650,000cu ft Discharge duration 6.25 hr; 60% into mooring area; 40% into corner of back channel	Reservoir Outlet 2	Flow velocities enhanced during the discharge duration. No circulatory flow pattern resulted.	Figure 18
Developmental	Reservoir Test #5	Average Tide: Ebb Tide Only Reservoir Capacity 650,000cu ft Discharge duration 2 hr; 60% into mooring area; 40% into corner of back channel	Reservoir Outlet 2	Flow velocities enhanced during the discharge duration. No circulatory flow pattern resulted.	Figure 19
Developmental	Reservoir Test #6	Average Tide: Ebb Tide Only Reservoir Capacity 325,000cu ft Discharge duration 6.25 hr; 60% into mooring area; 40% into corner of back channel	Reservoir Outlet 2	Flow velocities enhanced during the discharge duration. No circulatory flow pattern resulted.	Figure 20
Developmental	Reservoir Test #7	Average Tide: Ebb Tide Only Reservoir Capacity 325,000cu ft Discharge duration 2 hr; 60% into mooring area; 40% into corner of back channel	Reservoir Outlet 2	Flow velocities enhanced during the discharge duration. No circulatory flow pattern resulted.	Figure 21

TABLE 2 - SUMMARY OF EXPERIMENTAL RESULTS (con't)

TEST SERIES	TEST NUMBER	TEST CONDITIONS	INTAKE/ OUTLET TYPE	EXPERIMENTAL RESULTS	REFERENCES
Developmental	Reservoir Test #8	Average Tide: Ebb Tide Only Reservoir Capacity 400,000cu ft Discharge duration 6.25 hr; 100% into mooring area	Reservoir Outlet 3	Flow velocities enhanced during the discharge duration. Circulatory flow pattern resulted.	Figure 22
Verification	Verification Test #1	Average Tide: Flood and Ebb Tide for 3½ tide cycles Reservoir Capacity 400,000cu ft Discharge duration 6.25 hr; 100% into mooring area; no waves	Reservoir Outlet 4	Flow velocities enhanced during the diachrge duration. Circulatory flow pattern generated during the discharge. Plume of reservoir water travelled along the bakc channel and through the north channel into the marina entrance.	Figures 24, 25, 26, 27, 28, 29, 30
Verification	Verification Test #2	Average Tide: Flood and Ebb Tide for 3½ tide cycles Reservoir Capacity 400,000cu ft Discharge duration 6.25 hr; 100% into mooring area; Offshore wave height = 3 ft, wave period = 6 sec.	Reservoir Outlet 4	Flow velocities enhanced during the dishcarge duration. No circulatory flow pattern generated during the discharge. Plume of reservoir water travelled along the back channel and through the north channel into the marina entrance.	Figures 31, 32, 33, 34, 35, 36, 37
Verification	Verification Test #3	Average Tide: Flood and Ebb Tide for 3½ tide cycles Reservoir Capacity 400,000cu ft Discharge duration 6.25 hr; 100% into mooring area; Offshore wave height = 2 ft, wave period = 12 sec.	Reservoir Outlet 4	Flow velocities enhanced during the discharge duration. No circulatory flow pattern generated during the discharge. Plume of reservoir water travelled along the back channel, and through the north channel into the marina entrance.	Figures 38, 39, 40, 41, 42, 43, 44

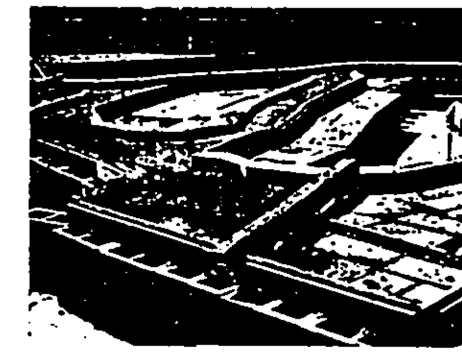
TABLE 3
SUMMARY OF WAVE TESTS

WAVE TEST # NUMBER	OFFSHORE WAVE CHARACTERISTIC		LOCATION OF GAGES (INDICATED IN FIGURE 1)									
	H (ft)	T (sec)	1		2		3		4		5	
			H (ft)	S (ft)	H (ft)	S (ft)	H (ft)	S (ft)	H (ft)	S (ft)	H (ft)	S (ft)
1	4.43	15.0	2.70	0.23	0.98	0.34	0.23	0.26	0.30	0.15	0.23	0.34
2	6.45	6.0	0.75	0.15	0.38	0.56	0.23	0.56	0.15	0.53	0.23	0.56
3	17.25	9.0	2.48	1.61	2.03	1.69	0.68	2.06	0.60	1.88	0.53	2.14
4	23.55	11.0	2.70	4.50	0.83	4.62	0.65	4.58	0.60	4.65	0.30	4.60

Symbols: H = Wave Height (ft)
S = Wave Setup (ft)
T = Wave Period (sec)

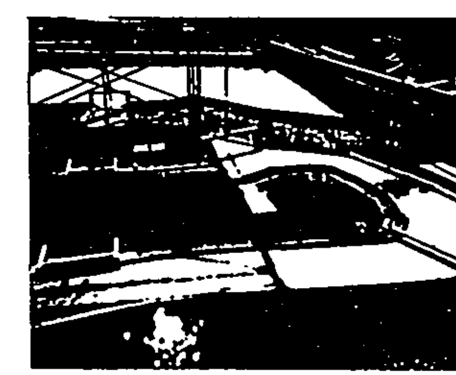
LEGEND

→	FLOW DIRECTION
(hatched)	REGION OF NO FLOW
(stippled)	PLUME OF RESERVOIR WATER

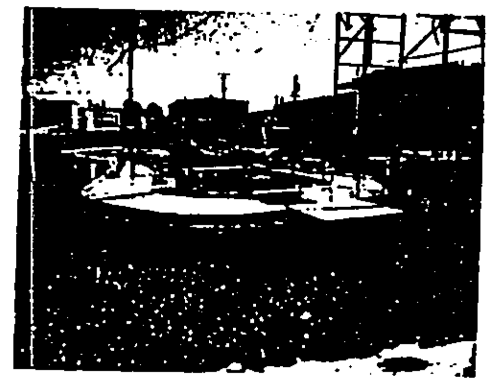


Photograph 1: Model under construction: the construction of the marina's channels in progress

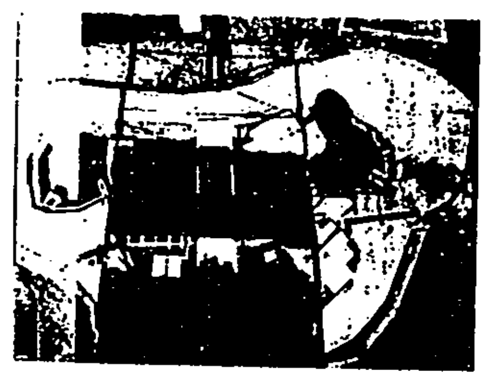
Photograph 2: Model under construction: the construction of the offshore bathymetry in progress



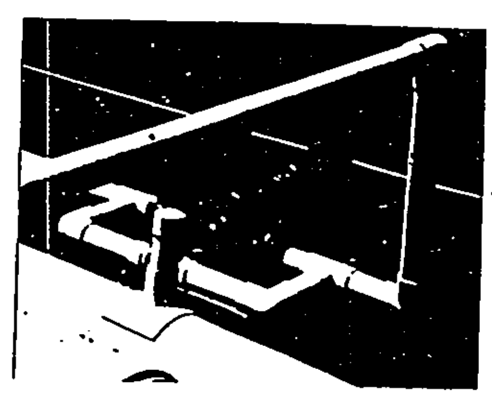
Photograph 3: Overall view of the model



Photograph 4: Side view of the model looking towards the South-east direction



Photograph 5: Plan view of the marina model, showing the final configuration



Photograph 6: Centrifugal pump which generated the tide in the model basin

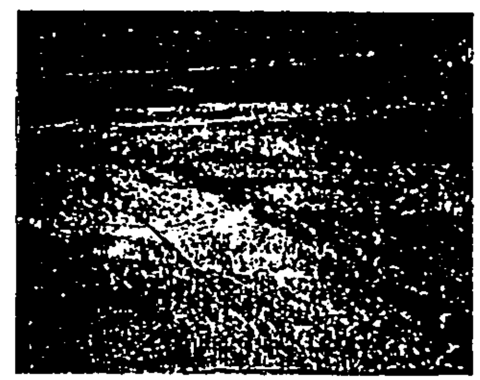
Photograph 7: Close up of the HRS's plunging type wave maker producing wave motion

Photograph 8: Test engineer measuring flow velocity using dye

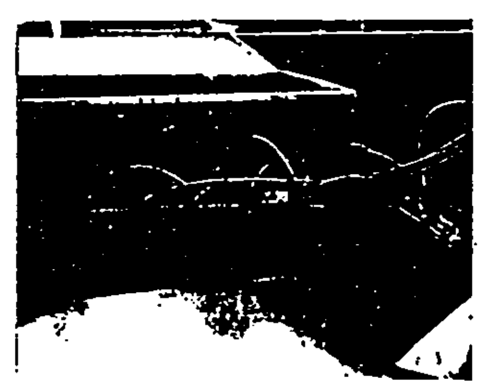
Photograph 9: Test engineer monitoring flow rates in the rotameters during the reservoir tests

Photograph 10: Developmental Tests: Wave Test No.3 - Waves traveling across the offshore topography approaching the marina entrance

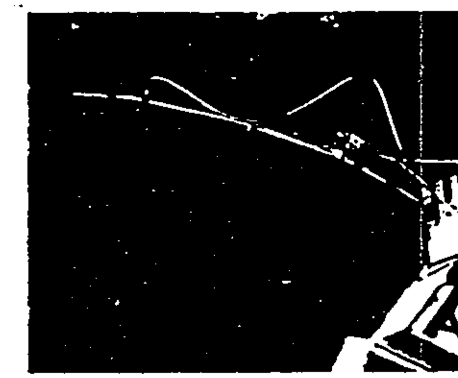
Photograph 11: Developmental Tests: Wave Test No. 3 - Close up of the waves approaching the offshore entrance channel



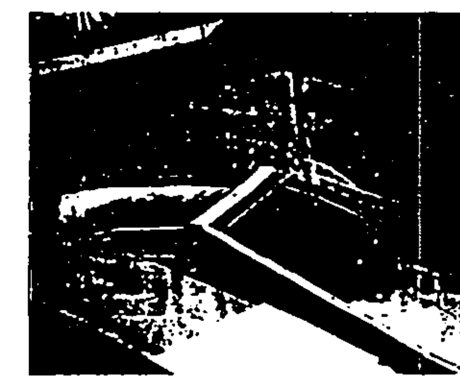
Photograph 12: Developmental Tests: Reservoir Test No.1 - The dye plume indicating the discharge of reservoir water into the mooring area with five 18" discharge ports

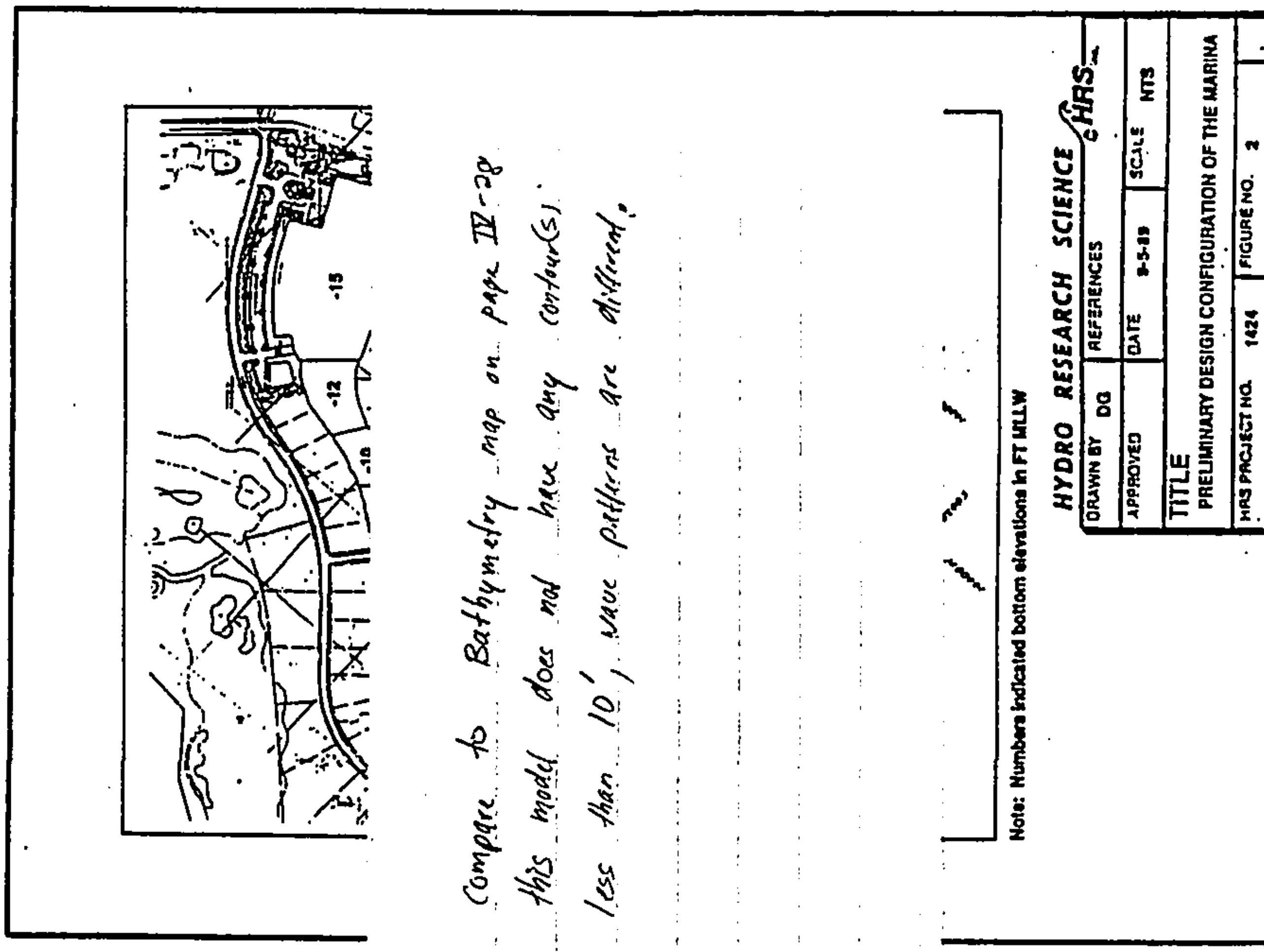


Photograph 13: Developmental Tests: Reservoir Test No. 7 - The dye plume indicating the discharge of reservoir water into the mooring area with three 18" discharge ports

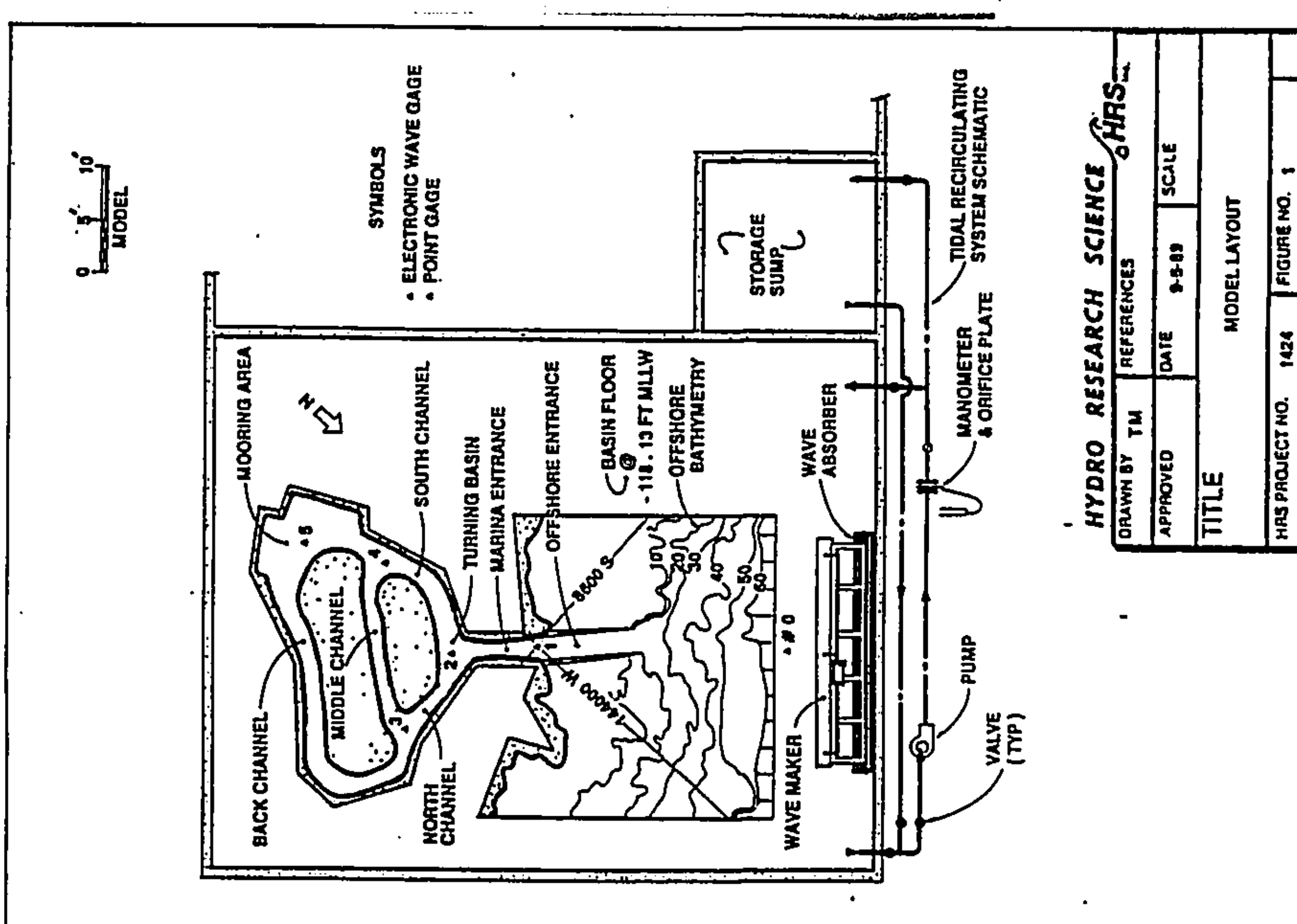


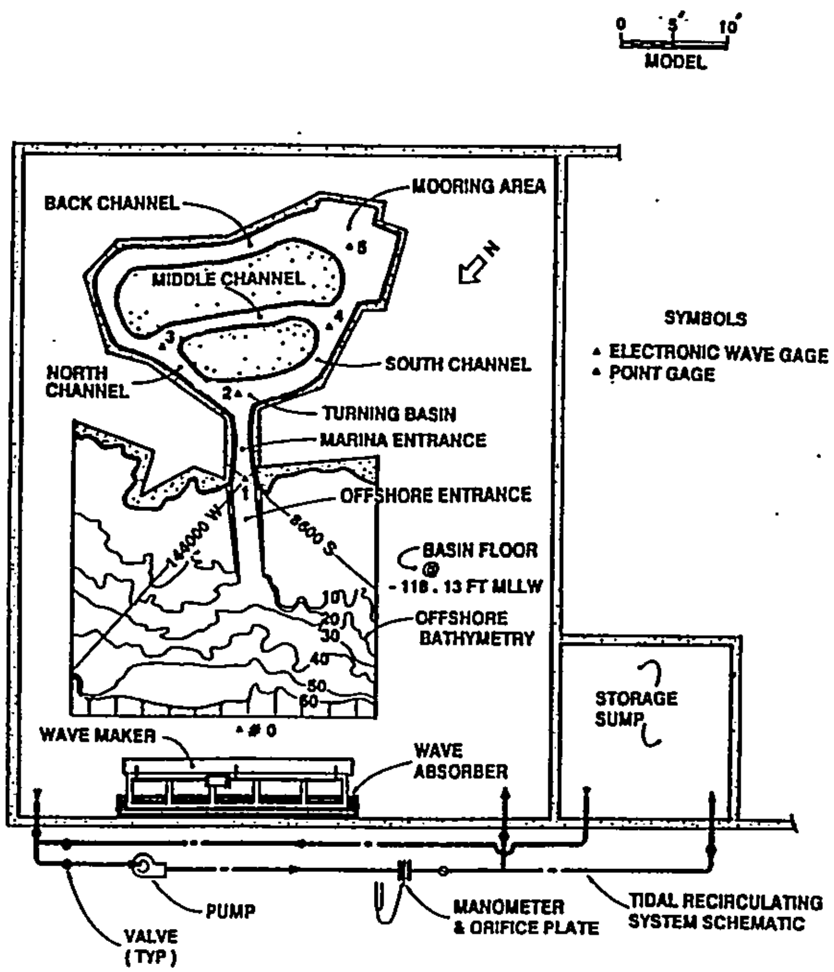
Photograph 14: Developmental Tests: Reservoir Test No. 7 - The dye plume indicating the discharge of reservoir water into the back channel with two 18" discharge ports





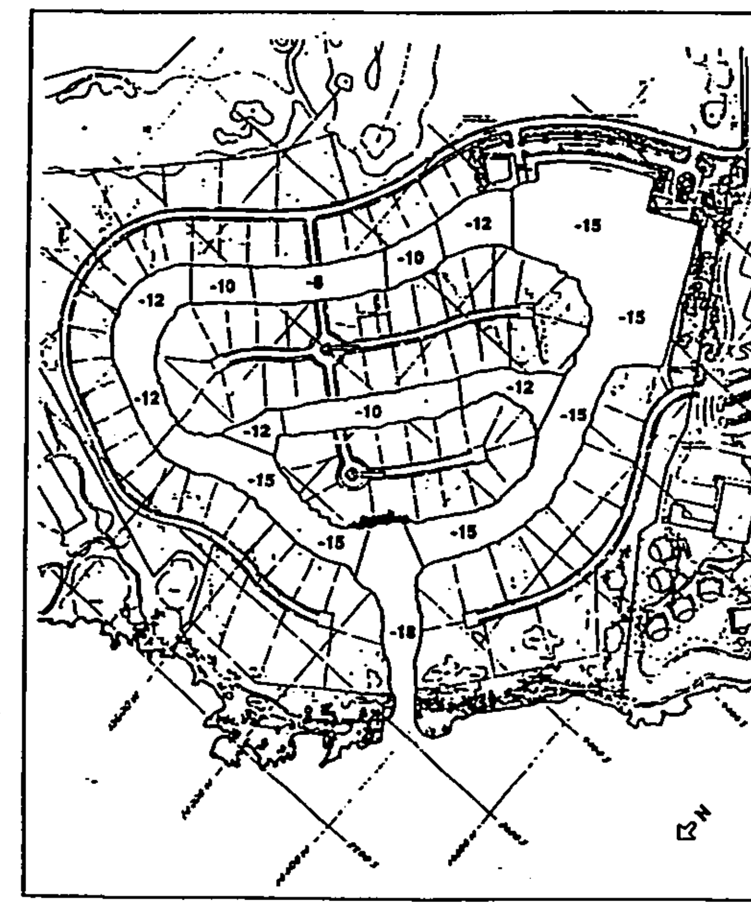
Compare to Bathymetry map on page IV-28
this model does not have any contour(s)
less than 10', wave patterns are different.





HYDRO RESEARCH SCIENCE HRS

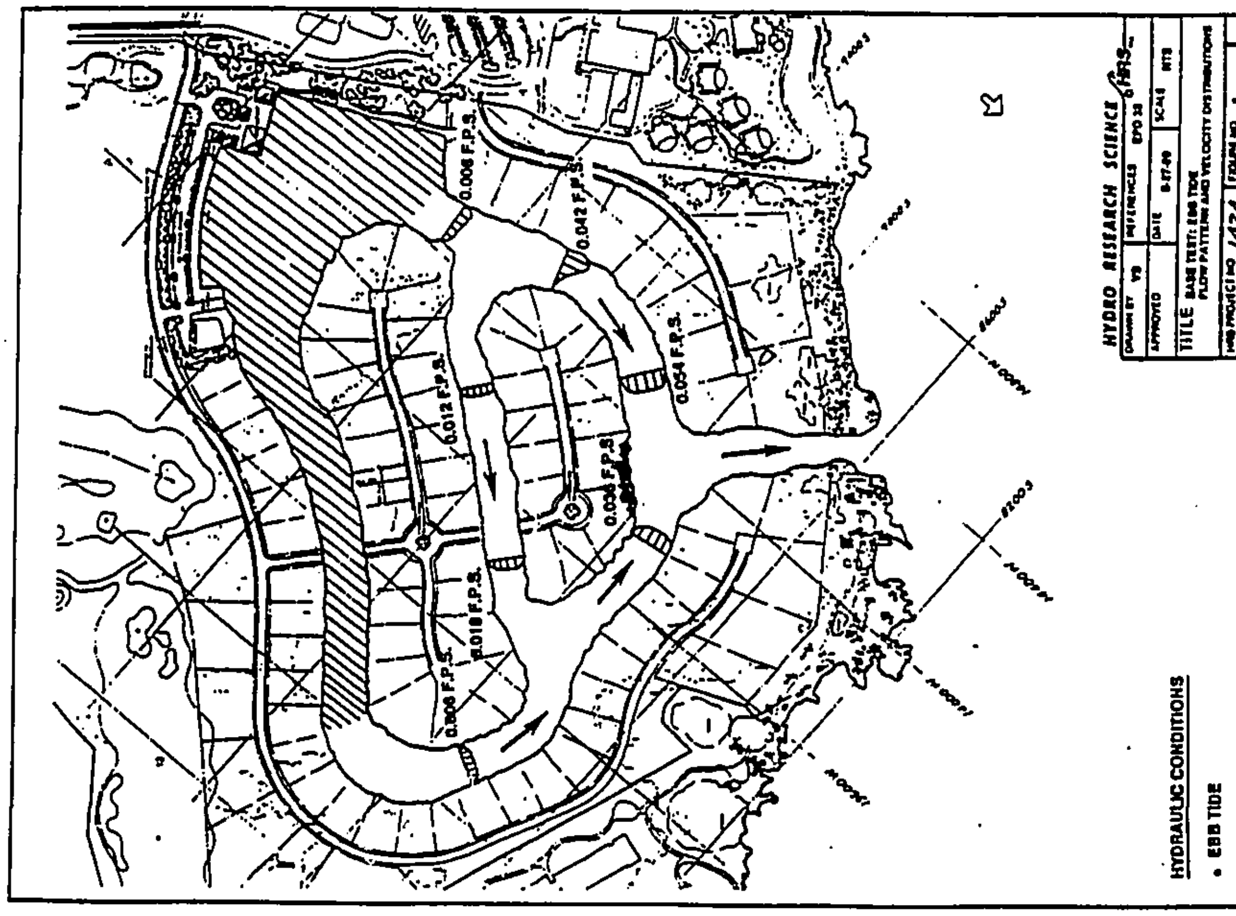
DRAWN BY TM	REFERENCES	
APPROVED	DATE 9-6-89	SCALE
TITLE MODEL LAYOUT		
HRS PROJECT NO. 1424	FIGURE NO. 1	

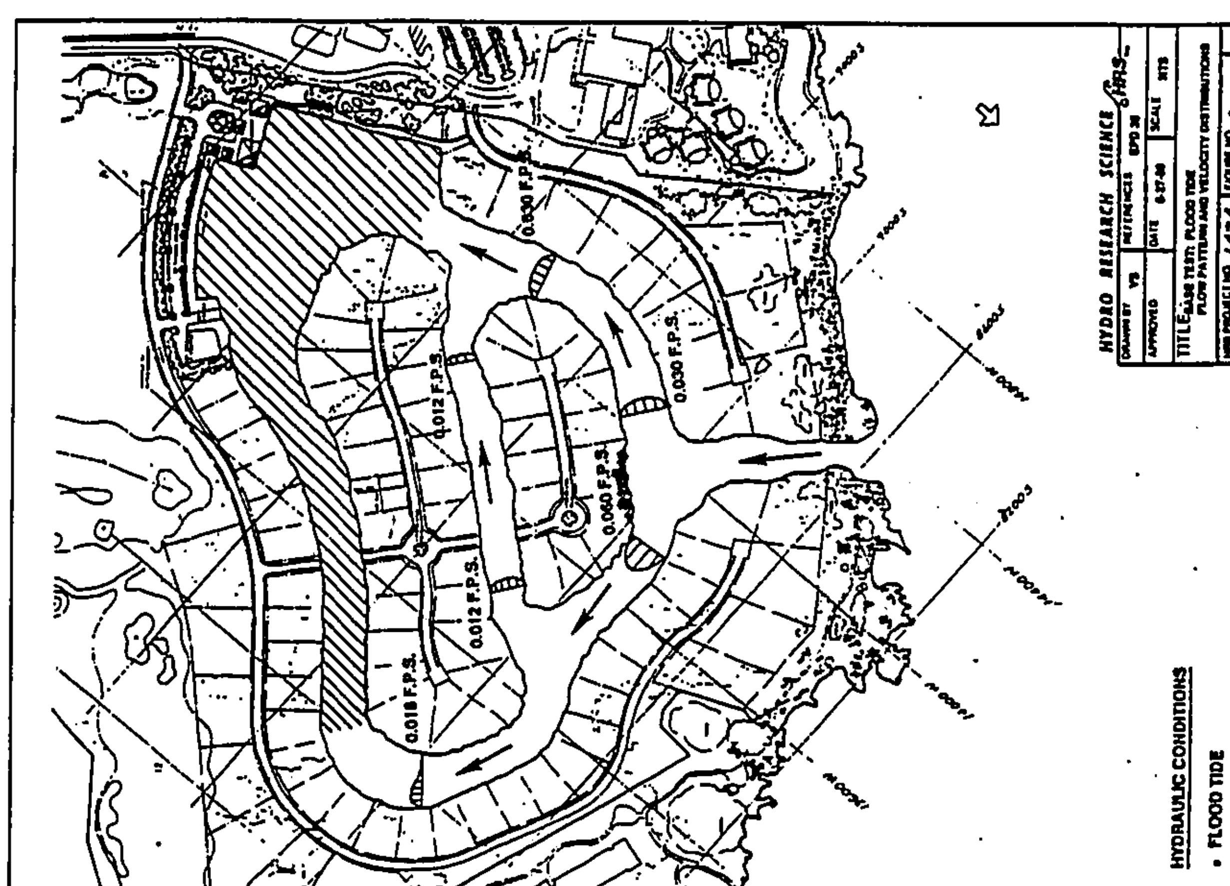


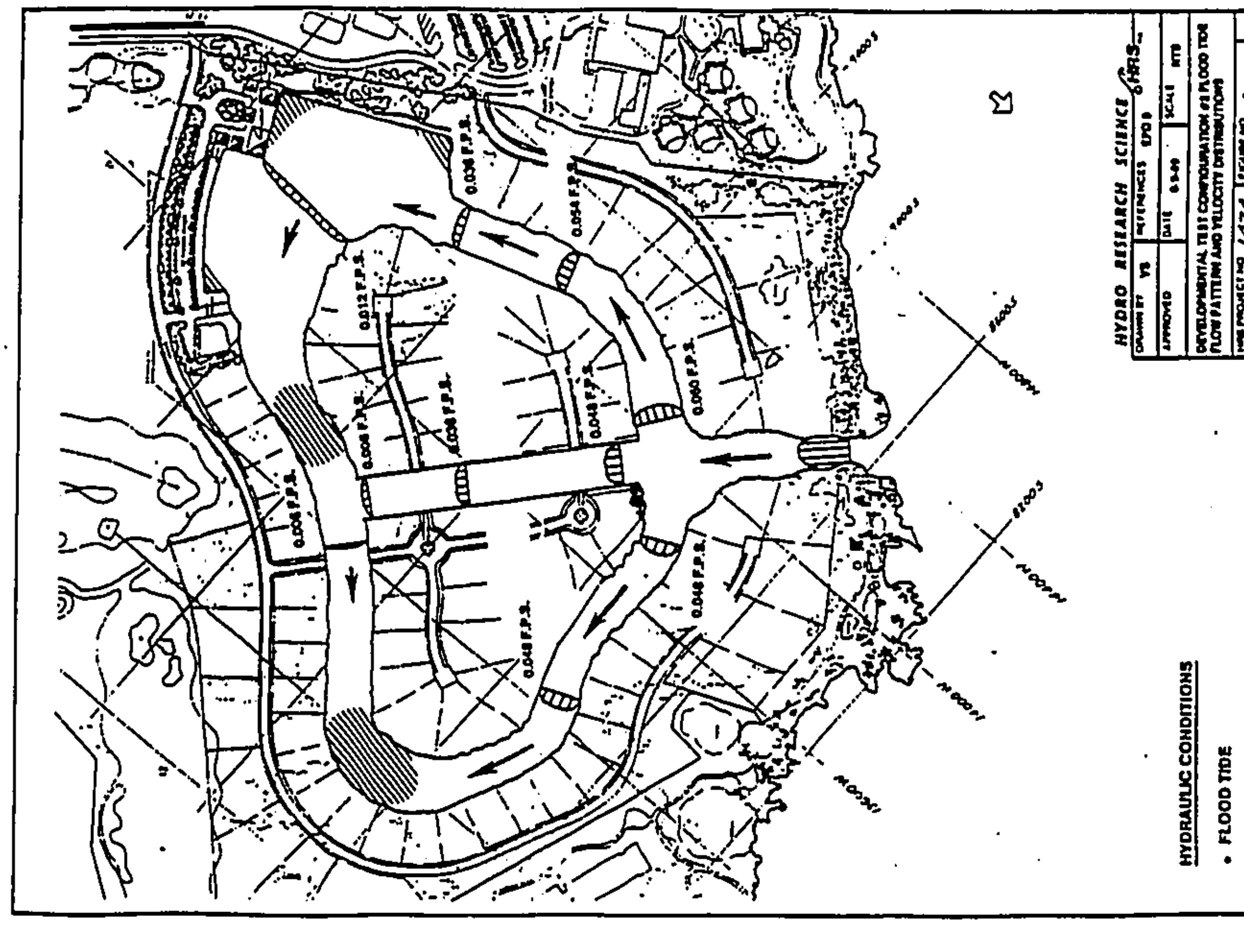
Note: Numbers indicated bottom elevations in FT MLLW

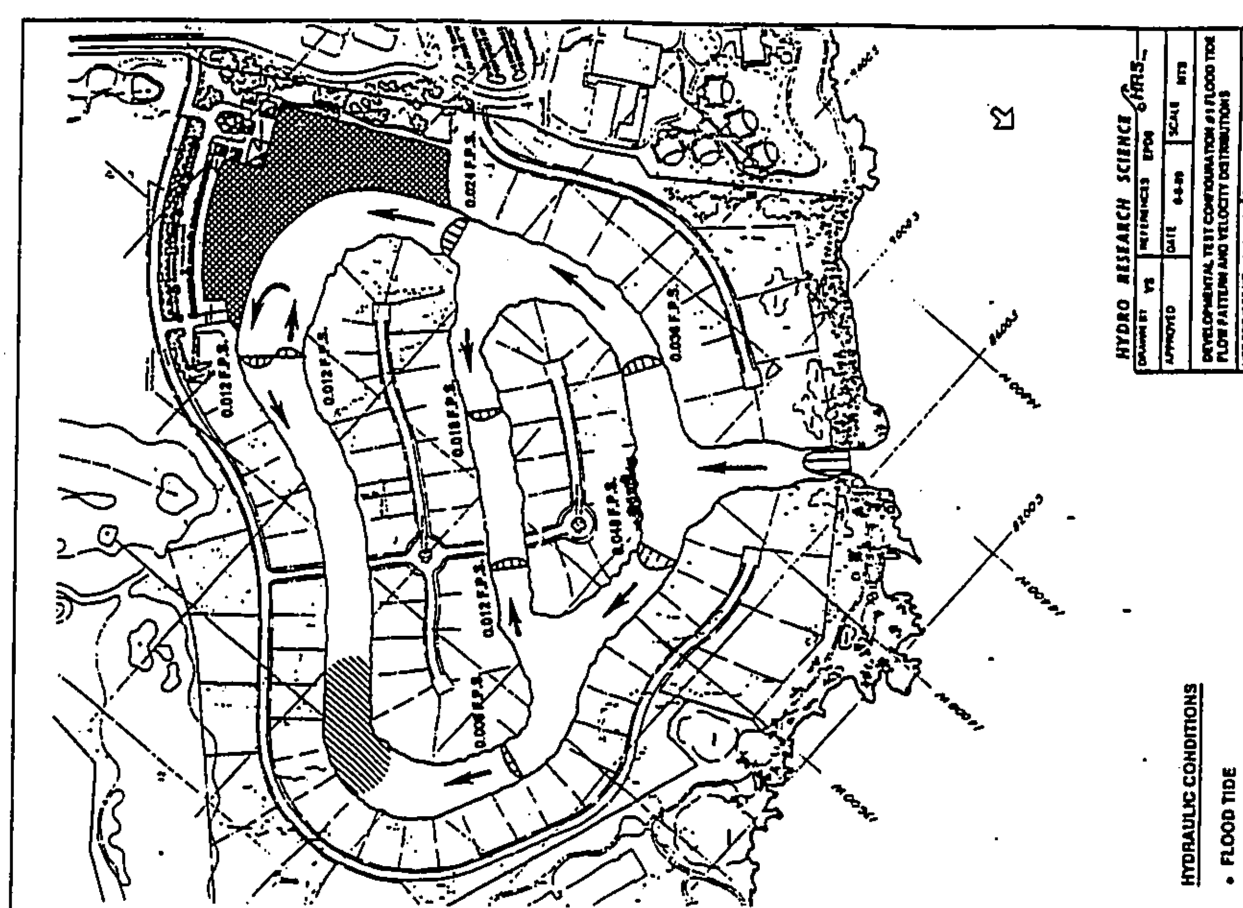
HYDRO RESEARCH SCIENCE HRS

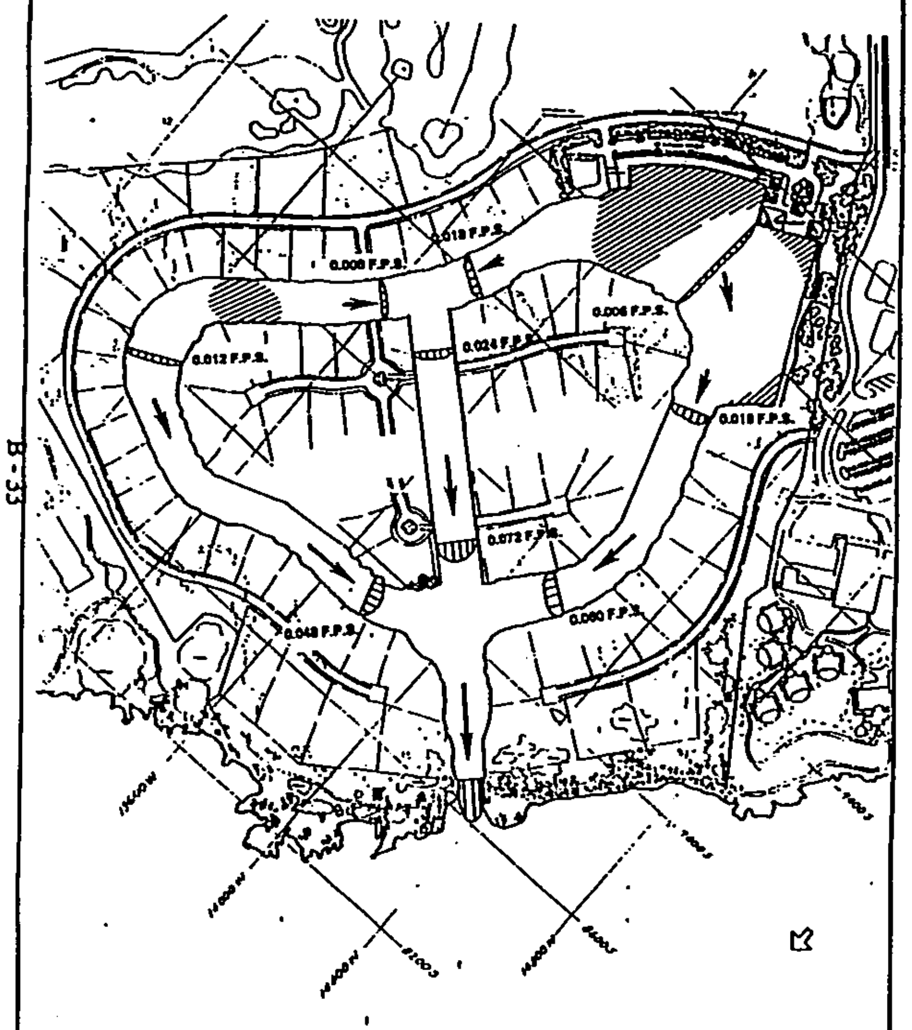
DRAWN BY DG	REFERENCES	
APPROVED	DATE 9-5-89	SCALE NTS
TITLE PRELIMINARY DESIGN CONFIGURATION OF THE MARINA		
HRS PROJECT NO. 1424	FIGURE NO. 2	


0.006 F.P.S.
0.042 F.P.S.
0.012 F.P.S.
0.054 F.P.S.
0.036 F.P.S.
0.018 F.P.S.
0.006 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
HRS PROJECT NO 1424
HYDRAULIC CONDITIONS
• EBB TIDE


0.030 F.P.S.
0.012 F.P.S.
0.030 F.P.S.
0.060 F.P.S.
0.012 F.P.S.
0.018 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
HRS PROJECT NO 1424
HYDRAULIC CONDITIONS
• FLOOD TIDE


HYDRAULIC CONDITIONS
• FLOOD TIDE
HYDRO RESEARCH SCIENCE


HYDRAULIC CONDITIONS
• FLOOD TIDE
HYDRO RESEARCH SCIENCE

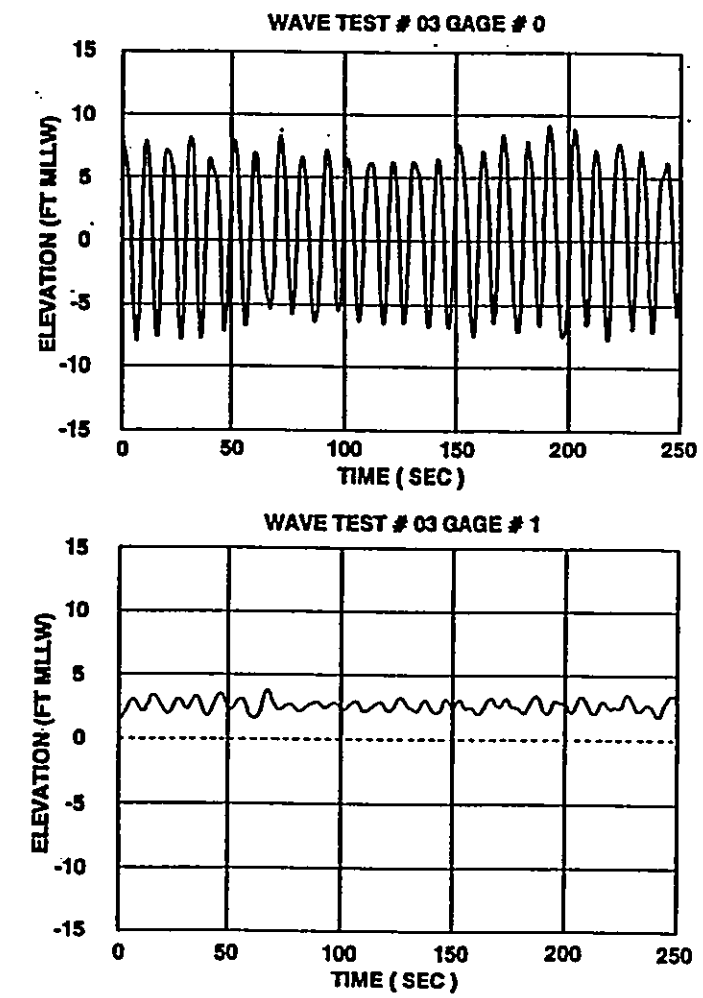


HYDRAULIC CONDITIONS

- EBB TIDE

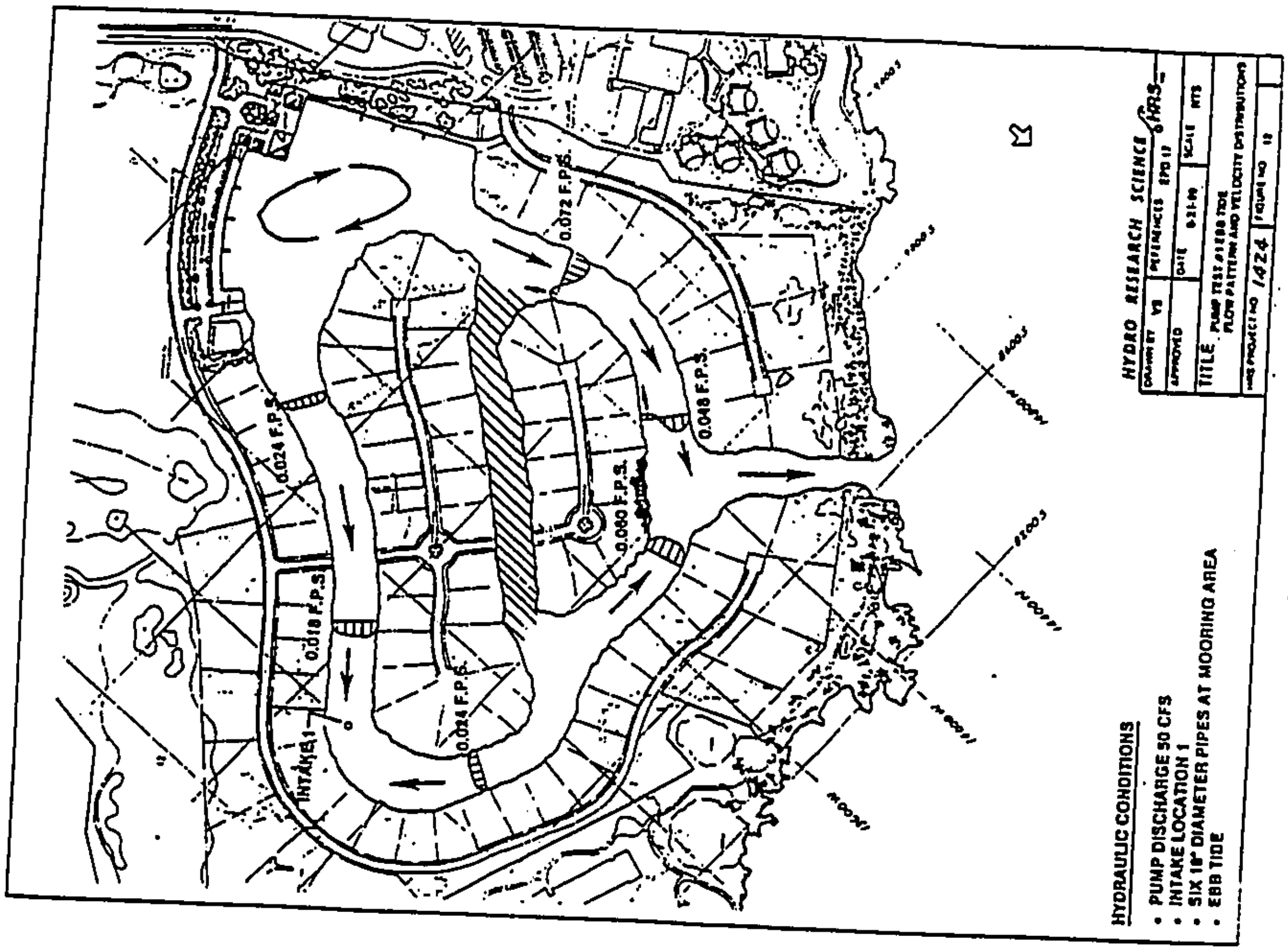
HYDRO RESEARCH SCIENCE HRS

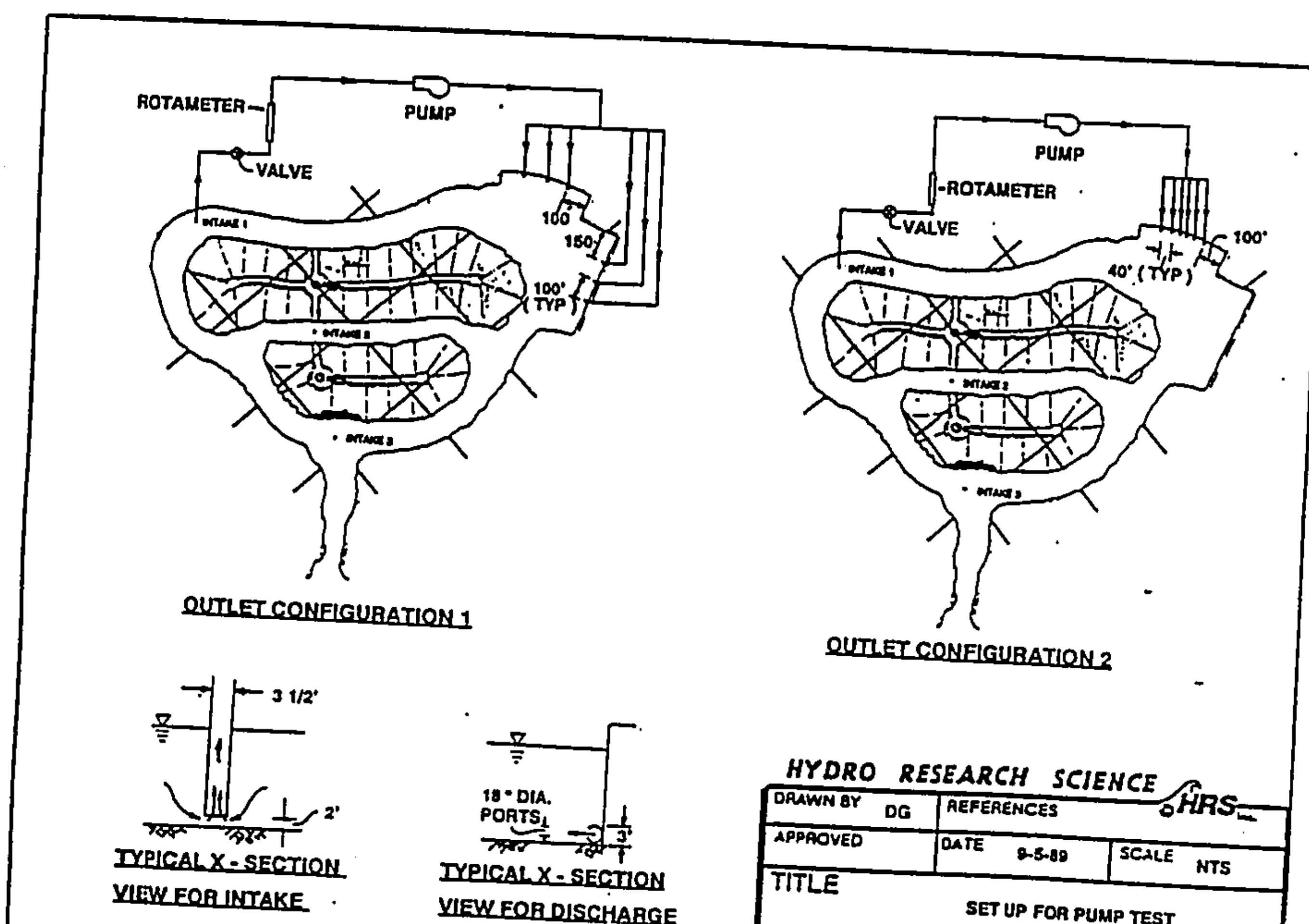
DRAWN BY VS	REFERENCES EPD 10	
APPROVED	DATE	SCALE NTS
DEVELOPMENTAL TEST CONFIGURATION #3 EBB TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS		
HRS PROJECT NO. 1424	FIGURE NO. 8	

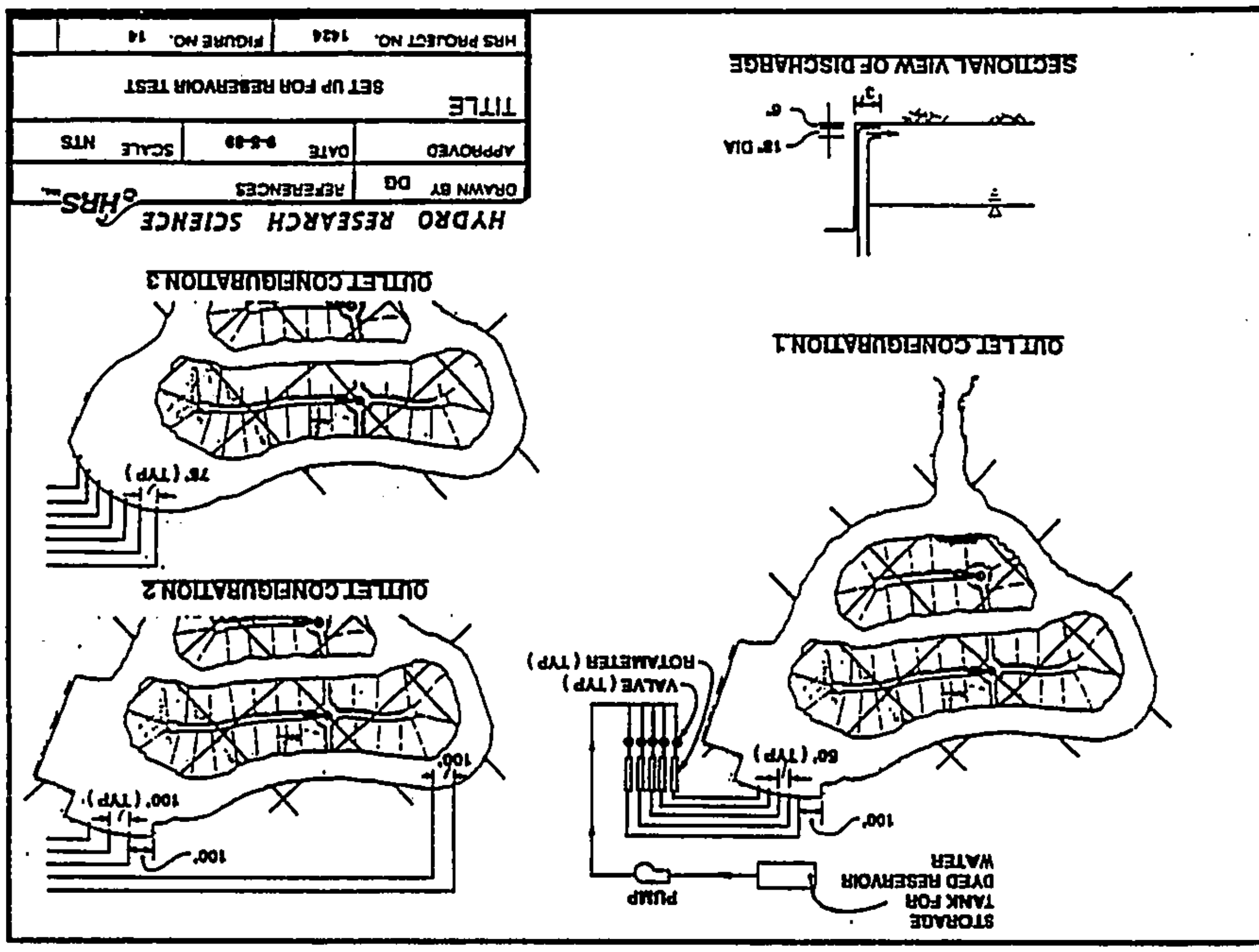


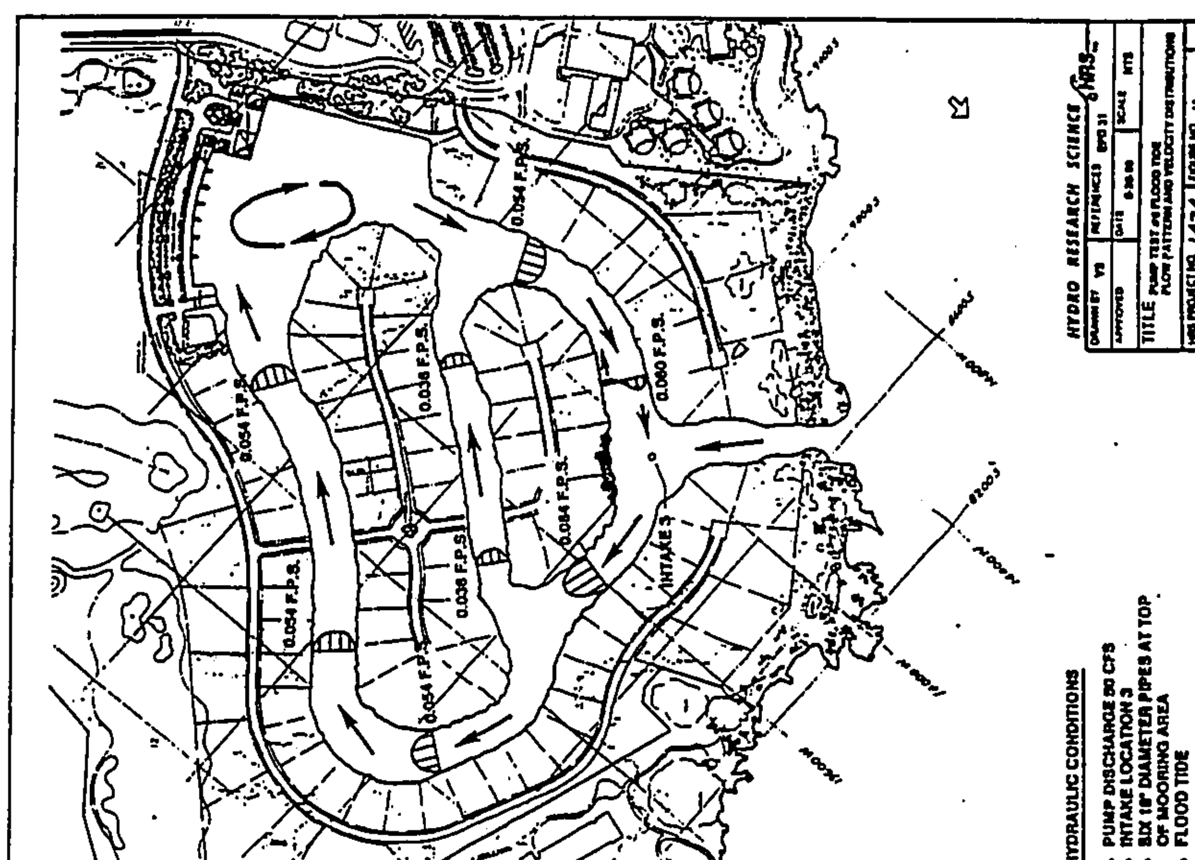
HYDRO RESEARCH SCIENCE HRS

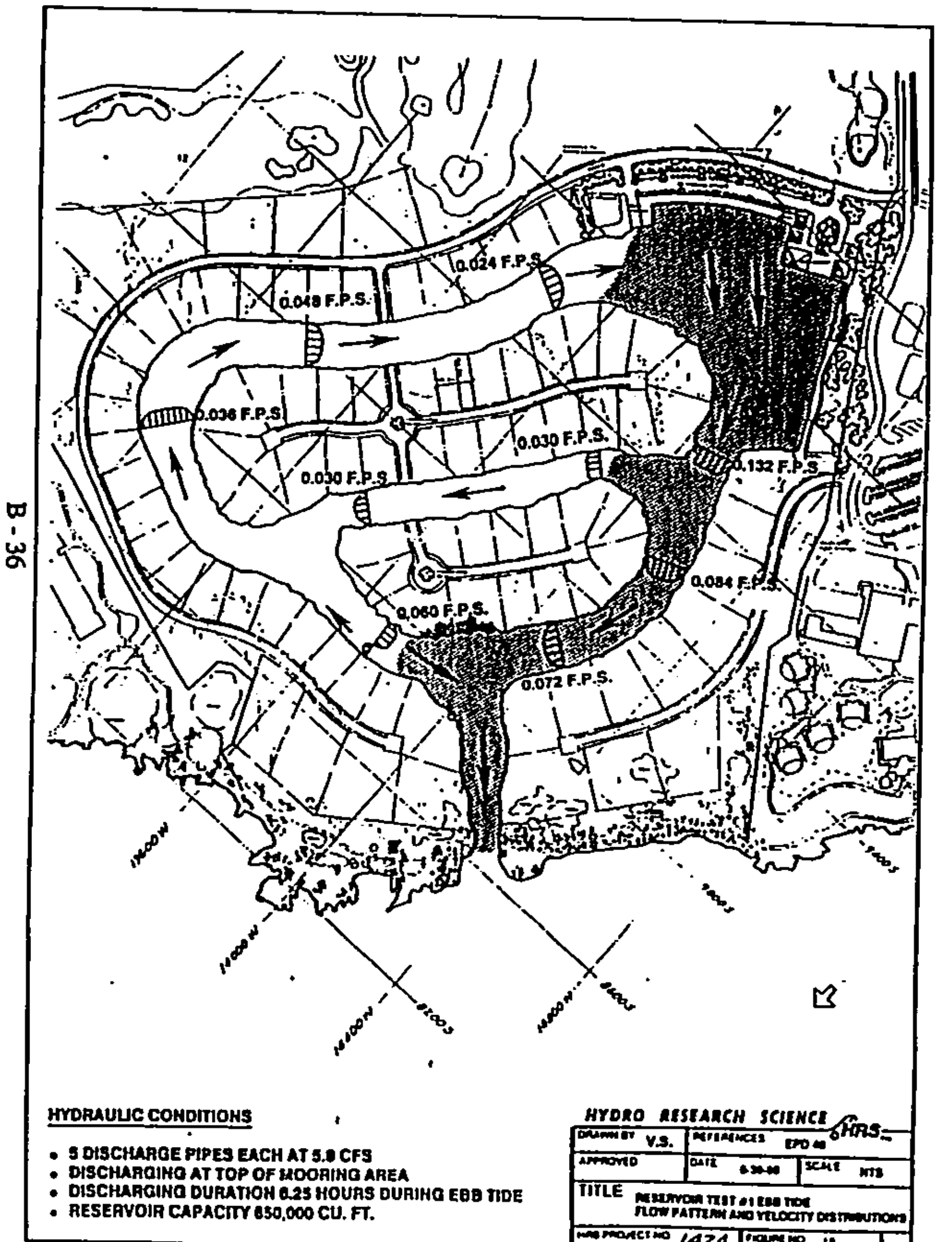
DRAWN BY MV	REFERENCES	
APPROVED	DATE 9-5-89	SCALE NTS
TITLE WAVE TEST # 3 : WAVE PROFILES		
HRS PROJECT NO. 1424	FIGURE NO. 10	


HYDRO RESEARCH SCIENCE
HRS
1424
HYDRAULIC CONDITIONS
• PUMP DISCHARGE 50 CFS
• INTAKE LOCATION 1
• SIX 18" DIAMETER PIPES AT MOORING AREA
• EBB TIDE
0.072 F.P.S.
0.048 F.P.S.
0.060 F.P.S.
0.024 F.P.S.
0.018 F.P.S.
0.034 F.P.S.
INTAKE 1

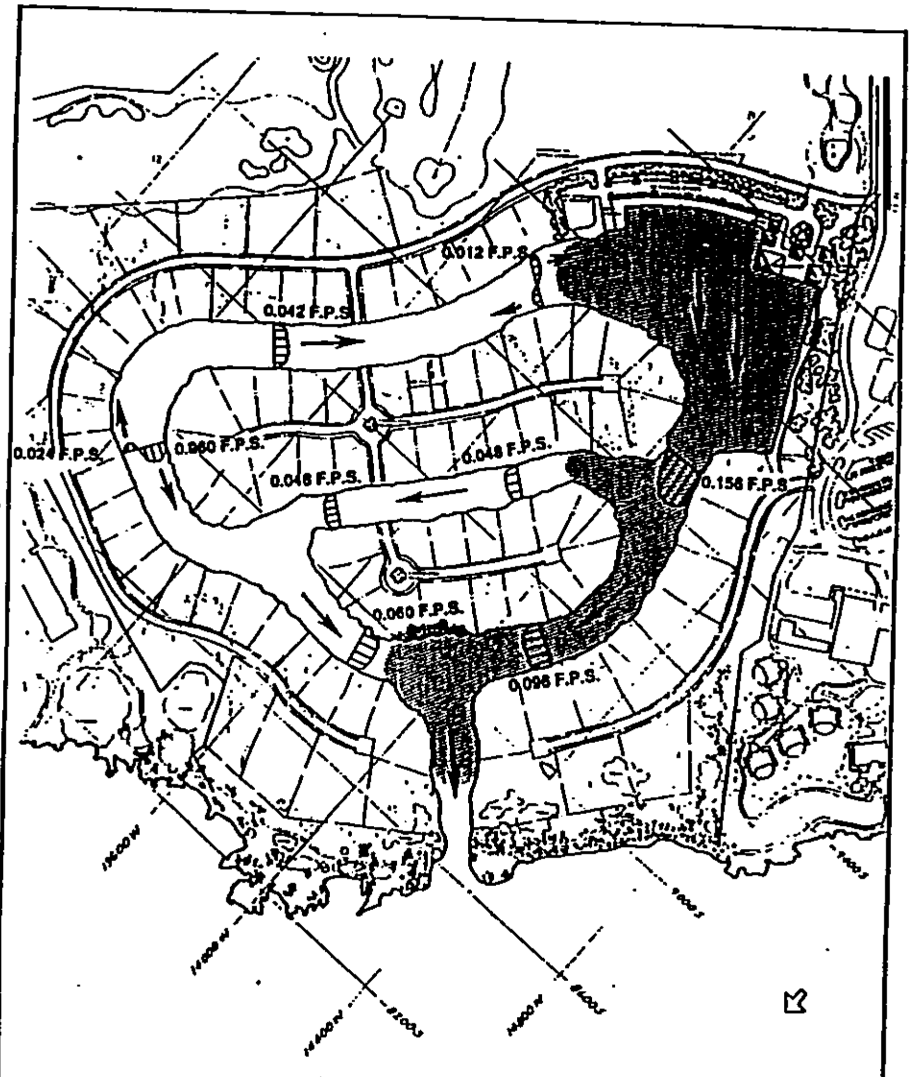

ROTAMETER
PUMP
VALVE
100'
150'
100' TYP
OUTLET CONFIGURATION 1
PUMP
ROTAMETER
VALVE
100'
40' (TYP)
OUTLET CONFIGURATION 2
3 1/2'
2'
TYPICAL X - SECTION
VIEW FOR INTAKE
18" DIA. PORTS
3'
TYPICAL X - SECTION
VIEW FOR DISCHARGE
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY DG
REFERENCES
APPROVED
DATE 9-5-89
SCALE NTS
TITLE
SET UP FOR PUMP TEST
HRS PROJECT NO. 1424
FIGURE NO. 11


HYDRO RESEARCH SCIENCE
DRAWN BY DG
REFERENCES
APPROVED
DATE 9-8-89
SCALE NTS
TITLE
SET UP FOR RESERVOIR TEST
HRS PROJECT NO. 1424
FIGURE NO. 14
SECTIONAL VIEW OF DISCHARGE
18" DIA
OUTLET CONFIGURATION 1
OUTLET CONFIGURATION 2
OUTLET CONFIGURATION 3
STORAGE TANK FOR DYED RESERVOIR WATER
PUMP
VALVE (TYP)
ROTAMETER (TYP)
60' (TYP)
75' (TYP)
100' (TYP)
100'


HYDRAULIC CONDITIONS
• PUMP DISCHARGE 50 CFS
• INTAKE LOCATION 3
• SIX 18" DIAMETER PIPES AT TOP OF MOORING AREA
• FLOOD TIDE
HYDRO RESEARCH SCIENCE
INTAKE 3
0.054 F.P.S.
0.036 F.P.S.
0.060 F.P.S.
0.084 F.P.S.
1424


0.024 F.P.S.
0.048 F.P.S.
0.036 F.P.S.
0.030 F.P.S.
0.030 F.P.S.
0.132 F.P.S.
0.084 F.P.S.
0.060 F.P.S.
0.072 F.P.S.
HYDRAULIC CONDITIONS
• 5 DISCHARGE PIPES EACH AT 5.9 CFS
• DISCHARGING AT TOP OF MOORING AREA
• DISCHARGING DURATION 6.25 HOURS DURING EBB TIDE
• RESERVOIR CAPACITY 650,000 CU. FT.
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY V.S.
REFERENCES EPD 40
APPROVED
DATE 6-30-90
SCALE NTS
TITLE RESERVOIR TEST #1 EBB TIDE
FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 18


0.024 F.P.S.
0.048 F.P.S.
0.036 F.P.S.
0.036 F.P.S.
0.036 F.P.S.
0.144 F.P.S.
0.048 F.P.S.
0.096 F.P.S.
HYDRAULIC CONDITIONS
• 5 DISCHARGE PIPES EACH AT 12.0 CFS
• DISCHARGING AT TOP OF MOORING AREA
• DISCHARGE DURATION 3 HOURS IN MIDDLE OF EBB TIDE
• RESERVOIR CAPACITY 650,000 CU. FT.
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY V.S.
REFERENCES EPD 41
APPROVED
DATE 7-3-90
SCALE NTS
TITLE RESERVOIR TEST #3 EBB TIDE
FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 19



HYDRAULIC CONDITIONS

- 5 DISCHARGE PIPES EACH AT 18.1 CFS
- DISCHARGING AT TOP OF MOORING AREA
- DISCHARGE DURATION 2 HOURS IN MIDDLE OF EBB TIDE
- RESERVOIR CAPACITY 650,000 CU. FT.

HYDRO RESEARCH SCIENCE HRS

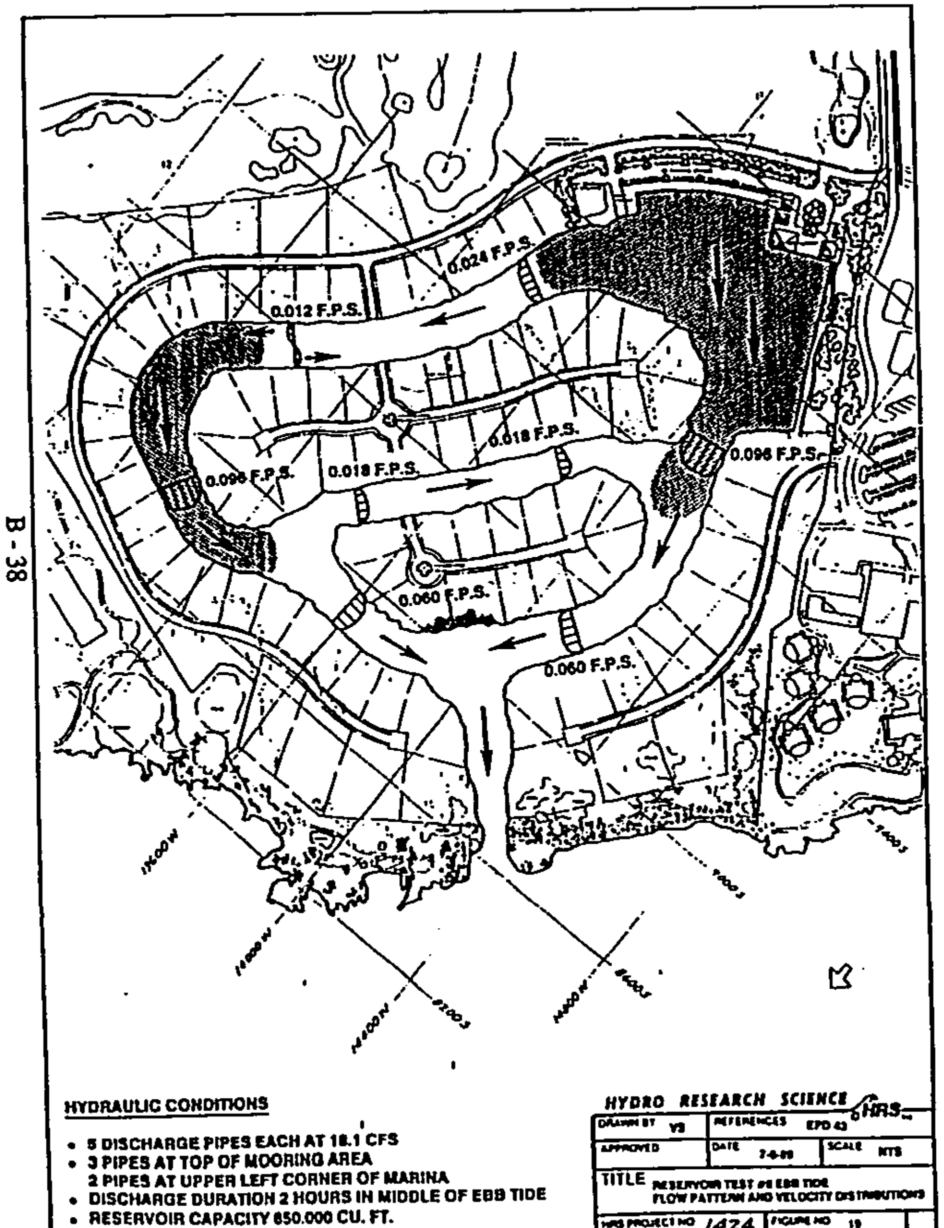
DRAWN BY V.S.	REFERENCES EPD 38	
APPROVED	DATE 8-30-90	SCALE NTS
TITLE RESERVOIR TEST #3 EBB TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS		
HRS PROJECT NO 1424	FIGURE NO 17	

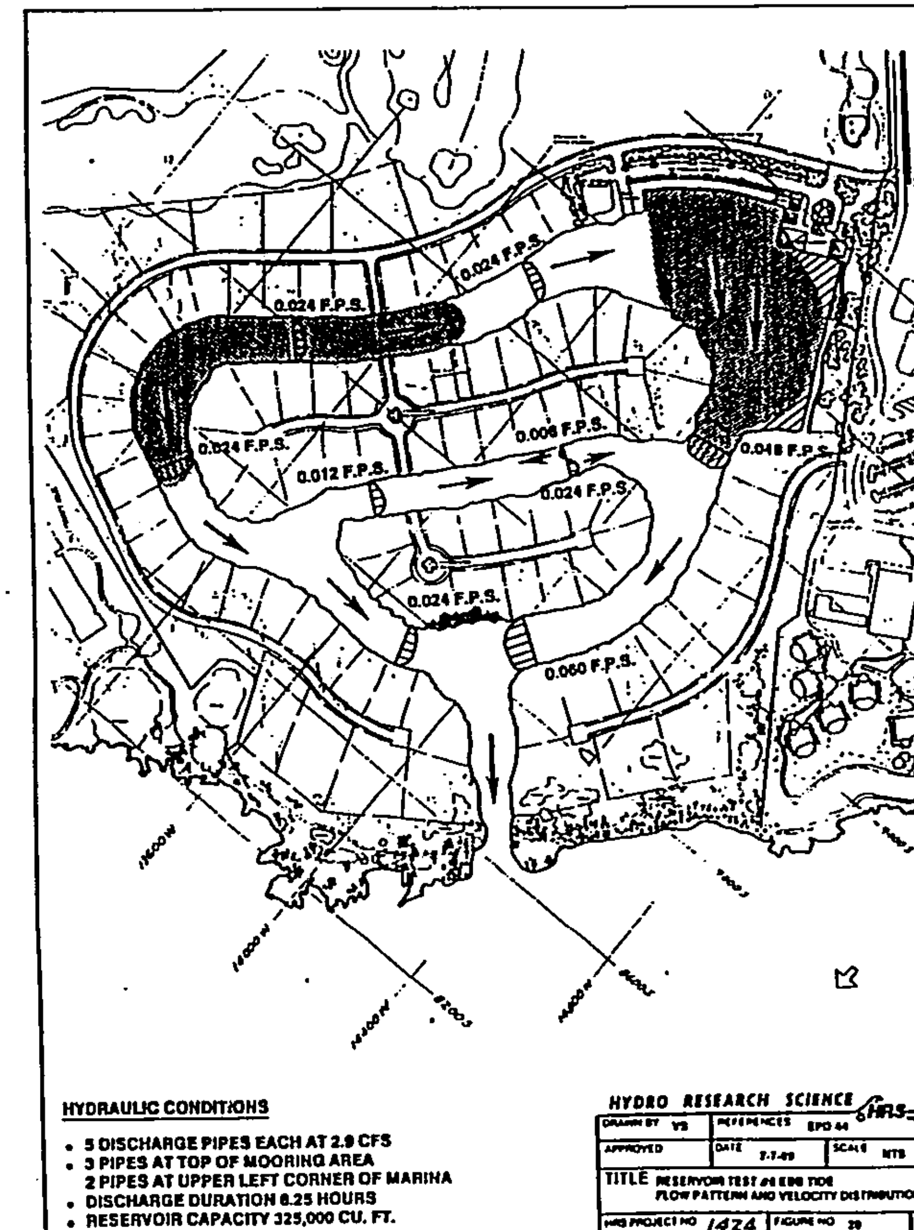
HYDRAULIC CONDITIONS

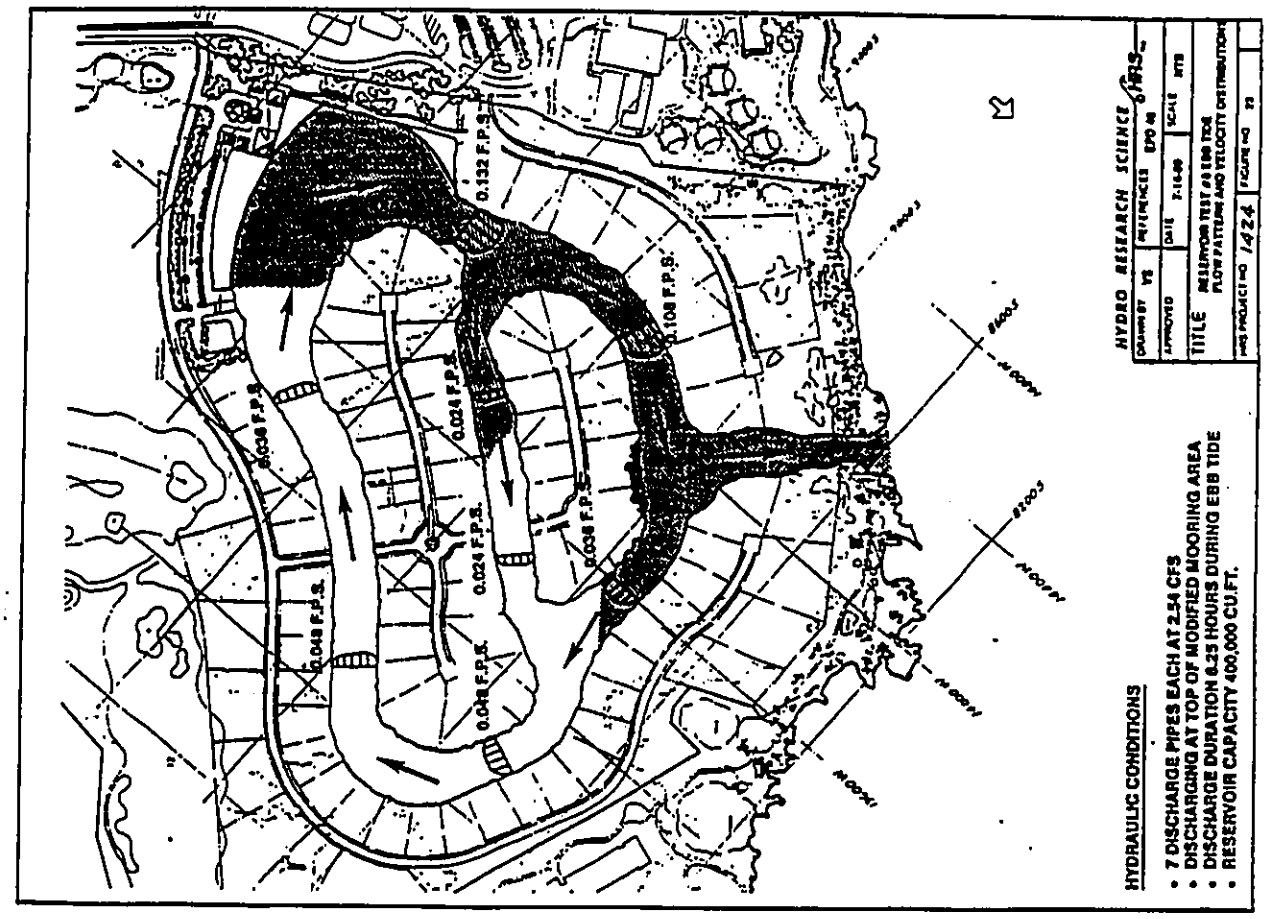
- 5 DISCHARGE PIPES EACH AT 5.8 CFS
- 3 PIPES DISCHARGING AT TOP OF MOORING AREA
  2 PIPES DISCHARGING AT UPPER LEFT CORNER OF MARINA
- DISCHARGE DURATION 6.25 HOURS
- RESERVOIR CAPACITY 650,000 CU. FT.

HYDRO RESEARCH SCIENCE HRS

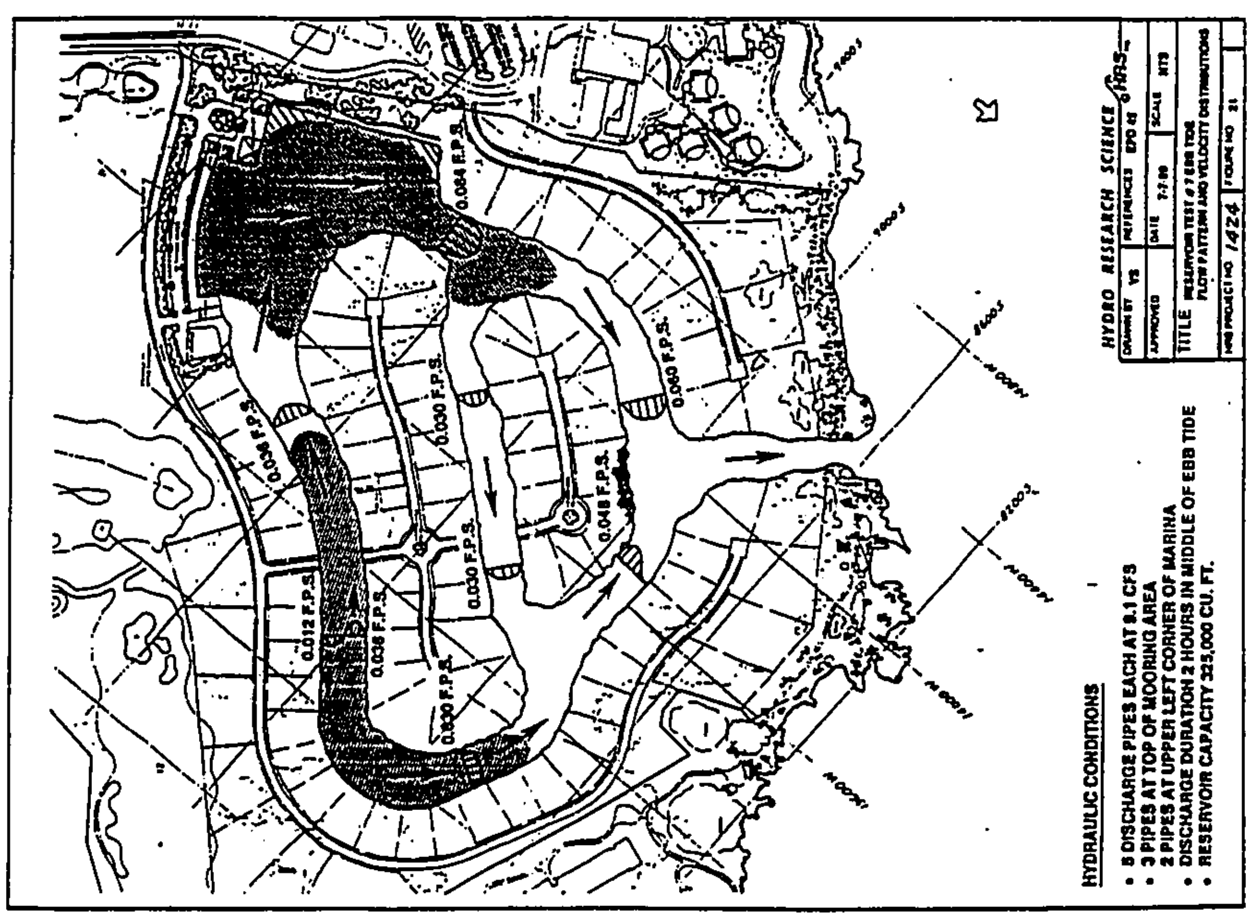
DRAWN BY VS	REFERENCES EPD 42	
APPROVED	DATE 7-6-90	SCALE NTS
TITLE RESERVOIR TEST #4 EBB TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS		
HRS PROJECT NO 1424	FIGURE NO 18	


0.024 F.P.S.
0.012 F.P.S.
0.018 F.P.S.
0.096 F.P.S.
0.018 F.P.S.
0.096 F.P.S.
0.060 F.P.S.
0.060 F.P.S.
HYDRAULIC CONDITIONS
• 5 DISCHARGE PIPES EACH AT 18.1 CFS
• 3 PIPES AT TOP OF MOORING AREA
2 PIPES AT UPPER LEFT CORNER OF MARINA
• DISCHARGE DURATION 2 HOURS IN MIDDLE OF EBB TIDE
• RESERVOIR CAPACITY 650.000 CU. FT.
HYDRO RESEARCH SCIENCE
TITLE RESERVOIR TEST #5 EBB TIDE
FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 19

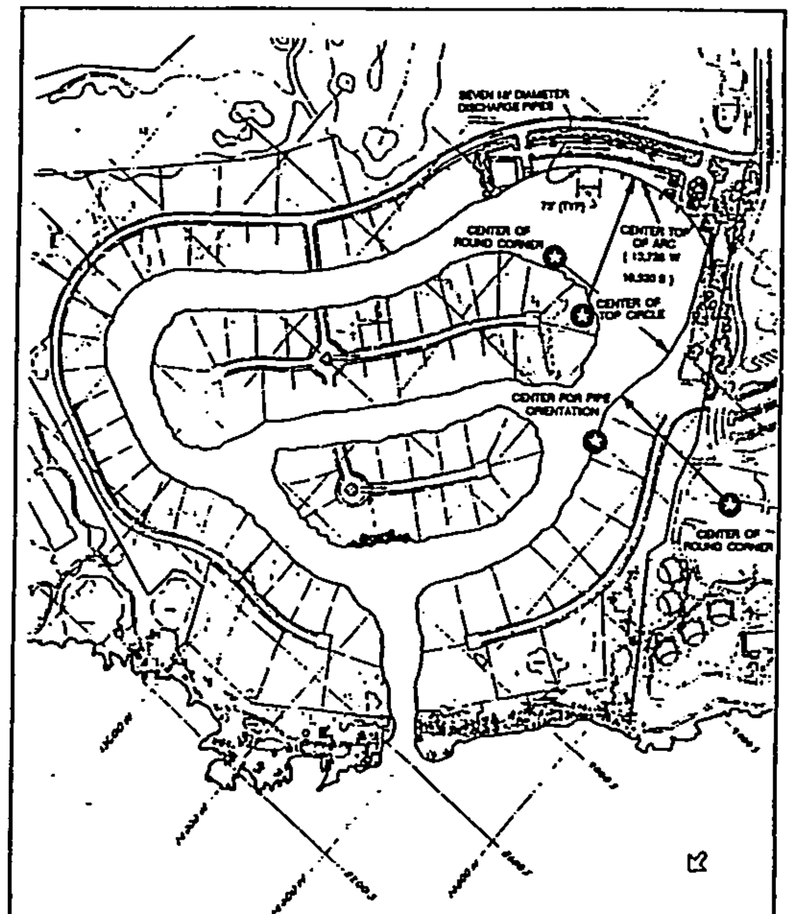

0.024 F.P.S.
0.024 F.P.S.
0.024 F.P.S.
0.012 F.P.S.
0.006 F.P.S.
0.048 F.P.S.
0.024 F.P.S.
0.024 F.P.S.
0.060 F.P.S.
HYDRAULIC CONDITIONS
• 5 DISCHARGE PIPES EACH AT 2.9 CFS
• 3 PIPES AT TOP OF MOORING AREA
2 PIPES AT UPPER LEFT CORNER OF MARINA
• DISCHARGE DURATION 6.25 HOURS
• RESERVOIR CAPACITY 325,000 CU. FT.
HYDRO RESEARCH SCIENCE
TITLE RESERVOIR TEST #6 EBB TIDE
FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 20



HYDRAULIC CONDITIONS
• 7 DISCHARGE PIPES EACH AT 2.54 CFS
• DISCHARGING AT TOP OF MODIFIED MOORING AREA
• DISCHARGE DURATION 6.25 HOURS DURING EBB TIDE
• RESERVOIR CAPACITY 400,000 CU.FT.
0.036 F.P.S.
0.048 F.P.S.
0.024 F.P.S.
0.024 F.P.S.
0.048 F.P.S.
0.024 F.P.S.
0.036 F.P.S.
0.132 F.P.S.
0.108 F.P.S.
HYDRO RESEARCH SCIENCE
1424



HYDRAULIC CONDITIONS
• 5 DISCHARGE PIPES EACH AT 8.1 CFS
• 3 PIPES AT TOP OF MOORING AREA
2 PIPES AT UPPER LEFT CORNER OF MARINA
• DISCHARGE DURATION 2 HOURS IN MIDDLE OF EBB TIDE
• RESERVOIR CAPACITY 325,000 CU. FT.
0.036 F.P.S.
0.012 F.P.S.
0.036 F.P.S.
0.030 F.P.S.
0.030 F.P.S.
0.030 F.P.S.
0.048 F.P.S.
0.084 F.P.S.
0.060 F.P.S.
HYDRO RESEARCH SCIENCE
1424



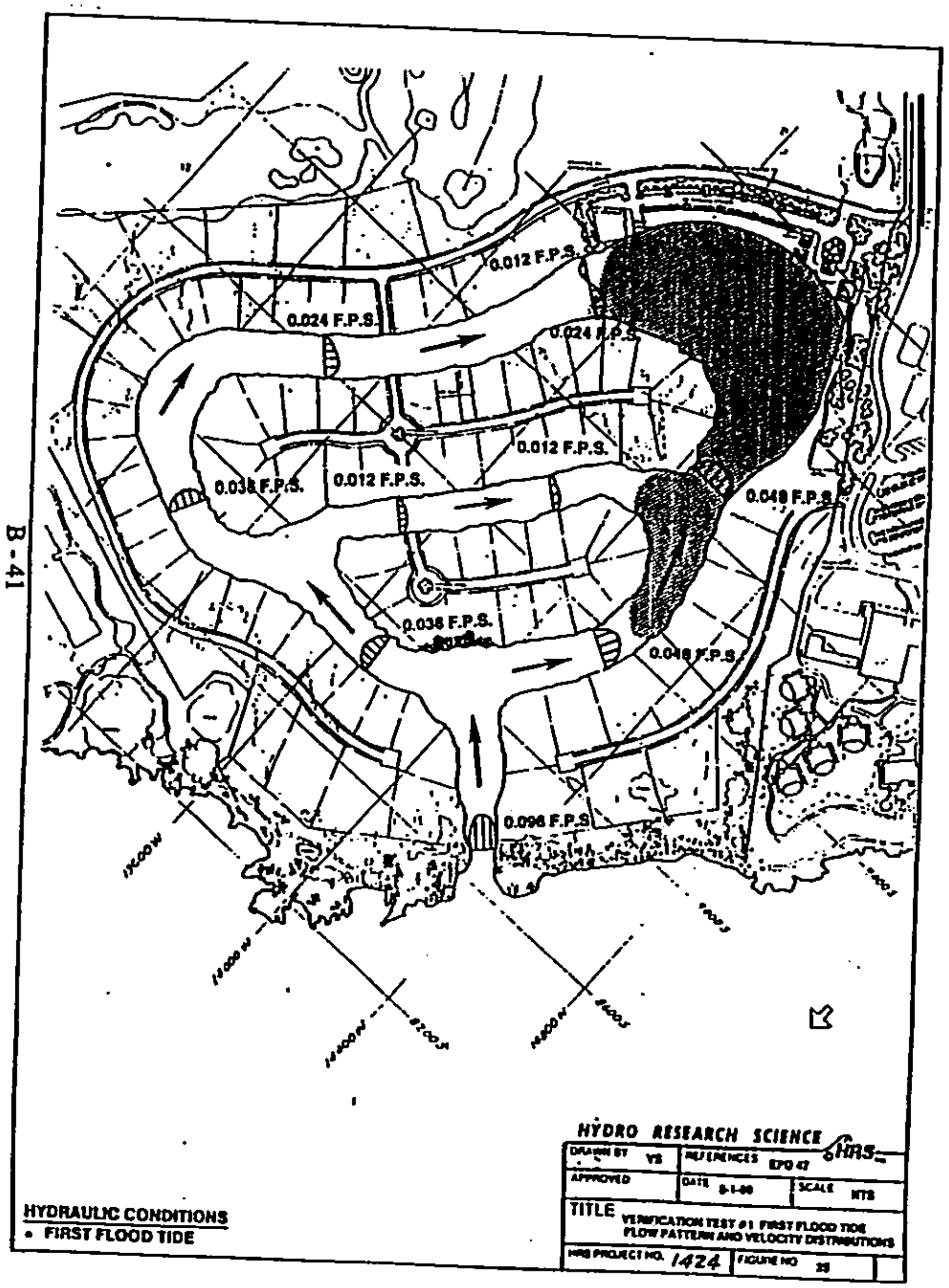
HYDRO RESEARCH SCIENCE HRS inc.

DRAWN BY DG	REFERENCES		
APPROVED	DATE 9-5-89	SCALE NTS	
TITLE FINAL CONFIGURATION WITH RESERVOIR OUTLET NO. 4 FOR VERIFICATION TEST			
HRS PROJECT NO. 1424	FIGURE NO. 23		

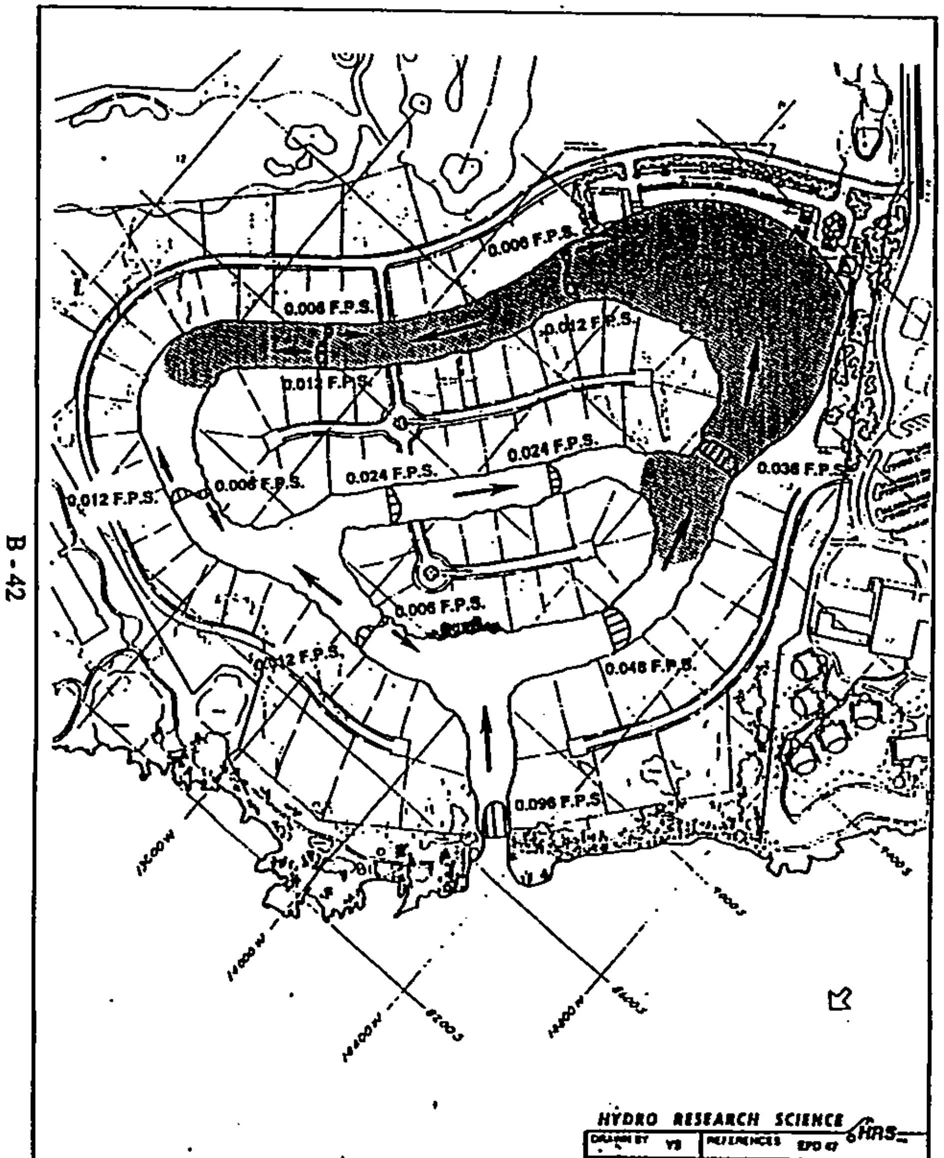
HYDRAULIC CONDITIONS
- 7 DISCHARGE PIPES EACH AT 2.54 CFS
- DISCHARGE PIPES AT TOP OF MOORING AREA
- DISCHARGE DURATION 6.25 HOURS
- RESERVOIR CAPACITY 400,000 CU. FT.
- PRE-EBB TIDE

HYDRO RESEARCH SCIENCE HRS inc.

DRAWN BY YS	REFERENCES EPD 47		
APPROVED	DATE 9-1-89	SCALE NTS	
TITLE VERIFICATION TEST #1 PRE-EBB TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS			
HRS PROJECT NO. 1424	FIGURE NO. 24		


0.012 F.P.S.
0.024 F.P.S.
0.024 F.P.S.
0.012 F.P.S.
0.036 F.P.S.
0.012 F.P.S.
0.048 F.P.S.
0.036 F.P.S.
0.048 F.P.S.
0.096 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY VS
REFERENCES EPD 47
APPROVED
DATE 8-1-80
SCALE NTS
TITLE VERIFICATION TEST #1 FIRST FLOOD TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO. 1424
FIGURE NO
HYDRAULIC CONDITIONS
• FIRST FLOOD TIDE


0.012 F.P.S.
0.012 F.P.S.
0.006 F.P.S.
0.006 F.P.S.
0.024 F.P.S.
0.012 F.P.S.
0.012 F.P.S.
0.042 F.P.S.
0.036 F.P.S.
0.060 F.P.S.
0.096 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY VS
REFERENCES EPD 47
APPROVED
DATE 8-1-80
SCALE NTS
TITLE VERIFICATION TEST #1 FIRST EBB TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO
HYDRAULIC CONDITIONS
• FIRST EBB TIDE

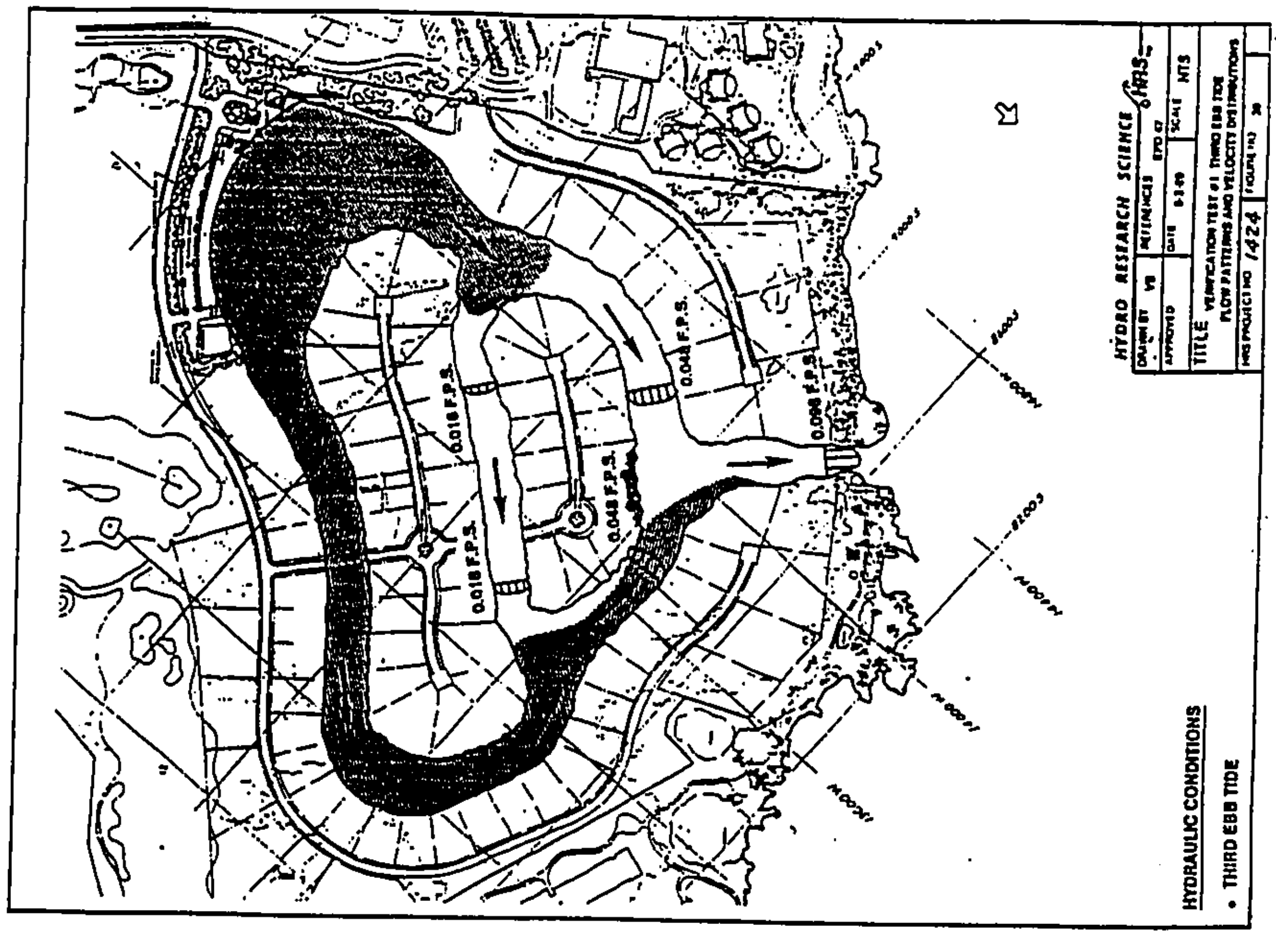


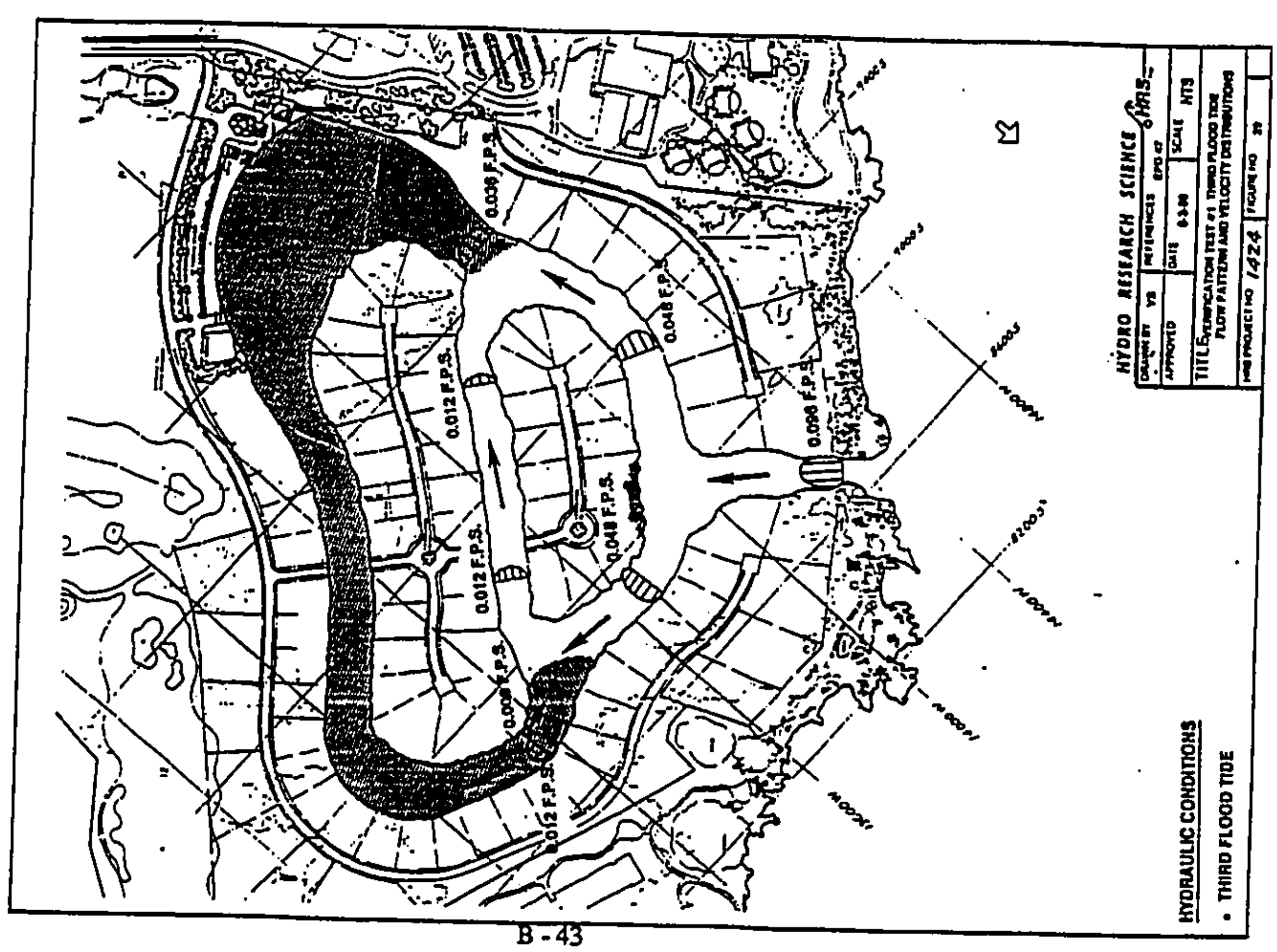
HYDRAULIC CONDITIONS

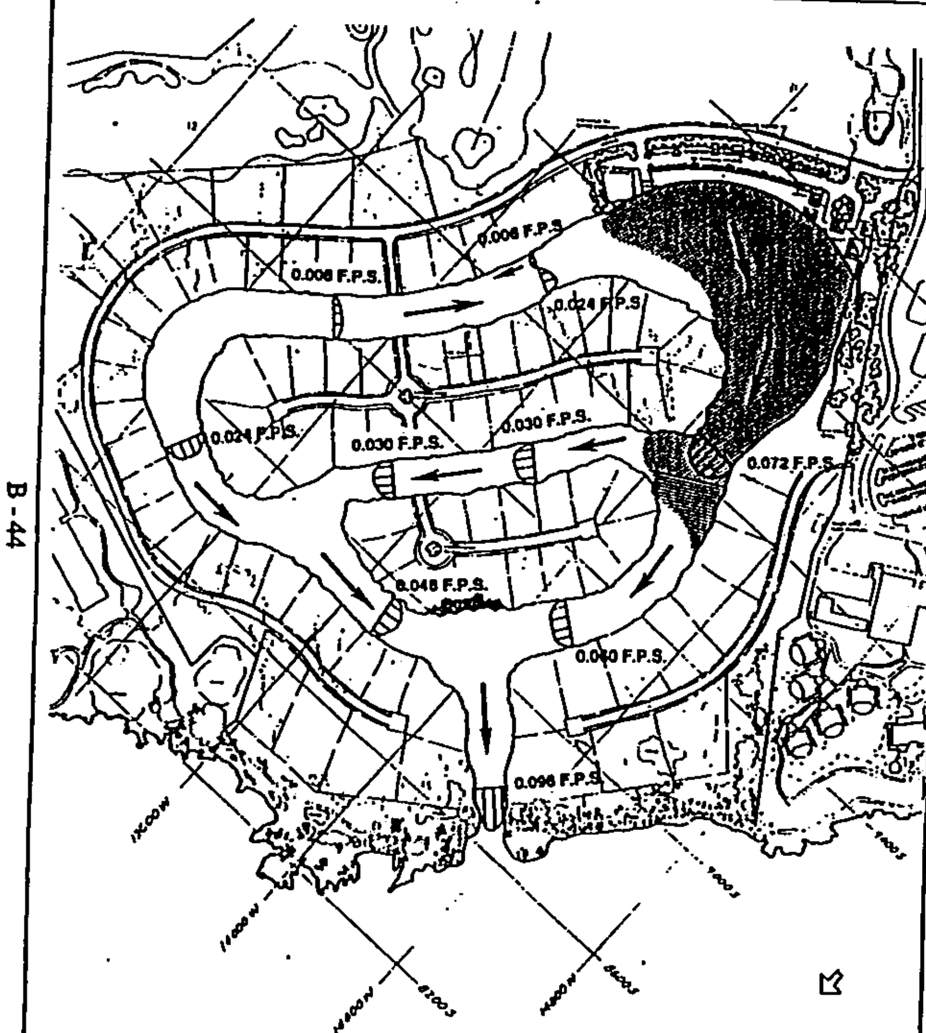
• SECOND FLOOD TIDE

HYDRAULIC CONDITIONS

• SECOND EBB TIDE


HYDRAULIC CONDITIONS
• THIRD EBB TIDE
0.018 F.P.S.
0.018 F.P.S.
0.048 F.P.S.
0.048 F.P.S.
0.096 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
NTS
TITLE VERIFICATION TEST #1 THIRD EBB TIDE FLOW PATTERNS AND VELOCITY DISTRIBUTIONS
1424


HYDRAULIC CONDITIONS
• THIRD FLOOD TIDE
0.036 F.P.S.
0.012 F.P.S.
0.012 F.P.S.
0.048 F.P.S.
0.048 F.P.S.
0.096 F.P.S.
0.012 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
NTS
TITLE VERIFICATION TEST #1 THIRD FLOOD TIDE FLOW PATTERNS AND VELOCITY DISTRIBUTIONS
1424

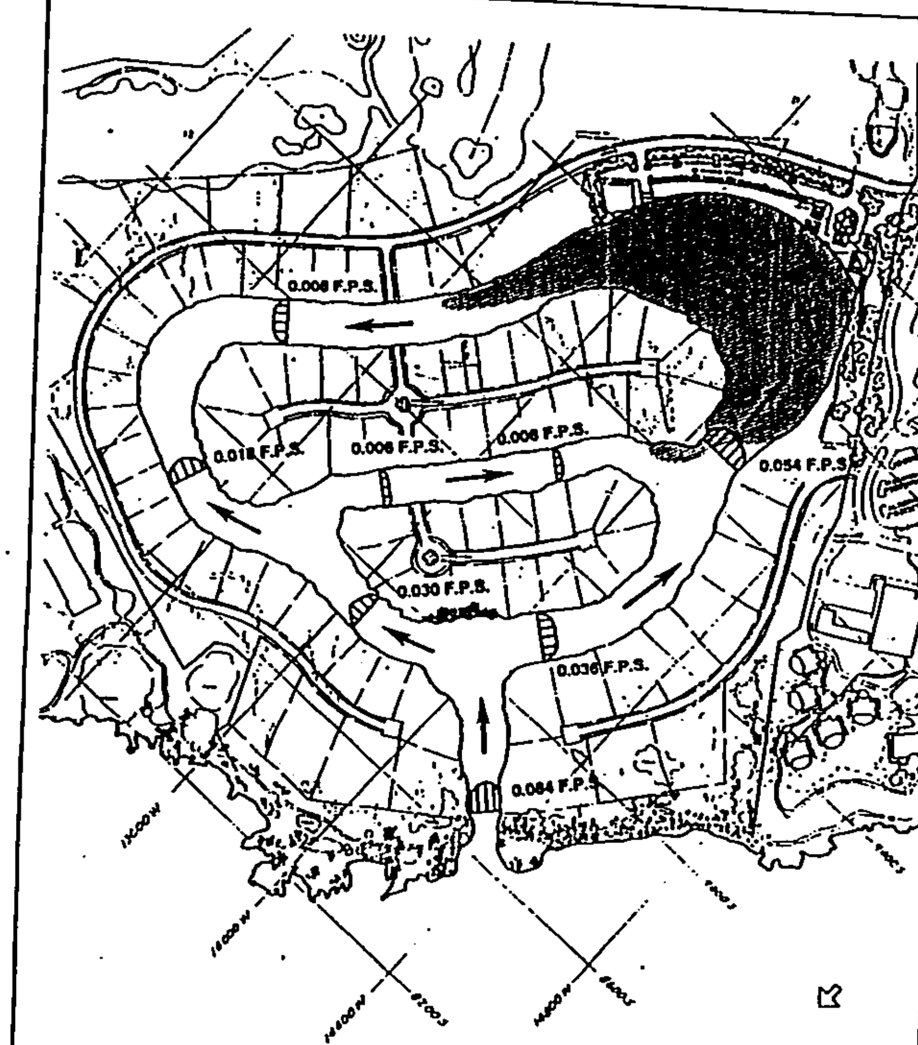


HYDRAULIC CONDITIONS

- 7 DISCHARGE PIPES EACH AT 2.54 CFS
- DISCHARGE PIPES AT TOP OF MOORING AREA
- DISCHARGE DURATION 6.25 HOURS
- RESERVOIR CAPACITY 400,000 CU. FT.
- PRE-EBB TIDE
- 3 FT WAVE HEIGHT, 6 SECOND PERIOD

HYDRO RESEARCH SCIENCE HRS

DRAWN BY VS	REFERENCES EPD 40		
APPROVED	DATE 8-8-90	SCALE NTS	
TITLE	VERIFICATION TEST #2 PRE-EBB FLOW PATTERN AND VELOCITY DISTRIBUTIONS		
HRS PROJECT NO 1424	FIGURE NO 31		

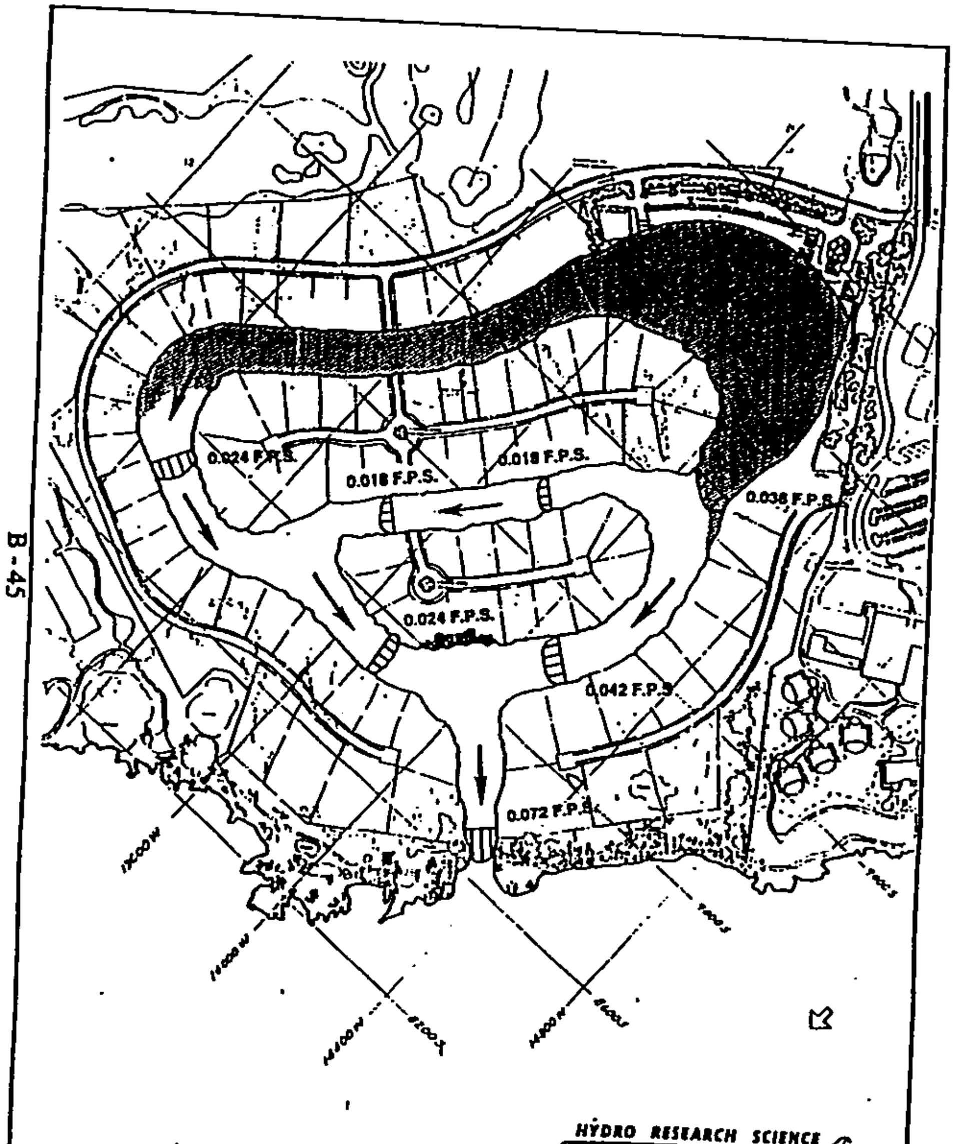


HYDRAULIC CONDITIONS

- FIRST FLOOD TIDE
- 3 FT WAVE HEIGHT, 6 SECOND PERIOD

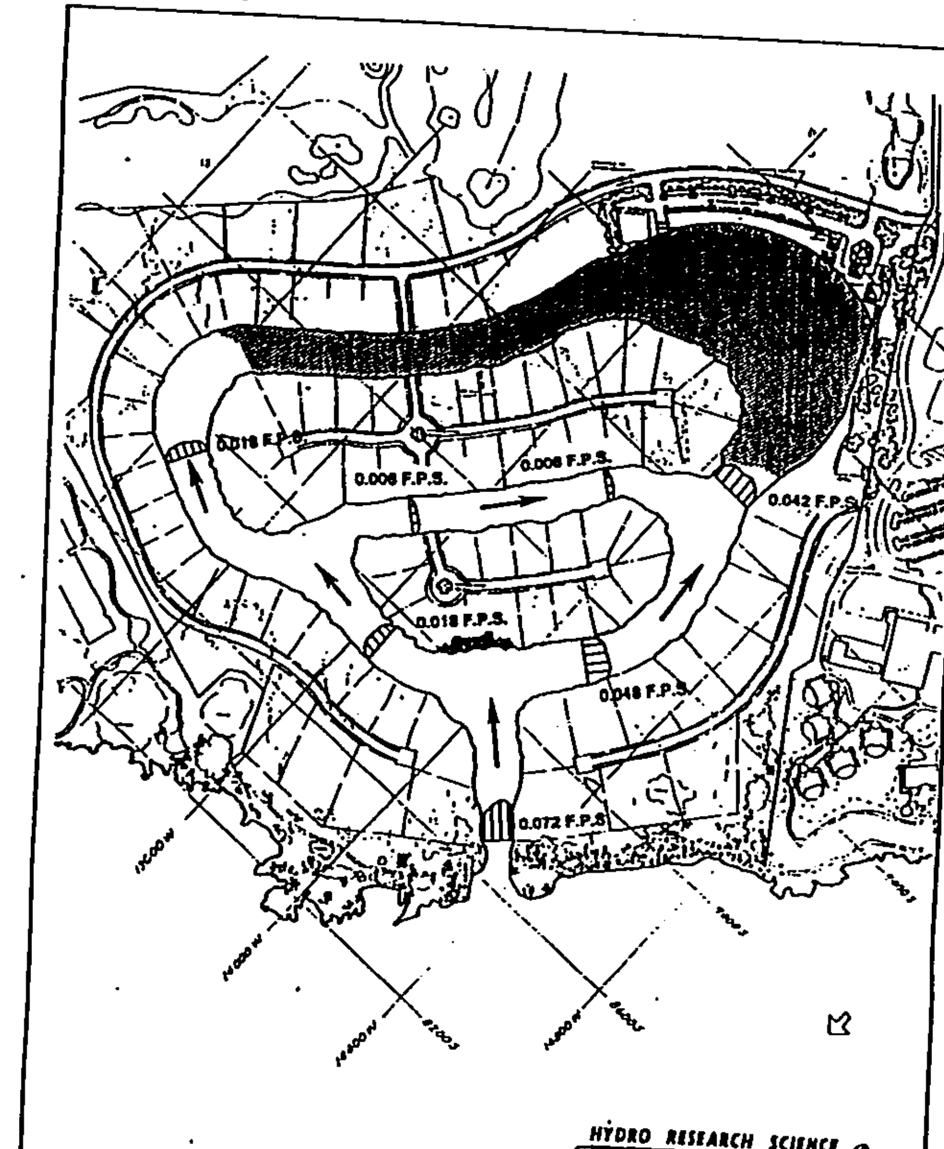
HYDRO RESEARCH SCIENCE HRS

DRAWN BY VS	REFERENCES EPD 40		
APPROVED	DATE 8-8-90	SCALE NTS	
TITLE	VERIFICATION TEST #2 FIRST FLOOD TIDE FLOW PATTERN AND VELOCITY DISTRIBUTION		
HRS PROJECT NO 1424	FIGURE NO 32		



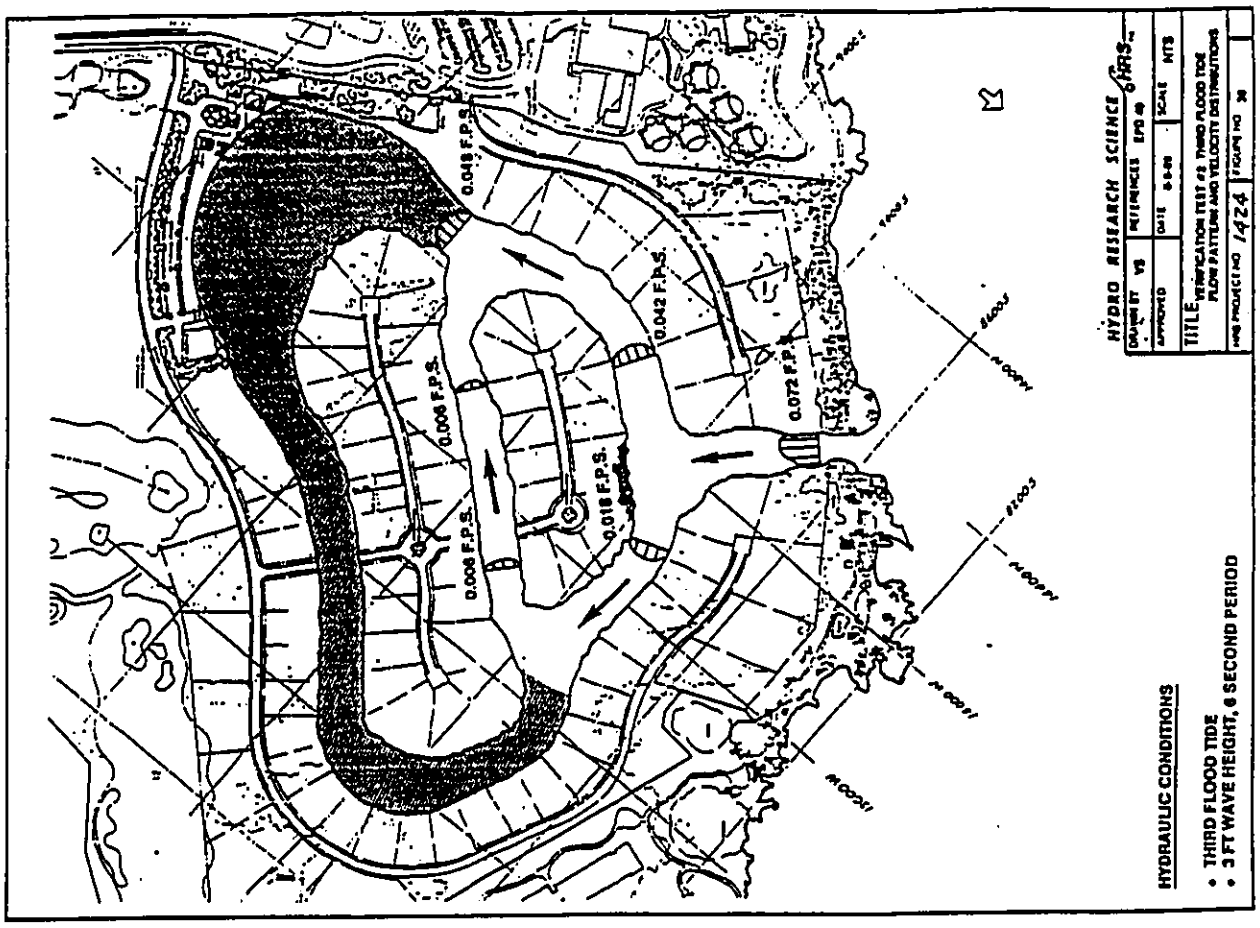
HYDRAULIC CONDITIONS

- FIRST EBB TIDE
- 3 FT WAVE HEIGHT, 8 SECOND PERIOD

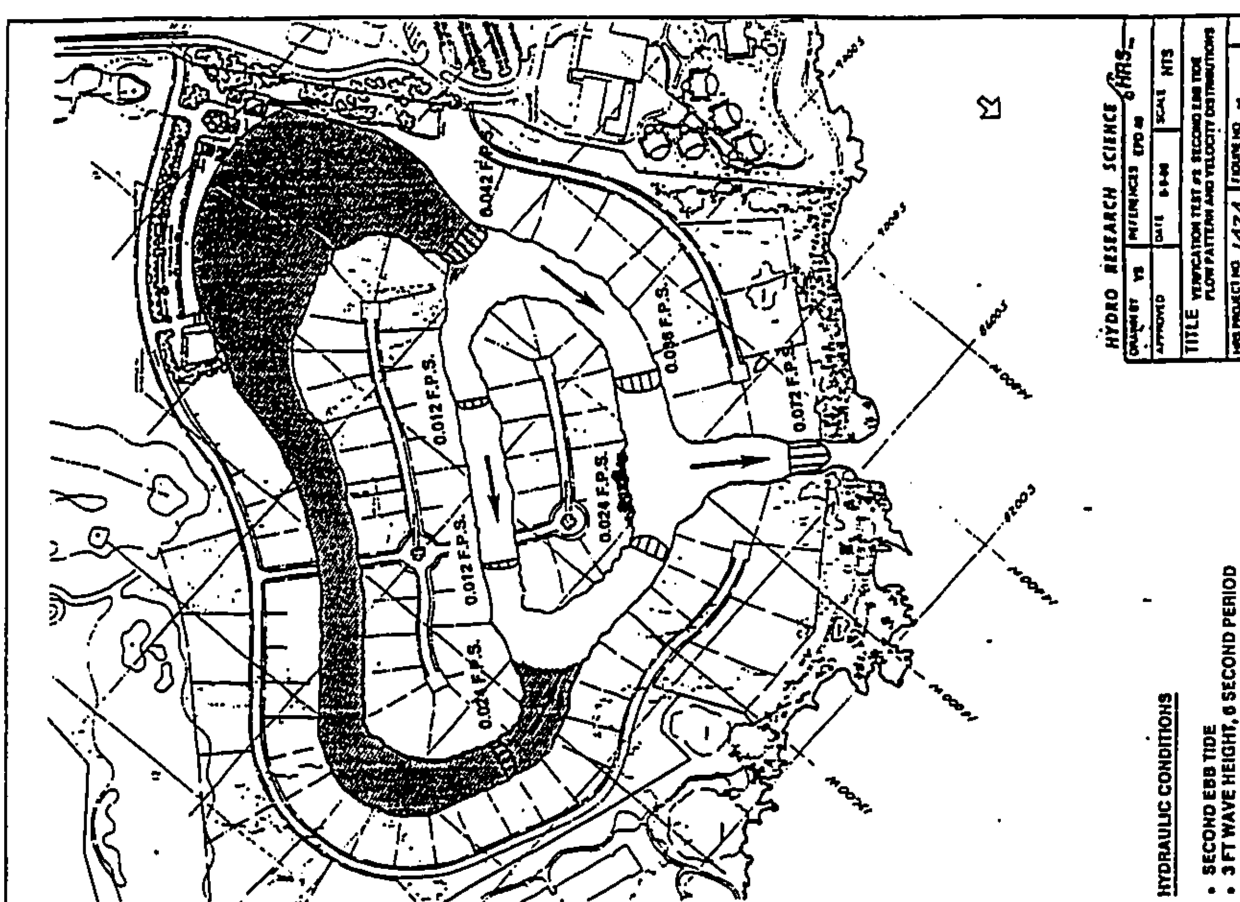


HYDRAULIC CONDITIONS

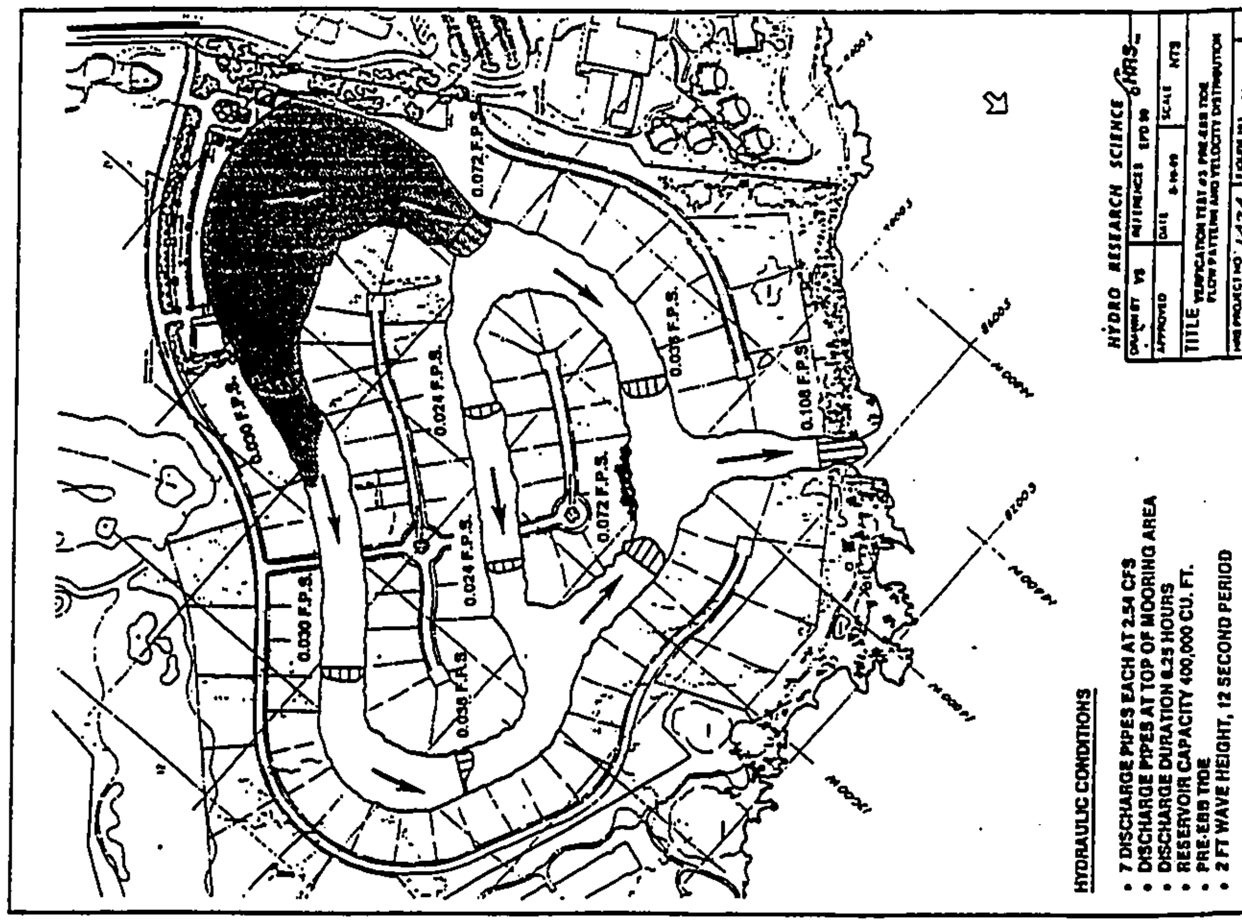
- SECOND FLOOD TIDE
- 3 FT WAVE HEIGHT, 8 SECOND PERIOD

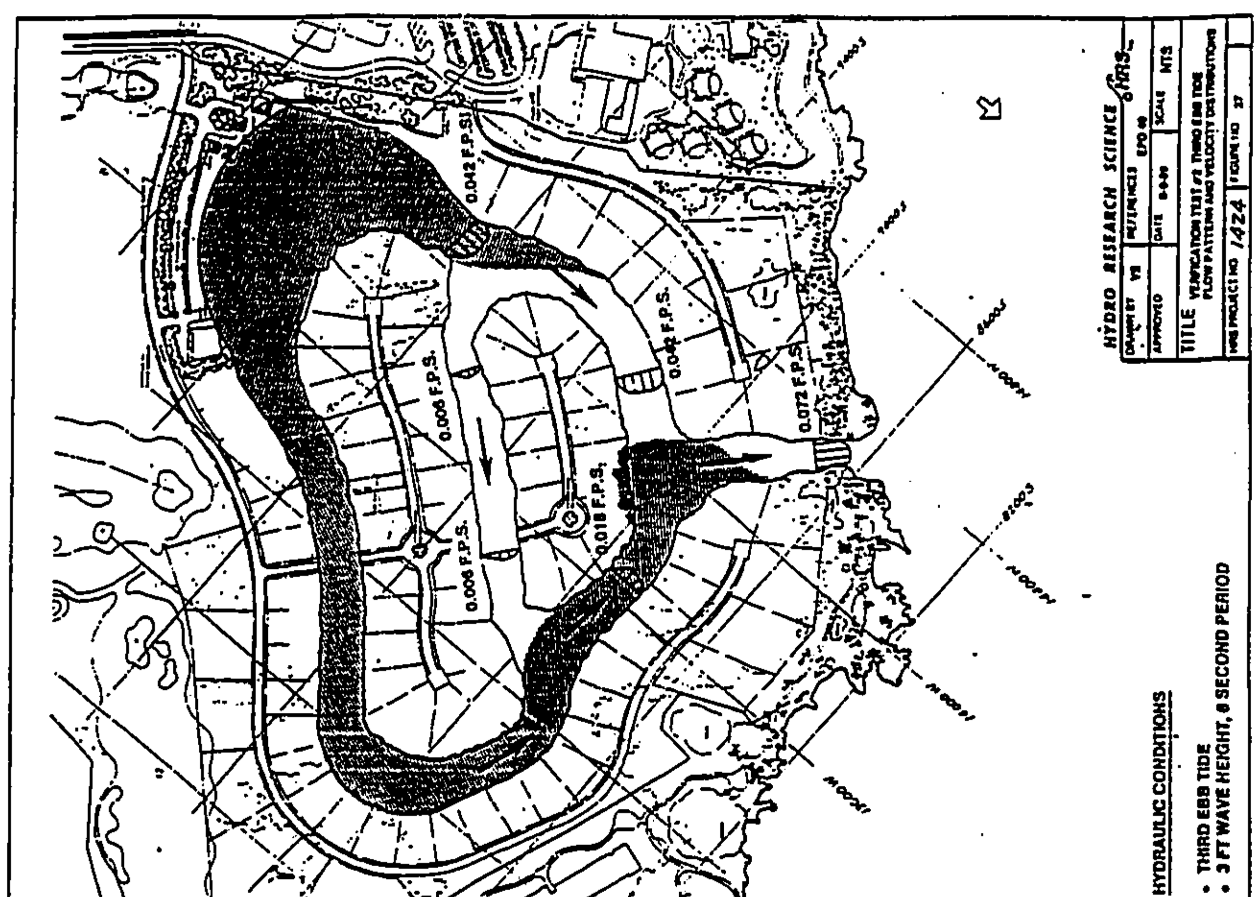


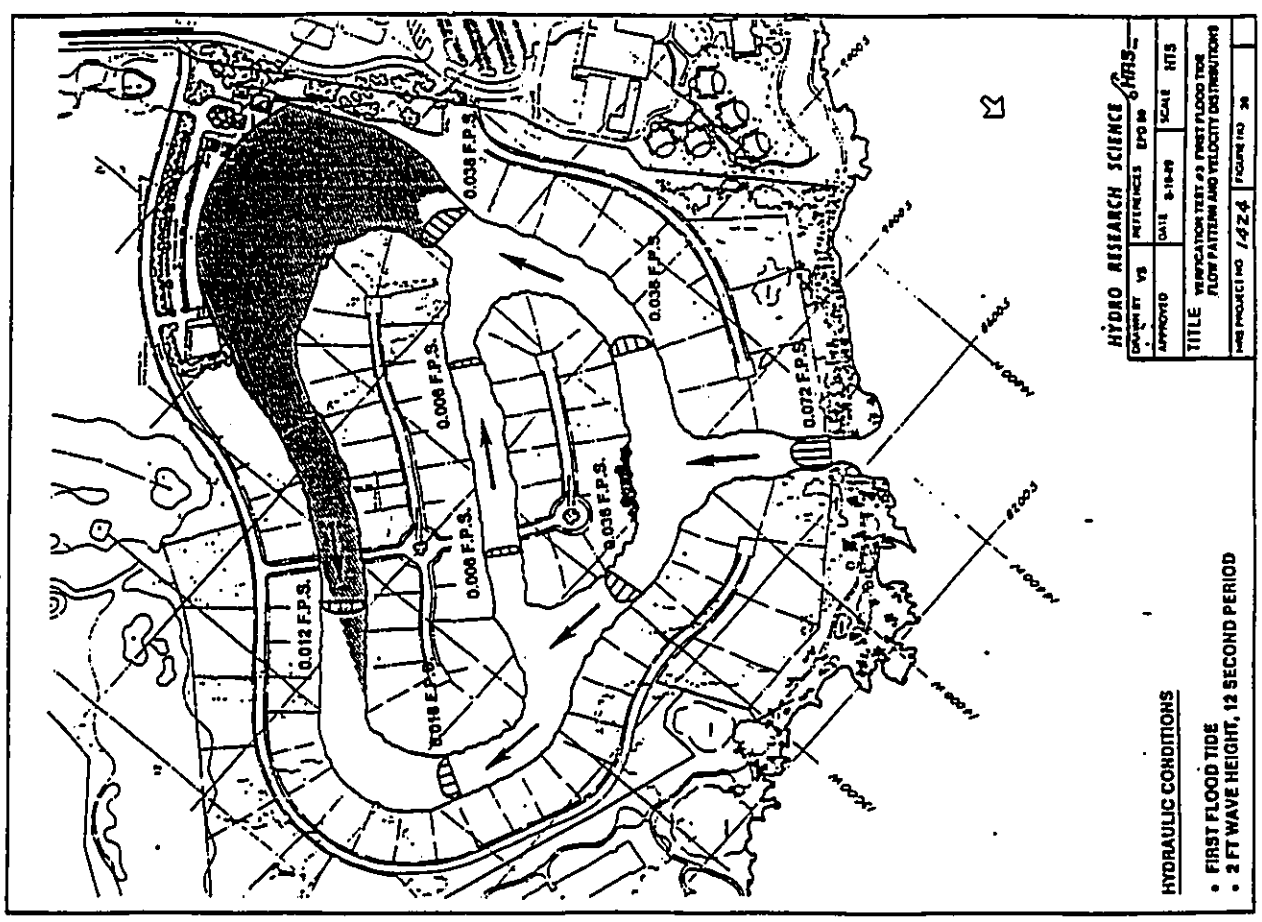
0.048 F.P.S.
0.042 F.P.S.
0.072 F.P.S.
0.006 F.P.S.
0.006 F.P.S.
0.018 F.P.S.
HYDRAULIC CONDITIONS
• THIRD FLOOD TIDE
• 3 FT WAVE HEIGHT, 6 SECOND PERIOD
HYDRO RESEARCH SCIENCE
HRS
TITLE
1424



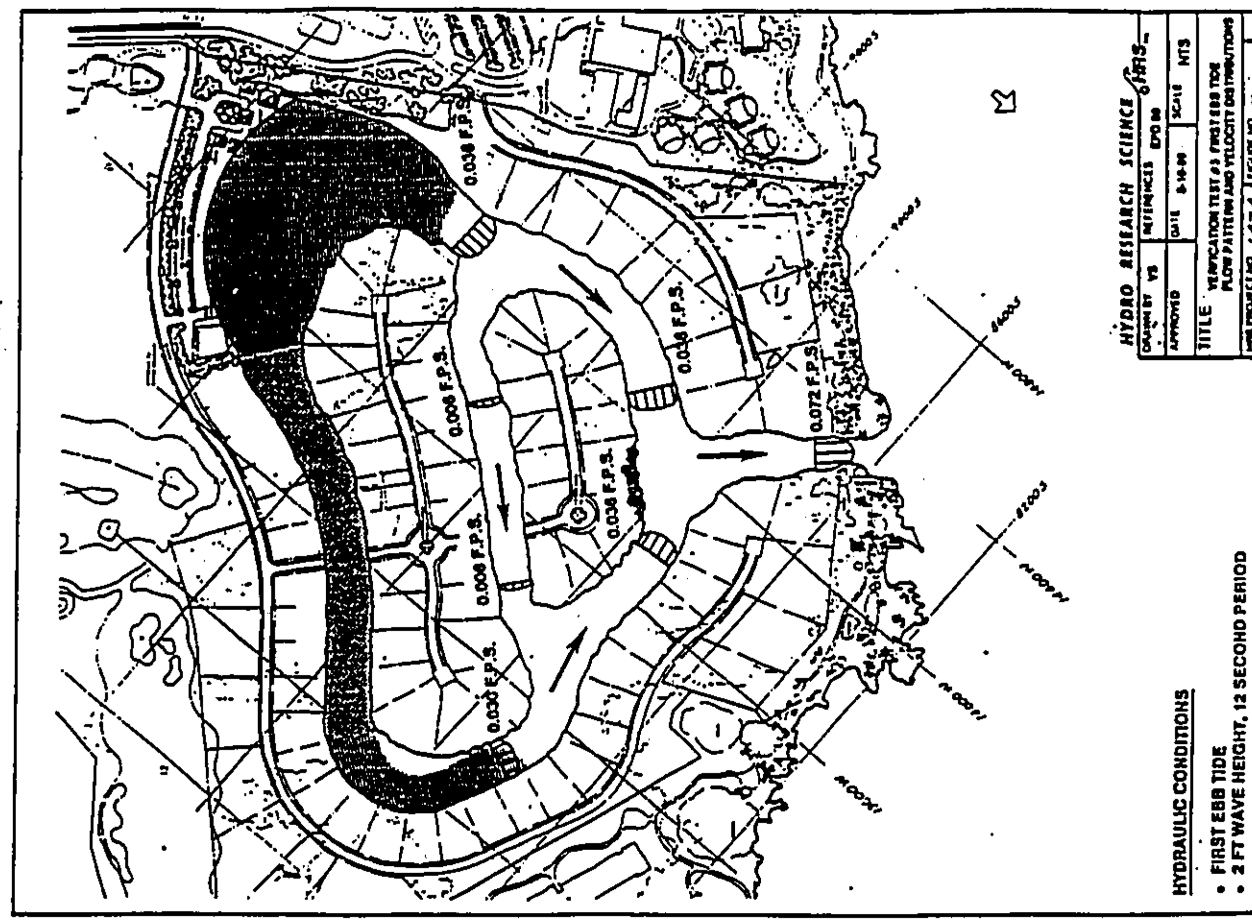
0.042 F.P.S.
0.036 F.P.S.
0.072 F.P.S.
0.012 F.P.S.
0.012 F.P.S.
0.024 F.P.S.
0.024 F.P.S.
HYDRAULIC CONDITIONS
• SECOND EBB TIDE
• 3 FT WAVE HEIGHT, 6 SECOND PERIOD
HYDRO RESEARCH SCIENCE
HRS
TITLE
1424


0.072 F.P.S.
0.030 F.P.S.
0.024 F.P.S.
0.036 F.P.S.
0.108 F.P.S.
0.030 F.P.S.
0.024 F.P.S.
0.072 F.P.S.
0.036 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
1424
HYDRAULIC CONDITIONS
• 7 DISCHARGE PIPES EACH AT 2.54 CFS
• DISCHARGE PIPES AT TOP OF MOORING AREA
• DISCHARGE DURATION 8.25 HOURS
• RESERVOIR CAPACITY 400,000 CU. FT.
• PRE-EBB TIDE
• 2 FT WAVE HEIGHT, 12 SECOND PERIOD

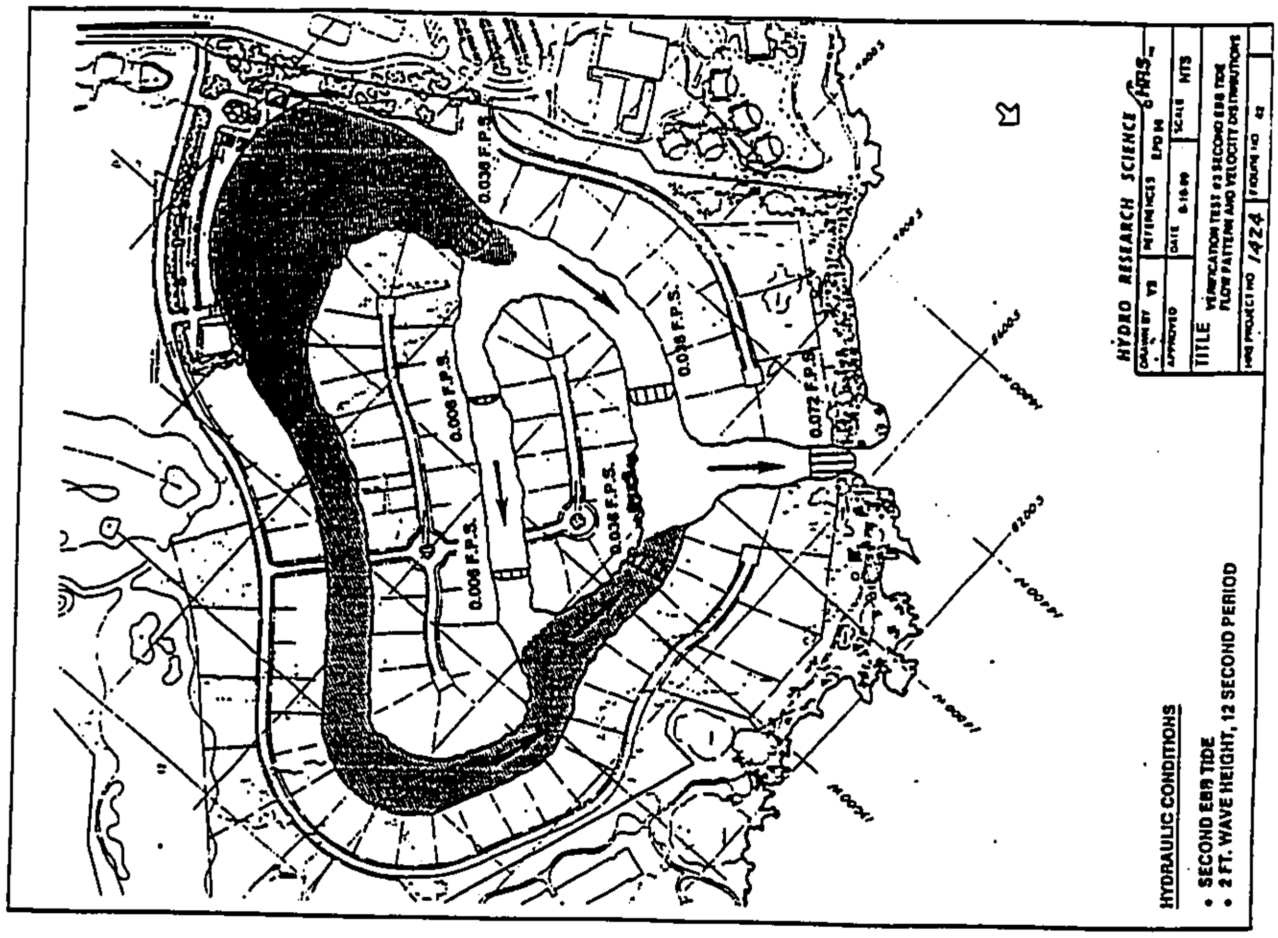

0.042 F.P.S.
0.042 F.P.S.
0.072 F.P.S.
0.006 F.P.S.
0.018 F.P.S.
0.006 F.P.S.
HYDRO RESEARCH SCIENCE
HRS
1424
HYDRAULIC CONDITIONS
• THIRD EBB TIDE
• 3 FT WAVE HEIGHT, 8 SECOND PERIOD

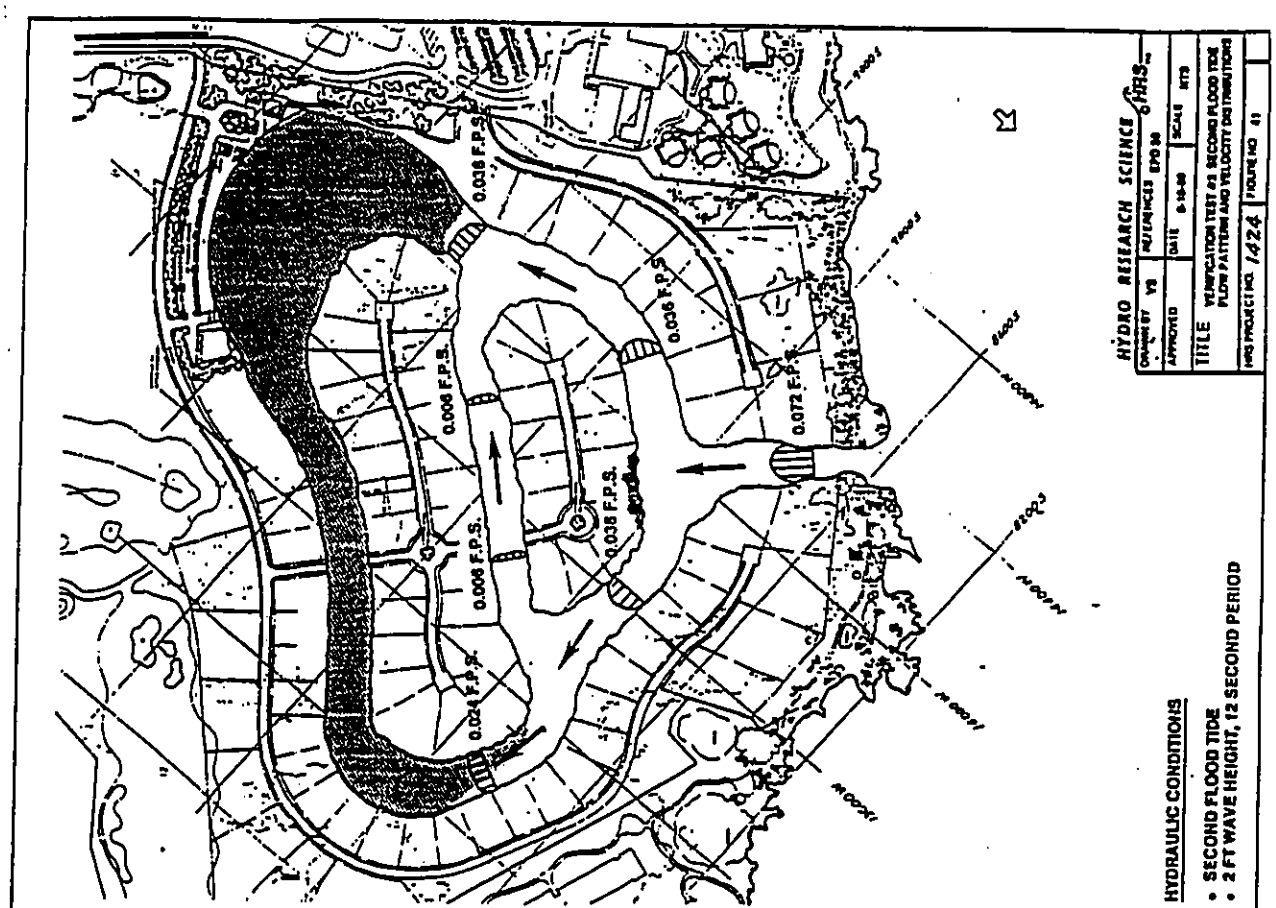


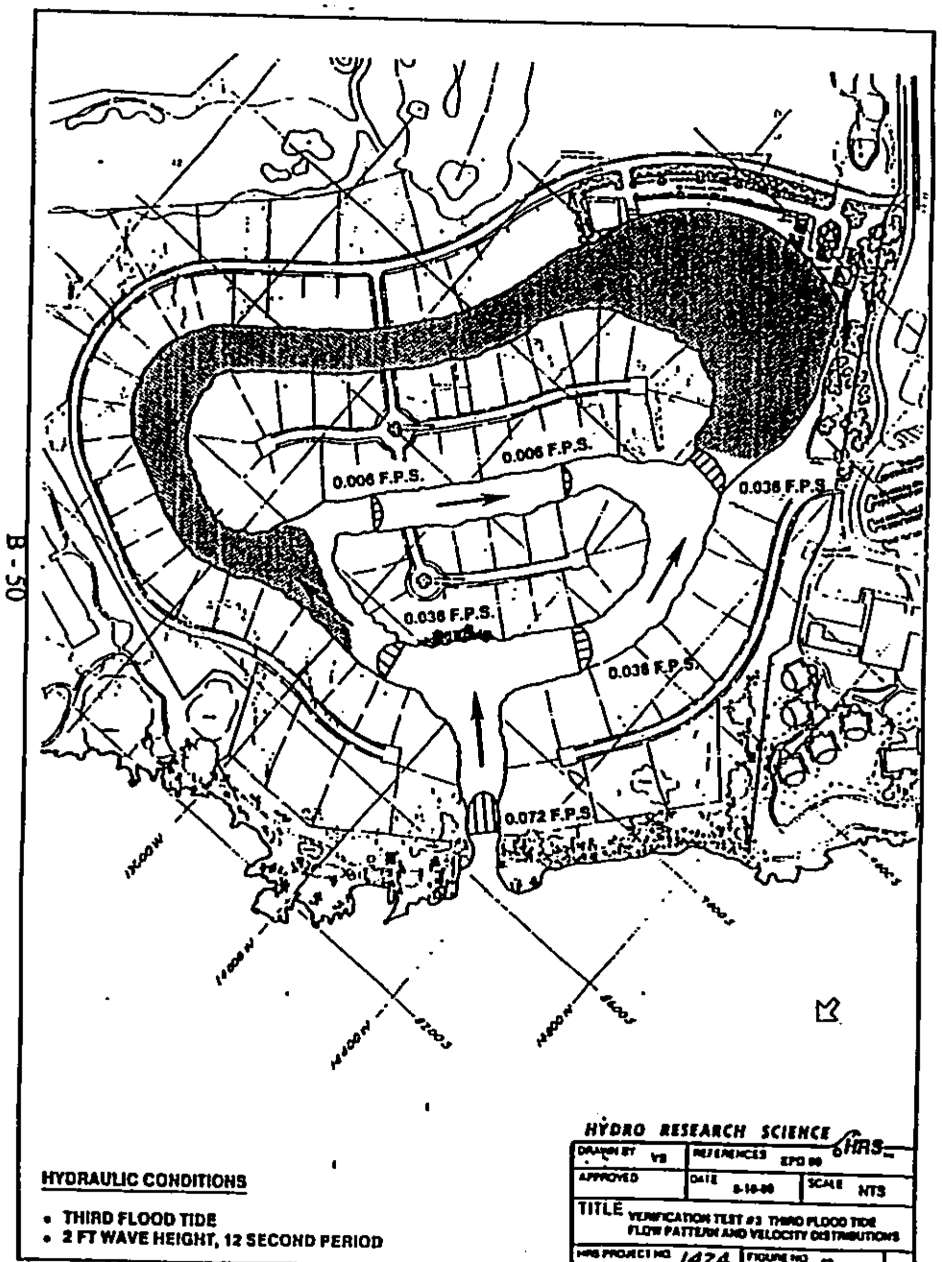
HYDRAULIC CONDITIONS
- FIRST FLOOD TIDE
- 2 FT WAVE HEIGHT, 12 SECOND PERIOD



HYDRAULIC CONDITIONS
- FIRST EBB TIDE
- 2 FT WAVE HEIGHT, 12 SECOND PERIOD

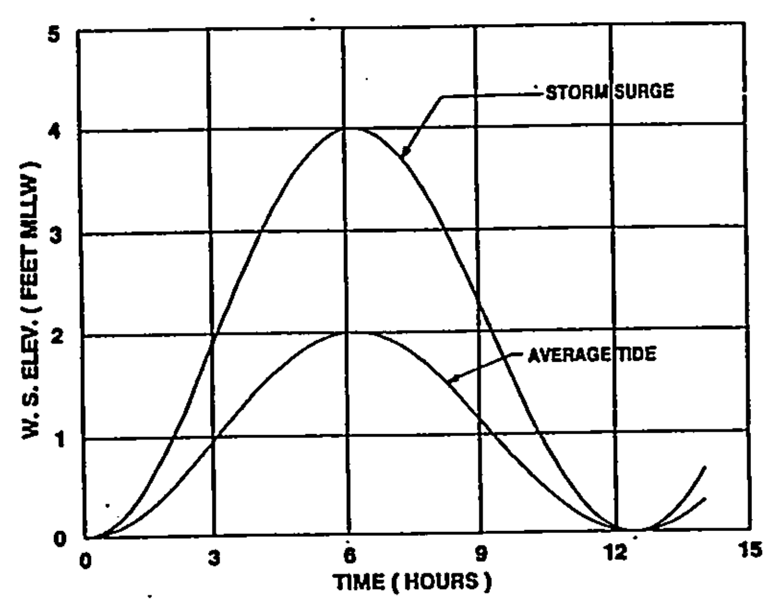

0.036 F.P.S.
0.006 F.P.S.
0.006 F.P.S.
0.038 F.P.S.
0.036 F.P.S.
0.072 F.P.S.
HYDRAULIC CONDITIONS
• SECOND EBB TIDE
• 2 FT. WAVE HEIGHT, 12 SECOND PERIOD
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY YS
REFERENCES EPD 90
APPROVED
DATE 6-19-90
SCALE NTS
TITLE VERIFICATION TEST #3 SECOND EBB TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 42


0.036 F.P.S.
0.006 F.P.S.
0.006 F.P.S.
0.024 F.P.S.
0.038 F.P.S.
0.036 F.P.S.
0.072 F.P.S.
HYDRAULIC CONDITIONS
• SECOND FLOOD TIDE
• 2 FT WAVE HEIGHT, 12 SECOND PERIOD
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY YS
REFERENCES EPD 90
APPROVED
DATE 6-19-90
SCALE NTS
TITLE VERIFICATION TEST #3 SECOND FLOOD TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 41


0.006 F.P.S.
0.006 F.P.S.
0.036 F.P.S.
0.036 F.P.S.
0.036 F.P.S.
0.072 F.P.S.
HYDRAULIC CONDITIONS
• THIRD FLOOD TIDE
• 2 FT WAVE HEIGHT, 12 SECOND PERIOD
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY VS
REFERENCES EPD 90
APPROVED
DATE 8-10-90
SCALE NTS
TITLE VERIFICATION TEST #3 THIRD FLOOD TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 43


0.006 F.P.S.
0.006 F.P.S.
0.036 F.P.S.
0.036 F.P.S.
0.072 F.P.S.
HYDRAULIC CONDITIONS
• THIRD EBB TIDE
• 2 FT WAVE HEIGHT, 12 SECOND PERIOD
HYDRO RESEARCH SCIENCE
HRS
DRAWN BY VS
REFERENCES EPD 90
APPROVED
DATE 8-10-90
SCALE NTS
TITLE VERIFICATION TEST #3 THIRD EBB TIDE FLOW PATTERN AND VELOCITY DISTRIBUTIONS
HRS PROJECT NO 1424
FIGURE NO 44

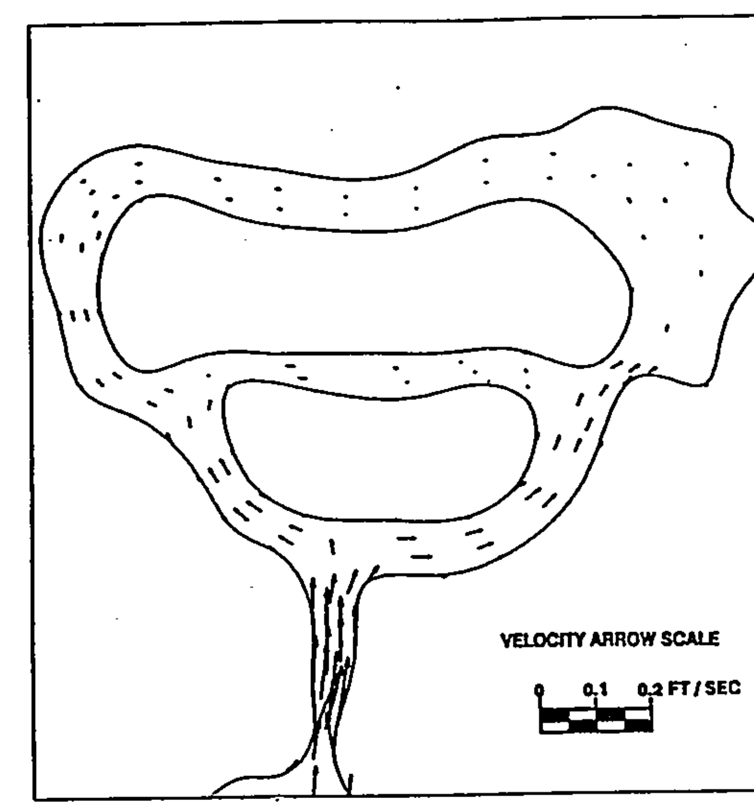
BOUNDARY CONDITIONS OF THE CHANGE IN W. S. ELEVATION FOR TESTS 1 AND 2



HYDRO RESEARCH SCIENCE HRS

DRAWN BY MV	REFERENCES		
APPROVED	DATE 9-5-89	SCALE NTS	
TITLE BOUNDARY CONDITIONS OF THE CHANGE IN W.S. ELEVATION FOR TESTS 1 AND 2			
HRS PROJECT NO. 1424	FIGURE NO. 45		

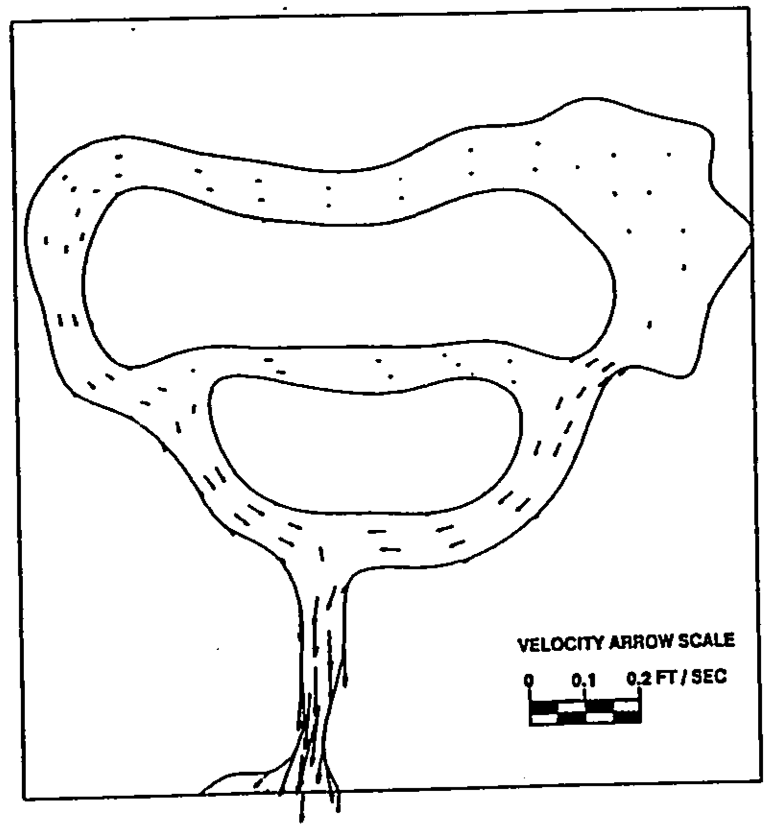
TEST 1 : FLOW PATTERN IN THE MIDDLE OF FLOOD TIDE



HYDRO RESEARCH SCIENCE HRS

DRAWN BY MV	REFERENCES		
APPROVED	DATE 9-5-89	SCALE NTS	
TITLE TEST 1 : FLOOD TIDE IN THE MIDDLE OF FLOOD TIDE			
HRS PROJECT NO. 1424	FIGURE NO. 46		

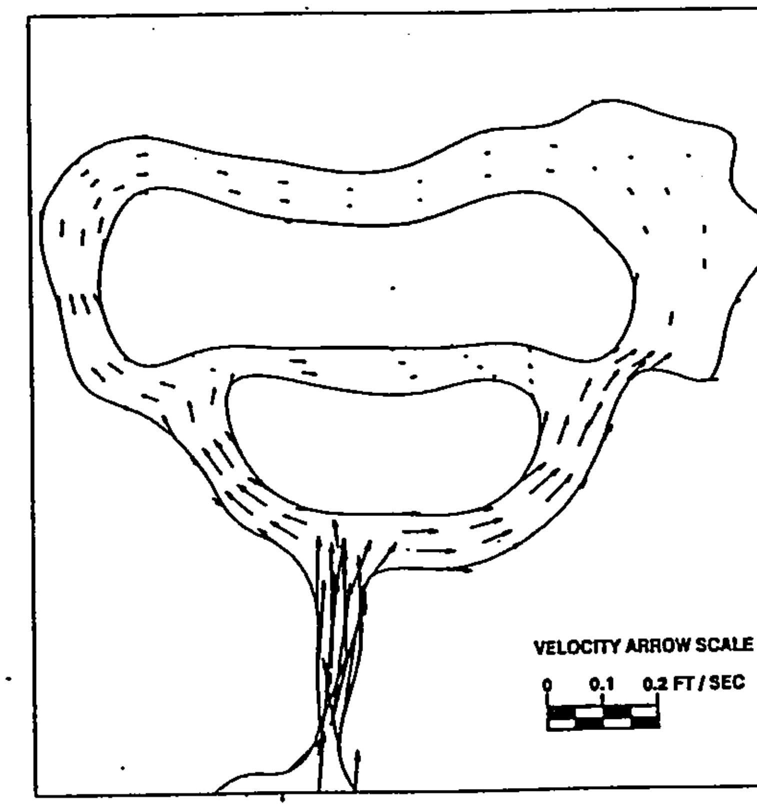
TEST 1 : FLOW PATTERN IN THE MIDDLE OF EBB TIDE



HYDRO RESEARCH SCIENCE HRS

DRAWN BY MV	REFERENCES	
APPROVED	DATE 9-5-89	SCALE NTS
TITLE TEST 1 : FLOW PATTERN IN THE MIDDLE OF EBB TIDE		
HRS PROJECT NO. 1424	FIGURE NO. 47	

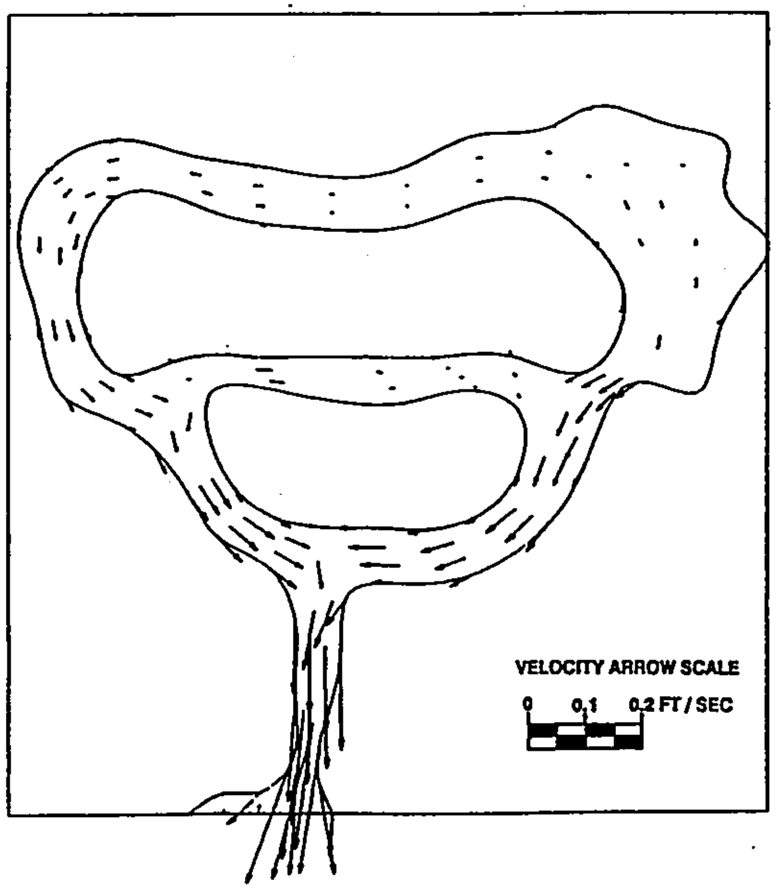
TEST 2 : FLOOD PATTERN IN THE MIDDLE OF FLOOD TIDE



HYDRO RESEARCH SCIENCE HRS

DRAWN BY MV	REFERENCES	
APPROVED	DATE 9-5-89	SCALE NTS
TITLE TEST 2 : FLOOD PATTERN IN THE MIDDLE OF FLOOD TIDE		
HRS PROJECT NO. 1424	FIGURE NO. 48	

TEST 2 : FLOW PATTERN IN THE MIDDLE OF EBB TIDE



HYDRO RESEARCH SCIENCE HRS

DRAWN BY MV	REFERENCES		
APPROVED	DATE 9-5-89	SCALE NTS	
TITLE TEST 2: FLOW PATTERN IN THE MIDDLE OF EBB TIDE			
HRS PROJECT NO. 1424	FIGURE NO. 49		

5.0 NUMERICAL MODEL STUDY

5.1 INTRODUCTION

5.1.1 GENERAL

5.1.1.1 Scope and Objective of Numerical Model Study

This section of the report describes the development and the simulation results of the numerical model study of the Mauna Lani Marina. The numerical study was performed to evaluate the flow pattern and the water levels at various locations inside the marina, under both average tide and hurricane storm surge condition using existing numerical programs.

5.1.1.2 Content

This section of the numerical model study is divided into the following four parts:

- INTRODUCTION
- NUMERICAL MODELS
- SIMULATIONS AND RESULTS
- SUMMARY AND CONCLUSION

5.1.1.3 Sources of Information

General information about the project area and the marina under study was supplied to HRS by Peratrovich, Nottingham & Drage. HRS also compiled a list of references and reviewed reports prepared by other consultants. These materials were used extensively for the development of the input files for the numerical models. A partial listing of the reference materials is presented at the end of the report.

5.1.2 DESCRIPTION OF THE STUDY

5.1.2.1 Layout

The Mauna Lani Marina is part of the Mauna Lani Resort development on the island of Hawaii. This marina will provide a mooring port for the pleasure boats in the vicinity of the project site.

5.1.2.2 Problem Defined

Estimation of the storm surge level inside the marina is one of the major concerns of land development along the banks of the waterways. The flooding potential of the waterfront properties can be evaluated by computing the surge level of past major hurricane storms. In addition, results obtained for average tide conditions can verify the results obtained from the physical model.

5.1.2.3 Marina Configuration

The preliminary design configuration was chosen for the numerical model study by HRS in consultation with Client. The results of this numerical model study should also be applicable to the final configuration selected by Client in the physical model study, because the two configurations are very similar except for the shape of the perimeter at the mooring area.

5.1.2.4 Hydraulic Conditions

The following hydraulic conditions were used for the numerical model study of the Mauna Lani Marina:

- Average Tide: A harmonic tide condition of 2 ft change in water surface elevation was adopted to be the average tide, similar to that investigated in the physical model testing. The shape of the harmonic tide motion followed that of a sine curve, with the crest water surface elevation at +2 ft MLLW and trough elevation at 0 ft MLLW, and a period of 12.5 hours. The average tide is illustrated in Figure 45.
- Storm Surge: A harmonic change in water surface elevation of 4 ft was adopted to be the storm surge condition. The shape of the harmonic surge motion followed that of a sine curve, with the crest water surface elevation at +4 ft MLLW and trough elevation at 0 ft MLLW. The duration of the storm surge was 12.5 hours. This storm surge information was extracted from an analysis of a report written by SEA concerning the hurricane wave climate offshore of the project site (Reference 10). The report indicated that the historical maximum water level setup due to hurricane wind and Coriolis force was approximately 2 ft. The approximate storm surge duration was 12 hours, with the peak surge occurring near the middle of the duration. The worst scenario will then be the super-imposition of this setup in phase with the normal tide, which produced the storm surge used in the following simulation. The storm surge boundary condition is illustrated in Figure 45.

- Note that setup due to wave action in shallow areas was not included in the computations. The wave setup will depend on the incoming wave climates. The effect of the wave setup would be to increase the mean water levels at various locations inside the marina. The magnitude of the setup in relation to different wave climate can be estimated from the physical model test results in Table 3.

5.2 NUMERICAL MODELS

5.2.1 GENERAL DESCRIPTIONS

Three numerical models were used in this study. The first program was a one-dimensional unsteady flow numerical model, UNSTEAD-100, developed by HRS. The program was used to transfer offshore information to the entrance boundary conditions. It was also used to perform a one-dimensional analysis of the time-varying velocities at the entrance. However, it was unable to compute the flow characteristics inside the marina due to the one-dimensional analysis limitation. Another program, named SURGE, adopted by the Federal Emergency Management Association for flood insurance studies, was studied in order to apply it to the marina conditions. The result was unsatisfactory because the program structure was implicitly developed for a large scale analysis. The program could not be applied effectively to the relatively small marina configuration. Finally, a program called TEA, developed by Massachusett Institute of Technology, was applied successfully to the current configuration. The TEA program is described in section 5.2.3 below.

5.2.2 UNSTEAD-100 NUMERICAL MODEL

The UNSTEAD-100 Numerical Model was developed by HRS for unsteady flow simulations. The model adopted the formulation of the one- dimensional Saint-Venant equation. The model can be applied to a variety of situations, including computation of flood wave translation in open channel flow. In this study, UNSTEAD-100 was used as a numerical tool to correlate boundary conditions offshore of the marina entrance. This procedure was intended to eliminate the offshore area from the two-dimensional numerical computation described below. Offshore flow patterns were not of key interest in this study, and eliminating the offshore area drastically reduced the effort needed for numerical computation.

5.2.3 TEA Model

The TEA program is a two-dimensional numerical program which analyzes the flow characteristics in frequency domains using the finite element technique. It is an effective program for the two-dimensional computation of flow patterns in a small-scale confined area. A detailed description of the program is documented in Reference 12.

5.3 TESTS AND RESULTS

5.3.1 SCOPE OF THE STUDY PROGRAM

5.3.1.1 Purpose of the Study

The purpose of the study was to evaluate flow patterns and water levels at various locations inside the marina, under both average tide and hurricane storm surge conditions.

5.3.1.2 Liaison with the Client

Close liaison was maintained with the Client during the course of the study through telephonic communications and meetings at the HRS facility. The plan of the study and the conditions for numerical simulations were selected by HRS and approved by the Client.

5.3.2 TEST PROGRAM

5.3.2.1 Scope of the Tests

Two simulation tests were performed in this study. Test 1 computed the flow pattern and the water surface elevations inside the marina for average tide, while Test 2 evaluated the storm surge condition.

5.3.2.2 Hydraulic Conditions Investigated

The tide setting for both tests was established using an offshore boundary condition at a water depth of approximately 130 ft. The hydraulic conditions of the average tide and the storm surge are discribed in Section 5.1.2.4.

5.3.2.3 Computation Procedures

The numerical computation process followed the procedures below :

- Using the HRS developed UNSTEAD-100 numerical program, the boundary conditions at the offshore were transferred to the entrance of the marina. This was done in order to minimize the computational effort required to calculate the offshore velocity field.
- A two-dimensional finite element grid system was established to encompass the entire channel network inside the marina. The distance between the grid points was in the order of 100 ft.
- An input file with the information of the grid system and the boundary conditions at the marina entrance was prepared.
- The numerical program TEA was executed to obtain an output file containing the numerical values of the resulting water surface elevations and velocities.
- The output information was processed using a CAD (Computer-Aided Design) system to produce a graphical representation of the velocity distribution in the marina.

5.3.2.4 Summary of Tests 1 and 2

Test flow patterns at the midpoint of flood and ebb tide are illustrated in Figures 46 to 49. Both tests indicated a similar flow pattern. The magnitude of the velocities in Test 2 was roughly twice as that of Test 1, in proportion with the surface water elevation change difference between the two tests. The results also indicated some low velocity areas along the back channel and in the mooring area.

The flow pattern and magnitude of velocities in Test 1 are similar to the physical model base test results. This established the validity of the findings in both the physical and the numerical model.

The tidal response for both tests was similar. Both the differences in surge height and the response phase lag were negligible. For the average tide, the water level at any location inside the marina changed almost simultaneously with the tide, and the peak water surface elevation was +2 ft MLLW while the trough was at 0 ft MLLW. Similarly, for the storm surge test, the water level at any location inside the marina rose to +4 ft MLLW and dropped back to 0 ft MLLW almost simultaneously with the offshore storm surge.

The negligible phase lags for the elevation differnces were in congruence with the physical model results. The traveling time for the surge wave to reach the marina entrance from the offshore boundary was small due to the short distance between the offshore boundary and the entrance as compared to the surge wave length. Once the surge wave penetrated the entrance, it was able to quickly reach the back channel with the least demodulation due to the small size of the marina. This resulted in the minimal phase lag in the numerical computation.

5.4 SUMMARY AND CONCLUSION

A two dimensional finite element numerical model was successfully applied to the marina to compute the change in water surface elevation and the flow patterns under the imposed offshore boundary condition of average tide and storm surge.

The following conclusions can be drawn from the results of the two tests:

- The water level inside the marina responded closely to the off-shore storm surge, with the change in surface elevation almost equal to the imposed offshore surge height.
- Numerical model results were consistent with the physical model findings.

6.0 REFERENCES

1. Drawing of the Hydrographic Survey of Panoa Bay, drawn April 10, 1989 by R. M. Towill Corporation, submitted by Peratrovich, Nottingham and Drage to HRS on April 21, 1989.

2. Drawing of the Concept of Mauna Lani Bridges Sheet 1 and 2, drawn October 1988 by Peratrovich, Nottingham & Drage, received by HRS on May 1, 1989.

3. Drawing of the Mauna Lani Marina Preliminary Design Plan, undated, from Peratrovich, Nottingham & Drage, received by HRS on April 24, 1989.

4. Drawing of the existing topography at the project site, undated, from Peratrovich, Nottingham & Drage, received by HRS on April 21, 1989.

5. Fax drawings of the proposed offshore entrance channel and the layout of the marina channels for construction, drawn May 3, 1989 by Peratrovich, Nottingham & Drage, received by HRS on May 3, 1989.

6. Fax drawings of the revised section for modeling channels and the wave directions for model set-up, drawn May 5, 1989 by Peratrovich, Nottingham & Drage, received by HRS on May 5, 1989.

7. Fax drawing of the marina chart at the project site, from Peratrovich, Nottingham & Drage, received by HRS on May 4, 1989.

8. "Deep water wave climate summary for the Mauna Lani Resort, Island of Hawaii" by Sea Engineering, Inc. dated April 1989, and submitted by Peratrovich, Nottingham & Drage to HRS on April 1989.

9. "Interim data report: nearshore wave and current measurements for the Mauna Lani Resort, North Kona, Hawaii" by Sea Engineering, Inc. dated May 1989, submitted by Peratrovich, Nottingham & Drage to HRS on May 1989.

10. "Hurricane Vulnerability Study for Kauai Poipu and Vicinity: Storm Wave Runup and Inundation" by Sea Engineering, Inc. and C.L. Bretschneider dated January 1986, submitted by Peratrovich, Nottingham & Drage to HRS on May 1989.

11. "Coastal flooding hurricane storm surge model manual vol. 1, 2 and 3" dated June 1985 by Federal Emergency Management Agency.

12. "TEA: A linear frequency domain finite element model for tidal embayment analysis" by J.J. Westerink, J.J. Connor, K.D. Stolzenbach, E.E. Adams and A.M. Baptista, Massachusetts Institute of Technology Energy Laboratory Report No. MIT-EL 84-012, February 1984.

APPENDIX C

TSUNAMI WAVE MODELING FOR MAUNA LANI COVE

TSUNAMI WAVE MODELING

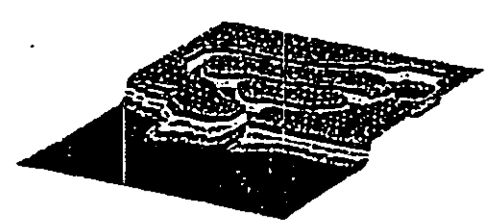
For

MAUNI LANI COVE

Island of Hawaii

Prepared by
MADER CONSULTING CO.
1049 Kamehame Drive
Honolulu, HI 96825

October 1989



TSUNAMI WAVE MODELING FOR MAUNI LANI COVE

Introduction

The proposed Mauna Lani Cove on the South Kohala Coast on the Island of Hawaii will have an entrance exposed to tsunami waves. The largest recorded inundation from a tsunami in the region of the project site is 11 feet. It occurred near Kiholo on April 1, 1946. The Flood Insurance Rate Map (FIRM) for the area and the 1982 Flood Insurance Study for the County of Hawaii, indicate that the 100-year tsunami elevation level of the project area ranges from seven to eight feet. Recent evaluation of the tsunami evacuation zone for the area by the Joint Institute for Marine and Atmospheric Research (JIMAR) of the University of Hawaii [1] recommends a 200-year tsunami evacuation height contour of 10 feet, which is about 400 feet inland in the project area. These studies do not address the effect of a tsunami on the cove so it was decided to perform numerical modeling of the effect of reasonably authentic worst-case tsunamis to determine the tsunami inundation at selected points in the cove and marina.

Tsunami Hazard Evaluation

The magnitude of the tsunami hazard at any land site depends on the expected extent of inundation of the land by tsunamis at the site, expected water depths and velocities within the inundation zone, and the exposure of persons and property within the potential inundation zone. There is no definite upper limit to the power of tsunamis approaching a coastal site. Tsunami hazard must be expressed in terms of expected average recurrence intervals or frequencies. What is expected in the future can be judged only on the basis of what has occurred in the past. The power of tsunamis that have approached the coast can be estimated from the extend of inundation and the runup heights on land. All estimates of tsunami hazard are site-specific and based on runup heights of historic tsunamis.

In the last decade procedures have been developed and applied for flood insurance purposes by the U. S. Army Corps of Engineers [2]. These procedures built upon historical wave height data compiled at the University of Hawaii and utilized a numerical model to synthesize the maximum tsunami wave crest as a function of frequency of occurence. This information was used to develop the inundation maps as part of a National flood insurance program.

The resulting highly synthesized wave heights from the flood insurance program with additional historical inputs provide reasonably authentic worst-case tsunami wave heights as a function of frequency of occurence. Usually the wave heights fall within the envelope of the 1946, 1957 and 1960 tsunami events. To determine the tsunami evacuation zones the wave is then "runup" on the shore at selected points using a one-dimensional model described by Bretschneider and Wybo in reference 3 and Cox in reference 4. Critical factors in the inundation calculation

include accurate topographic information and surface roughness. A contour line is drawn between points thus generated, representing the maximum probable inundation. Where possible it is compared with historical inundation information, flood insurance map lines and adjusted if warranted.

For the project area the 200-year tsunami wave height 200 feet inland was estimated by Curtis and Smaalders to be 10 feet using the techniques described. This corresponds to a wave height of about 8.5 feet above mean sea level at the shoreline and a wave height of 8.1 feet in 30 feet of water. This results in a wave amplitude (peak to trough) of 16.2 feet which is expected to occur once in every 200 years or has a 0.5 percent chance of being equalled or exceeded this year or any other year. Such a wave will result in 10 feet inundation at the undeveloped project area using the standard one-dimensional runup model for a surface roughness Manning "n" of 0.0325.

The surface roughness for typical Hawaiian terrain is described in reference 2 and 5. A Manning "n" of 0.0325 corresponds to a roughness characteristic of lava and grass with isolated trees. An "n" of 0.04 corresponds to many trees, boulders and high grass. The maximum inundation changes by only 30 feet out of 400 over this range of the roughness parameter in the project area.

Roughness in the numerical model in the *SWAN* code is described using the De Chezy friction model. The De Chezy coefficient depends not only on the bed roughness but also on the depth. The De Chezy coefficient is related to the Manning "n" by the depth to the 1/6 power. While not directly comparable, for the depths in the project area a De Chezy friction constant of 50 results in about the same friction effect as a Manning "n" in the 0.03-0.04 range.

The Numerical Model

The tsunami waves and their interaction with the local ocean topography and the cove were numerically modeled using the *SWAN* code which solves the shallow water long wave equations. It is described in detail in the monograph *Numerical Modeling of Water Waves* [6].

The long wave equations solved by the *SWAN* code are

$$\frac{\partial U_x}{\partial t} + U_x \frac{\partial U_x}{\partial x} + U_y \frac{\partial U_x}{\partial y} + g \frac{\partial H}{\partial x} = F U_y + F^{(x)} - g \frac{U_x (U_x^2 + U_y^2)^{1/2}}{C^2 (D + H - R)},$$

$$\frac{\partial U_y}{\partial t} + U_x \frac{\partial U_y}{\partial x} + U_y \frac{\partial U_y}{\partial y} + g \frac{\partial H}{\partial y} = -F U_x + F^{(y)} - g \frac{U_y (U_x^2 + U_y^2)^{1/2}}{C^2 (D + H - R)},$$

and

$$\frac{\partial H}{\partial t} + \frac{\partial (D + H - R) U_x}{\partial x} + \frac{\partial (D + H - R) U_y}{\partial y} - \frac{\partial R}{\partial t} = 0,$$

where

U_x = velocity in x direction (i index)
U_y = velocity in y direction (j index)
g = gravitational acceleration (9.8 m $\sec^{-2}$)
t = time
H = wave height above mean water level
R = bottom motion
F = Coriolis parameter
C = coefficient of De Chezy for bottom stress
$F^{(x)}, F^{(y)}$ = forcing functions of wind stress and barometric pressure in x and y direction
D = depth.

As described in the monograph, the *SWAN* code has been used to study the interaction of tsunami waves with continental slopes, shelves, bays and harbors such as Hilo harbor.

The *SWAN* code has been used to study the interaction of tsunami waves with continental slopes and shelves, as described in reference 7. Comparison with two-dimensional Navier-Stokes calculations of the same problems showed similar results, except for short wavelength tsunamis.

The *SWAN* code was used to model the effects of tides on the Musi-Upang estuaries, South Sumatra, Indonesia, by Safwan Hadi.[8] The computed tide and water discharge were in good agreement with experimental data.

The *SWAN* code was used to model the large waves that were observed to occur inside Waianae harbor under high surf conditions in reference 9. These waves have broken moorings of boats and sent waves up the boat-loading ramps into the parking lot. The numerical model was able to reproduce actual wave measurements. The *SWAN* code was used to evaluate various proposals for decreasing the amplitude of the waves inside the harbor. From the calculated results, it was determined that a significant decrease of the waves inside the harbor could be achieved by decreasing the harbor entrance depth. Engineering companies used these results to support their recommendations for improving the design of the harbor.

The effect of the shape of a harbor cut through a reef on mitigating waves from the deep ocean was studied using the *SWAN* code in reference 10. It was concluded that a significant amount of the wave energy is dissipated over the reef regardless of the design of the harbor. The reef decreased the wave height by a factor of 3. The wave height at the shore can be further decreased by another factor of 2 by a "V"-shaped or parabolic bottom design.

Other examples of applications of the *SWAN* code are presented in reference 11. They include the wave motion resulting from tsunami waves interacting with a circular and triangular island surrounded by a 1/15 continental slope and from surface deformations in the ocean surface near the island. The effects of a surface deformation in the Sea of Japan similar to that of the May 1983 tsunami was modeled. The interaction of a tsunami wave with Hilo Bay was described.

The *SWAN* code was used to model the effect of wind and tsunami waves on Maunalua Bay, Oahu as described in reference 12. The model reproduced the observed wave behavior at various locations in the bay for a 4 foot south swell with a 15 second period. A study was performed of the effect of an enlarged and deeper channel. The code was used to model the interaction with Maunalua Bay of waves outside the bay having periods of 15, 30, 60 seconds and a tsunami wave

with a 15 minute period. Wave amplitudes of 1 to 6 feet were considered with tides from mean lower low water to high tide (a 1.8 foot range). The same wave profiles within 10% were calculated at various locations studied throughout the bay for the current and the proposed bay with a larger and deeper entrance channel. The small difference between the current and the proposed bay varied with the wave period. The largest difference was found for the 30 second wave.

The 15 minute period tsunami wave doubled in amplitude as it passed over the bay and was highest at high tide. Severe flooding in the areas near the shore line was predicted. The tsunami effects were unrelated to channel configeration.

The calculated wave behavior at any location in the bay was a strong function of the entire bay with a complicated and time varying pattern of wave reflections and interactions.

Application of the Numerical Model to Mauna Lani Cove

The *SWAN* code was used to model the interaction with the current topography at the project site and with the proposed cove topography of waves having 30 second, 15 minute and 30 minute periods. The waves were directed parallel to the shoreline and to the cove entrance for maximum effect. The tsunami wave amplitude (peak to trough) in 30 feet of water was 16.2 feet which is expected to occur once in every 200 years or has a 0.5 percent chance of being equalled or exceeded this year or any other year. Such a wave will result in 8 to 10 feet inundation at the undeveloped project area. The effect of roughness of the terrain on the flooding was described using a De Chesy coefficient of 50 which is equivalent to the Manning "n" of 0.0325 to 0.04 used in the JIMAR and flood insurance programs. The effect of roughness is small.

The space resolution in the numerical model grid was 50 feet. The numerical calculations were performed at 0.5 second intervals. The calculations were performed on an IBM PS/2 Model 80 computer using a special version of the *SWAN* code that includes flooding and MCC developed graphics. A calculation required 1 to 6 hours of computer time.

The picture and line contour plots of the topography for the undeveloped site are shown in Figure 1. The interaction of the 200-year tsunami with the current topography is shown in Figures 2 and 3. The picture and line contour plots show the ocean flooding the land to the 9-10 foot level and inundating the land between 300 and 400 feet from the shoreline. These results are in good agreement with the results obtained using the procedures developed and applied for flood insurance purposes by the U. S. Army Corps of Engineers and the recent JIMAR study at the University of Hawaii of tsunami evacuation zones for the area.

The model was also evaluated for short period waves. The physical scale model of the cove and foreshore area built at the Hydro Research Science testing facility in Santa Clara, California has been used to study the effect of 4.4 feet high, 15 second period waves.[13] A comparision of the scale model and numerical results may be made using the following table. The station locations are shown in Figure 5.

Location	Physical Model	*SWAN* Calculation
No 2	2.7	2.6
No 3	1.0	1.1
No 4	0.2	0.3
No 7	0.3	0.3

The physical and numerical models are in good agreement for the short period wind waves. The physical model was also used to study the effect of tides and 6 hour surges. The water level in the cove was almost equal to the imposed offshore height of the tide or surge. A tsunami wave may have a period between 10 and 30 minutes so the flooding resulting from a tsunami wave is expected to be between the small amount of flooding associated with short period wind waves and the maximum flooding associated with long period surges and tides.

Tsunami Wave Interaction with Mauna Lani Cove

The interaction of an 8.1 feet high (above MLLW at 30 feet depth) 15 and 30 minute period tsunami wave with Mauna Lani Cove was numerically modeled. The picture contour plots of the topography used to describe Mauna Lani Cove are shown in Figure 4 and the line contour plots are shown in Figure 5. Figure 5 also shows the location of the cove stations used for the wave histories shown in Figure 8. The interaction of the 15 minute period tsunami with the Mauna Lani Cove topography is shown in Figures 6 and 7. The picture and line contour plots show the ocean flooding the land outside the cove to about 9 feet above MLLW and inundating the land some 300 feet from the shoreline. The presence of the cove does not significantly change the flooding along the coast. The wave histories at the various locations in the cove are shown in Figure 8 for the tsunami with a period of 15 minutes. Calculations were also performed for a 30 minute tsunami wave. A comparision of the maximum inundation at the various stations in the cove for a 15 and 30 minute tsunami may be made using the following table.

Location	15 min. Period	30 min. Period
No 1	9.9	10.8
No 2	9.9	9.9
No 3	5.9	7.6
No 4	5.3	6.6
No 5	5.6	6.9
No 6	5.3	6.6
No 7	5.3	6.3

Summary and Conclusions

Using standard techniques the 200-year tsunami in the region of the project is estimated to be 16.4 feet in amplitude when it arrives at the region boundary. The degree of inundation in the cove depends upon the period of the tsunami with greater inundation in the cove occurring for longer period tsunamis. A 15 minute tsunami results in cove inundations of 65 to 75% of the initial tsunami height and a 30 minute tsunami results in inundations of 75 to 95% of the initial tsunami height. Since the travel time from the entrance to the back of the cove is 2 to 3 minutes and a 15 minute period tsunami reaches its first maximum in 3.75 minutes and then starts to decay, the wave energy inside the cove is less for short period waves and increases as the wave period increases.

If the tsunami arrives at the same time as high tide, the maximum inundations would be 2 feet higher. A 200-year, 15 minute tsunami would result in an 8 foot level of inundation in the cove and a 30 minute tsunami would result in a 9.5 foot level of inundation. The proposed 10 foot level for construction of housing at the cove would probably prevent significant flooding of property. Mauna Lani Cove should be evacuated in the event of a tsunami warning and suitable measures should be taken to prevent dock and boat damage.

REFERENCES

1. George D. Curtis and Mark Smaalders, "A Methodology for Developing Tsunami Evacuation Zones," Proceedings of International Tsunami Symposium 89 (1989).
2. James R. Houston, Robert D. Carver, Dennis G. Markle, "Tsunami Elevation Elevation Frequency of Occurrence for the Hawaiian Islands," Technical Report H-77-16, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. (1977).
3. C. L. Bretschneider and P. G. Wybo, "Tsunami Inundation Prediction," Proceedings of 15th Coastal Engineering Conference (1976).
4. Doak Cox, "Potential Tsunami Inundation Areas in Hawaii," Hawaii Institute of Geophysics Report No. 14 (1961).
5. C. L. Bretschneider, H. J. Krock, E. Nakazaki and F. M. Casciano, "Roughness of Typical Hawaiian Terrain for Tsunami Run Up Calculation," University of Hawaii Department of Ocean Engineering report (1988).
6. Mader, Charles L. *Numerical Modeling of Water Waves*, University of California Press, Berkeley, California (1988).
7. Charles L. Mader, "Numerical Simulation of Tsunamis," Journal of Physical Oceanography, Vol. 4, pp. 74-82 (1974).
8. Safwan Hadi, "A Numerical Tidal Model of Musi-Upang Estuaries." A dissertation submitted to Oceanography Department of University of Hawaii (1985).
9. Charles L. Mader and Sharon Lukas, "Numerical Modeling of Waianae Harbor," Aha Hulikoa Hawaiian Winter Workshop Proceedings (January 1985).

10. Charles L. Mader, Martin Vitousek, and Sharon Lukas, "Numerical Modeling of Atoll Reef Harbors," Proceedings of the International Symposium on Natural and Man-Made Hazards, Rimouski (1986).
11. Charles L. Mader and Sharon Lukas, "*SWAN* – A Shallow Water, Long Wave Code: Applications to Tsunami Models," Joint Institute for Marine and Atmospheric Research report JIMAR 84-077 (1984).
12. "Oahu Intraisland Ferry System - Draft Environmental Impact Statement," State Department of Transportation, Harbors Division (1988).
13. "Hydraulic Model Study of the Mauna Lani Marina" Hydro Research Science Inc. report 192-89 (1989).

Figure Captions

Fig. 1 The undeveloped site topography showing the area above and below sea level. The entrance to the Mauna Lani Cove will be located at the 18 foot level in the center of the profiles. The contour interval is 1.18 feet.

Fig. 2 The ocean surface and land topography at 0, 113 and 225 seconds (time of maximum tsunami amplitude). The ocean surface contours change color according to the surface height. Flooding to the 9-10 foot level is shown. The contour interval is 1.18 feet.

Fig. 3 Cross sections in the Y direction (perpendicular to shoreline) of the water height. The cross sections are thru the X axis at the X values listed on each graph. The location of the normal shore line is shown for each cross section. The inundation zone and contour of maximum inundation are also shown.

Fig. 4 The Mauna Lani Cove topography used in the numerical modeling. The contour interval is 1.18 feet.

Fig. 5 The Mauna Lani Cove topography used in the numerical modeling and the location of the stations for reporting detailed wave histories. The contour interval is 2.00 feet.

Fig. 6 The ocean surface and land above water level topography at 0, 2, 4 minutes (time of maximum tsunami shoreline flooding). Flooding to the 9 foot level is shown. The contour interval is 1.18 feet.

Fig. 7 Continuation of Figure 6 showing the topography at 6 and 8 minutes. At 6 minutes the maximum cove inundation has occurred and by 8 minutes the tsunami withdrawal has exposed some of the ocean bottom surface. The inundation zone and maximum inundation are shown.

Fig. 8 The wave height histories at various locations in the cove for an 8.1 foot high, 15 minute tsunami wave.

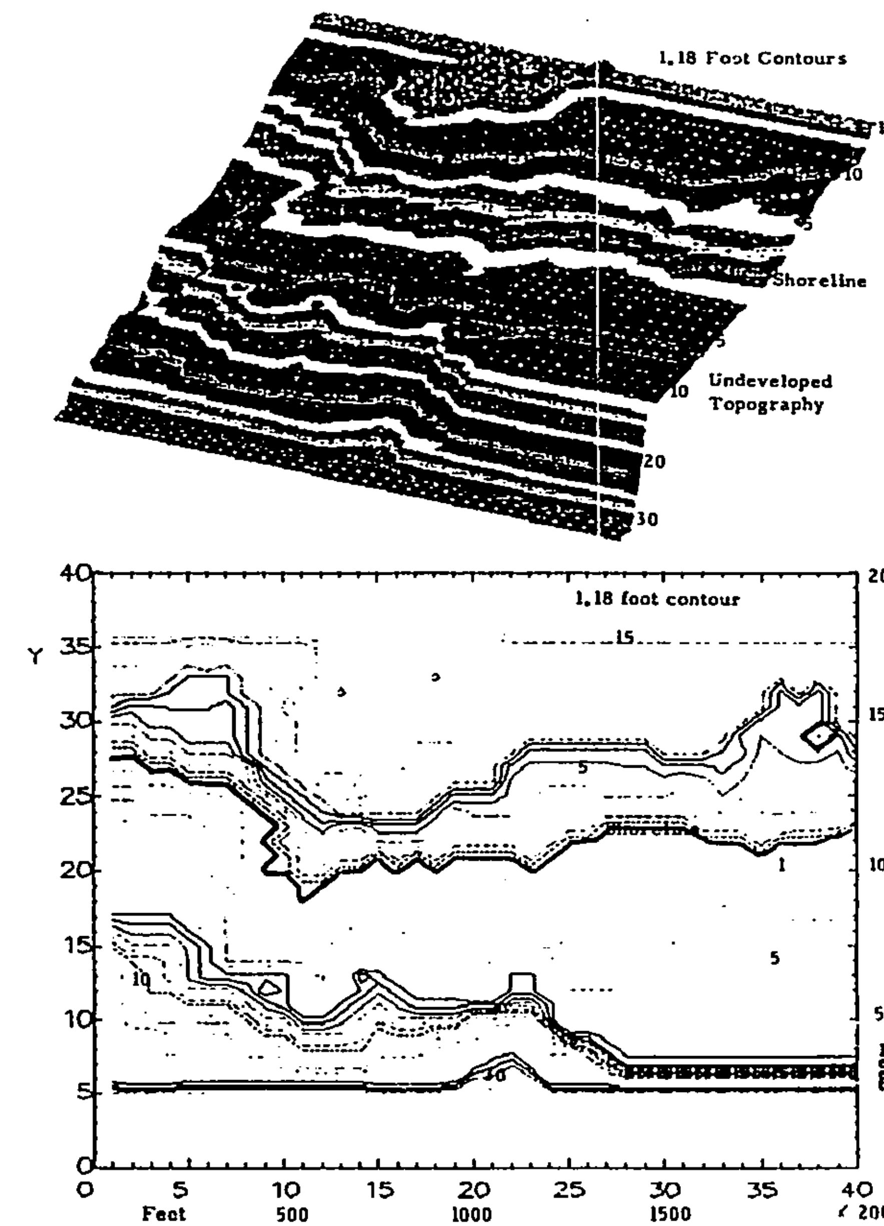


Fig. 1 The undeveloped site topography showing the area above and below sea level. The entrance to the Mauna Lani Cove will be located at the 18 foot level in the center of the profiles. The contour interval is 1.18 feet.

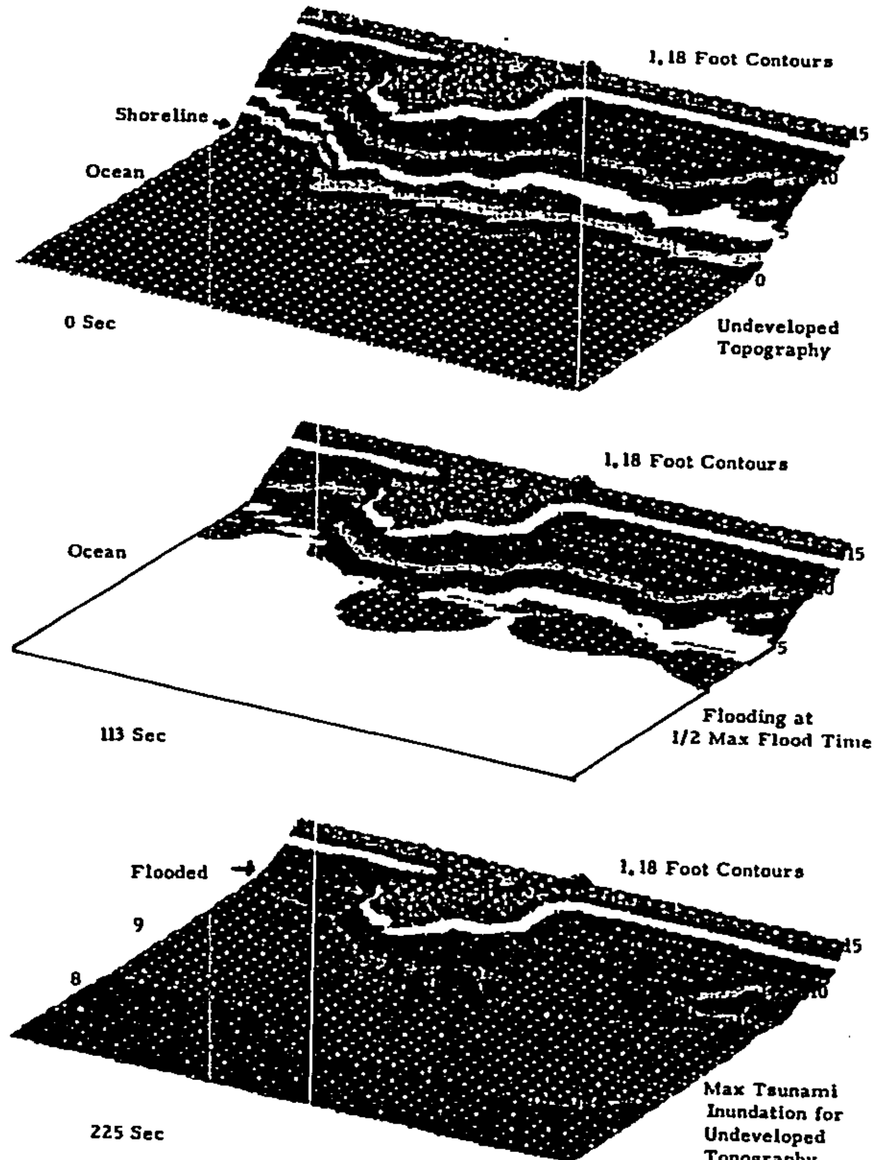


Fig. 2 The ocean surface and land topography at 0, 113 and 225 seconds (time of maximum tsunami amplitude). The ocean surface contours change color according to the surface height. Flooding to the 9-10 foot level is shown. The contour interval is 1.18 feet.

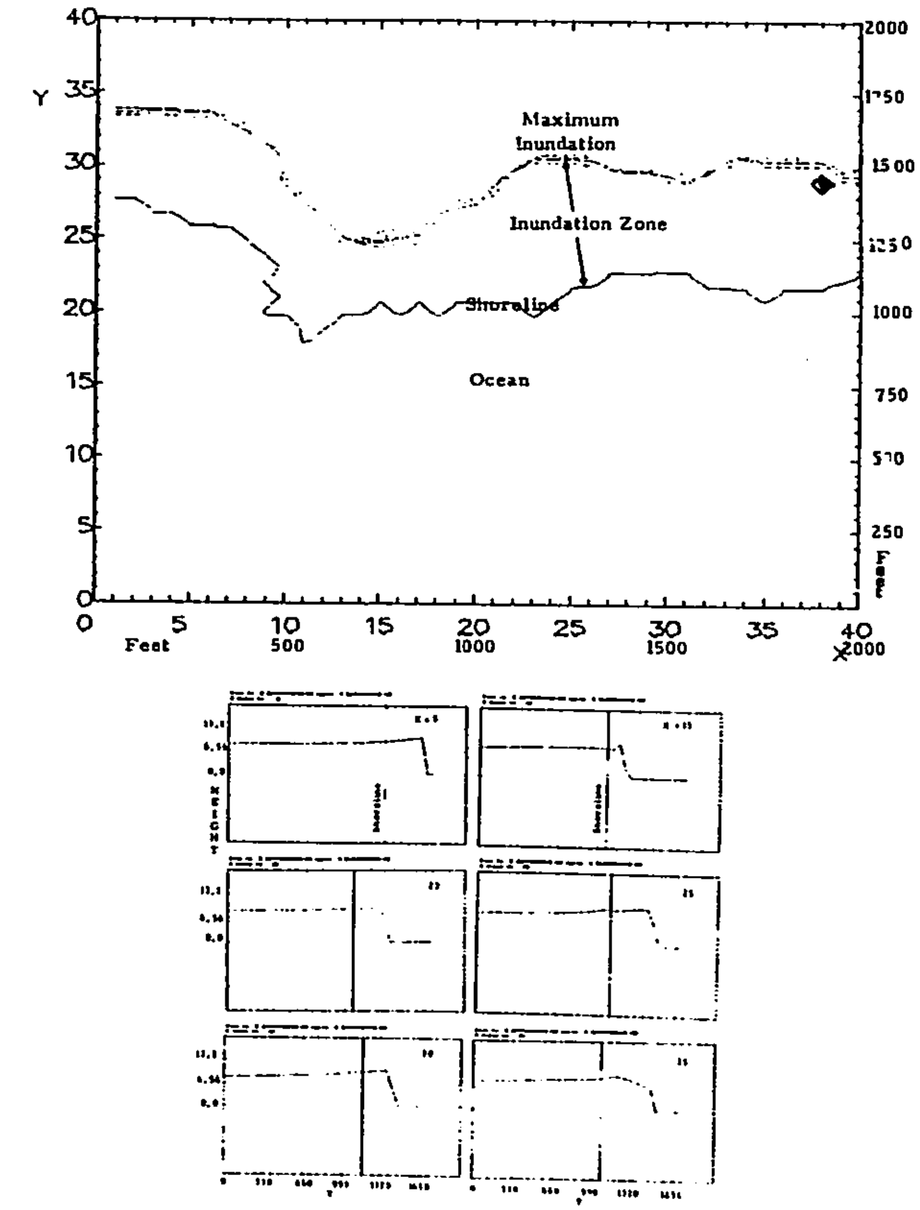


Fig. 3 Cross sections in the Y direction (perpendicular to shoreline) of the water height. The cross sections are thru the X axis at the X values listed on each graph. The location of the normal shore line is shown for each cross section.

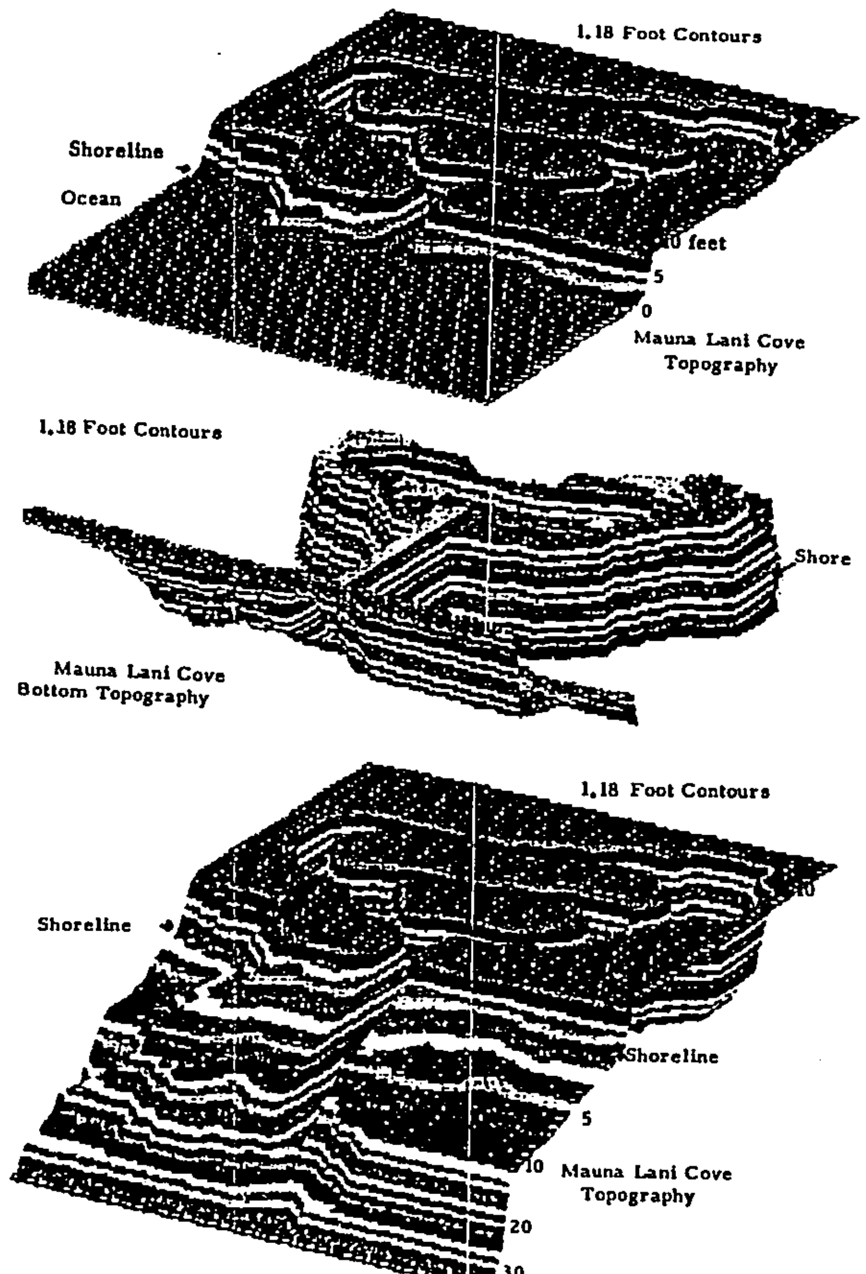


Fig. 4 The Mauna Lani Cove topography used in the numerical modeling.

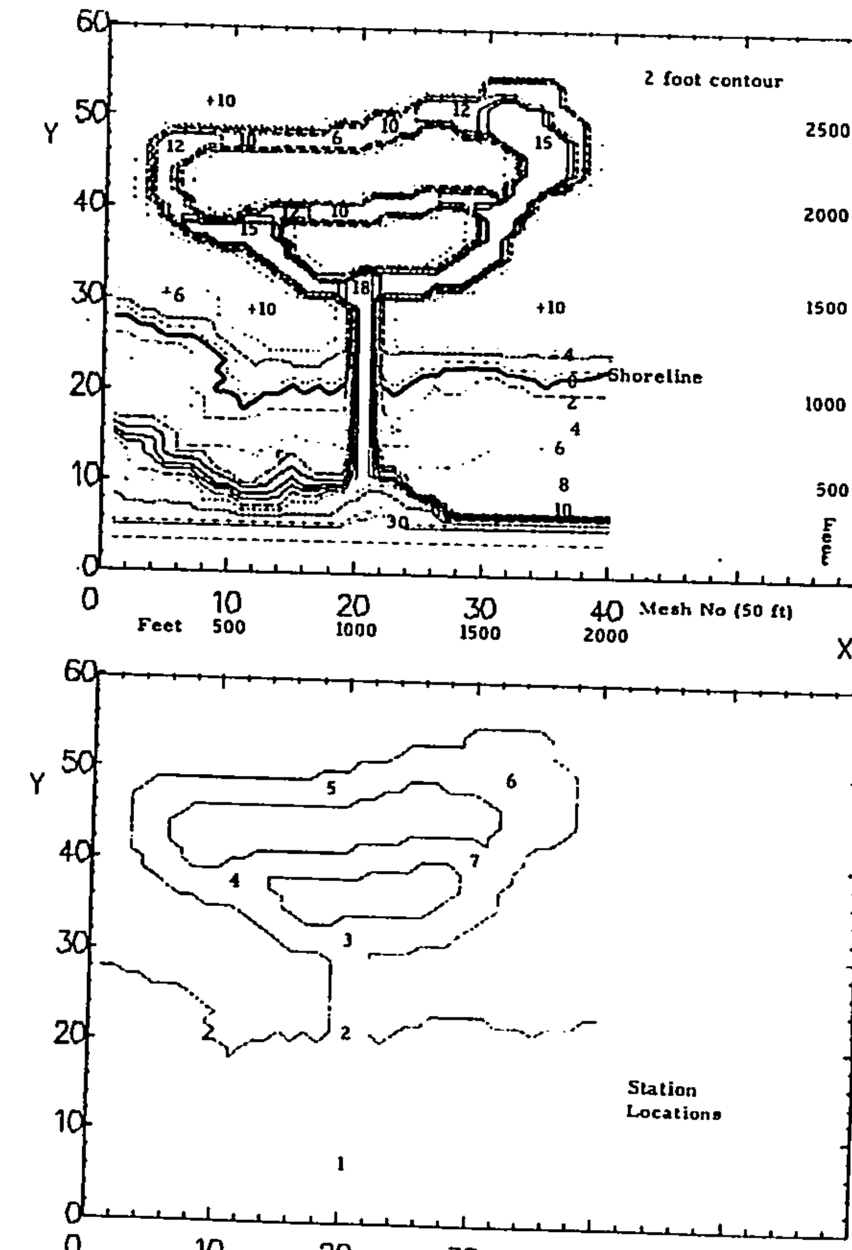


Fig. 5 The Mauna Lani Cove topography used in the numerical modeling and the location of the stations for reporting detailed wave histories.

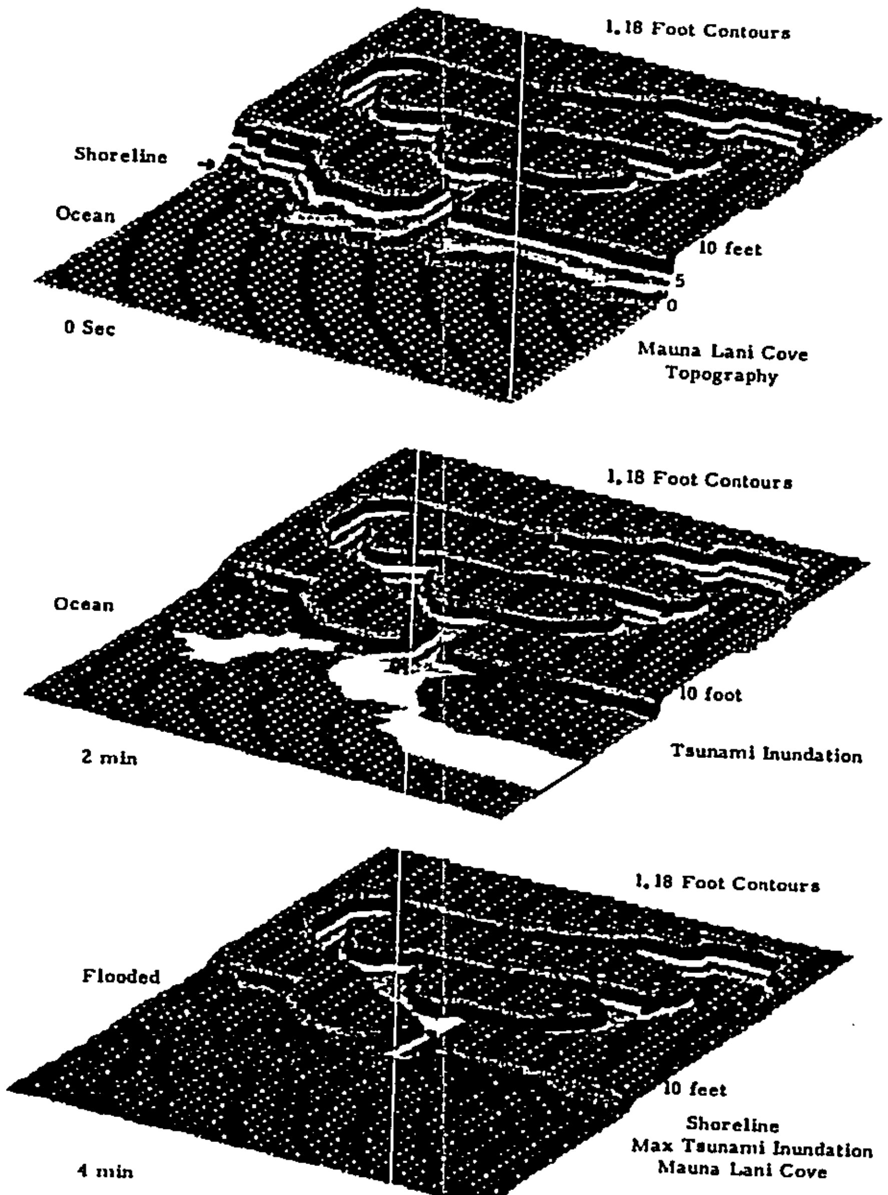


Fig. 6 The ocean surface and land above water level topography at 0, 2, 4 minutes (time of maximum tsunami shoreline flooding). Flooding to the 9 foot level is shown. The contour interval is 1.18 feet.

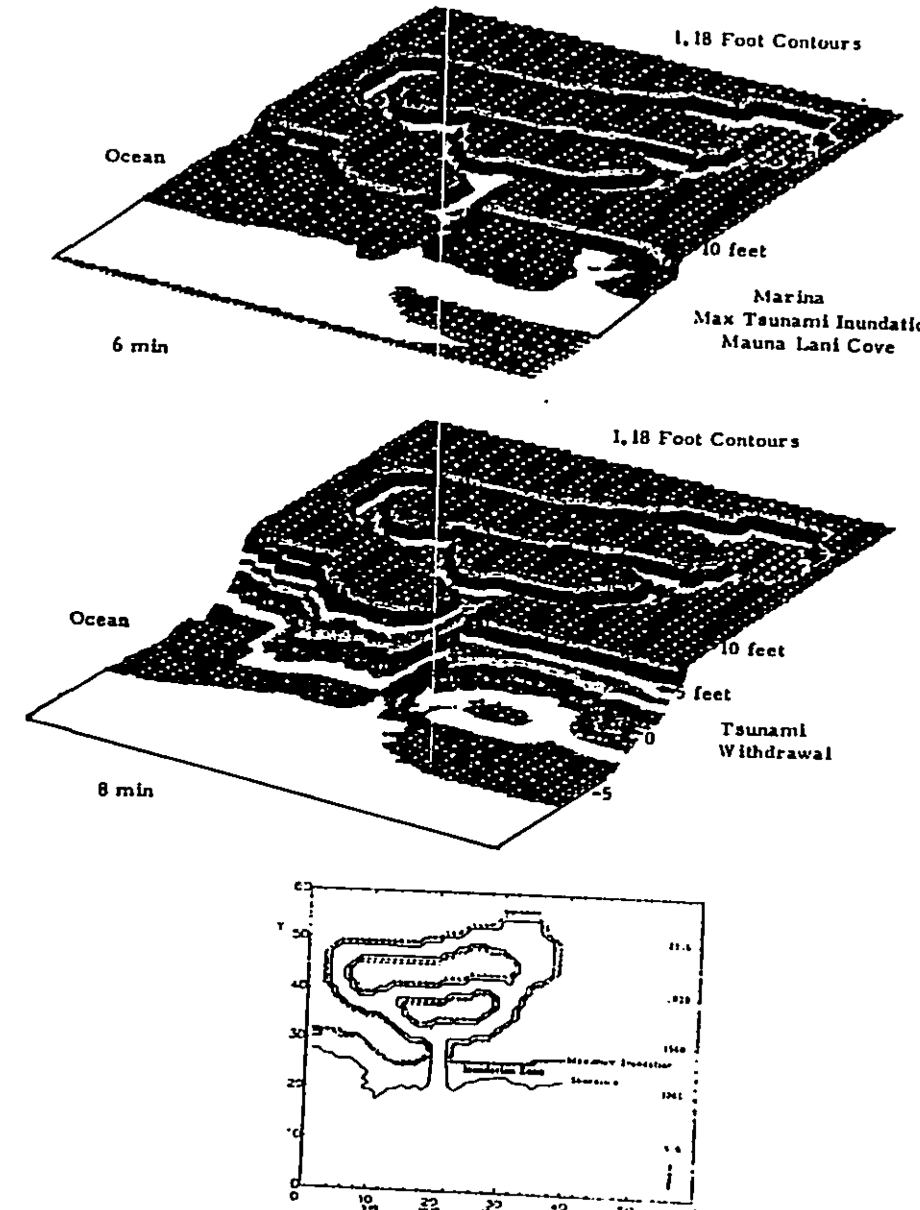


Fig. 7 Continuation of Figure 6 showing the topography at 6 and 8 minutes. At 6 minutes the maximum cove inundation has occurred and by 8 minutes the tsunami withdrawal has exposed some of the ocean bottom surface.

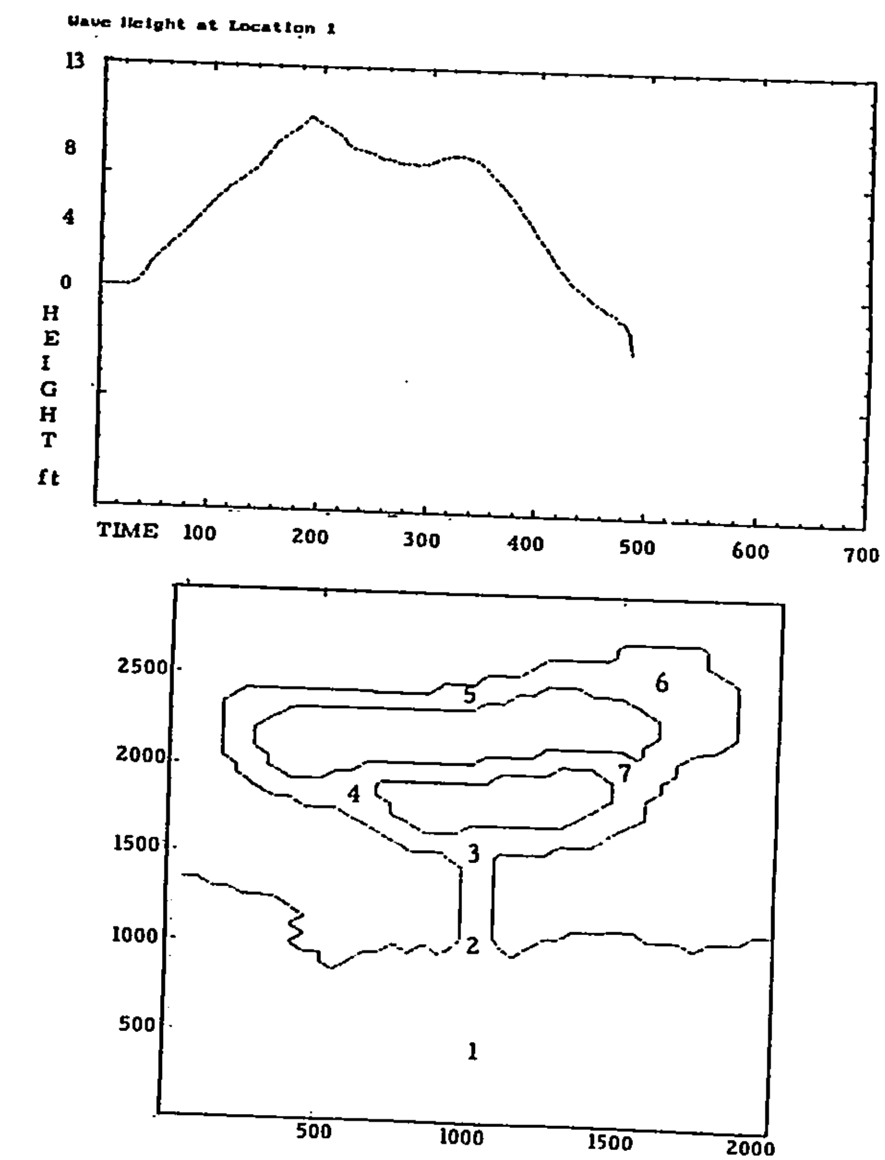
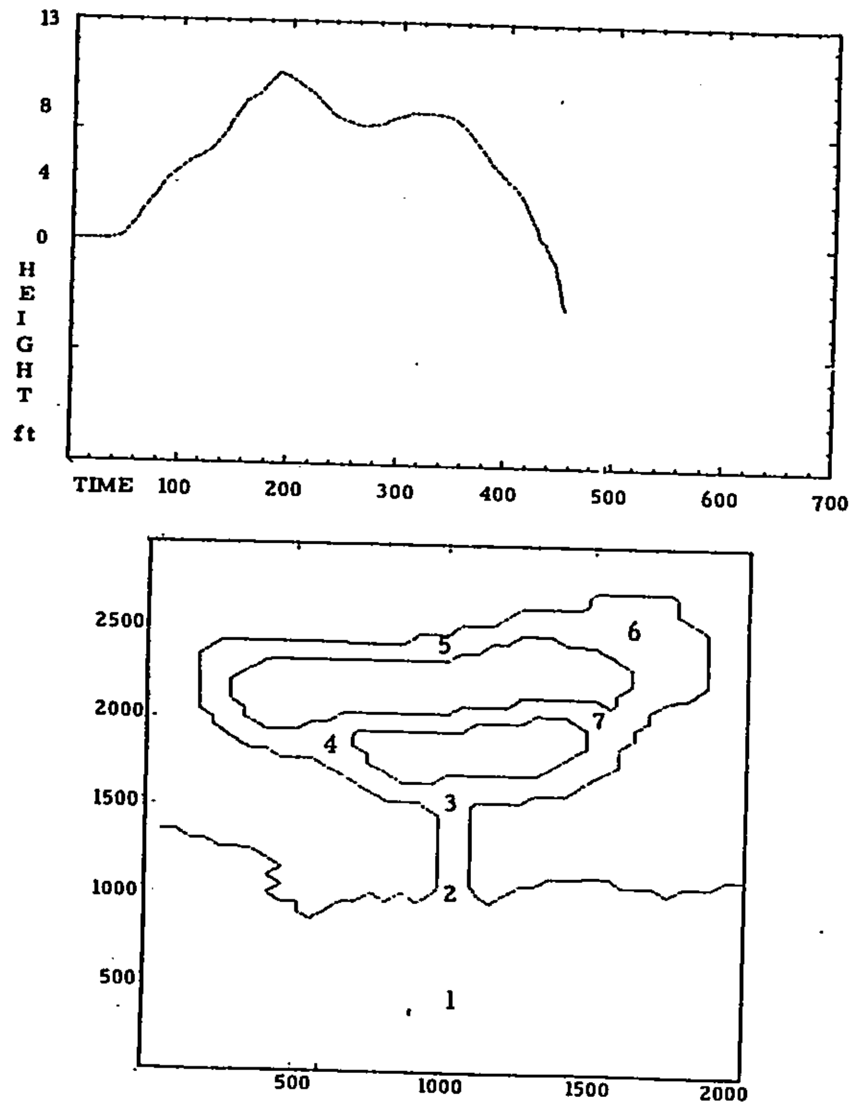


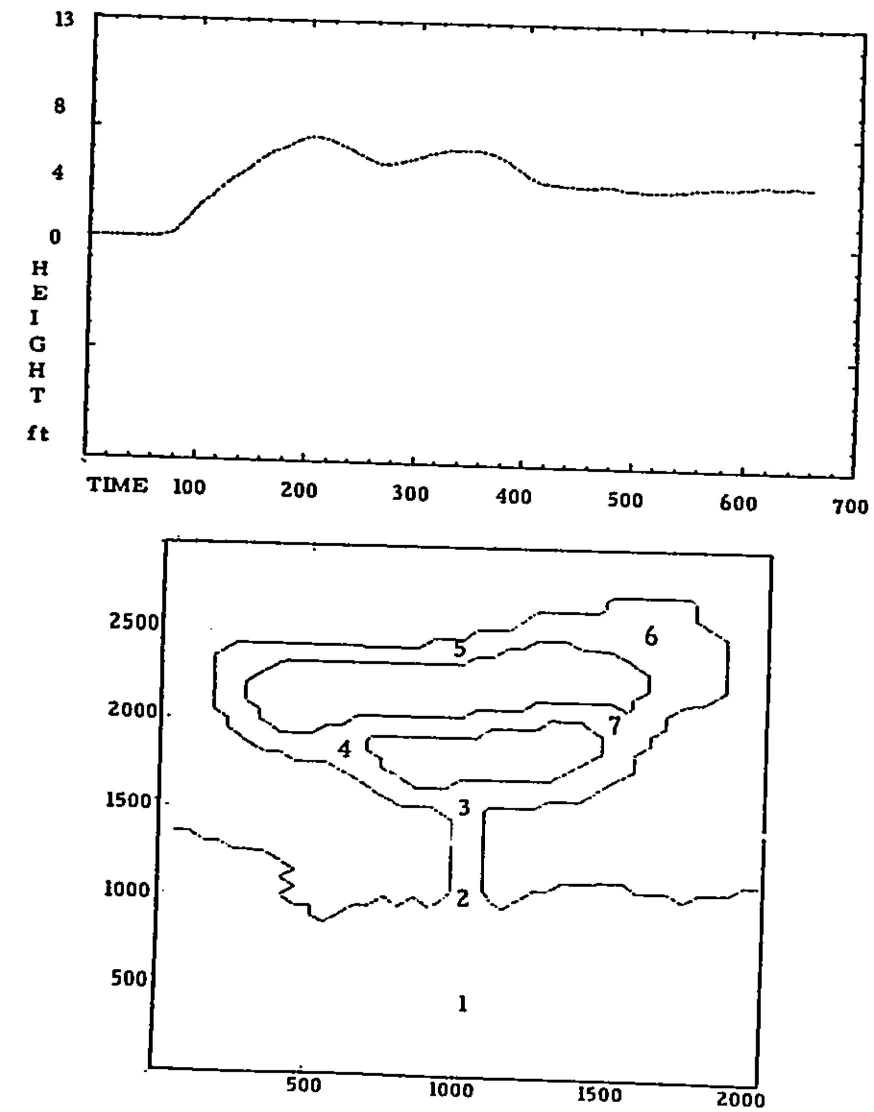
Figure 8.

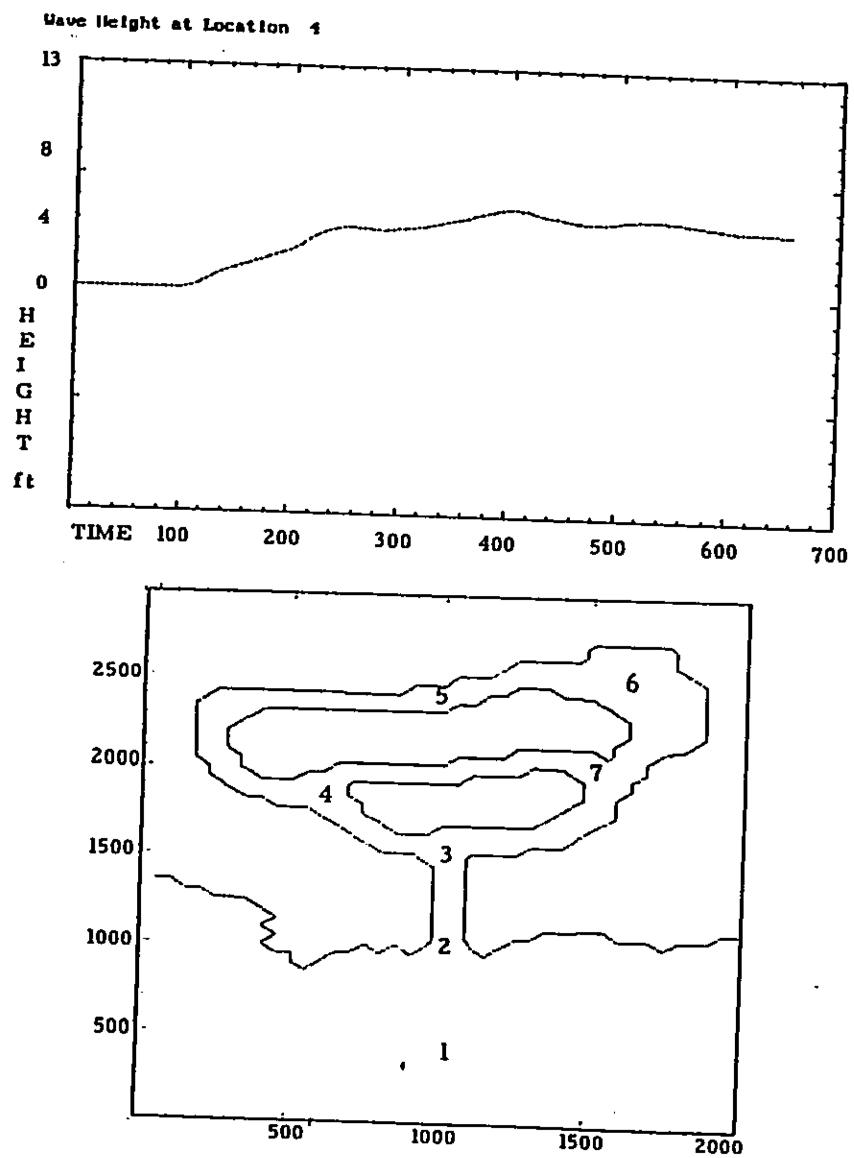
The wave height histories at various stations in the cove for an 8.1 feet high, 15 minute Tsunami wave.

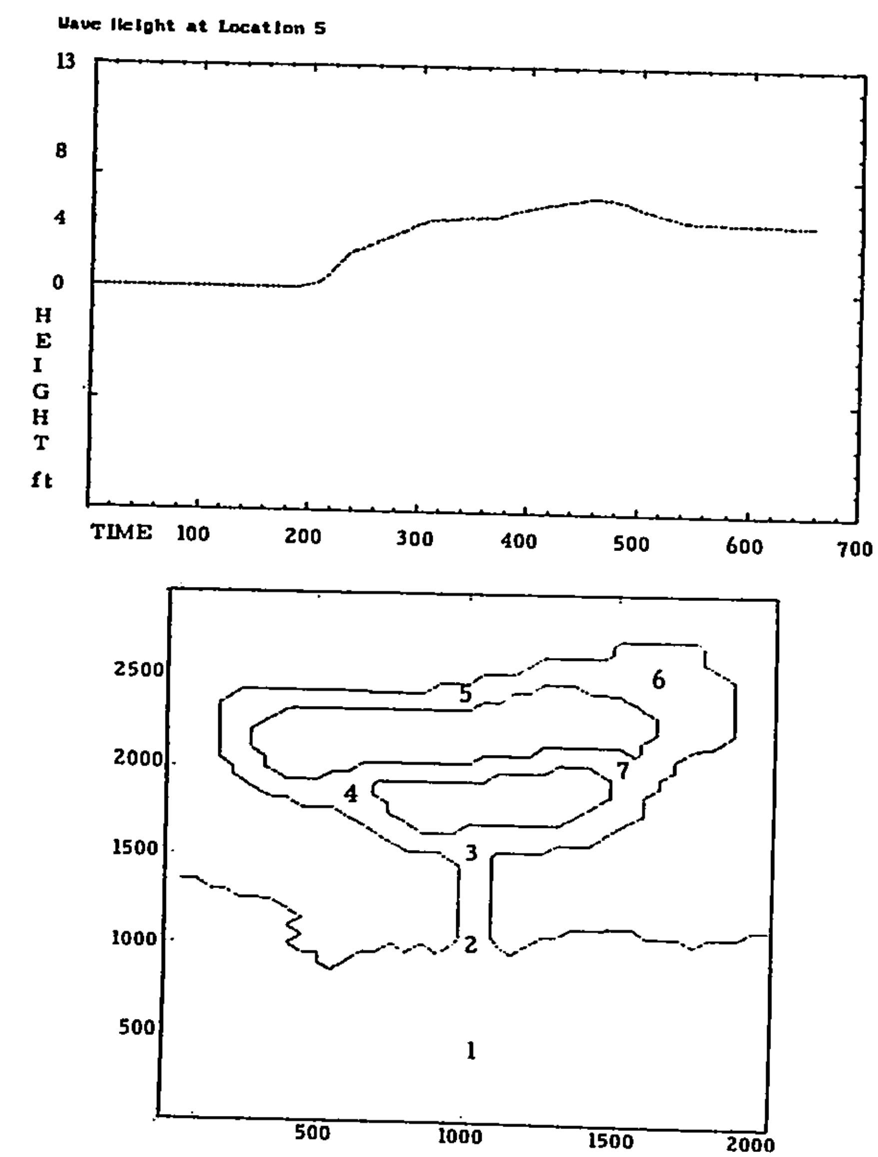
Wave Height at Location 2



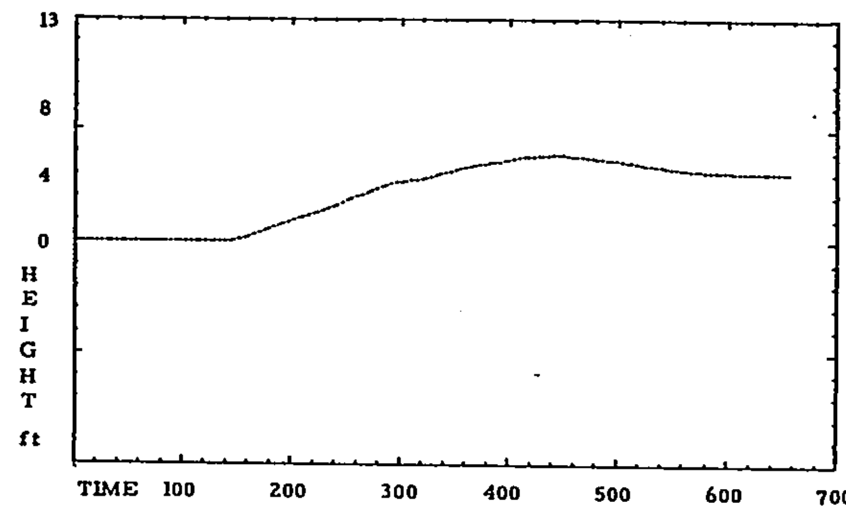
Wave Height at Location 3

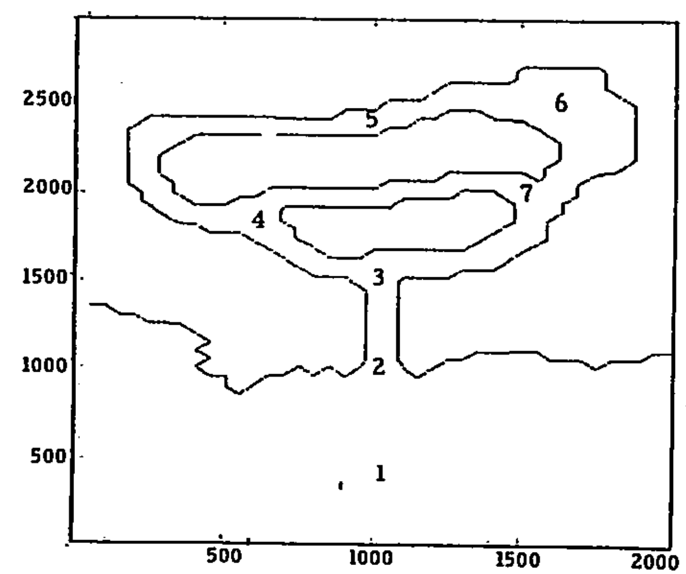



Wave Height at Location 4
13
8
4
0
HEIGHT ft
TIME 100 200 300 400 500 600 700
2500
2000
1500
1000
500
500 1000 1500 2000
1
2
3
4
5
6
7

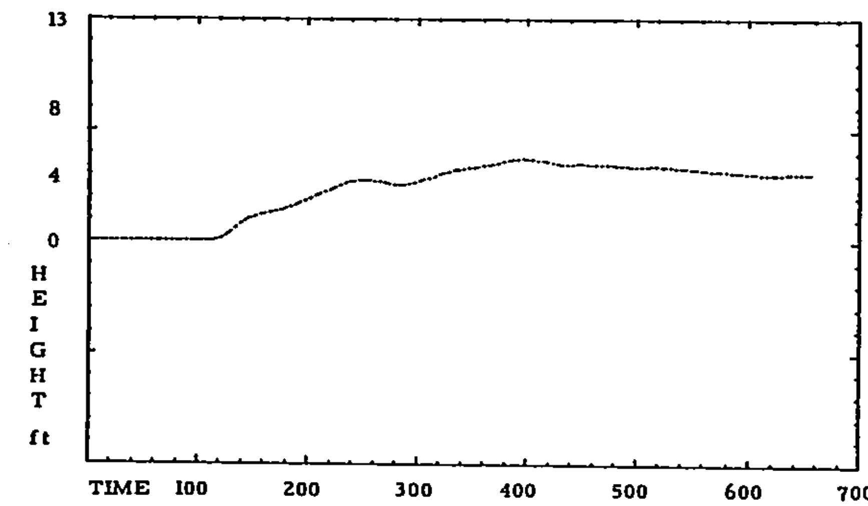

Wave Height at Location 5
13
8
4
0
HEIGHT ft
TIME 100 200 300 400 500 600 700
2500
2000
1500
1000
500
500 1000 1500 2000
1
2
3
4
5
6
7

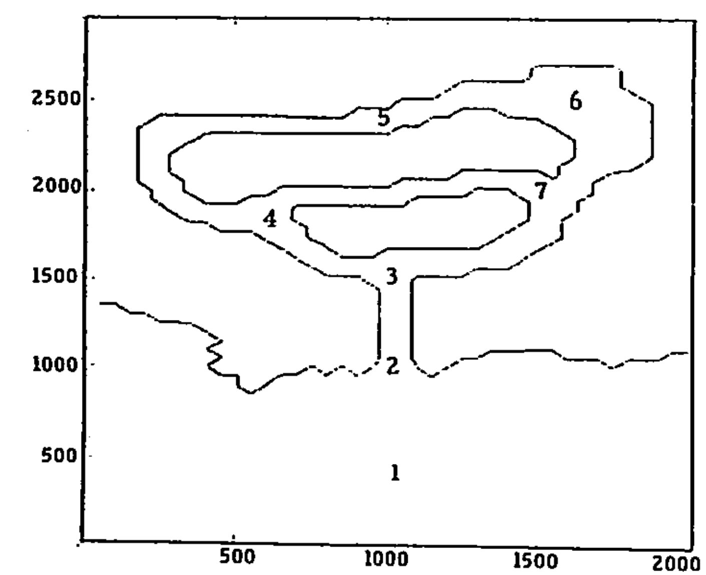
Wave Height at Location 6





Wave Height at Location 7





APPENDIX D

BOTANICAL SURVEY
MAUNA LANI MARINA
MAUNA LANI RESORT, ISLAND OF HAWAI'I

BOTANICAL SURVEY

MAUNA LANI MARINA

MAUNA LANI RESORT, ISLAND OF HAWAI'I

by

Winona P. Char

CHAR & ASSOCIATES
Botanical/Environmental Consultants
Honolulu, Hawaii

Prepared for: BELT COLLINS & ASSOCIATES

April 1989

Table of Contents

BOTANICAL SURVEY
MAUNA LANI MARINA
MAUNA LANI RESORT, ISLAND OF HAWAI'I

INTRODUCTION

Mauna Lani Resort, Inc., proposes to develop a residential/resort marina project as well as relocate two golf holes on a total area of about 120 acres. The site is situated between the existing Mauna Lani Bay Hotel and the Ritz-Carlton Mauna Lani Hotel, presently under construction. Undeveloped portions of the site are vegetated primarily with introduced grasses and kiawe trees while the shoreline areas support groves of coconut trees and rather dense milo thickets especially the areas around ponds.

Field studies to assess the botanical resources found on the proposed marina site as well as the relocation site for the two golf holes were conducted on 21 March 1989. A total of two botanists were used to gather the technical data contained in this report. The objectives of the field studies were to 1) provide a general description of the major vegetation types; 2) inventory the terrestrial, vascular flora; and 3) search for rare, threatened or endangered plants on the project site.

SURVEY METHODS

Prior to undertaking the field studies, a search was made of the pertinent literature to familiarize the principal investigator with other botanical studies conducted in the general area. Topographic maps and recent, colored aerial photographs were examined to determine access, terrain characteristics, vegetation patterns, boundaries, and reference points.

Access onto the site was by means of a number of unpaved roads which run throughout the site.

A walk-through survey method was used. Areas most likely to harbor native plant communities such as the open scrub on pahoehoe lava flows and the areas around the anchialine ponds were more intensively examined than landscaped or recently disturbed areas. Notes were made on plant associations and distributions, substrate types, topography, exposure, etc. Species identification was made in the field; plants which could not be positively determined were collected for later identification in the herbarium and for comparison with the taxonomic literature.

DESCRIPTION OF THE VEGETATION

An earlier botanical survey prepared for the Mauna Lani master plan (Earthwatch in Belt Collins & Associates 1985), describes three major vegetation cover types from the Mauna Lani Resort area. No proposed, listed or candidate endangered or threatened plant species were found during the earlier survey.

During this study, two major vegetation types, coastal strand and scrub vegetation are recognized; the scrub vegetation is further divided into two subtypes, open scrub and kiawe scrub. These correspond more or less closely to the vegetation types recognized during the earlier survey. A checklist of all the terrestrial, vascular plants inventoried during this study is presented at the end of this report.

One category 1 cadidate endangered species, the pololei fern (<u>Ophioglossum concinnum</u>), was found on the project site. A more detailed discussion follows in the "Discussion and Recommendations" section.

Coastal Strand

The shoreline along the proposed marina project site is characterized by a rocky lava coast with a narrow beach composed of a mixture of waterworn lava fragments and course coralline sand and rubble. A few anchialine ponds, largely overgrown with milo (Thespesia populnea) and containing much organic material on their bottoms, can also be found along the coast.

Strand vegetation on "sandy" areas consists of scattered clumps of coconut palm (Cocos nucifera) which become more numerous and form somewhat dense groves near the Mauna Lani Bay Hotel end of the property. Other trees and larger shrubs include tree heliotrope (Tournefortia argentea), kiawe (Prosopis pallida), beach naupaka or naupaka kahakai (Scaevola sericea), and pluchea (Pluchea symphytifolia). Locally common are sprawling mats of the pohuehue (Ipomoea pes-caprae) and Ipomoea violacea vines. Common herbaceous plants found here include Australian saltbush (Atriplex semibaccata) and aheahea (Chenopodium murale). On rocky portions of the coast, pickleweed (Batis maritima) and ohelo kai (Lycium sandvicense) form tangled clumps.

The brackish ponds are usually surrounded by dense milo thickets which also occasionally support a few trees and shrubs of noni (Morinda citrifolia), loulu (Pritchardia sp.), pandanus (Pandanus tectorius), and two kinds of kou (Cordia sebestena and subcordata). Also restricted to these pond areas are two sedges, kaluha (Bolboschoenus maritimus) and makaloa (Schoenoplectus lacustris).

Scrub Vegetation

Scrub vegetation occurs on 'a'a and pahoehoe lava flows on the project site, with vegetation cover usually sparse to sometimes almost absent on 'a'a flows. Scrub vegetation is characterized by kiawe trees (Prosopis pallida) and introduced grasses; the most abundant being buffel grass (Cenchrus ciliaris) and sixweeks threeawn (Aristida adcensionis). Locally abundant in scattered patches of varying sizes are fountain grass (Pennisetum setaceum) and the native pili grass (Heteropogon contortus). Smaller shrubs of hi'aloa (Waltheria indica) and 'ilima are abundant to common. Ubiquitous throughout the site, is threadstem carpetweed (Molluga cerviana).

Depending on the density of the cover of the kiawe trees, two subtypes of the scrub vegetation can be recognized on the project site.

Open scrub -- This cover type is characterized by very widely scattered kiawe trees among a low grass-shrub association. All those plants mentioned previously occur here in addition to such species as pigweed (Portulaca oleracea), hairy spurge (Chamaesyce hirta), wild cucumber (Cucumis dipsaceus), coat buttons (Tridax procumbens), 'ihi (Portulaca pilosa), and wild spider plant (Cleome gynandra), all of which are occasional in this cover type.

Where the substrate is broken pahoehoe, there is often an accumulation of soil and organic material between the cracks. The pololei fern, a candidate endangered species, may be found in these damp pockets of soil during the rainy months.

Kiawe scrub -- The kiawe tree cover varies from an open forest situation where the plants form about 50% cover to a dense thicket which may be almost impenetrable in places. Trees may vary in height from 12 to 18 ft. to as much as 25 ft. All those associated species mentioned in the section above occur here but in lesser numbers due to shade from the kiawe trees and more competition for available moisture.

DISCUSSION AND RECOMMENDATIONS

The vegetation on the proposed marina site is domincted largely by introduced (or alien) species such as kiawe and buffel grass although, in places, the native 'ilima and pili grass may be common. Of a total of 66 species inventoried during this survey, 43 (65%) are introduced; 4 (6%) are originally of Polynesian introduction; and 19 (29%) are native. Of the native plants, 16 are indigenous, i.e., native to the islands and elsewhere; and 3 are endemic, i.e., native only to the islands and not found elsewhere.

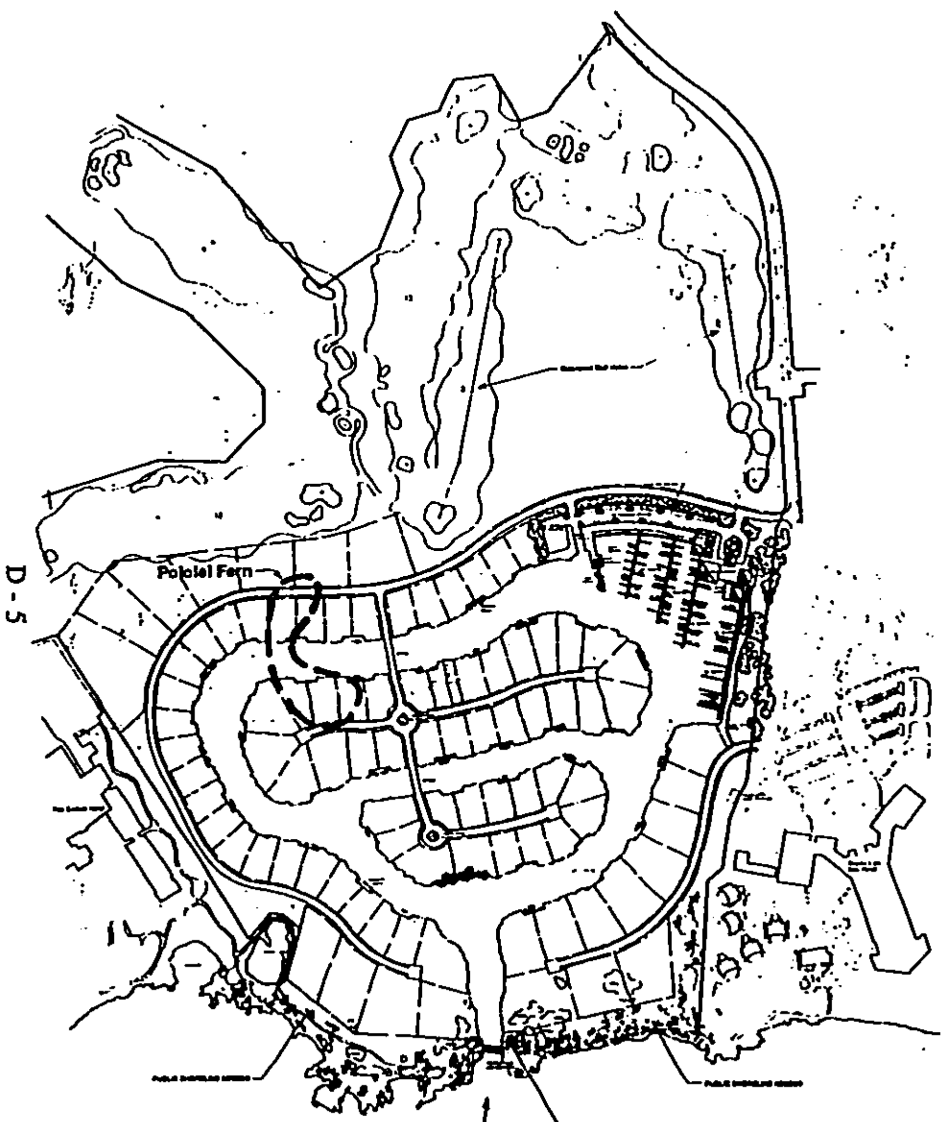
None of the native plants are officially listed as endangered or threatened (U. S. Fish and Wildlife Service 1985; Herbst 1987) and therefore protected by Federal and State endangered species' laws. However, one native plant, the pololei fern (Ophioglossum concinnum), is considered a category 1 candidate endangered species. A category 1 candidate endangered species should be regarded as candidate for addition to the endangered and threatened species list and, as such, consideration should be given them in environmental planning (U. S. Fish and Wildlife Service 1985).

The pololei fern is a small, perennial fern with long, paddle-shaped leaves, 3 to 5 inches long. The plants appear after the first heavy downpour of the rainy season, produce leaves and a simple, spiked reproductive structure, and dieback with only the underground stems surviving until the next rainy season. The fern has been recorded from O'ahu, Moloka'i, Maui, Lana'i

and Hawai'i (Degener and Degener 1932 et seq.). Recently a large population has been found on the coastal dunes of the Pacific Missile Range Facility on Kaua'i (Traverse Group, Inc., 1988). During the environmental studies for the new West Hawai'i Sanitary Landfill, a small population of three plants was found below the slopes of Pu'uanahulu at about 640 ft. elevation in vegetation composed of fountain grass with scattered kiawe trees (Char 1989). The fern may not be as rare as previously believed as more recent findings indicate that the plants appear widely scattered along the leeward coast of Hawai'i from Pu'ukohola Heiau to Hanuka. Given its ephemeral nature, the plants could be easily missed if botanical surveys were conducted during the drier parts of the year.

Seven colonies of plants occur on the site (Figure 1), within a relatively short distance of each other and have been flagged with pink and blue flagging. The plants are found in pockets of soil on old pahoehoe substrate where the vegetation consists of open scrub. It does not appear to compete well with the introduced grasses.

It is recommended that the pololei fern could be incorporated into a landscape planting utilizing native dryland and strand material at the interpretive center which will be located near the pond areas. Plans call for the ponds to remain undisturbed and integrated into the overall design.



Note: The proposed Mauna Lani Marina is shown in concept only. Design of facilities is subject to change, based on engineering analysis.

FIGURE 1
DISTRIBUTION OF POLOLEI FERN ON PROJECT SITE.
MAUNA LANI MARINA
Mauna Lani Resort
South Kohala, Hawaii
ROMA Design Group
Belt Collins & Associates
January 1989

LITERATURE CITED

Belt Collins & Associates. 1985. Final environmental impact statement, Revised master plan for Mauna Lani Resort, South Kohala, Hawaii. Prepared for Mauna Lani Resort. June 1985.

Char, W. P. 1989. Botanical survey, West Hawai'i Sanitary Landfill Site, North Kona District, Hawai'i. Prepared for R. M. Towill Corp. Jan. 1989.

Degener, O. and I. Degener. 1932 et seq. Flora Hawaiiensis. 7 vols. Privately published.

Herbst, D. 1987. Status of endangered Hawaiian plants. Hawaiian Botanical Society Newsletter 26(2): 44-45.

Lamoureux, C. H. 1984. Checklist of the Hawaiian Pteridophytes. Manuscript.

Porter, J. R. 1972. Hawaiian names for vascular plants. Coll. of Trop. Agr., Univ. of Hawaii, Manoa, Deparmental Paper No. 1.

St. John, H. 1973. List and summary of the flowering plants in the Hawaiian Islands. Pac. Trop. Bot. Garden Memoir No. 1.

Traverse Group, Inc. 1988. Natural resources management plan, Pacific Missile Range Facility, Barking Sands. Prepared for Natural Resources Management Branch, Pac. Div., Naval Facilities Engineering Command. Contract No. N62742-86-C-0538.

U.S. Fish and Wildlife Service. 1985. Endangered and threatened wildlife and plants; Review of plant taxa for listing as Endangered and Threatened Species; Notice of review. Fed. Register 50(188): 39526-39527 plus 57 page table.

Wagner, W. L., D. Herbst, and S. H. Sohmer. In press. Manual of the flowering plants of the Hawaiian Islands. B. P. Bishop Museum and Univ. Press of Hawaii, Honolulu.

PLANT SPECIES LIST

Following is a checklist of all those vascular plant species inventoried during the field studies. Plant families are arranged alphabetically within each of three groups: Ferns, Monocots, and Dicots. Taxonomy and nomenclature of the Ferns follow Lamoureux (1984); the flowering plants (Monocots and Dicots) are in accordance with Wagner et al. (in press). In most cases, common English and/or Hawaiian names given follow St. John (1973) or Porter (1972).

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name, when known.
3. Biogeographic status. The following symbols are used:
   E = endemic = native only to the Hawaiian Islands
   I = indigenous = native to the islands and also to one or more other geographic area(s)
   P = Polynesian = not native; plants of Polynesian introduction prior to Western contact (1778)
   X = introduced or alien = not native; all those plants brought to the islands intentionally or accidentally after Western contact.
4. Presence (+) or absence (-) of a particular species within each of two major vegetation types recognized on the project site (see text for discussion):
   c = Coastal Strand
   s = Scrub Vegetation

SCIENTIFIC NAME	COMMON NAME	STATUS	VEGETATION TYPE c	VEGETATION TYPE s
FERNS				
OPHIOGLOSSACEAE (Adder's Tongue Family)				
Ophioglossum concinnum Brack.	pololei fern	E	-	+
FLOWERING PLANTS				
MONOCOTS				
ARECACEAE (Palm Family)				
Cocos nucifera L.	coconut, niu	P	+	-
Pritchardia sp.	loulu	E?	+	-
CYPERACEAE (Sedge Family)				
Bolboschoenus maritimus ssp. paludosus (A. Nels.) T. Koyama	kaluha	I	+	-
Schoenoplectus lacustris ssp. validus (Vahl) T. Koyama	makaloa	I	+	-
PANDANACEAE (Pandanus Family)				
Pandanus tectorius S. Parkinson ex Z.	pandanus, hala	I	+	-
POACEAE (Grass Family)				
Aristida adscensionis L.	sixweeks threeawn	X	-	+
Cenchrus ciliaris L.	buffel grass	X	+	+
Chloris barbata (L.) Sw.	swollen finger grass	X	+	+
Cynodon dactylon (L.) Pers.	Bermuda grass, manienie	X	+	-
Digitaria setigera Roth	itchy crabgrass, kukaepua'a	I?	-	+
Eleusine indica (L.) Gaertn.	wiregrass, goose grass	X	+	+
Eragrostis cilianensis (All.) Link	stinkgrass	X	+	+

SCIENTIFIC NAME	COMMON NAME	STATUS	VEGETATION TYPE c	VEGETATION TYPE s
Eragrostis tenella (L.) P. Beauv. ex Roem. & Schult.	lovegrass	X	-	+
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	pili, pili grass	I?	-	+
Leptochloa uninervia (K. Presl) Hitchc. & Chase	sprangletop	X	+	-
Panicum torridum Gaud.	kakonakona	E	-	+
Pennisetum setaceum (Forsk.) Chiov.	fountaingrass	X	+	+
Setaria verticillata (L.) P. Beauv.	bristly foxtail	X	+	-
Sporobolus virginicus (L.) Kunth	beach dropseed, 'aki'aki	I	+	-
DICOTS				
AIZOACEAE (Fir-marigold Family)				
Sesuvium portulacastrum (L.) L.	'akulikuli	I	+	-
AMARANTHACEAE (Amaranth Family)				
Amaranthus spinosus L.	spiny amaranth	X	+	+
ASTERACEAE (Sunflower Family)				
Ageratum conyzoides L.	maile hohono	X	-	+
Bidens cynapiifolia Kunth	Spanish needle	X	-	+
Bidens pilosa L.	ki, ki nehe	X	+	+
Emilia fosbergii Nicolson	pualele	X	-	+
Hypochloris radicata L.	hairy cat's ear	X	-	+
Pluchea symphytifolia (Mill.) Gillis	sourbush	X	+	+
Reichardia tingitana (L.) Roth	reichardia	X	-	+
Sonchus oleraceus L.	sow thistle	X	+	+
Tridax procumbens L.	coat buttons	X	-	+
Indet. sp.		X	-	+
BATIDACEAE (Saltworth Family)				
Batis maritima L.	pickleweed	X	+	-

SCIENTIFIC NAME	COMMON NAME	STATUS	VEGETATION TYPE c	VEGETATION TYPE s
BORAGINACEAE (Borage Family)				
Cordia sebestena L.	foreign kou, kou haole	X	+	-
Cordia subcordata Lam.	kou	P	+	-
Heliotropium curassavicum L.	kipukai, nena	I	+	-
Tournefortia argentea L. f.	tree heliotrope	X	+	-
BRASSICACEAE (Mustard Family)				
Lepidium virginicum L.	wild peppergrass	X	-	+
CAPPARACEAE (Caper Family)				
Cleome gynandra L.	wild spider plant, hohohino	X	+	+
CASUARINACEAE (She-oak Family)				
Casuarina equisetifolia L.	common ironwood, paina	X	+	-
CHENOPODIACEAE (Goosefoot Family)				
Atriplex semibaccata R. Br.	Australian saltbush	X	+	-
Atriplex suberecta Verd.	saltbush	X	+	-
Chenopodium carinatum R. Br.	goosefoot	X	+	+
Chenopodium murale L.	aheahea	X	+	+
COMBRETACEAE (Indian Almond Family)				
Terminalia catappa L.	tropical almond, false kamani	X	+	-
CONVOLVULACEAE (Morning-glory Family)				
Ipomoea violacea L.		I?	+	-
Merremia aegyptia (L.) Urban	hairy merremia, koali kua hulu	X?	-	+
CUCURBITACEAE (Gourd Family)				
Cucumis dipsaceus Ehrenb ex Spach	wild cucumber	X	-	+

12

SCIENTIFIC NAME	COMMON NAME	STATUS	VEGETATION TYPE c	VEGETATION TYPE s
Citrullus lanatus (Thunb.) Matsum. & Nakai	watermelon	X	+	-
EUPHORBIACEAE (Spurge Family)				
Chamaesyce hirta (L.) Millsp.	hairy spurge, garden spurge	X	-	+
FABACEAE (Pea Family)				
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe	X	+	+
GOODENIACEAE (Goodenia Family)				
Scaevola sericea Vahl	naupaka kahakai	I	+	-
MALVACEAE (Mallow Family)				
Malva parviflora L.	cheese weed	X	+	+
Sida fallax Walp.	'ilima	I	+	+
Thespesia populnea (L.) Soland. ex Correa	milo	P	+	-
MOLLUGINACEAE (Carpetweed Family)				
Mollugo cerviana (L.) Ser.	threadstem carpetweed	X	+	+
NYCTAGINACEAE (Four-o'clock Family)				
Boerhavia repens L.	alena, nena	I	+	+
PLANTAGINACEAE (Plantain Family)				
Plantago major L.	broad-leaved plantain, laukahi	X	+	-
POLYGONACEAE (Buckwheat Family)				
Rumex crispus L.	curly dock, yellow dock	X	+	-
PORTULACACEAE (Purslane Family)				
Portulaca oleracea L.	pigweed, akulikuli kala	X	+	+

13

SCIENTIFIC NAME	COMMON NAME	STATUS	VEGETATION TYPE c	s
Portulaca pilosa L.	'ihi	X	+	+
RUBIACEAE (Coffee Family) Morinda citrifolia L.	noni	P	+	-
SOLANACEAE (Nightshade Family) Lycium sandwicense A. Gray	ohelo kai, 'ae'ae	I	+	-
STERCULIACEAE (Cacao Family) Waltheria indica L.	'uhaloa, hi'aloa	I?	+	+
VERBENACEAE (Verbena Family) Vitex rotundifolia L. f.	beach vitex, pohinahina	I	+	-

14

Addendum

CONVOLVULACEAE Ipomoea pes-caprae (L.) R. Br.	beach morning-glory, pohuehue	I	+	-

APPENDIX E

SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT MAUNA LANI MARINA, SOUTH KOHALA, HAWAII

SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT MAUNA LANI MARINA SOUTH KOHALA HAWAII

Prepared for

Belt Collins and Associates

By

Phillip L. Bruner
Assistant Professor of Biology
Director, Museum of Natural History
BYU-H
Laie, Hawaii 96762

30 March 1989

SURVEY OF THE AVIFAUNA AND FERAL MAMMALS AT
MAUNA LANI MARINA SOUTH KOHALA, HAWAII

INTRODUCTION

The purpose of this report is to summarize the findings of a two day (26-27 March 1989) bird and mammal field survey of property proposed for development at Mauna Lani Resort, South Kohala, Hawaii (see Fig. 1). Also included are references to pertinent literature as well as unpublished reports.

The objectives of the field survey were to:

1- Document what bird and mammal species occur on the property or may likely occur given the type of habitats available.

2- Provide some baseline data on the relative abundance of each species.

3- Determine the presence or likely occurence of any native fauna particularly any that are considered "Endangered" or "Threatened". If such occur or may likely be found on the property identify what features of the habitat may be essential for these species and suggest how those resources may best be protected.

4- Determine if the property contains any special or rare habitats that should be protected.

GENERAL SITE DESCRIPTION

The project site is located on approximately 88 acres in South Kohala, Hawaii (see Fig. 1). The habitat is a mix of barren lava flows, dryland exotic forest of Kiawe (*Prosopis pallida*) and a coastal patch of exotic trees. A number of small brackish ponds also occur in the coastal section of the property.

Weather during the field survey was clear. Winds were variable with both calm and gusty periods. The direction of the wind was primarily from the east.

STUDY METHODS

Field observations were made with the aid of binoculars and listening for vocalizations. These observations were concentrated during the peak activity periods of early morning and late afternoon. Attention was also paid to the presence of tracks and scats as indicators of bird and mammal activity.

At various locations (see Fig.1) eight minute counts were made of all birds seen or heard. Between these count

stations walking tallys of birds seen or heard were also kept. These counts provide the basis for the relative abundance estimates given in this report. Unpublished reports of birds known from similar habitat on lands elsewhere in West Hawaii were also consulted in order to acquire a more complete picture of possible avifaunal activity (Bruner 1979, 1980, 1984a, 1984b, 1984c, 1985a, 1985b, 1985c, 1988a, 1988b, 1989). Observations of feral mammals were limited to visual sightings and evidence in the form of skeletal remains, scats and tracks. No attempts were made to trap mammals in order to obtain data on their relative abundance and distribution. One night was devoted to searching for the presence of owls and the Hawaiian Hoary Bat (*Lasiurus cinerus semotus*).

Scientific names used herein follow those given in the most recent *American Ornithologist's Union Checklist* (A.O.U. 1983), *Hawaii's Birds* (Hawaii Audubon Society 1984), *A Field Guide to the Birds of Hawaii and the Tropical Pacific* (Pratt et al. 1987) and *Mammal Species of the World* (Honacki et al. 1982).

RESULTS AND DISCUSSION

Resident Endemic (Native) Land and Water Birds:

No endemic species were recorded during the course of the field survey. The only potential endemic resident bird that might occasionally occur in the area would be the Short-eared Owl or Pueo (Asio flammeus sandwichensis) This endemic subspecies is relatively common on the island of Hawaii particularly at higher elevations (Berger 1972, Hawaii Audubon Society 1984, Pratt et al. 1987). Pueo are listed by the State of Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife as "endangered" on Oahu but not elsewhere in the State. The coastal ponds on the property are too small and to encroached by over-hanging vegetation to be of much use to native endemic waterbirds.

Resident Indigenous (Native) birds:

One relatively fresh carcass of a Black-crowned Night Heron (Nycticorax nycticorax) was recovered beside one of the coastal ponds on the property. Apparently this species may forage at this site. None, however, were observed during the course of the survey.

Migratory Indigenous (Native) Birds:

Migratory shorebirds winter in Hawaii between the months of August through May. Some juveniles will stay through the summer months as well (Johnson et al. 1981, 1983, in press). Of all the shorebirds species which winter in Hawaii the Pacific Golden Plover (Pluvialis fulva) is the most abundant. Plovers prefer open areas such as mud flats, lawns, pastures, plowed fields and

roadsides. They arrive in Hawaii in early August and depart to their arctic breeding grounds during the last week of April. Johnson et al. (1981) and Bruner (1983) have shown plover are extremely site-faithful on their wintering grounds and many establish foraging territories which they defend vigorously. Such behavior makes it possible to acquire a fairly good estimate of the abundance of plover in any one area. These populations likewise remain relatively stable over many years (Johnson et al. in press). A total of 10 plover were counted on the property. These birds were foraging next to roadsides, on the golf course, along the shoreline and around the small ponds. The present nature of much of the habitat, however, is unsuitable for plover foraging territories as the vegetation is too dense and the grasses too tall. Several plover were heard calling after dark. Apparently they leave their foraging grounds along the coast and aggregate at night on the more upland barren lava flows. This behavior is probably an antipredator strategy similar to rooftop roosting which has been observed on Oahu (Johnson and Nakamura 1981).

Five Wandering Tattler (Heteroscelus incanus) were seen foraging along the rocky shoreline and in the shallow areas of the coastal brackish ponds during low tide. No studies on site-faithfulness in this species have been conducted but it is likely that they may exhibit some of the same abilities in this regard as Pacific Golden Plover. No other migratory species were recorded during the survey. The Ruddy Turnstone (Arenaria interpres and Sanderling (Calidris alba) are two other common winter migrants to Hawaii. Both of these species likely occur along the coastal portions of the property.

Resident Indigenous (Native) Seabirds:

None were observed on the property. Some seabirds nest and roost in barren lava flows in Hawaii but at much higher elevations (Pratt et al. 1987).

Exotic (Introduced) Birds:

A total of 15 species of exotic birds were recorded during the field survey. Table One shows the relative abundance of each species. The most abundant species were Warbling Silverbill (Lonchura malabarica), Zebra Dove (Geopelia striata) and House Finch (Carpodacus mexicanus). Black Francolin (Francolinus francolinus) and Gray(Francolinus pondicerianus) were also numerous. Given the present habitat and its location and based on other surveys in similar habitat (Bruner 1979, 1980, 1984a, 1984b, 1985a, 1985b, 1985c, 1988a, 1988b, 1989). as well as information provided in Berger (1972), Hawaii Audubon Society (1984), and Pratt et al. (1987) the following exotic bird species might also be expected to occasionally occur on or near the property: Barn Owl (Tyto alba), Ring-necked Pheasant (Phasianus colchicus),

California Quail (Callipepla californica), Japanese Quail (Coturnix japonica), Chestnut-bellied Sandgrouse (Pterocles exustus) and Yellow-fronted Canary (Serinus mozambicus). An earlier survey of Mauna Lani Property (Bruner 1984a) found Japanese Quail but did not record the following six species found on this survey: Black Francolin (Francolinus francolinus), Erckel's Francolin (Francolinus erckelii), Yellow-billed Cardinal (Paroaria capitata), Saffron Finch (Sicalis flaveola), House Finch (Carpodacus mexicanus), and Nutmeg Mannikin (Lonchura punctulata). The increase in the composition of the avifauna over a period of five years illustrates how rapidly exotic species may extend their range. By the same measure the decline in numbers or the total extripation of a species from a locality also demonstrates the susceptibility of exotic species to alien environments (Williams 1987).

Feral Mammals:

Feral Goats (Capra hircus) were observed on the property and adjacent lands. A total of 12 goats were counted on the survey. Several Small Indian Mongoose (Herpestes auropunctatus) were seen but no rats, mice or cats were recorded, However, it would be highly unusual if these ubiquitous mammals did not occur on the property. Without a trapping program it is difficult to conclude much about the relative abundance of these species, however, their numbers are probably typical for this type of habitat in this sector of the island. One, presumably feral, cat was recorded.

Records of the endemic and endangered Hawaiian Hoary Bat (Lasiurus cinerus semotus) are sketchy but the species has been reported from Hawaii (Tomich 1986). None were observed on this field survey despite night time observations. This species roosts solitarily in trees. Much remains to be known about the natural history of this bat and its ecological requirements here in Hawaii. Bruner (1984d) found bats on the Sheraton Waikoloa Beach Resort property which is located south of this site so it is certainly possible this endemic and endangered species might on occasion occur on the property.

CONCLUSION

A brief field survey can at best provide only a limited perspective of the wildlife present in any given area. Not all species will necessarily be observed and information on their use of the site must be sketched together from brief observations and the available literature. The number of species may vary throughout the year due to available resources and reproductive

success. Species which are migratory will quite obviously be a part of the faunal picture only at certain times during the year. Exotic species sometimes prosper for a time only to later disappear or become a less significant part of the ecosystem (Williams 1987). Thus only long term studies can provide an in depth view of the bird and mammal populations in a particular area. However, when brief field studies are coupled with data gathered from other similar habitats the value of the conclusions drawn are significantly increased.

The following are some general conclusions related to bird and mammal activity on the property.

1- The present habitat provides a limited range of living spaces which are utilized by the typical array of exotic species of birds one would expect at this elevation and in this type of environment in Hawaii. However, some species typically found in this habitat were not recorded. This could have been due to the fact that the survey was too brief or that their numbers are so low that they went undetected or a combination of these and other factors. No endemic or endangered birds or seabirds were recorded nor would they be expected to occur on this property.

2- The proposed development will significantly alter large areas of the existing habitats. Some species such as Nutmeg Mannikin and Warbling Silverbill prefer dry grass and brush. Their populations may decline in numbers following development. Populations of other species may actually increase with urbanization these include: Common Myna (Acridotheres tristis), Zebra Dove (Geopelia striata) and the ubiquitous House Sparrow (Passer domesticus). This latter species is limited to areas of human activity and often forages in feed lots and refuse dumps.

3- In order to obtain more definitive data on mammals, a trapping program would be required. No endangered species, however, were observed. Feral goat and mongoose were the most common mammals on the property. The goat population will likely decline following development.

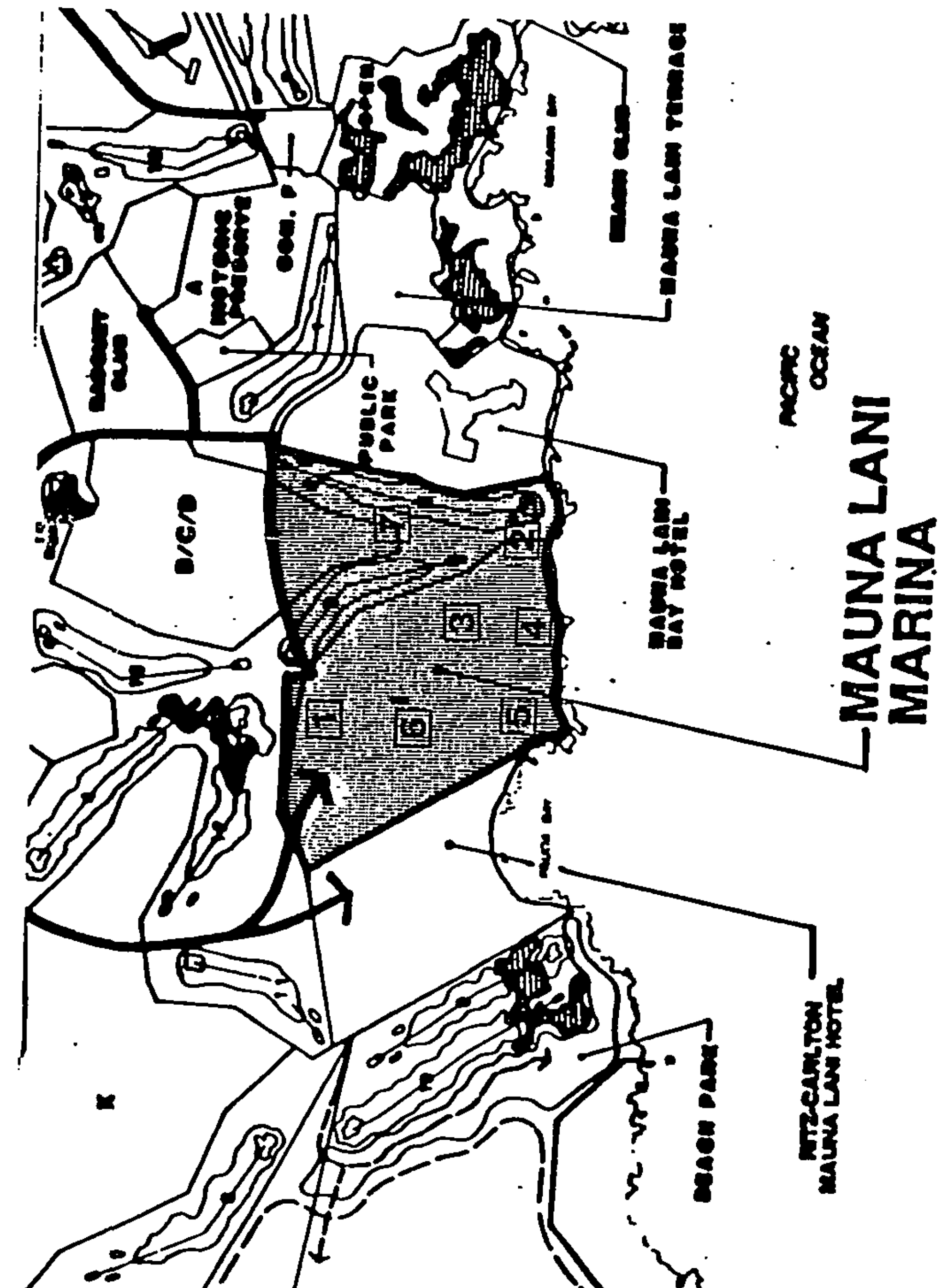


Fig. 1 Project property with locations of eight minute counts numbered.

KEY TO TABLE 1

RELATIVE ABUNDANCE = Number of times observed during survey or frequency on eight minute counts in appropriate habitat.

A = Abundant (ave. 10+) (number which follows is average of data from all survey days)

C = Common (ave. 5-10)

U = Uncommon (ave. less than 5)

R = Recorded (seen or heard at times other than on 8 min. counts. Number which follows is the actual number seen or heard).

TABLE 1

Exotic species of birds recorded on Mauna Lani property, South Kohala, Hawaii

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE*
Black Francolin	Francolinus francolinus	C = 6.1
Gray Francolin	Francolinus pondicerianus	C = 9.3
Erckel's Francolin	Francolinus erckelii	R = 1
Spotted Dove	Streptopelia chinensis	C = 5.8
Zebra Dove	Geopelia striata	A =10.5
Common Myna	Acridotheres tristis	C = 8.6
Yellow-billed Cardinal	Paroaria capitata	U = 4
Northern Cardinal	Cardinalis cardinalis	C = 6.1
Northern Mockingbird	Mimus polyglottos	U = 4.3
Saffron Finch	Sicalis flaveola	U = 3.6
Japanese White-eye	Zosterops japonicus	C = 8.9
Nutmeg Mannikin	Lonchura punctulata	C = 5.7
Warbling Silverbill	Lonchura malabarica	A =15.1
House Finch	Carpodacus mexicanus	A =10.5
House Sparrow	Passer domesticus	R =12

* (See page 13 for key to symbols)

SOURCES CITED

American Ornithologist's Union 1983. Check-list of North American Birds. 6th edition. American Ornithologist's Union, Washington, D.C.

Berger, A.J. 1972. Hawaii Birdlife. The Univ. Press of Hawaii, Honolulu. 270 pp.

Bruner, P.L. 1979. An Avifaunal and feral mammal survey of Makuhona Properties, Hawaii. Unpubl. ms.

——— 1980. An Avifaunal and feral mammal survey of Olohana Properties and Mauna Loa Lands, Hawaii. Unpubl. ms.

——— 1983. Territorial behavior of wintering Pacific Golden Plover in Hawaii. Ms. (Paper presented at 100th meeting of the Amer. Ornith. Union).

——— 1984a. An Avifaunal and feral mammal survey of Mauna Lani. Hawaii. Unpubl. ms.

——— 1984b. An Avifaunal and feral mammal survey of Mauna Kea Properties, Hawaii. Unpubl. ms.

——— 1984c. An Avifaunal and feral mammal survey of Waikoloa Beach Resort Property, Hawaii. Unpubl. ms.

——— 1984d. Letter to A. Yoklavich concerning recovery of a specimen of the Hawaiian Hoary Bat at Sheraton Royal Waikoloa, Hawaii. Date: 10 Oct. 84.

——— 1985a. An Avifaunal and feral mammal survey of additional Waikoloa Beach Resort Property, Hawaii. Unpubl. ms.

——— 1985b. An Avifaunal and feral mammal survey of property proposed for development at Parker Ranch, Hawaii. Unpubl. ms.

——— 1985c. An Avifaunal and feral mammal survey on property proposed for a resort-residential development at Kaupulehu, Hawaii. Unpubl. ms.

Bruner, P.L. 1988a. Survey of the avifauna and feral mammals at Waikoloa Village Property, Waikoloa, Hawaii. Unpubl. ms.

——— 1988b. Survey of the avifauna and feral mammals at Kaupulehu Property, Hawaii. Unpubl. ms

——— 1989. Survey of the avifauna and feral mammals at the proposed West Hawaii Sanitary Landfill Project, North Kona, Hawaii. Unpubl. ms.

Hawaii Audubon Society. 1984. Hawaii's Birds. Third Edition Hawaii Audubon Society, Honolulu. 96 pp.

Honacki, J.H., K.E. Kinman and J.W. Koeppl ed. 1982. Mammal species of the world: A taxonomic and geographic reference. Allen Press, Inc. and the Association of Systematic Collections, Lawrence, Kansas. 694 pp.

Johnson, O.W., P.M. Johnson, and P.L. Bruner. 1981. Wintering behavior and site-faithfulness of Golden Plovers on Oahu. 'Elepaio 41 (12): 123-130.

Johnson, O.W. and P.M. Johnson. 1983. Plumage-molt-age relationships in "Over-summering" and migratory Lesser Golden-Plovers. Condor 85: 406-419.

Johnson, O.W., M.L. Morton, P.L. Bruner, and P.M. Johnson. Winter range fat cyclicity in Pacific Golden-Plovers (Pluvialis fulva) and predicted migratory flight ranges. (In press).

Johnson, O.W. and R.M. Nakamura. 1981. The use of roofs by American Golden Plovers Pluvialis dominica fulva wintering on Oahu, Hawaiian Islands. Wader Study Group Bulletin. 31: 45-46.

Pratt, H.D., P.L. Bruner, and D.G. Berrett. 1987. A Field guide to the birds of Hawaii and the tropical Pacific. Princeton Univ. Press. 500 pp.

Tomich, P.Q. 1986. Mammals in Hawaii. Bishop Museum Press. Honolulu. 375 pp.

Williams, R.N. 1987. Alien Birds on Oahu 1944-1985. 'Elepaio 47(9): 87-92.

APPENDIX F

PRELIMINARY ASSESSMENT OF THE MARINE AND POND ENVIRONMENTS IN THE VICINITY OF THE PROPOSED MAUNA LANI COVE, SOUTH KOHALA, HAWAII

PRELIMINARY ASSESSMENT OF THE MARINE AND POND ENVIRONMENTS IN THE VICINITY OF THE PROPOSED MAUNA LANI COVE, SOUTH KOHALA, HAWAII

Prepared by

Marine Research Consultants
1720-A Paula Dr.
Honolulu, HI 96816

Prepared for

Belt, Collins & Associates
680 Ala Moana Blvd.
Honolulu, HI 92813

Revised

October 3, 1989

INTRODUCTION

Purpose

The Mauna Lani Resort is currently planning construction of an inland marina and waterway development with an entrance channel to the open ocean, called the Mauna Lani Cove. House lots will surround the periphery of the Cove, and will also occupy several islands left in the basin. Location of the project is between the northern boundary of the existing Mauna Lani Bay Hotel and the southern boundary of the under-construction Ritz-Carlton Hotel(see Figure 1). In order to place the harbor in this location, two existing golf holes will be moved inland to a position upland of the basin. The entrance channel will be created by excavating an area that extends from landward of the shoreline through approximately 500-800 feet of offshore area. Depth of dredging will extend to 18 feet of water depth, and width of the entrance channel will be approximately 125 feet. The purpose of this report is to present the results of a baseline survey evaluating the potential effects on water quality and marine biological community structure resulting from construction, and subsequent operation, of the Mauna Lani Cove and associated structures.

The evaluation includes descriptions of the environments that will be removed by channel excavation, as well as neighboring areas that may be influenced by water quality changes caused by construction and operation of the Mauna Lani Cove. The baseline survey also serves as the preliminary phase of any monitoring programs that may be required to meet requirements for permit approval by government agencies, including the County of Hawaii and the U.S. Army Corps of Engineers.

Objectives

1) to establish a baseline set of water chemistry parameters that delineate the presently occurring environmental conditions in the location of the proposed channel, in the areas adjacent to the channel, and in anchialine ponds adjacent to the area where the channel will penetrate the shoreline. Chemical composition of the environment was evaluated by analysis of all parameters specified by State of Hawaii, Department of Health water quality standards (Chapter 11-54-06 (3)), as well as several other parameters that are not listed by DOH, but provide important information.

2) to establish a comprehensive quantitative and descriptive baseline of biotic community structure parameters that could either be directly or indirectly affected by the proposed activity. Community structure parameters that are evaluated in the present report include abundance, distribution and diversity of benthos (bottom dwellers including stony and soft corals, echinoderms, molluscs and crustacea), and swimming species including reef fish, sea turtles and marine mammals. Emphasis is placed on reef corals because of the "keystone" status of this group; corals provide the habitat, and food source for other species assemblages. This information serves to identify any living resources that may be of significant commercial, recreational or esthetic value, or that represent rare, unique, and protected species. All methods used to assemble the baseline have incorporated criteria listed in DOH water quality standards (S11-54-07(3)(D)).

3) to evaluate the degree of natural stresses (sedimentation, wave scour, freshwater input, etc.) that influence nearshore marine communities in the vicinity of the proposed shoreline modifications. Typically, the composition of nearshore reef communities is intimately associated with the magnitude and frequency of these stresses, and any impacts caused by the proposed shoreline modification will be superimposed on natural environmental factors. Therefore, evaluating the range of natural stress is

a prerequisite for assessing the potential for additional change to the marine environment owing to construction and operation of the Mauna Lani Cove.

4) to evaluate the influence to nearshore circulation, salinity, and biotic composition from Honokohau Harbor. Honokohau is qualitatively similar in structure to the planned Mauna Lani Cove, and should provide insight into the probable effects that will result from construction and operation of the planned project.

5) to offer recommendations on construction procedures to minimize impacts and maximize benefits, based on the characteristics of the environment determined by the baseline.

ANALYTICAL METHODS

Water Quality

All field work was conducted on March 17-19, 1989, using a 13-foot boat. Figure 1 is a map showing the Mauna Lani shoreline and the proposed location of the channel and marina. Survey site locations are identified as transects perpendicular to the shoreline extending across the reef shelf. Site 1 bisects the area proposed to be dredged; site 2 lies to the south and site 3 lies to the north.

At each of the 3 transects, samples were collected at 5 distances from the shoreline, ranging from the highest wash of waves to approximately 500 meters (m) offshore. At each site, with the exception of the most shoreward, two samples were collected; a surface sample from within 10 centimeters (cm) of the air-sea interface, and a deep sample approximately 1 m from the sea floor. In addition, water samples were collected from two representative anchialine ponds located nearest the proposed entrance channel, one to the north, and one to the south of the channel entrance (see Figure 1). While there are no criteria specified for anchialine ponds in DOH standards, chemical constituents were also assessed in ponds.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the Water Quality Standards, Department of Health, State of Hawaii. These criteria include: total nitrogen, nitrate + nitrite nitrogen ($NO_3^- + NO_2^-$), ammonia (NH_4^+), total phosphorus, Chlorophyll a (Chl a), turbidity, dissolved oxygen, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{-3}) and silica (Si) were also reported because these parameters are sensitive indicators of biological activity and degree of groundwater mixing, respectively.

Water samples were collected in 1 liter polyethylene bottles. Subsamples for nutrient analyses were filtered in the field through glass-fiber filters into 125 milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and immediately placed on ice. Analysis for NH_4^+, PO_4^{3-}, and $NO_3^- + NO_2^-$ were performed using manual spectrophometric techniques on a fiber optic colorimeter. Total nitrogen and total phosphorus were analyzed in a similar fashion following ultra-violet digestion. Dissolved inorganic nitrogen (DON) and dissolved inorganic phosphorus (DOP) were calculated as the difference between total dissolved and dissolved inorganic N and P. The chemistry procedures were according to standard methods for seawater analysis (Strickland and Parsons 1968).

Water for other analyses was subsampled from 1 liter polyethylene bottles and kept chilled until analysis. Turbidity was determined on 60-ml subsamples fixed with HgCl to terminate biological activity. Fixed samples were kept refrigerated until turbidity was measured on a Turner Designs

nephelometer (No. 40) and reported in nephelometric turbidity units (NTU). Chl. a was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted and assessed fluorometrically. Salinity was determined using a AGE Model 2100 laboratory salinometer with a readability of 0.0001 $^o/oo$. Turbidity and Chl. a were analyzed by AECOS, an environmental laboratory located in Kailua, Oahu.

In-situ field measurements included dissolved oxygen and water temperature (YSI Model 58 meter with a readability of 0.01 milligrams per liter (mg/l) and 0.1 0 c. , respectively). pH was determined in the field with a Cole-Parmer Digisense millivolt meter with a readability of 0.001 pH units.

Biological Community Structure

Several methods were employed in the collection of qualitative and quantitative data. Qualitative reconnaissance surveys covering the entire subject area were conducted by divers swimming from the shoreline out to the limits of coral reef formation (approximately the 60 foot depth contour). These reconnaissance surveys were useful in making relative comparisons between areas, identifying any unique or unusual biotic resources, and providing a general picture of the physiographic structure and benthic assemblages occurring throughout the region of study.

Following the preliminary survey, 12 quantitative transect sites were selected along the 3 offshore stations sampled for water chemistry. Each transect site was selected to represent the typical zonation pattern of the particular station. Transects were 165 feet long, and were oriented parallel to the shoreline so that they bisected a cross-section of a reef zone. Ends of transects were marked by weighted floats. Quantitative benthic surveys were conducted by stretching a surveying tape over the reef surface between the marker floats. An aluminum quadrat frame, with dimensions of 3 feet by 2 feet, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substrata types within the quadrat frame. Only macrofaunal species greater than approximately 2 cm were noted; no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Following the period of field work, quadrat photographs were projected onto a grid and units of bottom cover for each benthic faunal species and bottom type were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1979, Grigg and Maragos 1974, Grigg 1983).

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fishes observed within a band approximately 6 feet wide along the transect path were identified to species and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance by divers was created, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral. This transect method is an adaptation of techniques described in Hobson (1974).

Anchialine pond biota was assessed by visual observation from the shoreline. Leaf litter within ponds was removed for inspection, but ponds were not disturbed in any other manner. Organisms were identified according to Maciolek and Brock (1974).

RESULTS AND DISCUSSION

Physical Setting

The geomorphology of the coastal area off the planned Mauna Lani Cove is composed of several distinct zones which are diagramed in Figure 2. The shoreline is composed of narrow beaches covered with coarse sand and basaltic rock. Several "systems" of interconnected anchialine ponds occur on the shoreline in topographically low areas. Anchialine ponds are shoreline pools without surface connection to the sea that contain water of measureable salinity, which oscillate with tidal fluctuation owing to inland extension of the oceanic water table. Maciolek and Brock (1974) describe the successional "life history" of anchialine ponds from early stages of bare lava rock basins to late senescent stages where ponds essentially become marshland owing to infill of sediment and organic plant material. The ponds fronting the Mauna Lani Cove appear to be approaching later successional phases. All of the anchialine ponds surveyed in the vicinity of the proposed project contained abundant decomposing leaf litter from shoreline vegetation.

The intertidal zone consists primarily of a basaltic ledge that is barren of most organisms. From the shoreline to approximately 800 feet offshore the bottom consists of a shallow terrace that is bisected by sand channels. The terrace is composed of a basaltic shelf covered with a calcium carbonate (limestone) veneer. Maximum depth of the platform is approximately 15 feet. The entire reef terrace is covered with a layer of fine sandy sediment. Other than sand channels, the only relief in this area is shallow depressions filled with coarse sand. Sandy sediment on the limestone pavement is in a constant state of resuspension by current and wave forces. This continual scouring, as well as concussive force associated with breaking waves prevents the development of substantial coral communities on the reef terrace (see Dollar 1975, 1982 for complete discussion of reef coral zonation as a function of wave stress).

At the seaward edge of the shallow reef terrace, the bottom slope steepens into a sharp drop-off that extends to depths of approximately 30 feet. Beyond the drop-off, bottom topography is a sloping reef platform typical of the nearshore coastal region of West Hawaii (see Dollar 1975, 1982). Owing to dissipation of wave energy beyond the drop-off, extensive coral communities colonize the slope to a depth of approximately 60 feet. Beyond the deepest extension of the reef coral communities, bottom topography consists of a sloping sand plain that extends to abyssal depths.

Patterns of current flow in the vicinity of the marina entrance channel have been monitored in an ongoing program (Sea Engineering 1989). To date, results indicate that currents in the region are relatively slow, typically 5 to 7 cm/sec (0.1 knot), with an overall net transport to the southwest of 1.3 cm/sec. The maximum measured velocity was 33 cm/sec (0.6 knot). No particular correlation with the tide was evident, however, the net transport to the southwest weakens during the flood tide.

Water Chemistry

Table 1 shows results of water chemistry analyses at all of the Mauna Lani Cove sampling sites shown in Figure 1. Specified limits of the measured water quality parameters set forth by the Department of Health for coastal waters are shown in Table 2. When comparing results from Table 1 with water quality standards listed in Table 2 it can be seen that geometric mean concentrations for all chemical parameters, except $NO_3^- + NO_2^-$ are below "geometric mean not to exceed" criteria for "wet" conditions in open coastal waters. Inspection of the data indicates that the relatively high

geometric mean of $NO_3^- + NO_2^-$ is a result of concentrations in excess of 15 uM within 30 feet of the shoreline at stations 1 and 3. No such nearshore increase is present at station 2.

Figure 3 shows the relationship of salinity with distance from shore. Within 30 feet of the shoreline salinity is decreased owing to efflux of groundwater. Such groundwater extrusion in most evident at Station 1, where salinity is approximately 24°/oo at the shoreline, a depression of about 10.5°/oo as compared to the open ocean. Station 2 exhibits almost no such salinity depression, with salinity at the shoreline only 0.4°/oo less than the open ocean.

Figure 4 shows plots of 7 water chemistry parameters as functions of salinity. In addition to the concentrations measured in the ocean samples, concentrations from 2 ponds located near the proposed channel entrance are included. Conservative mixing lines on each plot (except turbidity) are constructed by joining the endpoint concentrations of groundwater from wells located inland from the project site, and open ocean water. The locations of sample data points relative to the conservative mixing line provide an indication of nutrient dynamics that are occurring in the nearshore ocean. Data points falling above the mixing line indicate an external source of material into the system (e.g. runoff of sewage or fertilizer). Data points falling below the mixing line indicate a sink in the system removing dissolved material (e.g. biological uptake that is faster than physical mixing processes). When data points fall on the conservative mixing line, there are neither external sources nor sinks in the system, and materials reaching the ocean from land are dispersed by purely physical processes. Scaling dissolved nutrient parameters to salinity in this manner eliminates the need to consider tidal state while evaluating if materials from outside the system (potential pollutants) are influencing nearshore waters. This methodology is a standard approach for investigating nutrient dynamics in estuaries (e.g. Kaul and Froelich 1984, Officer 1979, Smith et al. 1987), but has rarely been used in the open ocean.

It can be seen in Figure 4 that concentrations of several dissolved constituents lie very close to the conservative mixing lines. Dissolved Si, $NO_3^- + NO_2^-$, and PO_4^{3-} all vary linearly, with salinity on lines of identical slope as the mixing lines. These 3 constituents are found in high concentration in groundwater (see concentrations in ponds in Table 1). Linear dispersion in the nearshore ocean indicates that presently there are no external sources of these materials emanating from land. Thus, the mean $NO_3^- + NO_2^-$ values in the vicinity of the Mauna Lani Cove site that are in excess of the DOH water quality standards are simply a result of high rates of groundwater efflux, and not from a potential pollution source.

Patterns of dispersion of other chemical parameters that are not present in substantially higher concentrations in groundwater than the ocean do not show a clean linear pattern of mixing. Concentrations of NH_4^+ lie above the mixing line, especially for pond samples. Decomposition of particulate organic material is a source of NH_4^+. It is likely that leaf litter in the ponds is decomposing and releasing NH_4^+. Dissolved organic nitrogen (DON) and phosphorus (DOP) occur in higher concentrations in most of the ocean samples relative to the ponds. Therefore, these materials do not appear to have the potential to be increasing in the nearshore ocean as a result of activities on land.

Turbidity shows a slightly decreasing trend moving seaward. All turbidity values, however, are low in comparison to DOH criteria. Uniform distribution of Chl. a (Table 1) indicates that there are no areas of plankton blooms across the reef platform. Dissolved oxygen concentration and pH show no trends with distance from shore. Temperature is slightly decreased at stations within 10 m of the shoreline, owing to input of cooler groundwater.

Benthic Community Structure

Table 3 shows the distribution of reef corals on 12 benthic transects in the vicinity of the planned Mauna Lani Cove. It can be seen that the coral community zonation pattern reflects the physical structure of the reef habitats (see Figure 2), and natural environmental stresses associated with the various habitats. Transects at each station at depths less than 15 feet bisected the shallow reef terrace zone. Owing to factors related to the shallow depth, living corals are relatively scarce on the reef terrace, with total cover ranging from 5% to 28%. At station 1, the location of the proposed channel, coral cover at stations ML1-8 and ML1-10 were 5.2% and 9.1%, respectively. Number of coral species is also low (2-4) on the reef platform. Porites lobata and Pocillopora meandrina are the only corals that appear on all shallow (< 15 feet) transects.

Beyond the edge of the reef drop-off, water depth and coral cover increase. On transects off the Mauna Lani greater than 15 feet in depth, total coral cover ranges from 49% to 86%. At station 1, directly off of the proposed marina alignment, coral cover was 75% at 20 ft. and 86% at 40 feet. Species number is also greater in the deep reef zone than the shallow terrace, ranging from 3-7. Dominant coral cover consists of interconnected mats of Porites compressa and large colonies of P. lobata. Smaller species present, with respect to areal coverage, include Montipora verrucosa, M. patula, and Pavona varians. The deeper reef zones are considered well-developed coral communities, typical of the coastline of West Hawaii described in Dollar (1975, 1982).

Only several species of motile invertebrates were observed anywhere on the reef platform. The major taxa of benthic organisms occurring within the survey area were sea urchins (Echinoidea) (see Table 4). The most abundant urchins in the reef terrace zone were the two species that bore into limestone surfaces, Echinometra matheai and Echinostrephus aciculatus. Several individuals of larger species of urchins, Tripneustes gratilla, Echinothrix diadema, and Heterocentrotus mammillatus were also observed, but are considered rare in occurrence.

The entire reef surface not inhabited by coral colonies is covered with a short mixed-species algal turf. Frondose benthic algae are rare in occurrence in all zones of the surveyed reef. No areas of dense algae that might be considered of commercial, or recreational harvesting value were observed.

Reef Fish Community Structure

A rich and diverse fish community, typical of West Hawaii, was found in reef areas off the proposed development. This community has been described in detail by Hobson (1974). The total number of species observed on transects was 67; species number ranged from 8 to 32 on transects, while individual fish encountered on transects ranged from 43 to 461 (see Table 5). Inshore areas (less than 10 feet deep) had both fewer species and total individuals, resulting in a lower overall species diversity. The lower number of inshore fishes is probably a result of the less favorable physical environment caused by heavy surge from wave action, and less habitat complexity from lowered coral growth. The highest species diversity was noted at depths of about 20 feet.

Several representative groups of reef fish were especially abundant on transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. At depths greater than 20 feet, the yellow tang (lau'i-pala, Zebrasoma flavescens) and the goldring surgeonfish (kole, Ctenochaetus strigosus) were particularly abundant. At shallower sites, the brown surgeonfish (ma'i'i'i, Acanthurus nigrofuscus) was predominant.'

Planktivorous damselfishes of the genera Chromis and Abudefduf were common. Also quite prominent in the water column were the black durgon (humuhumu-'ele'ele, Melichthys niger) and the

pinktail durgon (humuhumu-hi'u-kole, M. vidua). The reef triggerfish (Humuhumu-nukunuku-a-pua'a, Rhinecanthus rectangulus) was common in shallow water. Other common fishes included the many-bar goatfish (moano, Parupeneus multifasciatus) and the multiband butterflyfish (kikakapu, Chaetodon multicinctus). The angelfish Centropyge potteri and several wrasses were abundant in areas dominated by coral rubble. The saddleback wrasse (Thalassoma duperrey) was common in all environments.

Juvenile reef fishes were most abundant at the deeper transect sites in areas of Porites compressa. The lattice structure formed by this coral provides a sheltered refuge for small fish. Juveniles belonged mostly to the family Acanthuridae (surgeonfishes), with representatives from the families Labridae (wrasses), Mullidae (goatfishes), and Chaetodontidae (butterflyfishes).

Large schools of roving herbivorous fishes were an important part of the fish community at intermediate depths (10-20 feet). These schools were comprised of large adult fishes from a variety of species, including the yellowfin surgeonfish (pualu, Acanthurus xanthopterus), the orangeband surgeonfish (A. olivaceus), the convict tang (manini, A. triostegus), the unicornfish (kala, Naso unicornis) and the redlip parrotfish (uhu or palukaluka, Scarus rubroviolaceus). One such school was encountered directly on transect ML2-20', and other schools were observed during the study.

Surge zone fishes were not quantitatively assessed because of the difficulty in working on the wave-swept basalt terraces that these fishes inhabit. Visual observations, however, revealed that this biotope supported a large number of fishes, principally herbivores of the genera Kyphosus, Acanthurus, and Naso. The surge wrasse (hou, Thalassoma trilobatum), the Christmas wrasse (awela, T. purpureum), and the reef triggerfish (humuhumu-nukunuku-a-pua'a, Rhinecanthus rectangulus) were also abundant in the surge zone. Few juvenile fishes were seen in this environment, although inshore tidepools are generally inhabited by young individuals.

Several species of "food fishes" were observed during the survey. These included parrotfishes (Scarus spp.), goatfishes (Parupaneus and Mulloidichthys spp.), jacks (Caranx melamphygus), surgeonfishes (Acanthurus and Naso spp.) and the introduced Tahitian grouper (Cephalopholis argus). None of these fishes were particularly abundant and all tended to avoid divers. Squirrelfishes (Myripristis spp.) were common in ledges both inshore and near the bottom of the reef slope, but individuals tended to be small. A particularly large school (<50 individuals) of emperorfish (mu, Monotaxis grandoculis) was seen in about 40 feet of water, but were very difficult to approach.

One noteworthy point concerning the fish community off the proposed Mauna Lani Cove was the relative scarcity of butterflyfishes. Although one species (Chaetodon multicintus) was well represented, other species in this genus were not as common as would be expected. Because this group is commercially harvested by aquarium fish collectors, their scarcity may indicate that this fishery is affecting reef fish community structure at this site.

Threatened or Endangered Species

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by Federal jurisdiction. The threatened green sea turtle (Chelonia mydas) occurs commonly along the shoreline of the major Hawaiian Islands and is known to feed on selected species of macroalgae. Resting habitat of green sea turtles is commonly deeper reef areas characterized by undercut ledges and other topographical features. The endangered hawksbill turtle (Eretmochelys imbricata) is found infrequently in waters off Hawaii. Only one small green sea turtle was observed during the course of the present survey, although it is likely that turtles frequent the area on occasion

Populations of the endangered humpback whale (Megaptera novaeangliae) spend the winter months in the Hawaiian Islands, and are especially abundant off the West Coast of Hawaii. Several pods of whales were noted offshore of the proposed channel entrance during the course of the

present survey. However, all observed whales were at least 1000 feet from the shoreline, and did not transit or rest on the shallow reef terrace or reef platform zones.

Anchialine Ponds

Anchialine pond biotic communities are characterized by a rather unique assemblage of organisms of relatively low species diversity. Typically, the most abundant fauna of anchialine ponds are snails and shrimp. Maciolek and Brock (1974) classify four shrimp, three snails and two native fish as being "representative" pond organisms. Five pond organisms are considered rare by the U. S. Fish and Wildlife Service, but these organisms are not listed as endangered or threatened, or are they proposed for listing.

Observed anchialine pond biota were similar in the two ponds surveyed. No fish of either native or exotic species were noted in either pond. The lack of exotic fish can be considered an important environmental characteristic, as ponds containing exotic fish species are often impacted in terms of lack of shrimp (Maciolek and Brock 1974, Dollar 1986). Crustaceans included the red shrimps Halocaridina rubra, and Metabetaeus lohena and the transparent shrimp Palaemon debilis. Qualitative estimates of abundance indicate that shrimp were not overly abundant, as has been observed in some ponds on the Mauna Lani property. Individuals were predominantly sighted under leaf litter. Molluscs observed included Assiminea sp., Melania sp., and Theodoxus cariosa. The former two mollusk species were abundant in both ponds, while only several individuals of the third were noted. No vascular pond plants, or algal mats were present in either of the ponds at the time of the survey.

Honokohau Harbor

Circulation and Salinity

An expected effect of creating a harbor from inland dredging is alteration of freshwater (groundwater) efflux in the nearshore zone. Honokohau Harbor, located north of Kailua town on the coastline of West Hawaii, was originally created by blasting a basin from basaltic rock in a manner similar to the proposed plan for the Mauna Lani Cove. Original construction of the Harbor occurred in 1970, and expansion has taken place since then. Patterns of water circulation and biotic colonization of Honokohau have been the subject of study of a 10-year monitoring program conducted by the U.S. Army Corps of Engineers (1983).

In summary, the 10-year monitoring program showed that the circulation pattern of the Harbor is essentially a two-layer system. Warm, high salinity water from the open ocean made up the lower layer and a mixture of seawater and groundwater comprised the upper layer. Groundwater originating in the back basin rose through the water column and mixed with water from the lower layer to produce a large volume of surface water that continually flowed out the harbor entrance channel. Deep water was constantly supplied from the outside to replace that which was mixed and flowing out of the harbor at the surface. The pattern of deep inflow and surface outflow dominated the circulation, and while modified by tidal cycles, persisted at all times. The original harbor was flushed exceptionally well owing to groundwater input in the innermost part of the harbor. Groundwater input through the bottom tended to maximize the amount of mixing in the lower layer. Mass balance calculations

indicated the groundwater input produced a volume exchange in the inner basin that was about 10 times greater than would have resulted from tidal action alone (U. S. Army Corps of Engineers 1983).

Expansion of Honokohau to enlarge the inner basin resulted in maintenance of a two-layered system driven by ground-water input. The pumping action of groundwater, however, became less important even though the magnitude of input remained about the same as in the original harbor. While pumping throughput was about 5 times larger than tidal outflow in the original harbor, the processes were calculated to be approximately equal in magnitude in the expanded harbor. This change gave rise to a much more sluggish circulation in the inland-most portions of the new inner basin and a commensurate decrease in flushing. Residence time of the inner basin increased from the calculated time of about 12 hours prior to expansion. Following expansion, only a small fraction of the water in the innermost end of the inner basin appeared to exchange on each tidal cycle, and the best estimate of residence time suggested values on the order of ten days. The reduction in horizontal circulation in the inner basin and subsequent increase in residence time resulted in increased phytoplankton populations in the inner harbor (U.S. Army Corps of Engineers 1983).

In order to reassess the effects of Honokohau Harbor in 1989, specifically with respect to effects on the nearby ocean, 18 sets of water samples were collected and analyzed for salinity. Figure 5 shows sampling locations in Honokohau Harbor, and Table 6 shows salinities for surface and bottom samples from each location. When salinities are plotted as functions of distance from the harbor entrance (Figure 6), it can be seen that there are distinct patterns with respect to depth in the water column and location in the harbor. Within the harbor (negative values of distance in Figure 6), vertical stratification is very distinct with a constant difference of about 6 ^{o}/oo. Beyond the Harbor entrance, the range of difference between surface and bottom water is approximately 2-4 ^{o}/oo. It can also be seen that at all stations beyond the Harbor entrance, bottom salinities are within 1^o/oo of open ocean salinity.

Examination of Table 1 shows that at the stations nearest to shore at Transects 1 and 3 off the area proposed for the Mauna Lani Cove, there are surface-bottom salinity differences of approximately 6^o/oo and 5^o/oo, respectively. Such stratification is of essentially the same magnitude as found within Honokohau Harbor, and is greater than observed outside the Harbor.

Benthic Community Structure

Figure 5 shows the locations of 3 transects near the entrance of Honokohau Harbor where coral community structure was assessed. Transect sites were selected to bisect the regions of maximal coral coverage of each location. It can be seen in Table 7 that coral cover was highest (87%) on the central transect (#2), and was lowest (12%) on the transect farthest from the channel entrance (#1). The transect nearest the channel (#3) had coral cover of 22%. Transect 2, while located only about 1000 feet to the northeast of transect 1 is composed of a high cover community that consists largely (44%) of P. compressa, a thin branching species that is highly susceptible to breakage from wave stress. Transect 3, which is located adjacent to the channel entrance also appears to be subject to wave stress owing to the lack of cover of P. compressa.

These results suggest that the existence of the Harbor and entrance channel are not singularly responsible for variation of coral cover in the immediate vicinity. If this scenario were the case, it would be expected that cover would decrease with distance from the entrance. Rather, it appears that exposure to long-period swells and breaking waves is the major determinant of coral community structure. Transect 3 located closest to Nolo Point appears to absorb the most direct force of north swells. As a result, coral cover is low and consists of species (primarily Porites lobata) that are capable of assuming growth forms that are most resistant to concussive force of waves.

As discussed in the section above, variations in salinity owing to the Harbor do not appear to be of a magnitude capable of altering benthic structure. In fact, as reported in the Army Corps of Engineers Report, deep water continually flows into the Harbor from outside. Such flow patterns would indicate that there is no potential for alteration of biotic communities outside the Harbor. In the outer portions of the harbor there does not appear to be any increase in sedimentation or turbidity that might affect communities outside the entrance.

In addition, it has been shown in the 10-year monitoring program of Honokohau Harbor that the channel walls, particularly of the outer Harbor, serve as a substratum for coral colonization that is comparable to natural habitats, including lava flows and reef surfaces denuded by freshwater floods (U. S. Army Corps of Engineers 1983). The COE report also suggests that the wave protected environment of the harbor may also promote more rapid growth and colonization by some species compared to natural habitats. In conclusion, the 10-year monitoring program of Honokohau found that harbor construction and operation have not resulted in significant adverse impacts to established colonies in the original harbor and outside the harbor. The inland configuration, shallow depth, small size, rapid flushing, lack of impacts to water quality, and suitable substrata in the outer harbor are all potentially contributing factors for successful coral development (U.S. Army Corps of Engineers 1983).

CONCLUSIONS

Project Construction

While a section of the existing reef and associated biota will be removed by channel construction, it is emphasized that in order to maintain environmental integrity to the highest degree possible, careful attention should be focused in project planning on minimizing impacts associated with movement of suspended materials away from the channel. Prior to construction of the Mauna Lani Cove, it is expected that engineering evaluations will be conducted to assess the underlying substrata of the region to be removed, the expected grain-size distribution and settling characteristics of generated sediment, and pattern and extent of shock waves generated by blasting. Based on the results of these evaluations, measures can be implemented to mitigate as much as possible negative impacts from construction. In addition, based on these evaluations, it will be possible to further refine estimates of potential environmental alteration beyond the preliminary assessments presented below.

Concerning general construction practices, blasting and excavation will remove a segment of the existing reef terrace and associated biota. Survey results indicate that the present bottom cover in this area consists of 5-9% living corals. The major group of fauna inhabiting the terrace are boring sea urchins. It is important to note that dredging and blasting will be confined to the shallow reef terrace where natural physical conditions are relatively severe; no blasting or dredging will take place on the deeper reef platform, where coral cover is upwards of 50%.

While organisms on the reef terrace will be eliminated during construction, a long-term result of the project may likely be an increase of living coral following construction of the channel. As reported in the 10 yr. monitoring survey of Honokohau (U.S. Army Corps of Engineers 1983), corals rapidly recolonized the outer harbor and channel walls following construction. Surveys of the coral communities outside the existing harbor entrance indicate that coral abundance near the entrance is greater than in neighboring communities farther away. Similarly, healthy and diverse coral communities have been observed inside of Kawaihae Harbor (ORCA 1978). A similar situation is likely to occur at the Mauna Lani Cove. Owing to the greater depths of the channel walls and floor relative to the surrounding reef terrace, it is likely that the newly created substrata will be a more suitable settling

area than the natural setting, and coral cover will increase above the present 5-9% There is no reason to suspect that sea urchins will not also recolonize the new surfaces.

Other than direct effects of substrata removal by blasting, potential alteration to water quality and biotic structure could potentially occur by increased sedimentation and turbidity. These parameters will increase during the construction process, and the length of time of decreased water quality will depend on the length of the construction period.

The effects of sediment stress to corals have been extensively reviewed by Johannes (1975), Dodge and Vaisnys (1977), Bak (1978), Brown and Howard (1985) and Grigg and Dollar (1989). In summary, while it is clear that increased sedimentation can have a deleterious effect on corals, especially when buried, sedimentation can also result in no negative impacts. Because sediments are suspended by natural processes in many reef environments, most corals can withstand a certain level of sediment supply to the living surface. Many species have the ability to remove sediment from their tissues by distension of the coenosarc with water, or ciliary action which can nullify lethal effects of sedimentation (Yonge 1931).

In case studies of the effects of sedimentation, the range of environmental effects varies through the entire spectrum of stress. Cases where effects of dredging have caused mortality have been generally limited to areas of confined circulation such as Castle Harbor, Bermuda (Dodge and Vaisnys 1977), and Kaneohe Bay, Hawaii (Banner, 1974). In areas of unrestricted circulation, however, there have been instances of increased sedimentation reported that do not appear to cause any substantial effects to reefs. Sheppard (1980) reported that following dredging and blasting for a military Harbor in Diego Garcia Lagoon, coral cover appeared to show no effects from increased siltation. In addition to the discussion concerning lack of impacts from Honokohau Harbor, a survey of the Kawaihae Deep Draft Harbor located in South Kohala, Hawaii, also showed that coral communities located just outside the harbor breakwater, as well as inside the harbor are flourishing (ORCA 1978).

At the Mauna Lani Resort, results of another shoreline modification project can be used to illustrate the likely effects of increased sediment during construction of the planned Mauna Lani Cove entrance channel. Monitoring of beach construction at Makaiwa Bay (Dollar 1987), located approximately 0.5 miles south of the Mauna Lani Cove site, showed that while substantial sediment plumes in the water column were created by excavation of the shoreline, there were no temporary or permanent negative effects to benthos and fish communities. Rapid flushing of the bay by normal current exchange, and the ability of live corals to exercise sediment removal behavior appeared to prevent measureable changes in community structure parameters. The monitoring survey also showed that water quality parameters were not permanently affected by temporary sediment loads, and quickly returned to preconstruction levels after the new beach was completed (Dollar 1987).

Several other scenarios around the Hawaiian Islands can also be drawn upon to substantiate that impacts from sedimentation do not always result in substantial, irreversible damage to neighboring marine environments. Studies conducted at Princeville, Kauai (Grigg and Dollar 1980), French Frigate Shoals (Dollar and Grigg 1981), and Hilo Bay (Dollar 1985), all investigated the impacts to reef coral communities subjected to high levels of sediment stress. Results of these studies indicate that Hawaiian reef communities possess the adaptive ability to maintain community integrity under conditions of substantial, but temporary, sediment stress.

The common factor in all of these case studies is that as long as sediment generating activities occur in environments with unrestricted circulation, and that the sediment stress is episodic, rather than chronic in nature, there is no negative impact (either temporary or permanent) to coral reef communities. At the Mauna Lani site, it is expected that sediment suspension and removal by current action will prevent build-up of material on the sea floor, and allow organisms to maintain functional cleaning mechanisms. Current measurements in the region of the planned marina development indicate that while currents are relatively slow, typically 5 to 7 cm/sec., there is a net transport in an offshore direction (southwest). Suspended sediment will be transported away from the site of generation by these currents out to sea, rather than toward shore.

One exception to the above scenarios where substantial coral damage was noted owing to blasting of channels for underwater pipelines was at Keahole Pt., West Hawaii. Blasting exposed an area of volcanic cinders that were larger than the fine-grained sediments normally created by excavation. Size of the cinders prevented suspension in the water column; instead the material remained near the sea floor and caused abrasive damage to nearby benthos (J. Naughton, R. Brock, personal communication).

A potential concern associated with excavation of the shoreline is an increase in incidences of toxic fish poisoning, termed ciguatera. The dinoflagellate thought to be responsible for the toxicity, Gambierdiscus toxicus, exists as an epiphyte on algae. While definitive cause and effect relationships between environmental alteration and toxic outbreaks have not been elucidated, increased incidences of Gambierdiscus toxicus have been implicated with initial algal colonization of substrata bared by construction activities such as dredging.

On Oahu, construction of the West Beach Project involves a substantial amount of dredging of the nearshore environment. Part of the ongoing monitoring program for West Beach involves routine counts of population densities of Gambierdiscus on live seaweed (S.E.A. Ltd. 1988). While no clear-cut limits are defined relating the number of Gambierdiscus cells to ciguatera outbreaks, it is generally believed that counts of less than 100 cells per gram seaweed do not represent potential toxic situations (R. York, personal communication). To date, West Beach monitoring results do not indicate substantial increases in toxic potential associated with the project. During the month of April, when cell counts have been highest, offshore stations average 19.6 cells per gram seaweed, while shore stations average 0.1 cells per gram.

State Department of Health records report 102 incidences of ciguatera poisoning in Hawaii between 1980 and 1986; 20 of these cases occurred in Kona. Of the 20 cases, however, there have been no substantiated incidences of the disease associated with construction of Honokohau Harbor, which occurred in part during the 1980-86 interval. As Honokohau is located on the same coastline as the proposed project site, there is no reason to expect a priori that construction at the Mauna Lani Cove site will cause incidences of ciguatera.

Marina Operation

Patterns of salinity distribution measured at Honokohau Harbor, as well as results of other monitoring surveys (U.S. Army Corps of Engineers 1983), indicate that circulation in inshore marinas does not necessarily result in substantial alterations to nearshore environments. Rather, groundwater flow into the landward end of the Harbor sets up a layered flow with brackish water flow out on the surface and seawater flow in over the seafloor. Such a pattern results in no potential for stress on benthic organisms or fish communities. Surface salinity stratification owing to outflow from the Honokohau Harbor does not appear to differ substantially from the existing stratification from groundwater efflux at the Mauna Lani Cove site.

House lots located in the vicinity of the marina should not influence water quality in the basin, as long as injection wells, cesspools, or other structures that introduce waste material directly into the water table are not present.

A recent literature review compiled by the Golf Course Superintendents Association of America (GCSAA)(November 1988) summarizes the impacts of existing golf courses on environmental quality. The findings indicate that golf courses do not pose a significant pollution threat to the nation's water supplies. Scientific studies show that pesticides used on golf courses do not seep into groundwater, nor are these pesticides a threat to human health. The best available scientific evidence demonstrates that these pesticides are both safe and effective, especially when used by trained professionals such as golf course superintendents. More than anyone else, applicators are exposed to the chemicals, so safety considerations ensure pesticide use will occur only as necessary. Of the 150 acres which comprise a typical golf course, only about 6 acres (greens and tees) are regularly treated. Fairways (about 30 acres) are usually treated only as needed, while the remaining area usually receives no biocide treatment.

Golf courses also help reduce sedimentation pollution by presenting topsoil erosion. Carefully managed golf course turf grasses have been found to have 15 times less runoff than does a lower quality lawn. Studies have also shown that grasslands experience 84 to 668 times less erosion than areas planted in wheat or corn (DeBoot and Grabriels 1980). Golf courses can greatly reduce erosion and runoff effects compared to other land uses that result in impervious surfaces, such as roadways.

Soil retention studies conducted on a golf course in Hawaii indicate that upwards of 90% of the applied fertilizer N and 100% of P is taken up by the thatch/soil complex (Chang and Young 1977). Management practices preventing overirrigation/fertilization, and excess application of biocides should prevent influences to coastal and pond waters. A survey of the effects of existing golf course irrigation and fertilization on nearshore marine waters off West Hawaii showed that courses, including those at the Mauna Lani are not presently causing alteration in biological community function and structure. However, courses located upland from a semi-enclosed inlet, Keauhou Bay, did show an increase in dissolved nitrogen that appears to be attributable to golf course fertilization (Dollar and Smith 1988). These results emphasize the need to use only the most conservative construction designs for retaining water in the thatch-soil layers, and employing stringent management practices to avoid application of excess fertilizer material that could leach to groundwater and reach the marina.

Endangered Species

Potential for negative impacts to endangered and protected species can be mitigated by several planning procedures. Blasting should be limited to summer months when Humpback whales are not present in Hawaiian waters. On-site monitoring programs at the time of blasting should be emplaced to insure that sea turtles or marine mammals are not in the immediate area.

Anchialine Ponds

Anchialine ponds will not be directly impacted by removal or infilling during marina and channel construction. Water chemistry characteristics may be altered when the surrounding topography is modified during construction, owing to changes in groundwater flow patterns. There is no reason to suspect, however, that if such alteration occurs, it will cause irreversible changes to pond chemistry and biota. Normal, undisturbed anchialine ponds are subjected to extreme natural variability in water chemistry parameters on a daily basis as a result of tidal fluctuations. Pond biota are unique in their ability to tolerate these extreme fluctuations. In this regard, pond biota may be considered an extremely resilient, and hearty assemblage. The requirement of broad physiological tolerance ranges also explains the relative paucity of pond species.

Monitoring of a pond system in the vicinity of the Waikoloa Resort showed that nearby development (hotels, golf courses) does not cause changes beyond the range of natural variability (Brock et al. 1987). Over the period that development has taken place at Waikoloa (9 years) it appears that increases in pond nutrient levels owing to leaching from a golf course are not damaging because these nutrient levels occur frequently at higher concentrations as a result of natural processes. As the studies of Honokohau indicated, harbors do not necessarily alter, in a negative sense, the pattern of groundwater dilution with ocean water. Thus, there does not appear to be reason to suspect that anchialine ponds will be impacted by altered mixing of groundwater and seawater. One factor that may influence pond dynamics is dust deposition during construction. It is suggested that ponds be covered with shade cloth during construction to prevent dust accumulation. A monitoring program at each phase of construction should verify if water chemistry parameters in anchialine ponds are altered over the course of construction and operation of the Mauna Lani Cove.

SUMMARY AND RECOMMENDATIONS

1) The marine environment offshore of the planned Mauna Lani Cove is characterized by two major bio-geomorphological zones. A shallow flat limestone-covered terrace, extends from the shoreline approximately 800 feet offshore, with water depth less than 15 feet.Q Beyond a shallow drop-off, a sloping reef platform extends to depths of 60 feet. All dredging and blasting to create the entrance channel will occur on the reef terrace.

2) Water quality off the entire development site can be considered typical of class AA, open coastal areas as most measured parameters are within DOH water quality standards. The parameter that exceeds DOH standards ($NO_3^- + NO_2^-$) occurs in high concentration as a result of input of groundwater at the shoreline. Water chemistry characteristics normalized to salinity indicate a lack of dissolved material input from land sources other than groundwater. Dissolved material entering the ocean from groundwater extrusion is rapidly mixed with oceanic water near the shoreline.

3) Corals are relatively scarce (5-9% bottom cover) on the reef terrace out to a distance of about 800 feet from shore, owing to chronic stress from waves and surge. Coral communities are well developed and percent coral cover is about 60% on the deep reef platform. The zone of coral community occurrence extends to water depths of approximately 60 feet.

4) Overall, the fish community at the Mauna Lani site is fairly typical of assemblages found in Hawaiian reef environments. The number of species, total number of individuals, and overall composition indicate a healthy and diverse fish community. The reduced size of some food fishes, their tendency to avoid divers, and general scarcity indicated that this area is subjected to a substantial, but not overwhelming, degree of fishing pressure. The scarcity of certain reef fishes also suggests that the community is somewhat affected by the commercial collection of aquarium fishes. Threatened and protected species (whales and turtles) occur in the area, as they do along the entire coast of West Hawaii. The region of the planned project does not, however, appear to be a habitat that is of special relevance to protected or endangered species.

5) Excavation of the entrance channel will result in destruction of existing marine habitat and associated organisms in the channel alignment. This area constitutes the region of lowest coral cover on any offshore reef zone. As excavation is planned for a relatively large offshore area, it is of extreme importance to focus efforts on minimizing impacts associated with suspended sediments created by construction. Planning of channel construction should minimize the duration of blasting and dredging phases, in order to keep the period of suspended sediment plume generation to the shortest possible

time. Engineering studies must verify that substrata exposed by blasting and dredging do not contain volcanic cinder, and that the majority of particulate material created by excavation is suitable in size to be suspended and dispersed by predominating current velocities. If these conditions are met there does not appear to be the potential for substantial or permanent negative alteration of the marine environment. Similar projects in areas of unrestricted circulation have illustrated that suspended material generated by excavation can be dispersed by normal circulation before substantial settlement on the bottom. Marine communities appear to be able to withstand sediment stress utilizing natural adaptations such as cleaning mechanisms. At the Mauna Lani site, the predominant direction of currents that will disperse suspended sediment is offshore, away from reef areas. As much as possible, design of the entrance channel should take advantage of the natural channels in the area which will minimize sediment suspension.

6) Marine communities near the area to be excavated are presently subjected to substantial stress from severe water motion on the shallow reef terrace. Excavation of the channel may eventually result in increased environmental quality. Channel walls and floor should be suitable for benthic organism settlement and growth. It is probable that a richer assemblage of organisms will colonize the excavated channel compared to the present reef terrace. Reef corals will probably colonize the walls and floor of the lagoon. Because corals are "keystone" species, other forms of marine flora and fauna should also colonize the channel. Reef fish will undoubtedly inhabit the area in proportion to the amount of suitable shelter created. There is no reason to expect increased levels of ciguatera toxin associated with construction of the Mauna Lani Cove.

7) None of the biotic assemblages observed in and near the area to be excavated constitutes rare, endangered or commercially valuable resources. Because the excavated area constitutes a very small percentage of the total reef platform fronting the Mauna Lani property, the overall integrity of the area will not likely be altered by the project.

8) Impacts to protected and endangered marine species can be avoided by timing of construction to avoid summer months, and with on-site monitoring at the time of blasting.

9) Operation of the Mauna Lani Cove, once completed, does not appear to present potential for negative impacts. Monitoring programs, and recent measurements in Honokohau Harbor found that harbor construction and operation have not resulted in alteration of water quality and circulation in the nearshore regions adjacent to the structure. Stratified circulation patterns set up by groundwater inflow at the back of the harbor cause deep water inflow of ocean water at the harbor mouth. As a result, salinity within the deep layers of the harbor are only slightly reduced, and residence time in the inner basins is short. No significant adverse impacts to established coral colonies in the original harbor and outside the harbor have been observed. On the contrary, the harbor provides new surfaces suitable for coral colonization that have been rapidly settled. The inland configuration, shallow depth, small size, rapid flushing, lack of impacts to water quality, and suitable substrata in the outer harbor are all potentially contributing factors for successful coral development. If hydraulic models and engineering solutions indicate that the configuration of the planned project will result in circulation and turnover patterns similar to, or better than, Honokohau Harbor, there is no reason to believe that the planned Mauna Lani Cove will cause ecosystem responses different than those at Honokohau.

10) House lots located on the shoreline of the planned Mauna Lani Cove do not appear to present the potential to alter nearshore or pond water quality as long as cesspools, injection wells, or other structures that introduce materials directly into the water table are not present. Effects from golf course holes in the vicinity of the marina can be mitigated by prudent management practices which prevent application of excess fertilizer and biocides.

11) Structure of anchialine ponds located on either side of the proposed entrance channel will not be physically altered (filled in or excavated) by the proposed project. Effects to water quality from nearby construction, if they should occur at all, are not likely to exceed the range of natural variability. Pond biota are adapted to extremes ranges of environmental parameters under natural conditions. If slight changes to these parameters occur from construction of the project, it is not likely that physical composition will change to an extent to alter biotic structure. Covering ponds during construction to prevent dust accumulation should prevent any major changes in pond circulation patterns. Maintenance of ponds once the project is completed could actually prolong the "lifetime" of the pond systems by arresting the successional progression that eventually leads to infilling.

12) The present survey serves as a baseline for any required monitoring programs that might be required to meet county, state or federal permit requirements.

REFERENCES CITED

Banner, A. H. 1974. Kaneohe Bay, Hawaii: Urban pollution and a coral reef ecosystem. Proc. 2nd. Int. Coral Reef Symp. 2:685-702.

Bak, R. P. M. 1978. Lethal and sublethal effects of dredging on coral reef. Mar. Poll. Bull. 2:14-16.

Brock, R. E., J. E. Norris, D. A. Ziemann and M. T. Lee 1987. Characteristics of water quality in anchialine ponds of the Kona, Hawaii, Coast. Pac. Sci. 41:200-208.

Brown, B. E. and L. S. Howard. 1985. Assessing the effects of "stress" on reef corals. Adv. in Mar. Biol. 22:1-63.

Chang, S. Y. K. and R. H. F. Young. 1977. An investigation into environmental effects of sewage effluent reuse at the Kaneohe Marine Corps Air Station Klipper golf course. Tech. Mem. Rep. No. 53. Water Resources Research Center, University of Hawaii.

DeBoot, M. and D. Grabriels (eds). 1980. Assessment of erosion. John Wiley and Sons, New York. pp. 219-221.

Dodge, R. E. and J. R. Vaisnys. 1977. Coral populations and growth patterns: Responses to sedimentation and turbidity associated with dredging. J. of Mar. Res. 35:715-730.

Dollar, S. J. 1975. Zonation of reef corals off the Kona Coast of Hawaii. M.S. Thesis. University of Hawaii.

Dollar, S. J. 1979. Ecological response to relaxation of sewage stress off Sand Island, Oahu, Hawaii. Water Resources Research Center Tech. Rpt. No. 124. Water Resources Research Center, University of Hawaii.

Dollar, S. J. 1982. Wave stress and coral community structure in Hawaii. Coral Reefs 1:71-81.

Dollar, S. J. 1985. Environmental assessment of Hilo Bay: Marine biological community structure in the vicinity of the proposed Hilo sewage outfall extension. Prepared for M & E Pacific, Inc.

Dollar, S. J. 1986. Baseline assessment of the marine environment and anchialine ponds at Awakee, North Kona, Hawaii. Prepared for Helbert, Hastert, Van Horn & Kimura.

Dollar, S. J. 1987. Effects to water quality and marine community structure from beach reconstruction at Makaiwa Bay, Mauna Lani Resort, South Kohala, Hawaii. Prepared for Mauna Lani Resort, Inc.

Dollar, S. J. and R. W. Grigg. 1981. Impact of a kaolin clay spill on a coral reef in Hawaii. Marine Biology 65:269-76.

Dollar, S. J. and S. V. Smith. 1988. The effects of golf course irrigation and fertilization on nearshore marine waters off West Hawaii. Prepared for Helber, Hastert & Kimura, Planners.

Grigg, R. W. and S. J. Dollar. 1980. Environmental impact assessment of nearshore marine life at Princeville, Kauai, Hawaii. Prepared for Princeville Development Corp.

Grigg, R. W. and S. J. Dollar. 1989. Natural and anthropogenic disturbance on coral reefs. In: Coral Reefs, Vol. 25. Z. Dubinsky, ed. In press.

Grigg, R. W. and J. E. Maragos. 1974. Recolonization of hermatypic corals on submerged lava flows in Hawaii. Ecology 55:387-395.

Hobson, E. S. 1974. Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii. Fishery Bull. 72:915-1031.

Johannes, R. E. 1975. Pollution and degradation of coral reef communities. In: Tropical Marine Pollution, E. J. Ferguson Wood and R. E. Johannes (eds.) Elsevier Scientific Publishing, Amsterdam. pp. 13-50.

Kaul, L. W. and P. N. Froelich, 1978. Modeling estuarine nutrient geochemistry in a simple system. Geochim. Cosmochim. Acta, 48:1417-1433.

Kinzie, R. A. and R. H. Snider, 1978. A simulation study of coral reef survey methods. In: Coral reefs: research methods, UNESCO, ISBN 92-3-101491-9.

Maciolek, J. A. and R. E. Brock, 1974. Aquatic survey of the Kona Coast ponds, Hawaii Island. Sea Grant Advisory Report, UNIHI-SEAGRANT-AR-74-04.

Ocean Research, Consulting and Analysis, Ltd. (ORCA) 1978. Reconnaissance surveys of the marine environment; Kawaihae small boat harbor project site, Island of Hawaii, Prepared for Department of the Army, Pacific Ocean Div. Hawaii Corps of Engineers, Fort Shafter, Hawaii.

Officer, C. B. 1979. Discussion of the behavior of nonconservative dissolved constituents in estuaries. Est. Coastal Mar. Sci. 9:91-94.

S.E.A. Ltd. 1988. West Beach Monitoring Program. Rpt. No. 12.

Sea Engineering, Inc. 1989. Interim data report. Nearshore wave and current measurements for the Mauna Lani Resort, North Kona, Hawaii. Prepared for: Peratrovich, Nottingham & Drage, Inc. Seattle, Washington.

Sheppard, C. 1980. Coral fauna of Diego Garcia lagoon following harbor construction. Mar. Poll. Bull. 11:227-230.

Smith, S. V. et al. 1979. Stoichiometry of C, N, P and Si fluxes in a temperate-climate embayment. J. Mar. Res. 45:427-460.

Strickland J. D. H. and T. R. Parsons. 1968. A practical handbook of sea-water analysis. Fisheries Research Bd. of Canada, Bull. 167. 311 p.

U. S. Army Corps of Engineers 1983. A decade of ecological studies following construction of Honokohau small boat harbor. U.S. Army Engineer District, Honolulu, HI.

Yonge, C. M. 1931. The biology of reef building corals. Sci. Rept. Brit. Mus. (N. H.,), I:353-391.

TABLE 1. Water chemistry parameters from transects off planned Mauna Lani Cove. For transect locations, see Figure 1. "S" denotes surface samples, "D" denotes deep samples.

STATION		DISTANCE FROM SHORE (m)	PO4 (uM)	TOTAL P (uM)	DOP (uM)	NO3 + NO2 (uM)	NH4 (uM)	TOTAL N (uM)	DON (uM)	Si (uM)	TURBIDITY (ntu)	SALINITY (o/oo)
1-1	S	500	0.23	0.41	0.18	0.08	0.51	8.04	7.45	34.14	0.23	34.476
	D		0.19	0.48	0.29	0.08	0.08	9.44	9.28	5.39	0.19	34.253
1-2	S	100	0.17	0.37	0.20	0.22	0.11	6.31	5.98	7.57	0.42	34.159
	D		0.17	0.36	0.19	0.17	0.17	6.44	6.10	6.38	0.18	34.182
1-3	S	50	0.21	0.41	0.20	2.78	0.29	7.49	4.42	30.77	0.32	33.319
	D		0.19	0.39	0.20	1.02	0.22	7.47	6.23	18.92	0.27	33.190
1-4	S	10	0.71	0.98	0.27	27.51	0.53	30.82	2.78	230.41	0.64	26.764
	D		0.45	0.64	0.19	14.68	0.31	20.93	5.94	182.27	0.38	30.027
1-5	S	0.1	0.84	0.90	0.06	38.23	0.40	40.76	2.13	314.66	0.52	29.955
2-1	S	500	0.16	0.36	0.20	0.06	0.02	7.50	7.42	5.00	0.12	34.303
	D		0.17	0.37	0.20	0.08	0.02	6.88	6.73	6.98	0.18	34.313
2-2	S	100	0.15	0.37	0.22	0.37	0.02	7.60	7.21	12.93	0.23	33.980
	D		0.17	0.36	0.19	0.24	0.13	6.44	6.07	9.36	0.23	34.088
2-3	S	50	0.21	0.61	0.40	1.22	0.06	11.69	10.41	20.26	0.21	38.709
	D		0.19	0.45	0.26	0.80	0.06	9.65	8.79	15.61	0.21	33.804
2-4	S	10	0.19	0.35	0.16	0.80	0.58	11.55	10.17	14.91	0.28	33.877
	D		0.19	0.38	0.19	0.80	0.24	9.82	8.78	14.31	0.43	33.865
2-5	S	0.1	0.19	0.41	0.22	0.95	0.20	7.54	6.39	14.91	0.85	33.908
3-1	S	500	0.17	0.40	0.23	0.22	0.02	6.88	6.64	9.36	0.23	34.156
	D		0.17	0.37	0.20	0.15	0.02	6.35	6.18	6.98	0.20	34.243
3-2	S	100	0.20	0.37	0.17	1.78	0.35	6.56	4.43	33.74	0.22	33.266
	D		0.17	0.35	0.18	0.68	0.20	6.52	5.64	18.87	0.38	33.757
3-3	S	50	0.16	0.37	0.21	1.29	0.24	6.79	5.26	29.78	0.20	33.365
	D		0.16	0.41	0.25	0.80	0.08	8.54	7.66	28.39	0.34	33.461
3-4	S	10	0.29	0.49	0.20	5.37	0.26	11.82	6.19	72.80	0.56	32.131
	D		0.25	0.43	0.18	4.88	0.26	11.17	6.03	65.86	0.47	32.228
3-5	S	0.1	0.56	0.65	0.09	19.48	0.26	22.96	3.22	223.47	0.39	27.333
GEOMETRIC MEAN			0.223	0.441	0.195	0.809	0.135	9.629	6.067	22.96	0.292	32.620
[illegible]			1.03	1.85	0.02	88.00	1.14	91.62	[illegible]	275.59		5.171
[illegible]			[illegible]	2.05	0.03	90.04	[illegible]	104.39	[illegible]	[illegible]		[illegible]

F - 10

TABLE 1. continued

STATION		CHL a. (ug/L)	DISSOLVED O2 (% SAT.)	TEMPERATURE (deg. C)	pH
1-1	S	0.19	100	25.6	8.18
	D	0.21	99	25.7	8.17
1-2	S	0.18	99	25.6	8.19
	D	0.17	98	25.6	8.18
1-3	S	0.21	99	25.6	8.17
	D	0.22	101	25.4	8.2
1-4	S	0.33	100	25.6	8.21
	D	0.41	97	25.4	8.16
1-5	S	0.42	96	25.3	8.15
2-1	S	0.18	97	25.7	8.18
	D	0.19	96	25.7	8.19
2-2	S	0.19	98	25.6	8.16
	D	0.20	100	25.7	8.15
2-3	S	0.31	101	25.5	8.16
	D	0.27	99	25.7	8.15
2-4	S	0.33	98	25.6	8.14
	D	0.21	96	25.4	8.20
2-5	S	0.20	94	25.5	8.16
3-1	S	0.21	97	25.8	8.17
	D	0.18	100	25.7	8.16
3-2	S	0.32	100	25.6	8.15
	D	0.17	94	25.4	8.16
3-3	S	0.19	97	25.3	8.16
	D	0.31	99	25.3	8.19
3-4	S	0.22	100	25.3	8.15
	D	0.25	96	25.2	8.15
3-5	S	0.31	98	25.2	8.19
MUND 1		0.23	89	24.3	8.12
MUND 2		0.34	85	24.6	8.1

TABLE 2. Specific criteria in DOH water quality standards for open coastal waters.

Parameter	Geometric mean not to exceed the given value		Not to exceed the given value more than 10% of the time		Not to exceed the given value	
	(ug/l)	(uM)	(ug/l)	(uM)	(ug/l)	(uM)
Total Nitrogen	150.00* 110.00**	10.71 7.85	250.00* 180.00**	17.86 12.86	350.00* 250.00**	25.00 17.86
Ammonia Nitrogen	3.50* 2.00**	0.25 0.14	8.50* 5.00**	0.61 0.35	15.00* 9.00**	1.07 0.64
Nitrate +Nitrite Nitrogen	5.00* 3.50**	0.36 0.25	14.00* 10.00**	1.00 0.71	25.00* 20.00**	1.78 1.43
Total Phosphorus	20.00* 16.00**	0.64 0.52	40.00* 30.00**	1.29 0.97	60.00* 45.00**	1.93 1.45
Chlorophyll a (ug/l)	0.30* 0.15**		0.90* 0.50**		1.75* 1.00**	
Turbidity (Nephelometric Turbidity Units)	0.50* 0.20**		1.25* 0.50**		2.00* 1.00**	

*"Wet" criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.

**"Dry" criteria apply when the open coastal waters receiveless than three million gallons per day of fresh water discharge per shoreline mile.

Applicable to both wet and dry conditions:

pH units shall not deviate more than 0.5 units from a value of 8.1.

Dissolved oxygen - Not less than 75% saturation.

Temperature - Shall not vary more than 1 deg. C from ambient conditions.

Salinity - Shall not vary more than 10% from natural or seasonal changes considering hydrologic input and oceanographic factors.

TABLE 3. Reef coral species abundance statistics on transects in the vicinity of the planned Mauna Lani Cove. For transect locations, see Figure 1.

SPECIES	TRANSECT (depth) ML1 8'	ML1 10'	ML1 20'	ML1 40'	ML2 7'	ML2 10'	ML2 20'	ML2 40'	ML3 8'	ML3 15'	ML3 30'	ML3 60'
Porites lobata	0.2	8.8	55.5	47.7	5.5	26.8	49.0	45.3	4.7	39.0	33.2	39.7
Porites compressa			15.7	34.3			10.5	34.2		5.8	14.2	9.3
Pocillopora meandrina	0.5	0.3	0.1	0.6	1.2	0.4		0.2	0.5	6.8	0.3	1.3
Montipora verrucosa			1.9	1.9		0.2	1.8	1.4		0.5	0.7	0.4
Montipora patula				1.3						3.6	0.5	0.2
Pavona varians			1.0			0.3		0.3		0.2	0.1	
Leptastrea purpurea	4.5				0.2					0.1		
Palythoa tuberculosa			0.3					0.1				
TOTAL CORAL COVER	5.2	9.1	74.5	85.8	ь.9	27.7	61.3	81.5	5.2	56.0	49.0	50.9
SPECIES COUNT	3	2	6	5	3	4	3	6	2	7	6	5
SPECIES DIVERSITY	0.48	0.14	0.73	0.87	0.59	0.18	0.58	0.80	0.40	0.99	0.79	0.64

TABLE 4. Sea urchin abundance on transects in the vicinity of the planned Mauna Lani Cove. For transect locations, see Figure 1.

SPECIES	TRANSECT ML1 8'	ML1 10'	ML1 20'	ML1 40'	ML2 7'	ML2 10'	ML2 20'	ML2 40'	ML3 8'	ML3 15'	ML3 30'	ML3 60'
Echinometra mathaei	62	53	28	13	82	53	34	21	63	39	27	22
Echinostrephus aciculatus	52	33	12	13	54	34	13	9	46	23	12	15
Tripneustes gratilla	13	31	2	4	26	22	5	2	43	14	3	1
Heterocentrotus mammilatus	0	0	2	6	0	0	9	5	0	1	3	5
Echinothrix diadema	0	0	0	1	0	0	1	3	0	0	2-	0
TOTAL	127	117	39	37	162	109	62	40	152	77	47	43

TABLE 5. Reef fish species abundance statistics on transects in the vicinity of the planned Mauna Lani Cove. For transect locations, see Figure 1.

SPECIES	ML1 8'	ML1 10'	ML1 20'	ML1 40'	ML2 7'	ML2 10'	ML2 20'	ML2 40'	ML3 8'	ML3 15'	ML3 30'	ML3 60'
						TRANSECT (depth)						
AULOSTOMIDAE												
Aulostomus chinensis							1				1	2
FISTULARIIDAE												
Fistularia petimba	1											
CIRRHITIDAE												
Paracirrhites arcatus	1		2			1	2	2		1	1	1
P. forsteri				1			1					
MULLIDAE												
Mulloides flavolineatus								3	26			61
Parupeneus multifasciatus		4	6	4	4	6	4	2	6	6	5	12
P. bifasciatus			1									2
SERRANIDAE												
Cephalopholis argus							2					
CARANGIDAE												
Caranx orthogrammus	1											
LUTJANIDAE												
Aphareus furcatus			1									
Lutjanus fulvus												1
CHAETODONTIDAE												
C. lunula										1		2
C. quadrimaculatus							2					
C. miliaris							3		1	2		52
C. ornatissimus		2	2				2	2		4	1	
C. multicinctus			4	8			7	5		2	6	3
C. auriga							2			1		
C. tremblii									1	1		
C. trifasciatus										1	1	
Forcipiger flavissimus			2	2			5	3			2	14
POMACANTHIDAE												
Centropyge potteri			3	3				2				6
POMACENTRIDAE												
Abudefduf sordidus			30	11					5	20	30	25
Plectro. imparipennis	1				2	2				1		1
Stegastes fasciolatus		6	11	3	3					6	7	
Chromis agilis				3								
C. hanui			3									
C. vanderbilti	22	15			13	25				20		20
C. ovalis							25			65		
Dascyllus albisella												9

TABLE 5. continued.

SPECIES	ML1 8'	ML1 10'	ML1 20'	ML1 40'	ML2 7'	ML2 10'	ML2 20'	ML2 40'	ML3 8'	ML3 15'	ML3 30'	ML3 60'
						TRANSECT (depth)						
LABRIDAE												
Novaculichthys taeniourus						1						
Cheilinus unifasciatus			2	2			1	2				3
Pseudocheilinus octotaenia			3	1				1			2	2
Coris gaimard		2										3
Thalassoma duperrey	18	34	8	7	13	28	7	6	13	14	10	17
T. ballieui			1	2							11	
Gomphosus varius		3	1	3	2		2	1	1			4
Stethojulis balteata			2			1			3			1
Halichoeres ornatissimus				2			2					
Labroides phthirophagus											1	
SCARIDAE												
Calotomus sp.			1									
Scarus sordidus			6	8				4			7	1
S. perspicillatus		3					3				1	
S. psittacus		1	1									1
S. rubroviolaceus		27				5	25					
juvenile Scarus		42	5	5			15	3	7	4	10	18
ACANTHURIDAE												
Zebrasoma flavescens		33	33	31		12	55	30		16	43	75
Acanthurus achilles			7	1			4		2			
A. triostegus		43	2				13					
A. leucopareius							3	5	2			
A. olivaceus		19				10	19	3				
A. xanthopterus							10					
A. nigrofuscus		122	11	4		35	20		36	23	19	3
A. nigrorus									5	2		
Ctenochaetus strigosus		27	84	54			78	35		105	44	66
C. hawaiiensis								1				
Naso lituratus		13	6	9		9	9	4	1	4	8	13
N. unicornis		55	2									
N. hexacanthus											1	25
ZANCLIDAE												
Zanclus cornutus		3						2		1	3	11
MONACANTHIDAE												
Pervagor spilosoma		1	1					1				1
BALISTIDAE												
Rhinecanthus rectangulus	4	1			5	2				3		
Sufflamen bursa			3	2							3	6
Melichthys vidua			4				2	2		6	8	
M. niger	1		7					5				
OSTRACIIDAE												
Ostracion meleagris					1				1			
TETRAODONTIDAE												
Arothron hispidus				1						1		
Canthigaster jactator									1			
NUMBER SPECIES	8	21	32	23	8	13	30	24	16	25	24	32
NUMBER INDIVIDUALS	49	456	255	167	43	137	325	125	111	310	225	461
SPECIES DIVERSITY	1.324	2.400	2.558	2.390	1.753	2.055	2.641	2.465	2.131	2.270	2.659	2.822

TABLE 6. Salinity of water samples inside and outside of Honokohau Harbor. For station locations, see Figure 5.

STATION	SURFACE (o/oo)	BOTTOM (o/oo)
1	21.191	27.499
2	21.343	28.934
3	22.4	30.512
4	22.948	31.629
5	24.22	31.876
6	24.467	32.102
7	24.434	33.009
8	24.962	33.461
9	25.467	32.55
10	31.318	34.159
11	35.422	34.378
12	31.434	34.452
13	32.333	34.467
14	31.891	34.399
15	30.553	34.395
16	31.213	34.224
17	32.818	34.089

TABLE 7. Reef coral species abundance on transects in the vicinity of Honokohau Harbor. Water depth on all transects is 30 feet. for transect locations, see Figure 5.

	TRANSECT (depth)		
SPECIES	H-1	H-2	H-3
Porites lobata	12.1	40.6	21.2
Porites compressa	0.2	43.6	0.4
Pocillopora meandrina	0.1	3.3	0.4
Montipora verrucosa			0.4
Palythoa tuberculosa	0.1		
TOTAL CORAL COVER	12.5	87.5	22.4
SPECIES COUNT	4	3	4
SPECIES DIVERSITY	0.17	0.83	0.27

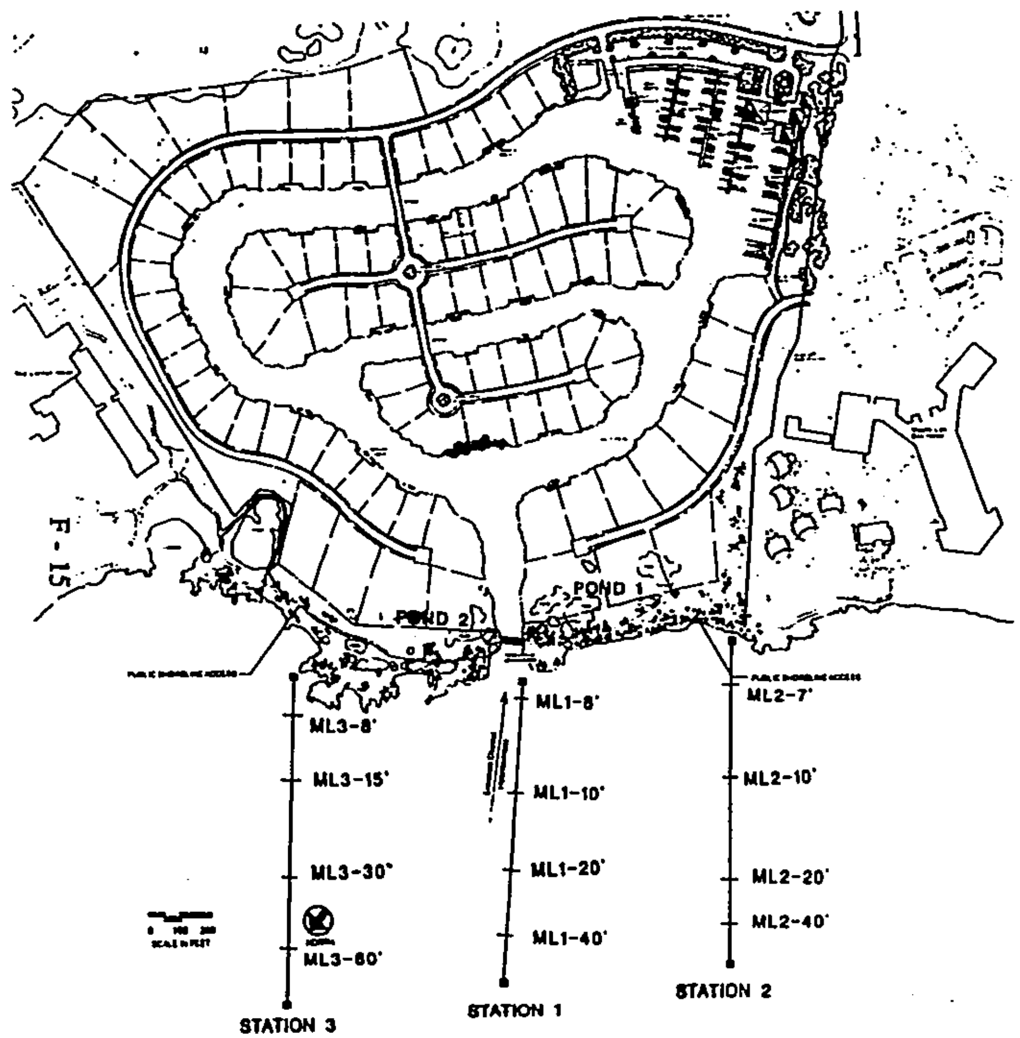


FIGURE 1. Map of shoreline between Mauna Lani Bay Resort and Ritz-Carlton Hotel site showing location of planned Mauna Lani Cove entrance channel. Water chemistry sampling stations 1-3 are also shown, as are locations of reef transect survey sites. Locations of shoreline anchialine ponds are also shown.

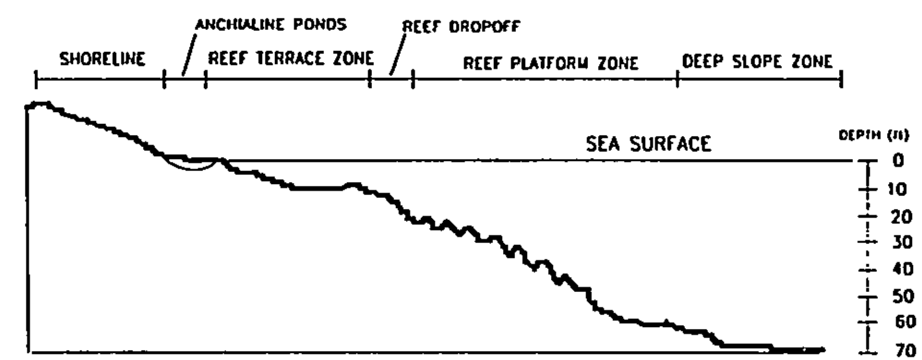


FIGURE 2. Diagrammatic cross-section of shoreline and reef in area to be dredged for Mauna Lani Cove channel.

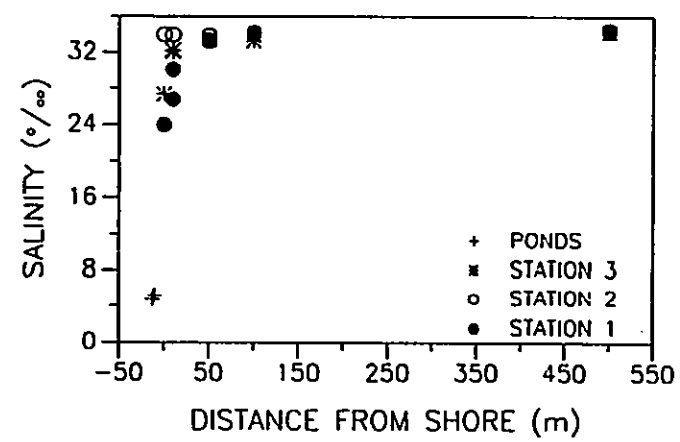


FIGURE 3. Plot of salinity as a function of distance from shore for water samples collected in anchialine ponds and nearshore ocean off the planned Mauna Lani Cove site. For station locations, see Figure 1.

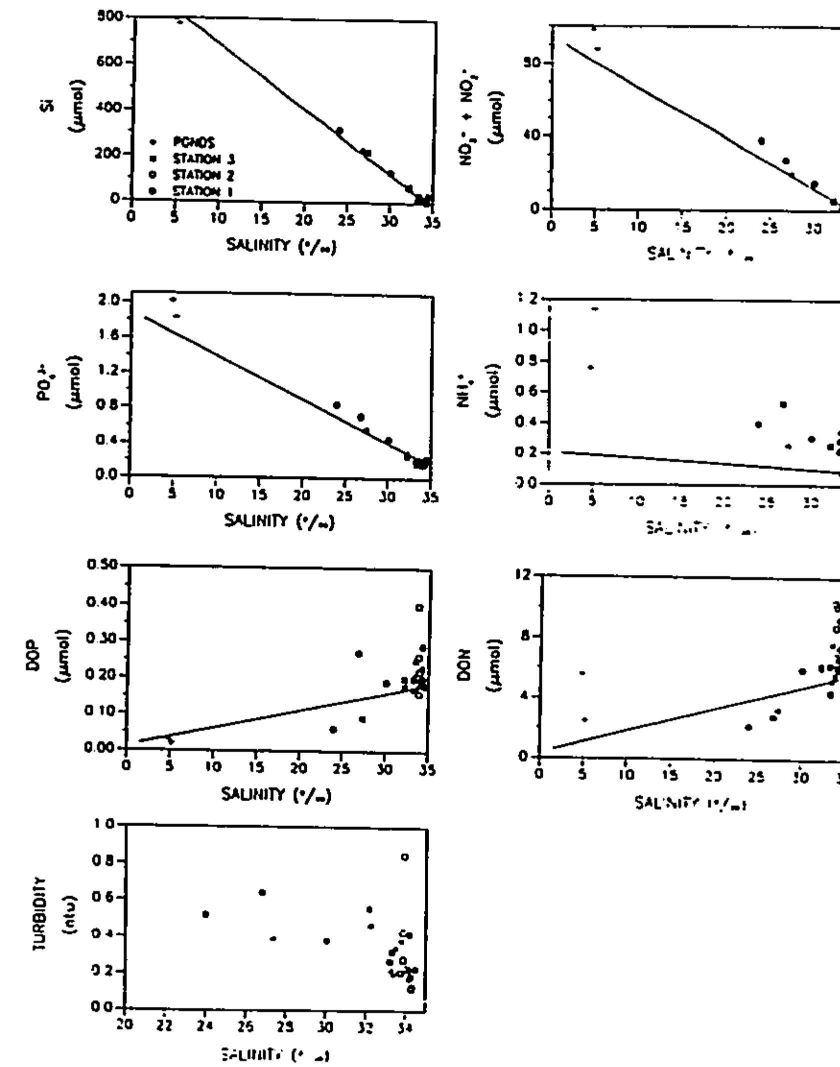


FIGURE 4. Plots of water chemistry parameters as functions of salinity Conservative mixing lines are constructed from endpoints of open ocean salinity and well water

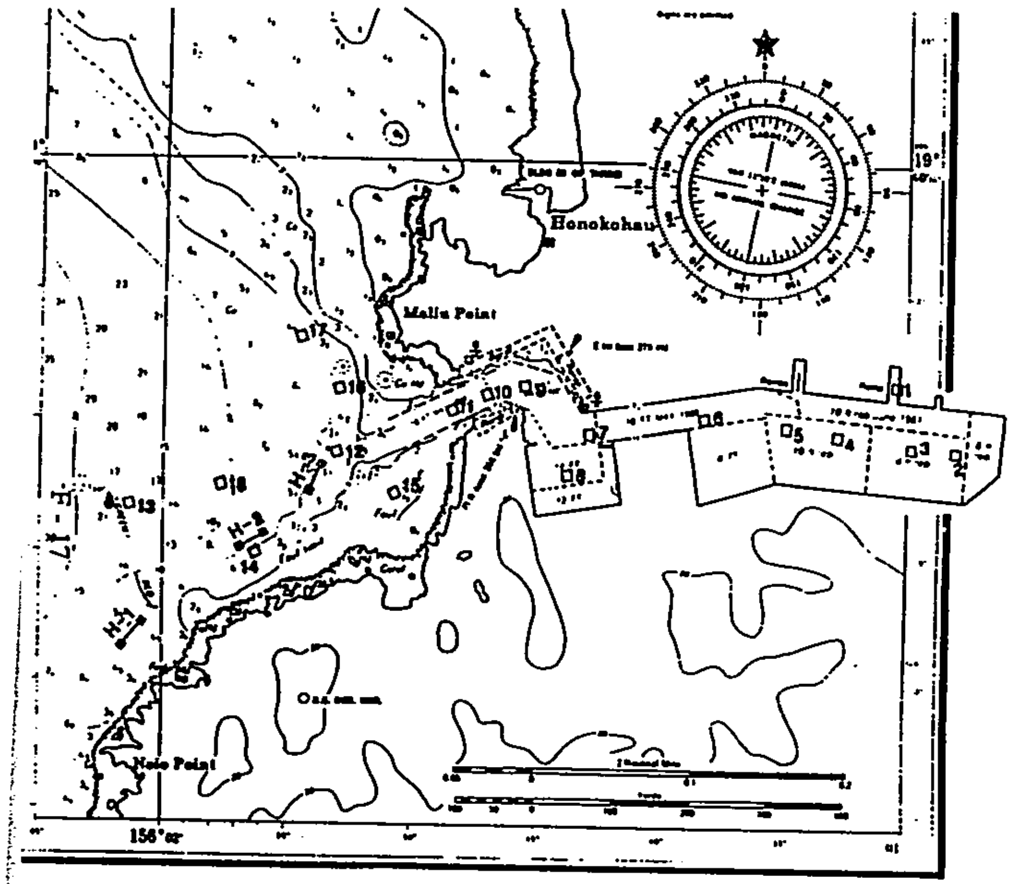


FIGURE 5. Map of Honokohau Harbor showing locations of numbered water samples, and reef coral transects.

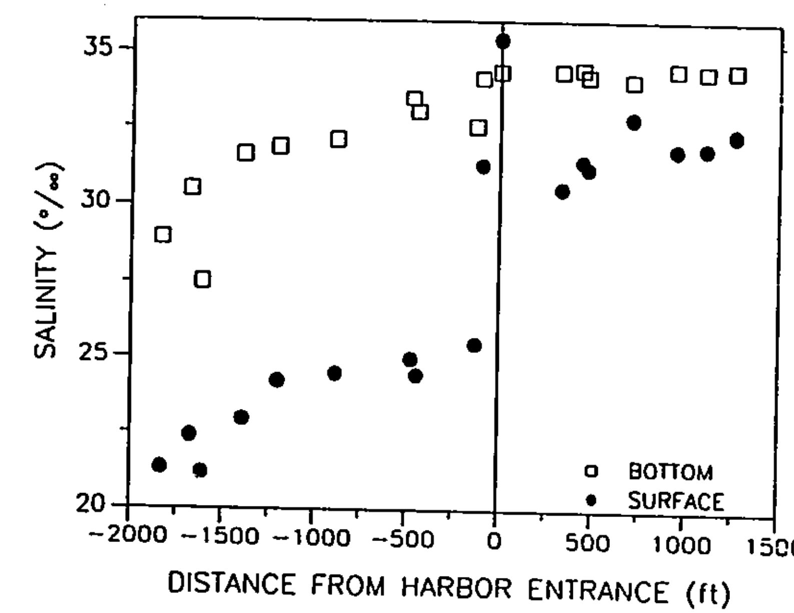


FIGURE 6. Plot showing surface and bottom water salinity as function of distance from the mouth of Honokohau Harbor. Negative distance is toward the back of the harbor (landward), and positive distance is toward the open ocean.

APPENDIX G

COASTAL PROCESSES INVESTIGATIONS
MAUNA LANI RESORT,
NORTH KONA, ISLAND OF HAWAII

COASTAL PROCESSES INVESTIGATONS MAUNA LANI RESORT, SOUTH KOHALA, ISLAND OF HAWAII

Prepared For:

Peratrovich, Nottingham & Drage, Inc.
1100 Eastlake Ave., Suite 310
Seattle, Washington 98109

Prepared By:

Sea Engineering, Inc.
Makai Research Pier
Waimanalo, Hawaii 96795

October 1989

TABLE OF CONTENTS

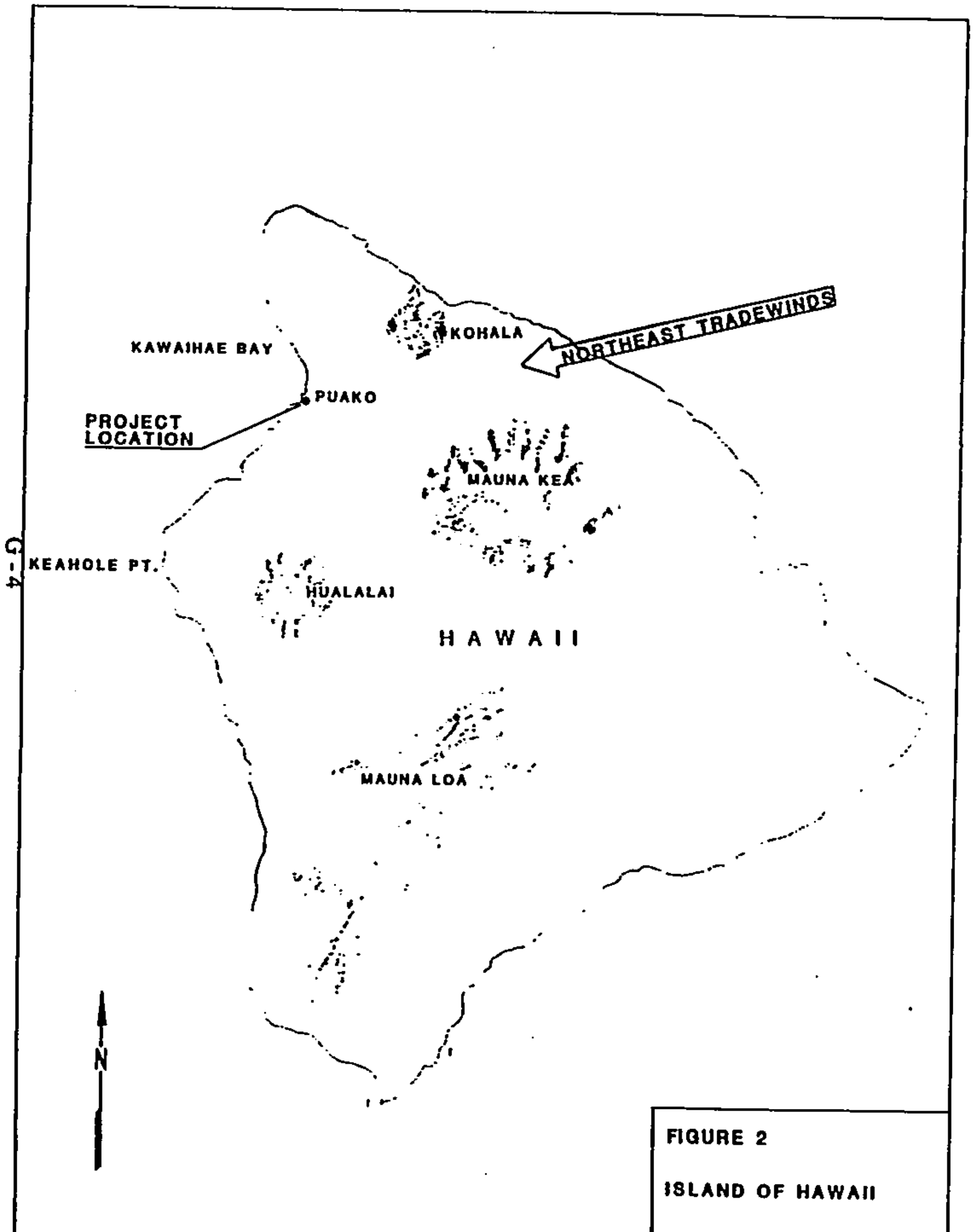


FIGURE 2

ISLAND OF HAWAII

INTRODUCTION

Sea Engineering, Inc. conducted a two day site inspection during October 1989 of the coastal property belonging to Mauna Lani Resorts on the Island of Hawaii for the purpose of assessing possible impacts of a proposed marina channel entrance on the existing shoreline. The proposed channel would be less than 20 feet deep and would transect the shoreline about 1,600 feet north of the existing Mauna Lani Hotel. The project location is shown on Figures 1 and 2, and a vicinity map is provided on Figure 3.

Channels and groins constructed perpendicular to a coastline inhibit longshore sand transport and cause erosion of the shore by altering the supply of sand. In the case of navigation channels, the interruption of the longshore transport causes the additional problem of channel infill.

This study was designed to collect as much information as possible in a brief period of time regarding the littoral processes of the study area, with particular attention paid to the possibility and extent of longshore transport. Field investigations included the following general tasks:

1) Observations of the coastal characteristics and condition, from the backshore to the nearshore ocean bottom;

2) survey of existing sand resources; onshore and offshore to a depth of about -20 ft., and

3) conversations with local residents and resort employees who have observed the beach and the waters in the study area for as long as forty years.

Results of field investigations and the conclusions drawn are presented in this report following a brief discussion of littoral processes in general and their application to the project area.

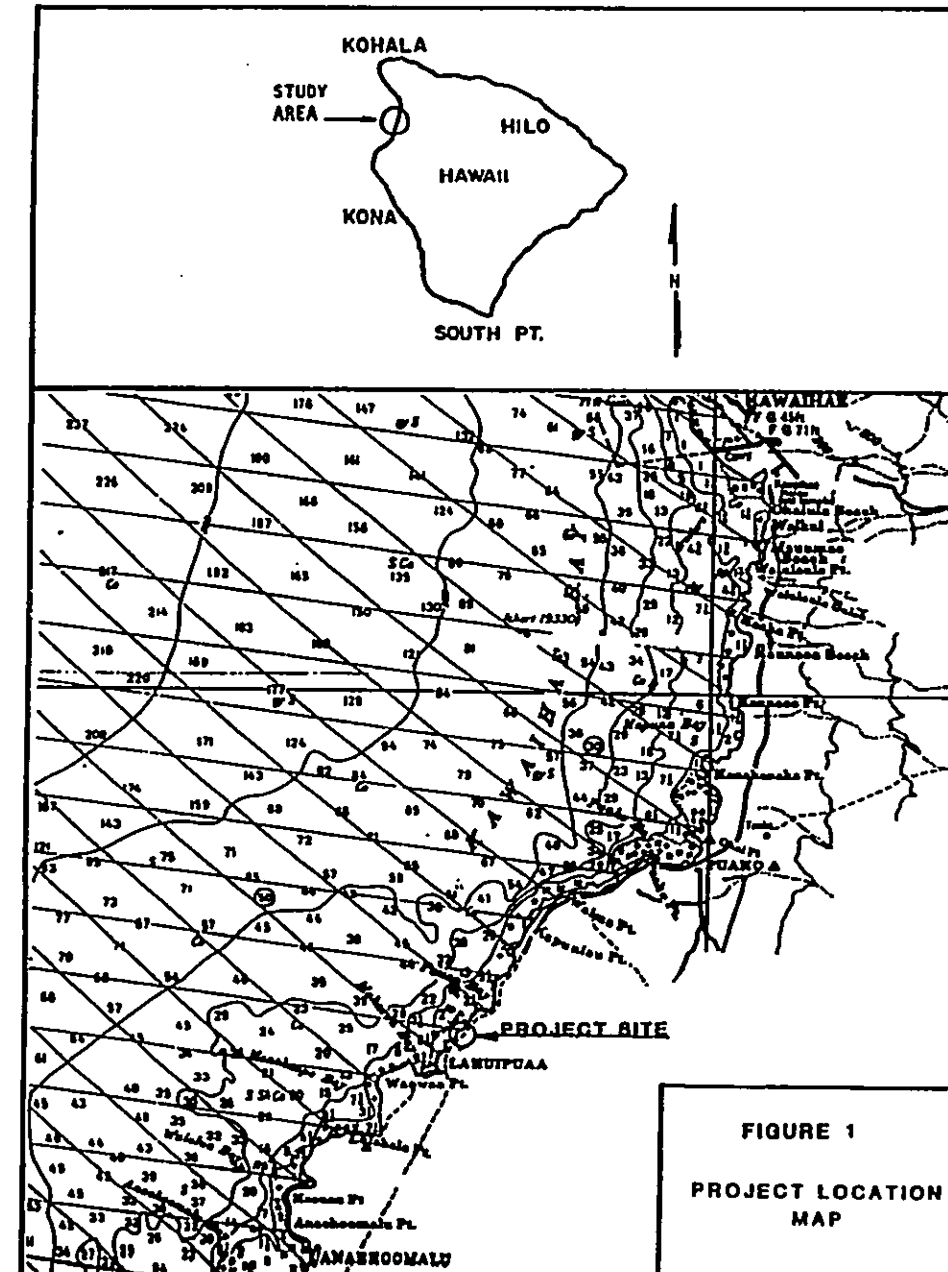


FIGURE 1

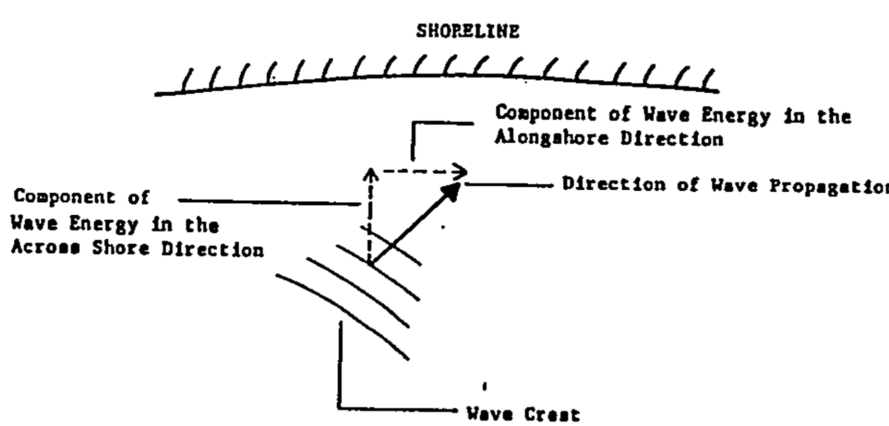
PROJECT LOCATION MAP

GENERAL DISCUSSION OF SAND TRANSPORT MECHANISMS

Sand Transport By Waves

Littoral transport is defined as the movement of sand within the zone extending from the shoreline to a point just beyond the line of wave breaking, i.e., the area influenced by wave breaking. Littoral transport is broken into two components; across shore sediment transport defined as onshore-offshore and alongshore sediment transport defined as sediment movement parallel to the shoreline. It is the alongshore sediment motion that is of interest since the proposed channel running perpendicular to the shoreline could impede this movement.

Sand transport parallel to the shoreline is produced by incident waves approaching obliquely to the shoreline. When waves enter shallow water the wave crests refract or bend to align themselves with the bottom contours. This occurs because that portion of the wave in deeper water travels faster than the portion in shallow water causing the wave to bend. Often complete wave refraction does not occur and waves approach the shoreline at an angle. This can occur when there is an abrupt change in the bottom contours or when waves approach shore at an acute angle. In either case the waves impart energy both perpendicular to the shoreline and parallel to the shoreline as shown in the sketch below.



The angle of wave propagation is measured from the normal to the shoreline and as this angle increases so does the component of alongshore transport. Waves arriving at an angle to the shoreline move material alongshore in two ways: by the skewed uprush and backwash of water on the beach and by the longshore current generated.

Besides the longshore component of sediment motion there is also an across shore component, the results of which are often particularly evident after storm conditions. The larger storm waves alter the beach profiles by decreasing the beach slope and moving sand offshore. This sand is generally not lost from the nearshore environment, and following the storm during typically prevailing conditions of small, long period waves the sand is moved back to the shore.

Seaward of the breaker line there is an offshore zone of sediment transport. This zone extends to a depth where the water motion near the bottom begins to affect the bottom sediment. Sediment in this zone moves in a sinusoidal motion with shoreward motion under the wave crest and seaward motion under the wave trough but in general with no net movement. The angle of wave propagation produces a longshore component in this zone also.

The general Hawaiian wave climate shown on Figure 4 can be described by four primary wave types: (1) northeast tradewind waves generated by the prevailing wind; (2) south swell generated by southern hemisphere winter storms; (3) north swell produced by winter storms in the North Pacific; and (4) kona storm waves from the south to west produced by local fronts and low pressure systems common during late winter and spring. The tradewind and kona storm waves are short period seas (5 to 10 seconds), while north and south swell waves have a longer period (12 to 20 seconds). These general deepwater wave types follow different paths to reach the Mauna Lani Resort. The project area is well sheltered from northeast tradewind waves by the island of Hawaii itself. The project area is partially sheltered from north swell by the Hawaiian islands to the northwest and from south swell by Keahole Point on the island of Hawaii, with only a portion of the deepwater energy from these wave types able to refract and diffract into the project area. Kona storm waves approach the project area directly, and likely represent the larger waves reaching the shore during a typical year.

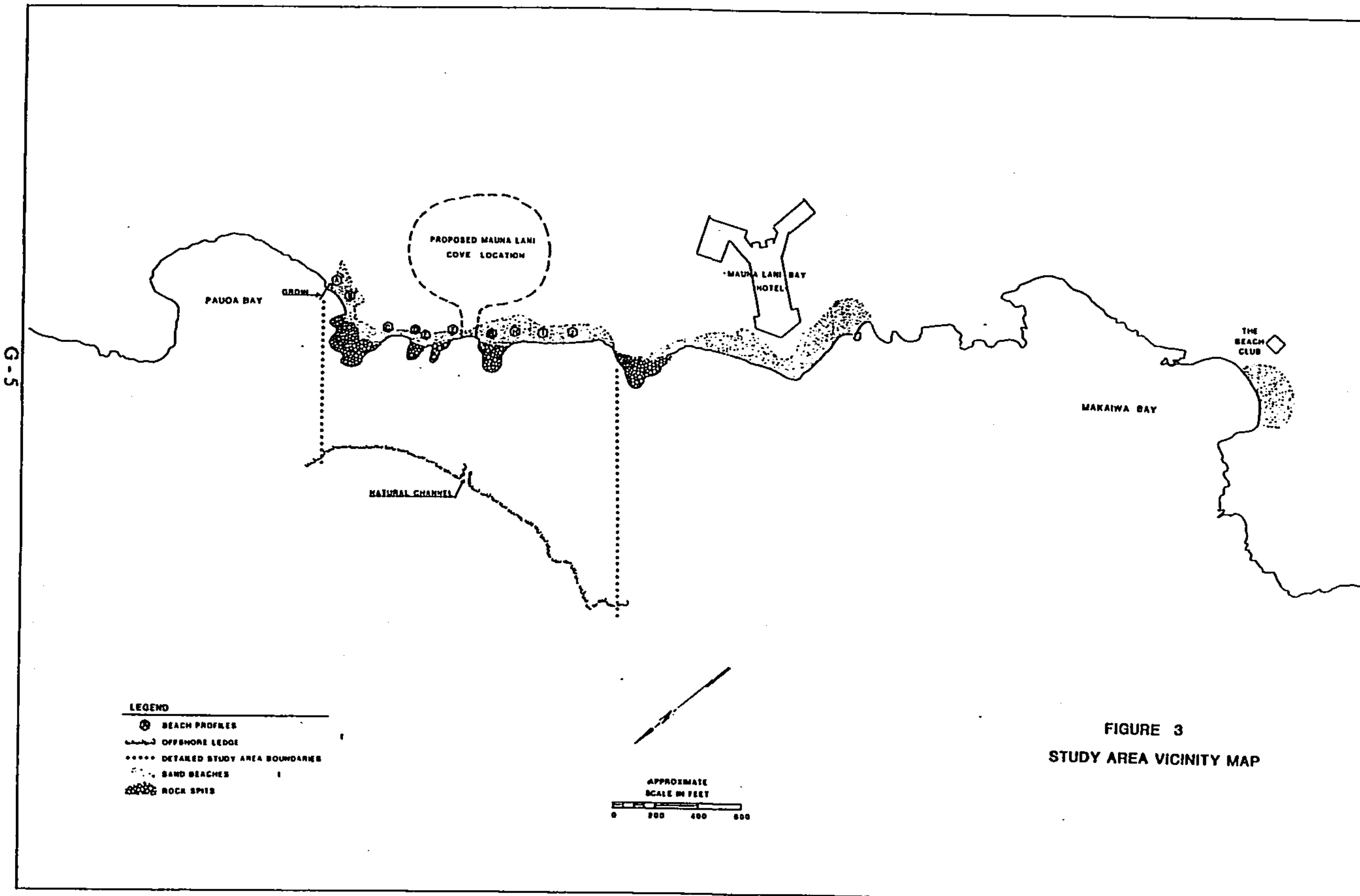


FIGURE 3
STUDY AREA VICINITY MAP

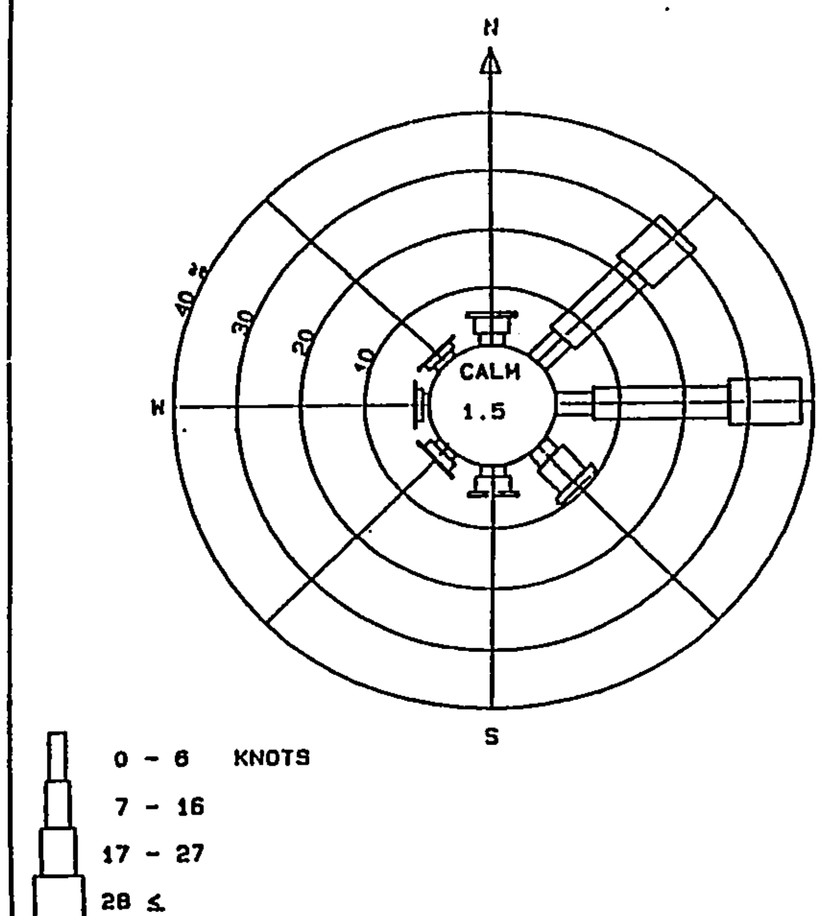
TABLE 1
PERCENT FREQUENCY HISTOGRAM OF WAVE HEIGHT AND PERIOD

PERCENT FREQUENCY (%)
(1/13/89 - 7/25/89)

HEIGHT (FEET)	WAVE PERIOD (SEC.) 0.0- 2.0	2.0- 4.0	4.0- 6.0	6.0- 8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	16.0-18.0	18.0-20.0	TOTAL
0.0- 0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5- 1.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5
1.0- 1.5	0.0	8.0	1.2	1.6	2.8	5.9	16.3	15.7	2.9	0.0	54.3
1.5- 2.0	0.0	0.7	1.6	0.9	0.7	4.7	9.5	7.3	1.0	0.3	26.6
2.0- 2.5	0.0	0.3	0.9	0.3	0.2	1.6	4.3	2.1	0.7	0.0	10.4
2.5- 3.0	0.0	0.0	0.9	0.0	0.3	0.7	1.2	1.2	0.2	0.0	4.5
3.0- 3.5	0.0	0.0	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.0	1.7
3.5- 4.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.2	0.0	0.0	1.2
4.0- 4.5	0.0	0.0	0.0	0.0	0.3	0.2	0.2	0.0	0.0	0.0	0.7
TOTAL	0.0	9.3	4.7	2.9	5.2	13.1	32.4	26.8	5.2	0.3	100.0

THE TOTAL NUMBER OF DATA = 578
THE RANGE OF WAVE HEIGHTS (FEET) : 1.0 - 4.3
THE RANGE OF WAVE PERIODS (SEC.) : 2.0 - 19.7

THE WAVE HEIGHT IS THE SPECTRALLY BASED SIGNIFICANT WAVE HEIGHT.
THE WAVE PERIOD IS THE PERIOD ASSOCIATED WITH THE SPECTRAL PEAK.



WIND ROSE

FIGURE 5

WIND ROSE BASED ON SSMO DATA

10

11

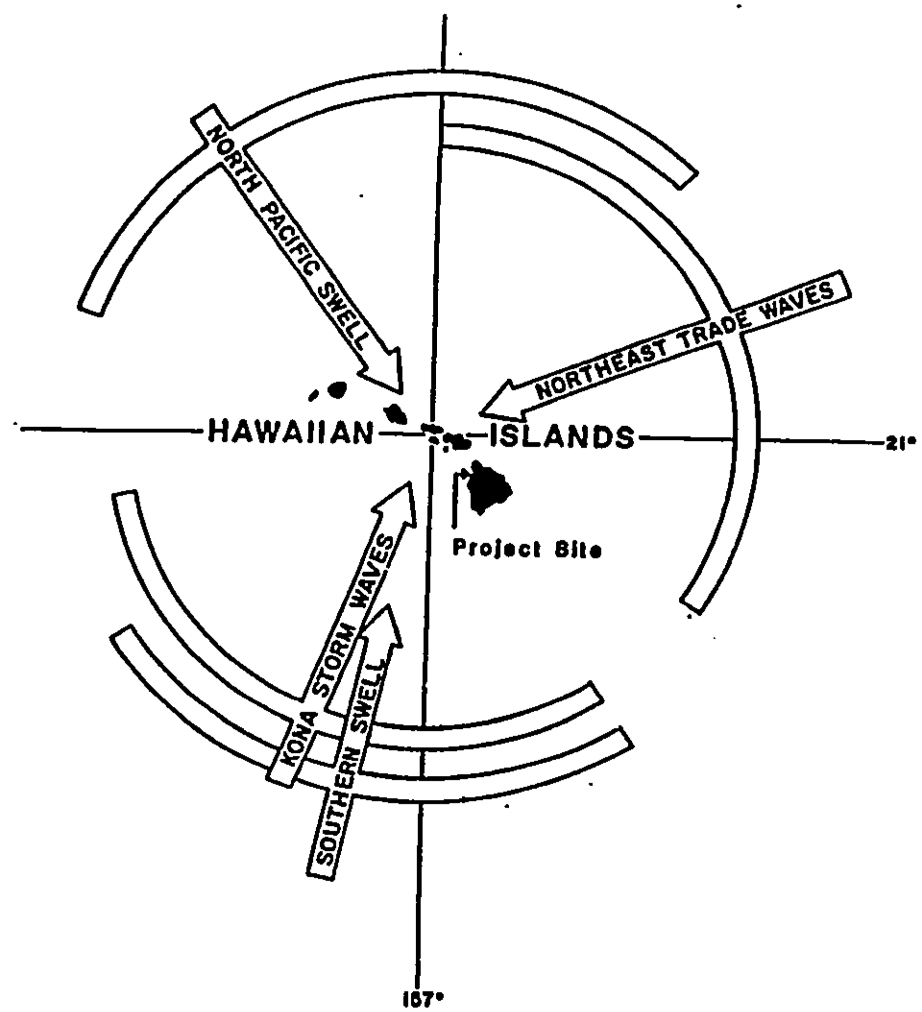


FIGURE 4

GENERALIZED WAVE TYPES

Wave data for the project area was collected by Sea Engineering, Inc. under separate contract for a 6-month period, January 12 to July 25, 1989, using an insitu recording wave gauge, located at the 35-foot depth directly seaward of the proposed marina entrance. A summary of the data collected is provided on Table 1. The first three months of data collection (January - April) is considered the winter season when north swell and kona waves can be expected to occur, and the last three months (April - July) is the summer season when south swell occurs. Wave heights generally did not exceed about 2 feet, and wave periods were typically 10 to 16 seconds. The relatively long wave periods are indicative of swell waves, which would presumably undergo considerable refraction to reach the project site, and the small wave heights are consistent with this.

Wind Driven Sediment Transport

Wind also plays a role in sediment transport, moving sand in the direction the wind is blowing. Sand is moved by the wind in three distinctive ways. Suspension occurs when small sand grains are lifted into the airstream and are blown appreciable distances. Sand particles carried in the wind by a series of short jumps along the beach surface is called saltation. Particles can also roll or be bounced along the beach as a result of wind forces or the impact of descending saltation particles in a process called surface creep. The wind rose shown on Figure 5 illustrates the prevailing wind direction and speed in the vicinity of the Hawaiian Islands. Mauna Kea and the Kohala Mountains somewhat shelter the waters off northwest Hawaii, however the trades funneling through the saddle between the Kohala Mountains and Mauna Kea blow offshore through Kawaihae Bay and the Mauna Lani Resort with slightly stronger winds than those over adjacent waters (Paul Hariguchi, Weather in Hawaiian Waters, 1979). Evidence suggests that wind does play a part in offshore transport of sediment. Local observers suggest after natural vegetation was removed there was an increase in sediment erosion. The vegetation acts as a wind block causing a decrease in wind velocity and in the concentration of entrained sediment.

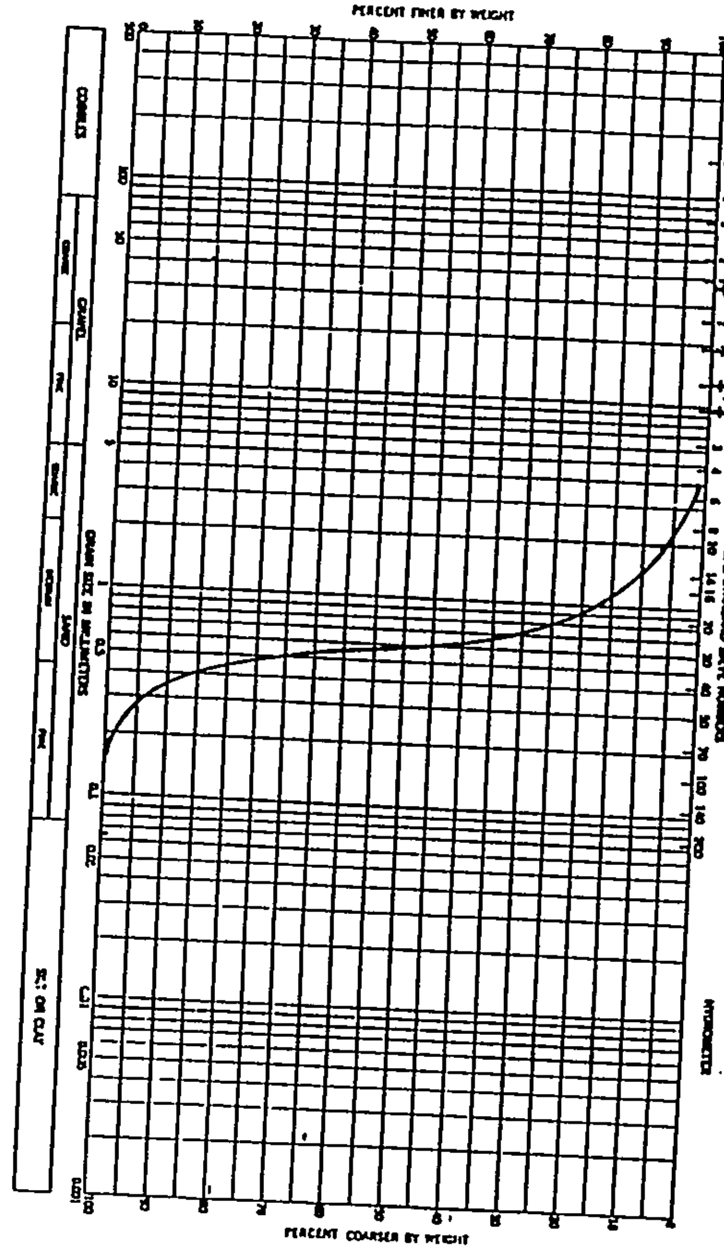


FIGURE 7

REPRESENTATIVE ONSHORE SAND SIZE

At the ledge, the bottom drops from between -10 and -15 feet to between -20 and -40 feet. Seaward of the ledge, the bottom is still predominantly rock and coral.

Offshore from the project site there are two canyons or channels running perpendicular to the ledge and shoreline, each about 20 feet wide and running shoreward 100 feet. Figure 3 shows the location and extent of this channel.

At the north end of the study area, on the south side of Pauoa Bay, there is a man-made groin that extends seaward of the beach. The reef extending from the rocky point to the south of the groin almost reaches the tip of the groin, forming a protected bowl. The beach there has more sand than the adjacent beach.

At the right of Pauoa Bay, which faces west, there is no vegetation and no sand on the shore.

Sand Survey

Offshore

A diver was towed in a zig-zag pattern through the offshore part of the study area in a search for sand deposits. Only small, widely separated sand patches were found. The photograph in Figure 8 shows one of the larger patches. It is about 2 feet by 3 feet and less than 3 inches thick. The two channels offshore of the project site have slightly larger patches in about 21 feet of water, but even these measure only a few square feet in extent and a few inches in thickness.

Onshore

Ten representative beach profiles were taken in the study area (Transects A - J) from just landward of the sand extent to its seaward toe. The locations of the profiles along with the horizontal extent of sand in the project area can be seen on Figure 3. The beach profiles are given in Figures 9 through 13.

FIELD INVESTIGATIONS

General observations were made of the coastline from the Mauna Lani Beach Club at Makaiwa Bay on the south to Pauoa Bay on the north. More detailed observations, including sand surveys, were conducted in the vicinity of the cove project, consisting of about 1,000 feet of shoreline and nearshore bottom centered on the proposed seaward entrance to the development and extending out to the 20 foot depth. This detailed study area is outlined in Figure 3.

General Observations

Details of the Mauna Lani Resort coastline can be seen on Figure 2. It is basically lava rock with small natural pocket beaches of mixed coralline and lava rock sand between rock spits and two man-made beaches of coralline sand at the Hotel and Beach Club. The coastline in general faces northwest, but the beach at the Beach Club sits in a small embayment formed on the northern side of a rocky promontory, giving it a northeasterly exposure. North of the Beach Club are several inshore fishponds connected to the ocean by narrow channels followed by the Mauna Lani Hotel's beach.

North of the Hotel is the detailed study area shoreline, which consists of several rock spits as can be seen in Figure 6. Between the rock spits are small natural beaches. The sand at the top of the berm connects these beaches landward of the spits. In places this is a strip of sand only a few feet wide, but at some locations the sand extends shoreward as much as 60 feet from the berm crest. A considerable amount of vegetation is found landward of the berm crest, including palm trees, low shrubs and Naupaka (crawling vines).

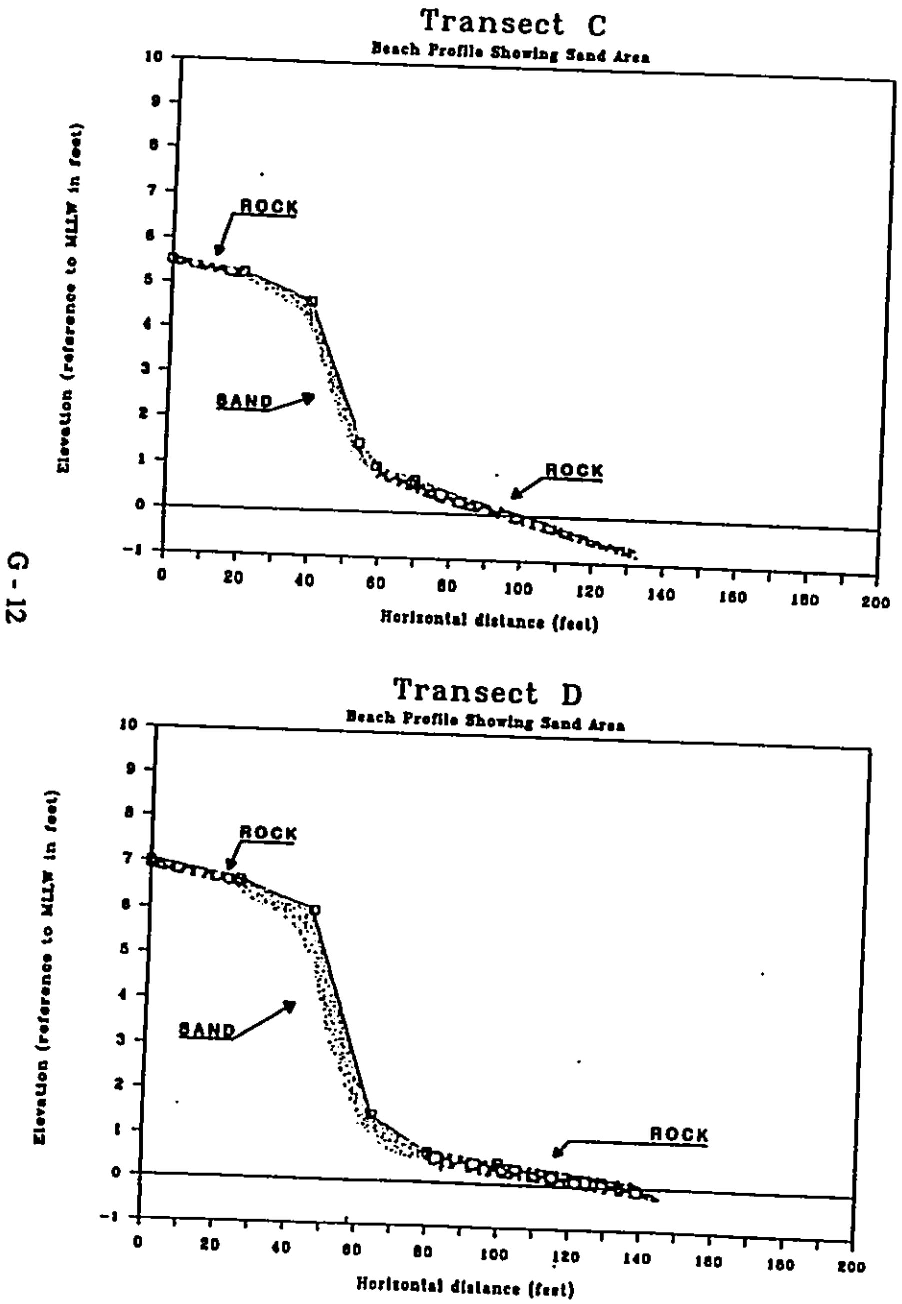
The beach face is steep with slopes on the order of 1 on 10 and a grain-size analysis shows medium to coarse sand with a notable absence of any fine sand. Figure 7 shows the details of the sand analysis. The toe of the beach is at or above the mean low lower water (MLLW) line.

The nearshore bottom is rock and coral, and slopes gradually out to a ledge that runs roughly parallel to the shore about 500 to 600 feet seaward of the shoreline.

FIGURE 6

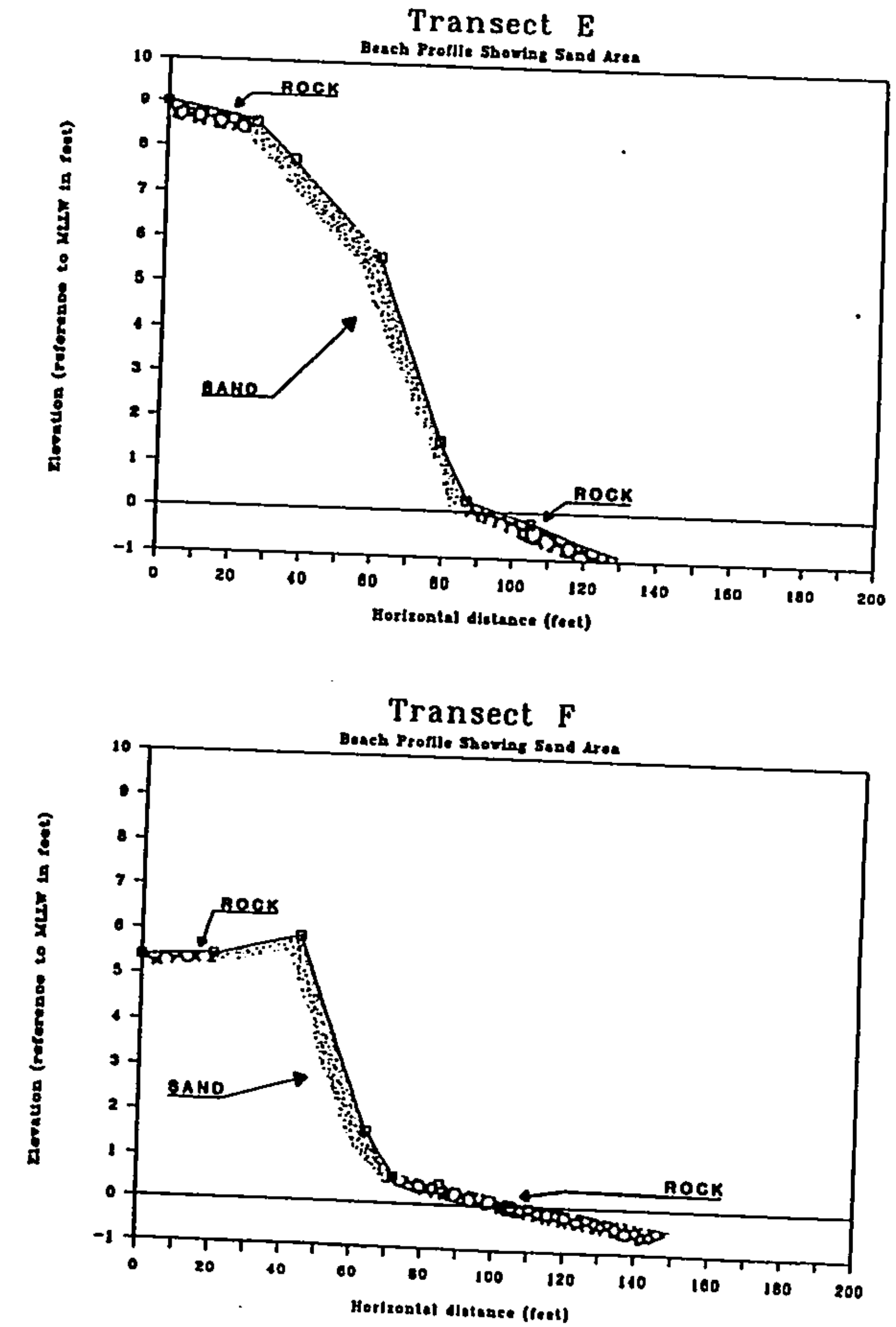
ROCK SPIT PERPENDICULAR TO THE BEACH. THESE NATURAL BARRIERS SHOW NO EVIDENCE OF ALONGSHORE SEDIMENT TRANSPORT.

FIGURE 10



18

FIGURE 11



19

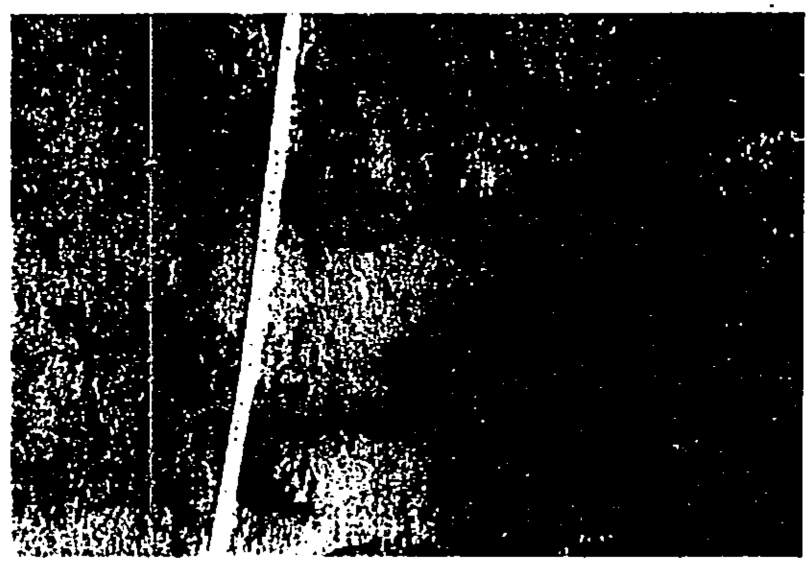


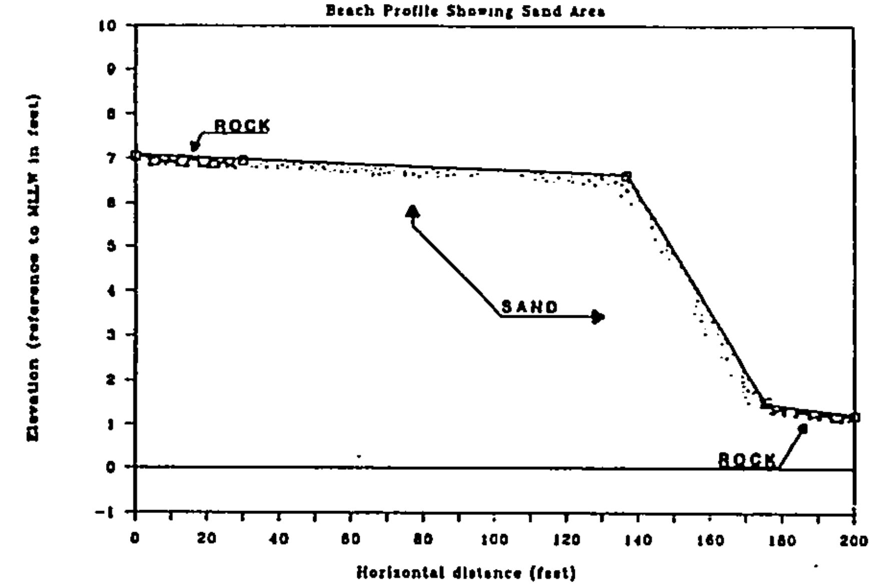
FIGURE 8

TYPICAL SAND PATCH
2 FEET X 3 FEET
SURROUNDED BY ROCK

FIGURE 9

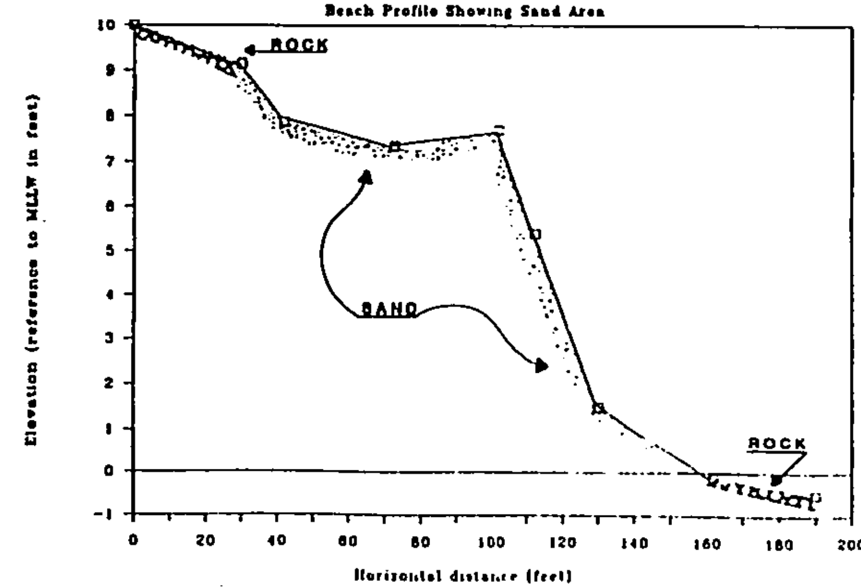
Transect A

Beach Profile Showing Sand Area



Transect B

Beach Profile Showing Sand Area



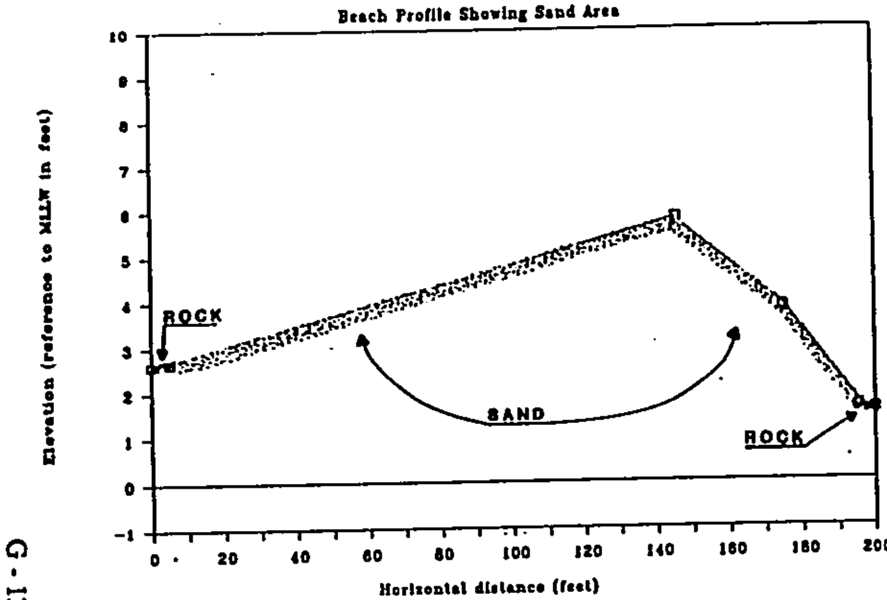
3) The gradual loss of natural beaches over the last 30 years is quite possibly related to the strong offshore tradewinds that blow periodically through the region. Evidence pointing to this likelihood includes the following points:

- The winds have been seen to move sand above the waterline at the Beach Club.
- The loss of natural beaches in the area seems to correlate with the removal of shoreline vegetation that would have protected the beaches from offshore winds.
- Existing natural beaches are in areas that still have some backshore vegetation. Pauoa Bay, which is devoid of vegetation, is also devoid of beach sand.
- The absence of fine sand on existing beaches above the high water mark could be due to a wind transport mechanism.
- Removal of vegetation in the study area during marina construction could result in more rapid loss of sand if alternate methods of wind protection are not employed.

FIGURE 12

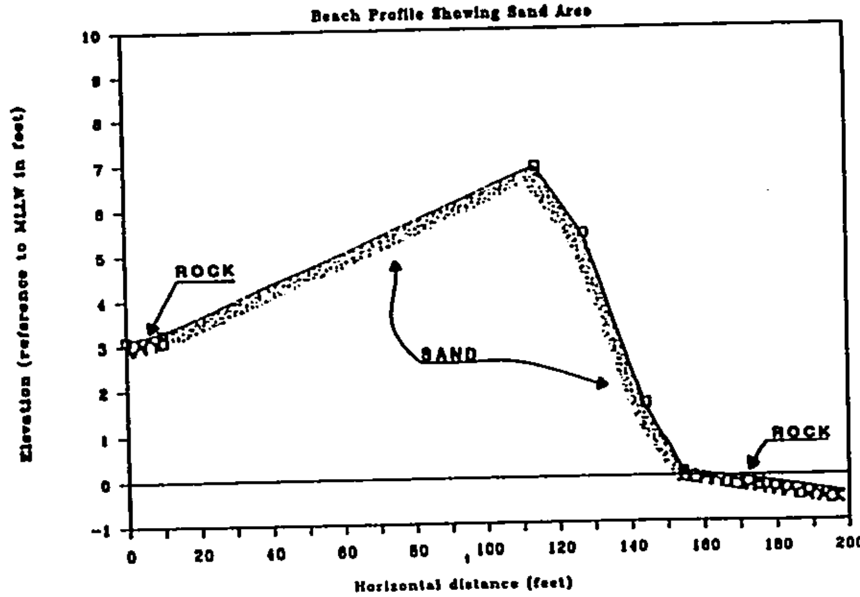
Transect G

Beach Profile Showing Sand Area



Transect H

Beach Profile Showing Sand Area



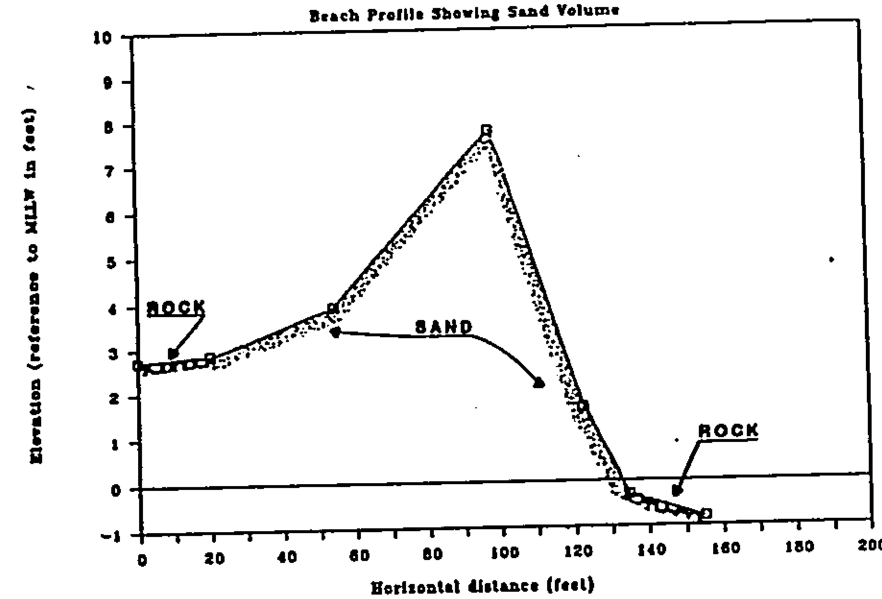
20

24

FIGURE 13

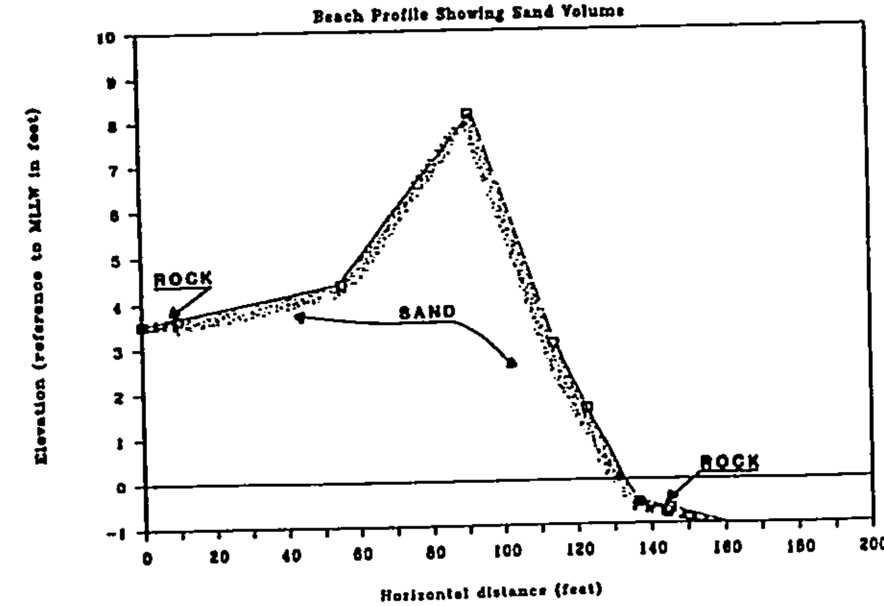
Transect I

Beach Profile Showing Sand Volume



Transect J

Beach Profile Showing Sand Volume



21

25

The profiles show that most sand is limited to a zone landward of the mean lower low water elevation. Most of the sand is out of the littoral zone and is only affected by wave action during storm or high wave conditions.

Local Historical Knowledge

Conversations were held with local residents and resort employees who have observed the beach and waters in this area on a daily basis for as long as 40 years. The following information was reported.

1) Local beaches have experienced slow, steady erosion over the last ten to thirty years. Palm trees have been lost near the hotel due to the recession of the beach. Figure 14 shows a fallen palm tree near the waterline in the study area.

2) Essentially the only large waves to affect this part of the coast come from the southwest and west during kona storms. The winter's North Pacific swell and summer's South Pacific swell do not produce large surf here. During Kona storms, there is a solid line of large breakers offshore, and the wave runup can overtop the wall along the shoreline between the hotel and the Beach Club. The top of the wall is about +5 feet MLLW.

   Kona storms can cause severe erosion of the local beaches, but the sand seems to return rapidly after the storm. The steady erosion appears to be independent of the storm related sand movement.

3) In the 1940's and early 1950's, most of the coastline was lined with Kiawe trees that were near enough to the shore for their branches to extend past the waterline. All the beaches had more sand then than at present. In particular, Pauoa Bay had a nice beach that had to be reached by water to get around the Kiawe trees.

   In the late 1950's, removal of the Kiawe trees began in Pauoa Bay and was continued along adjacent shorelines. Loss of sand seemed to coincide with the removal of this vegetation. The groin at the south end of Pauoa Bay was built sometime around the late 1950's, apparently to stop the sand loss, but the sand loss continued in spite of the groin.

FIGURE 14

SHORELINE EROSION EVIDENCE
BY UNDERMINED TREES

APPENDIX H

NEARSHORE WAVE AND CURRENT MEASUREMENTS FOR THE MAUNA LANI RESORT, NORTH KONA, HAWAII

FINAL DATA REPORT

NEARSHORE WAVE AND CURRENT MEASUREMENTS FOR THE MAUNA LANI RESORT SOUTH KOHALA, HAWAII

Prepared For:

Peratrovich, Nottingham & Drage, Inc.
1100 Eastlake Ave., Suite 310
Seattle, Washington 98109

Prepared By:

Sea Engineering, Inc.
Makai Research Pier
Waimanalo, Hawaii 96795

October 1989

TABLE OF CONTENTS

LIST OF FIGURES

H-2

LIST OF TABLES

PURPOSE AND SCOPE

This data report presents the results of a wave and current measurement program conducted at the Mauna Lani Resort, South Kohala, Island of Hawaii. The study, conducted by Sea Engineering, Inc. under contract to the firm of Peratrovich, Nottingham & Drage, Inc., was accomplished to aid in the design and assessment of a proposed marina to be constructed at the resort.

The study scope of work consisted of the following tasks:

1) deployment of a Sea Data Model 635-11 Wave Gauge and a General Oceanics Model 6011-T Current Meter seaward of the proposed marina entrance at the 30 to 50 foot depth for a total measurement period of 6-months, with servicing and data retrieval after the first 3-months; and,

2) analysis of the wave current data and preparation of a study report.

The wave gauge and current meter were initially deployed on January 12, 1989, and were serviced and redeployed on April 13, 1989. The gauges were retrieved on July 25, 1989. This report presents the wave and current data collected during the entire 6-month study period.

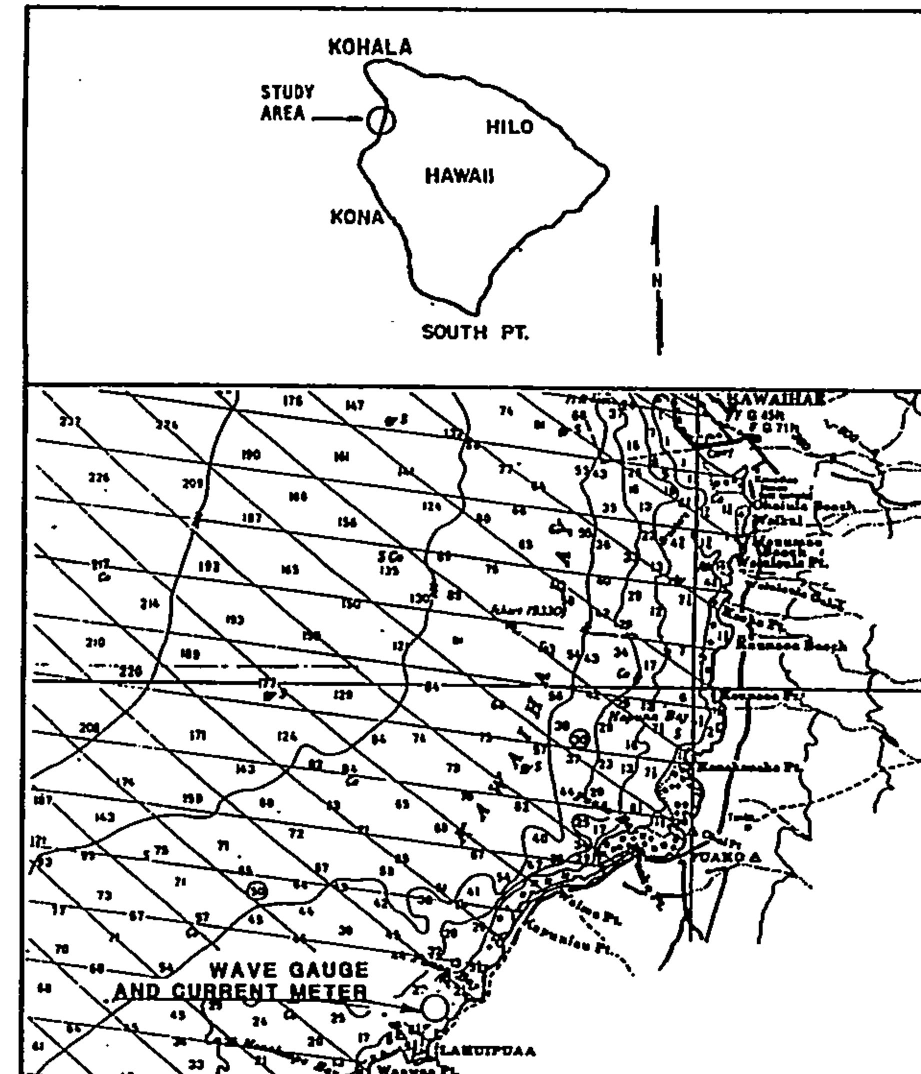


FIGURE 1
MAUNA LANI RESORT
WAVE GAUGE AND
CURRENT METER LOCATION

WAVE MEASUREMENT METHODOLOGY AND RESULTS

The wave gauge was deployed at the 35-foot depth, seaward of the proposed marina entrance location. The gauge was programed to record a 34 minute wave record (2,048 pressure samples at 1 second intervals) every 8 hours. Data recovery was 100% for the six month data collection period. Analysis of the data cassettes was preformed by Pacer Systems, Inc. (formerly the Sea Data Corporation), and included:

1) reading the data cassette and transcribing it onto a 9-track magnetic tape, including decoding the data and translating it into engineering units;

2) analysis of the statistical descriptors for every record, including the mean, variance, and the minimum and maximum deviation from the mean; and

3) obtaining the power spectrum from wave data corrected for hydrostatic pressure attenuation, and calculating the following spectral parameters:

   H_{sig} - the significant wave height as obtained from the spectral variance

   T_{peak} - the wave period associated with the spectral peak

   TO - the spectral period

   T_z - the spectral estimate of the mean zero-crossing period

   T_c - the spectral estimate of the mean crest period

   e - spectral width parameter

A complete summary of the spectral data wave analysis is provided in the appendix.

The first three months of wave data collection (January - April) is considered the winter season in Hawaii, when north swell produced by severe winter storms in the Aleutian area of the North Pacific Ocean and mid-latitude low pressure systems reaches the north and west shores of the islands. North Pacific swell typically has periods of 12 to 20 seconds and deepwater heights of 5 to 15 feet. Wind and waves from the south to west, termed "Kona" conditions, also occur most frequently in late winter. Kona storm waves are generated by winds associated with local fronts or low pressure systems and typically have periods of 6 to 10 seconds and heights up to 10+ feet.

The last three months of wave data collection (April - July) is representative of the summer season. South swell generated by Antarctic winter storms reaches Hawaii during the summer months, approaching from the south-southwest with typical periods of 12 to 22 seconds and deepwater heights of 1 to 4 feet.

In order to note possible seasonal differences in the wave climate during the measurement period, the wave data summaries are presented for both the 3-month winter and summer periods and the entire 6-month study period.

In general, the average wave heights were a little higher during the first 3-months, and the wave periods a little longer during the second 3-months, however the differences in the seasonal wave climate were small. Wave heights generally did not exceed about 2 feet, and wave periods were typically 10 to 16 seconds. The maximum measured wave height was 4.3 feet with a 9 second period which occurred in early March.

TABLE 1a
PERCENT FREQUENCY HISTOGRAM OF WAVE HEIGHT AND PERIOD
(1/13/89 - 4/12/89)

HEIGHT (FEET)	WAVE PERIOD (SEC.) 0.0- 2.0	2.0- 4.0	4.0- 6.0	6.0- 8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	16.0-18.0	18.0-20.0	TOTAL
0.0- 0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5- 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0- 1.5	0.0	5.6	0.7	0.4	3.4	9.0	10.9	7.1	0.7	0.0	37.8
1.5- 2.0	0.0	0.4	0.0	0.4	0.7	9.0	11.6	4.9	1.5	0.4	28.8
2.0- 2.5	0.0	0.7	1.1	0.7	0.4	3.4	7.5	2.2	0.4	0.0	16.5
2.5- 3.0	0.0	0.0	1.5	0.0	0.7	1.5	2.6	2.6	0.4	0.0	9.4
3.0- 3.5	0.0	0.0	0.0	0.4	0.7	0.4	0.4	0.7	0.7	0.0	3.4
3.5- 4.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1	0.4	0.0	0.0	2.6
4.0- 4.5	0.0	0.0	0.0	0.0	0.7	0.4	0.4	0.0	0.0	0.0	1.5
TOTAL	0.0	6.7	3.4	1.9	7.9	23.6	34.5	18.0	3.7	0.4	100.0

THE TOTAL NUMBER OF DATA = 267
THE RANGE OF WAVE HEIGHTS (FEET) : 1.0 - 4.3
THE RANGE OF WAVE PERIODS (SEC.) : 2.0 - 19.7

TABLE 1b
PERCENT FREQUENCY HISTOGRAM OF WAVE HEIGHT AND PERIOD
PERCENT FREQUENCY (%)
(4/12/89 - 7/25/89)

HEIGHT (FEET)	WAVE PERIOD (SEC.) 0.0- 2.0	2.0- 4.0	4.0- 6.0	6.0- 8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	16.0-18.0	18.0-20.0	TOTAL
0.0- 0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5- 1.0	0.0	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.0
1.0- 1.5	0.0	10.0	1.6	2.6	2.3	3.2	20.9	23.2	4.8	0.0	68.5
1.5- 2.0	0.0	1.0	2.9	1.3	0.6	1.0	7.7	9.3	0.6	0.3	24.8
2.0- 2.5	0.0	0.0	0.6	0.0	0.0	0.0	1.6	1.9	1.0	0.0	5.1
2.5- 3.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
3.0- 3.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
TOTAL	0.0	11.6	5.8	3.9	2.9	4.2	30.5	34.4	6.4	0.3	100.0

THE TOTAL NUMBER OF DATA = 311
THE RANGE OF WAVE HEIGHTS (FEET) : 1.0 - 3.1
THE RANGE OF WAVE PERIODS (SEC.) : 2.0 - 19.7

TABLE 1c
PERCENT FREQUENCY HISTOGRAM OF WAVE HEIGHT AND PERIOD
PERCENT FREQUENCY (%)
(1/13/89 - 7/25/89)

HEIGHT (FEET)	WAVE PERIOD (SEC.) 0.0- 2.0	2.0- 4.0	4.0- 6.0	6.0- 8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	16.0-18.0	18.0-20.0	TOTAL
0.0- 0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5- 1.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5
1.0- 1.5	0.0	8.0	1.2	1.6	2.8	5.9	16.3	15.7	2.9	0.0	54.3
1.5- 2.0	0.0	0.7	1.6	0.9	0.7	4.7	9.5	7.3	1.0	0.3	26.6
2.0- 2.5	0.0	0.3	0.9	0.3	0.2	1.6	4.3	2.1	0.7	0.0	10.4
2.5- 3.0	0.0	0.0	0.9	0.0	0.3	0.7	1.2	1.2	0.2	0.0	4.5
3.0- 3.5	0.0	0.0	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.0	1.7
3.5- 4.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.2	0.0	0.0	1.2
4.0- 4.5	0.0	0.0	0.0	0.0	0.3	0.2	0.2	0.0	0.0	0.0	0.7
TOTAL	0.0	9.3	4.7	2.9	5.2	13.1	32.4	26.8	5.2	0.3	100.0

THE TOTAL NUMBER OF DATA = 578
THE RANGE OF WAVE HEIGHTS (FEET) : 1.0 - 4.3
THE RANGE OF WAVE PERIODS (SEC.) : 2.0 - 19.7

THE WAVE HEIGHT IS THE SPECTRALLY BASED SIGNIFICANT WAVE HEIGHT.
THE WAVE PERIOD IS THE PERIOD ASSOCIATED WITH THE SPECTRAL PEAK.

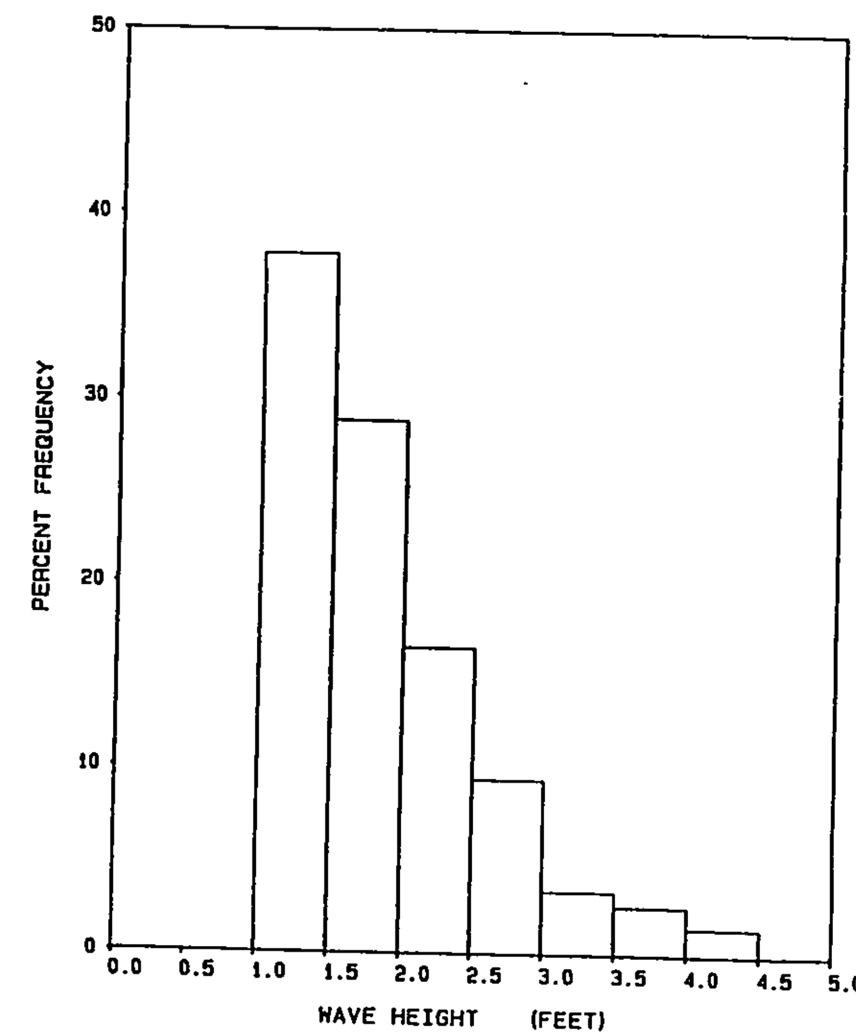


FIGURE 2a
WAVE HEIGHT DISTRIBUTION
HAUNA LANI, HAWAII
1/13/89 - 4/12/89

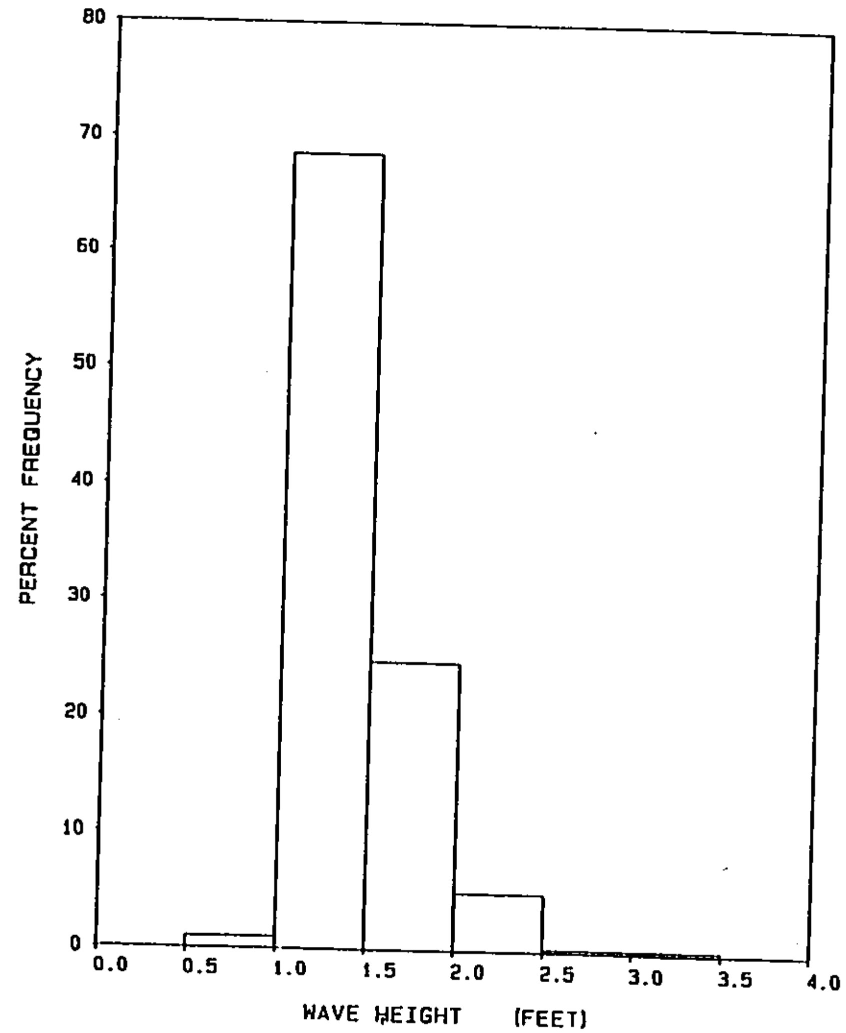


FIGURE 2b

WAVE HEIGHT DISTRIBUTION
HAUNA LANI, HAWAII
4/12/89 - 7/25/89

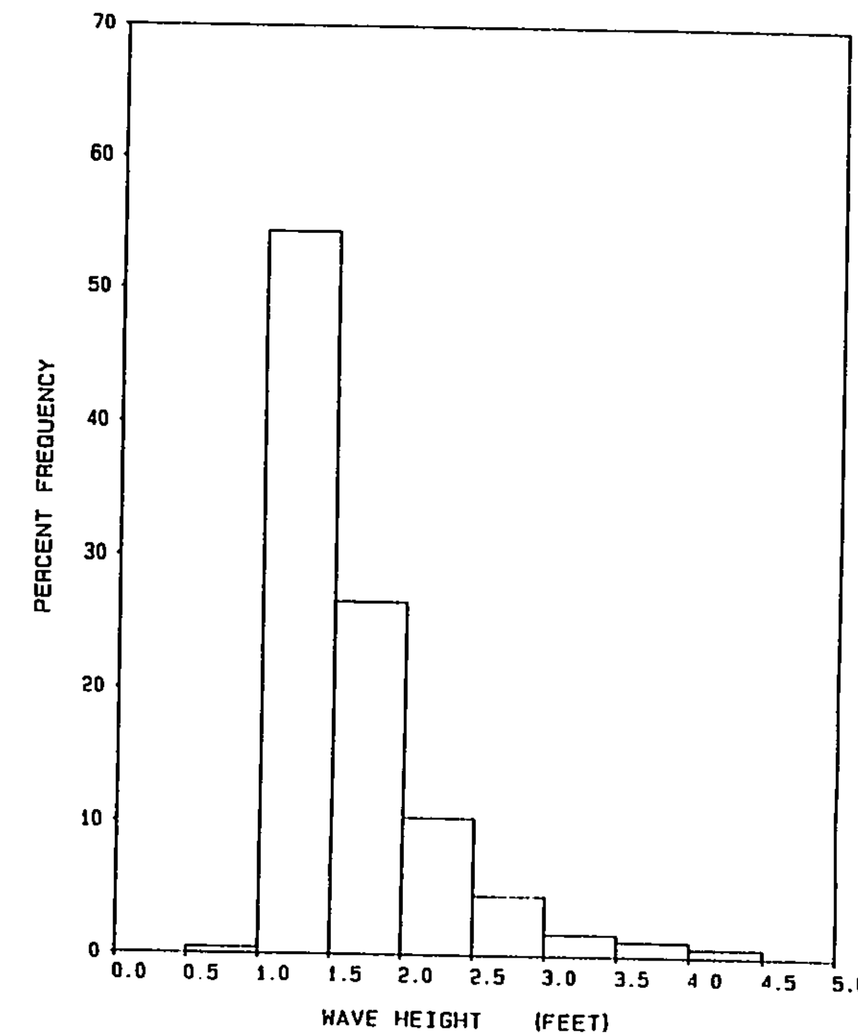


FIGURE 2c

WAVE HEIGHT DISTRIBUTION
HAUNA LANI, HAWAII
1/13/89 - 7/25/89

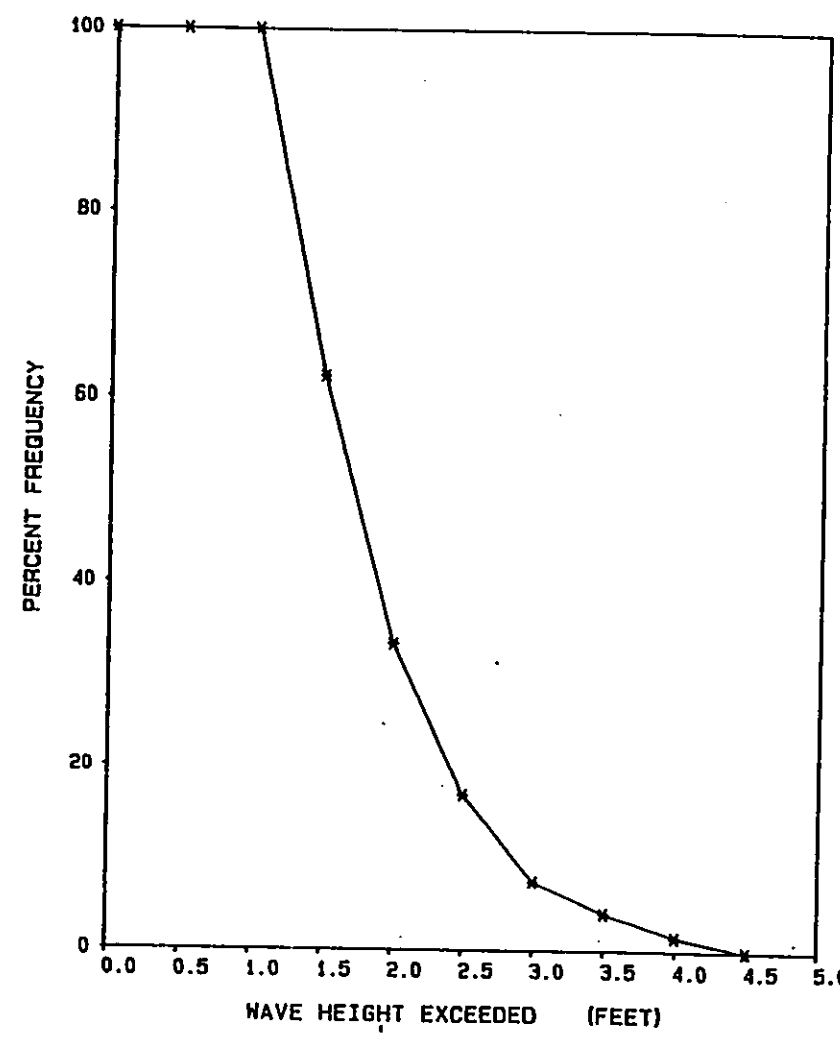


FIGURE 3a

CUMULATIVE WAVE HEIGHT DISTRIBUTION
HAUNA LANI, HAWAII
1/13/89 - 4/12/89

9

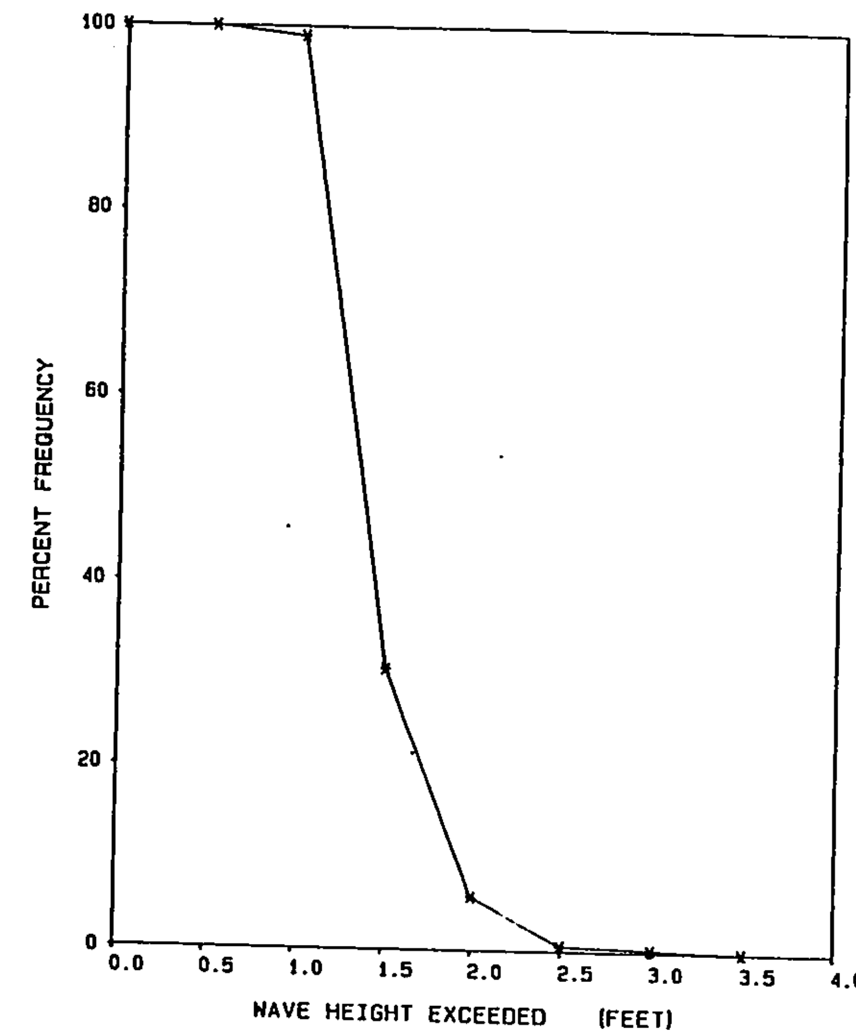


FIGURE 3b

CUMULATIVE WAVE HEIGHT DISTRIBUTION
HAUNA LANI, HAWAII
4/12/89 - 7/25/89

10

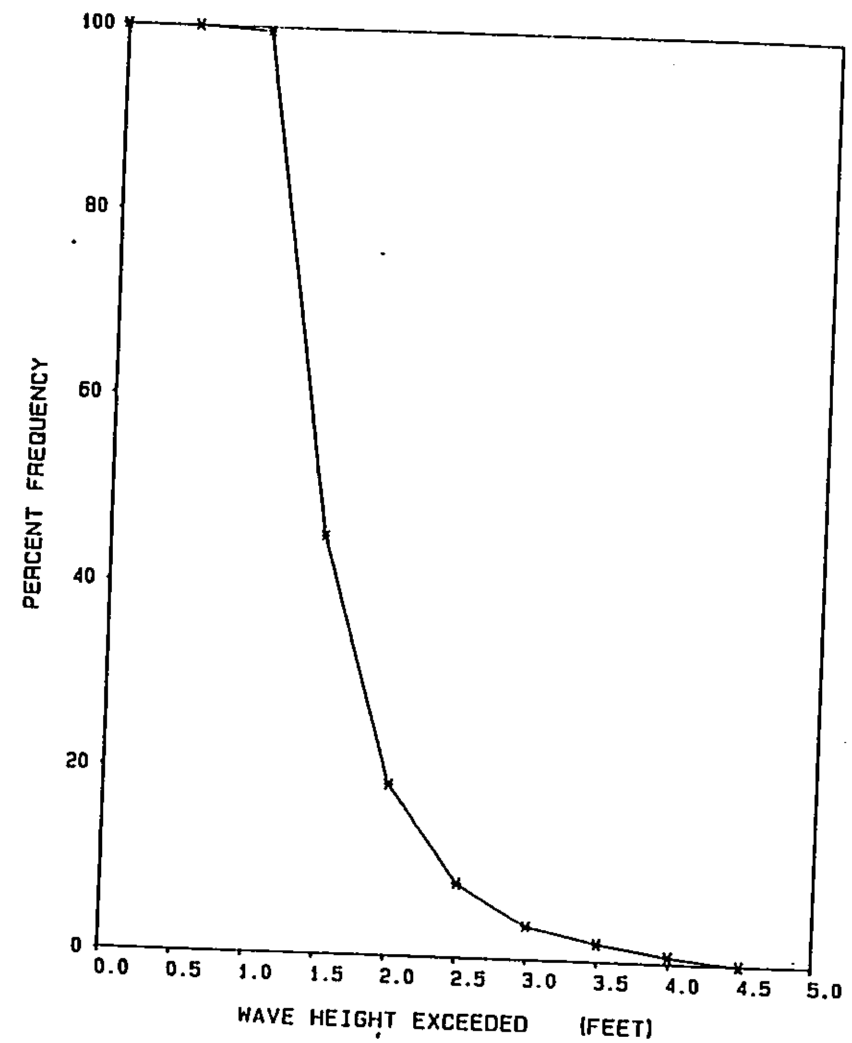


FIGURE 3c

CUMULATIVE WAVE HEIGHT DISTRIBUTION
MAUNA LANI, HAWAII
1/13/89 - 7/25/89

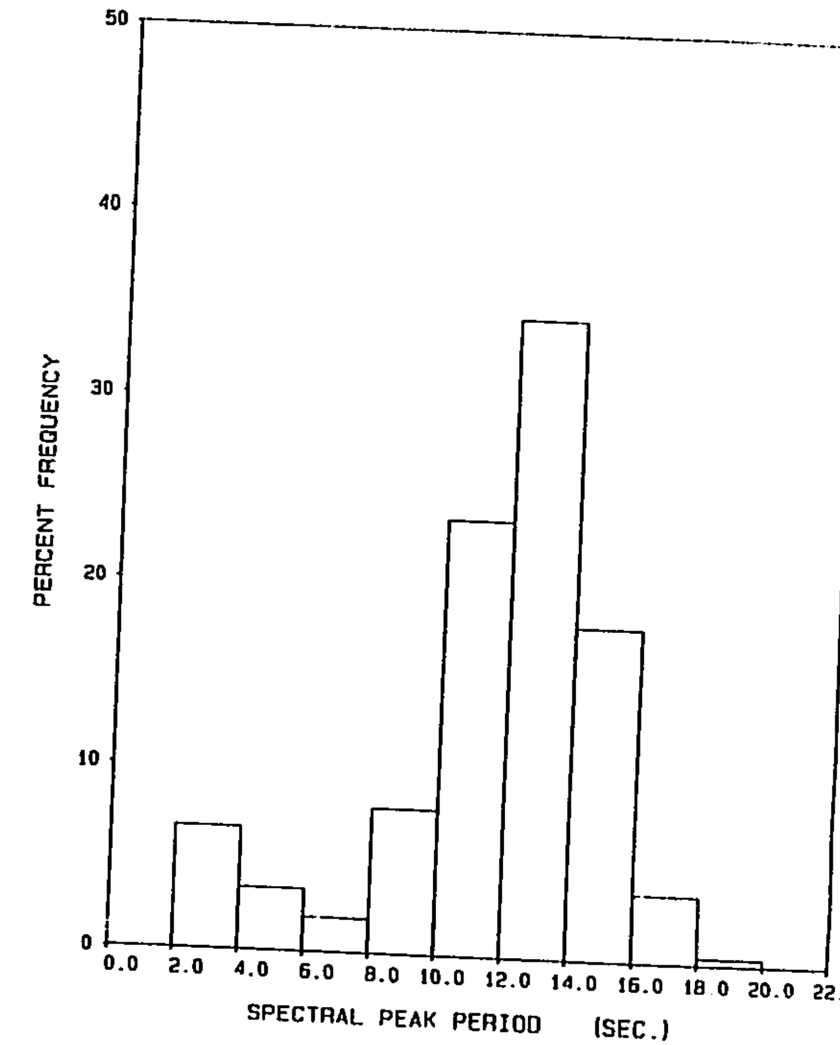


FIGURE 4a

SPECTRAL PEAK PERIOD DISTRIBUTION
MAUNA LANI, HAWAII
1/13/89 - 4/12/89

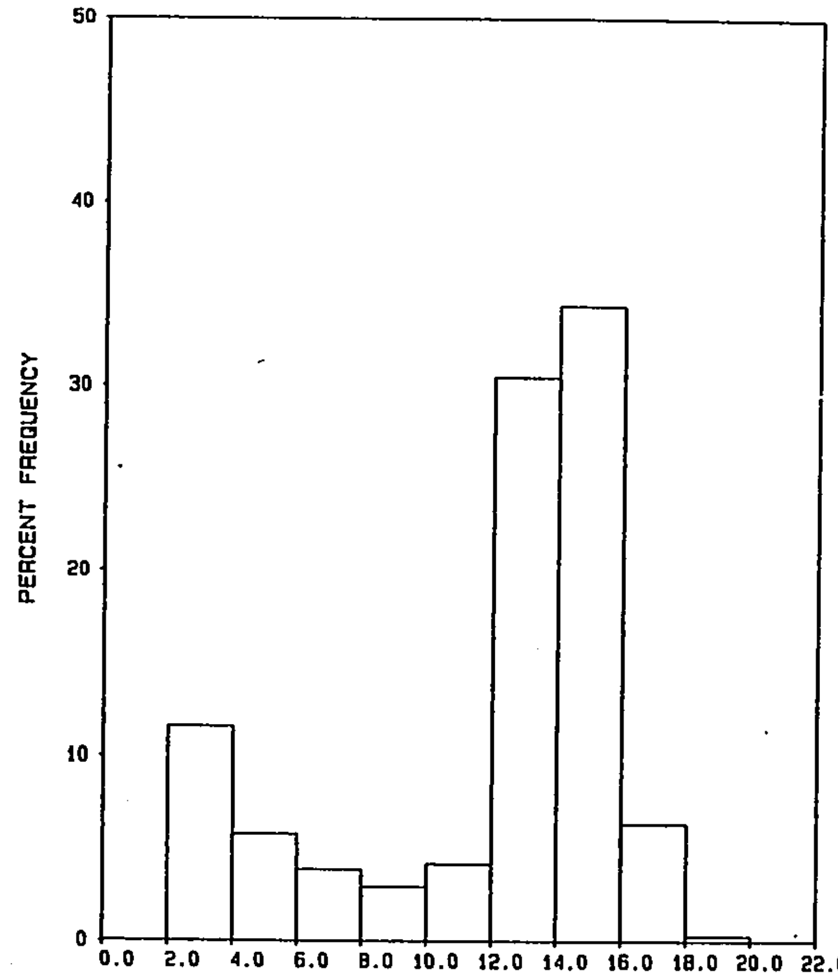


FIGURE 4b

SPECTRAL PEAK PERIOD DISTRIBUTION
MAUNA LANI, HAWAII
4/12/89 - 7/25/89

13

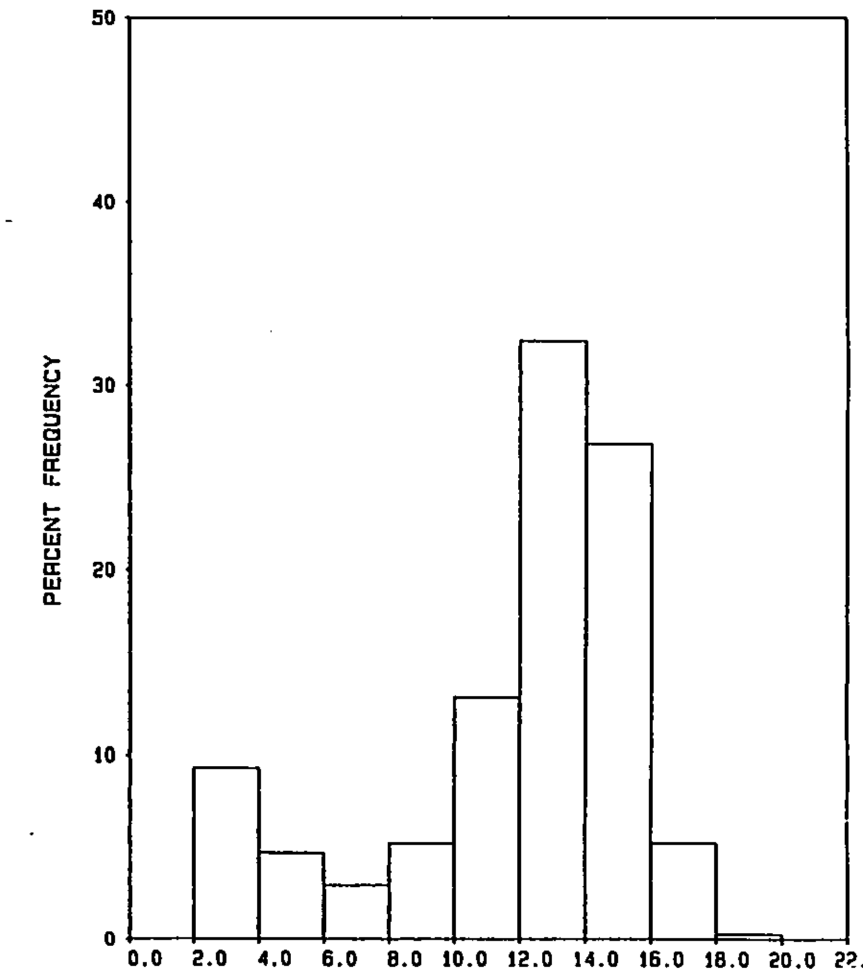


FIGURE 4c

SPECTRAL PEAK PERIOD DISTRIBUTION
MAUNA LANI, HAWAII
1/13/89 - 7/25/89

14

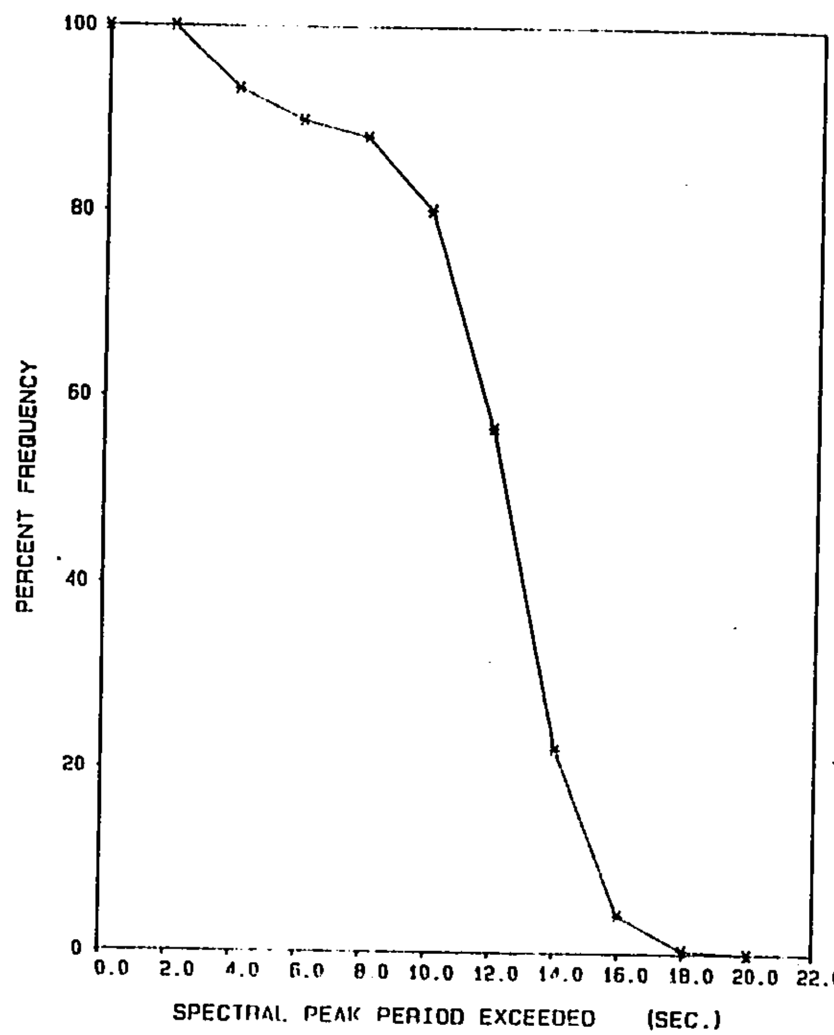


FIGURE 5a

CUMULATIVE SPECTRAL PEAK PERIOD DISTRIBUTION
HAUNA LANI, HAWAII
1/13/89 - 4/12/89

15

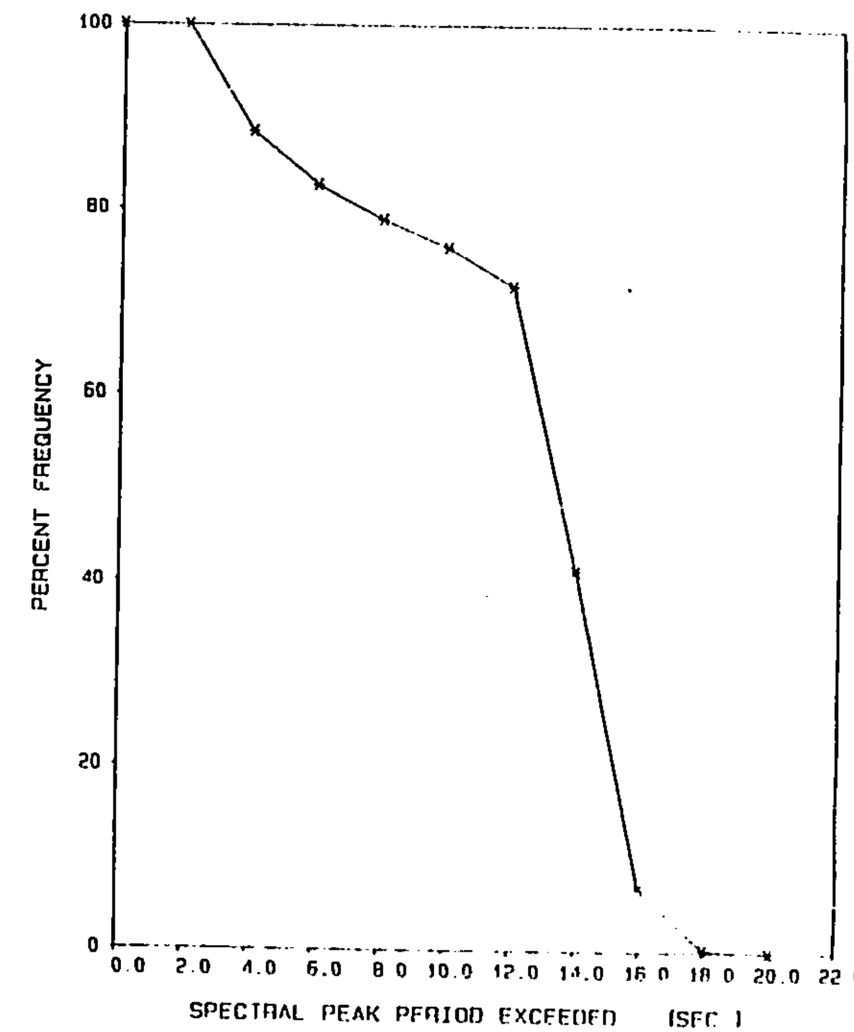


FIGURE 5b

CUMULATIVE SPECTRAL PEAK PERIOD DISTRIBUTION
HAUNA LANI, HAWAII
4/12/89 - 7/25/89

16

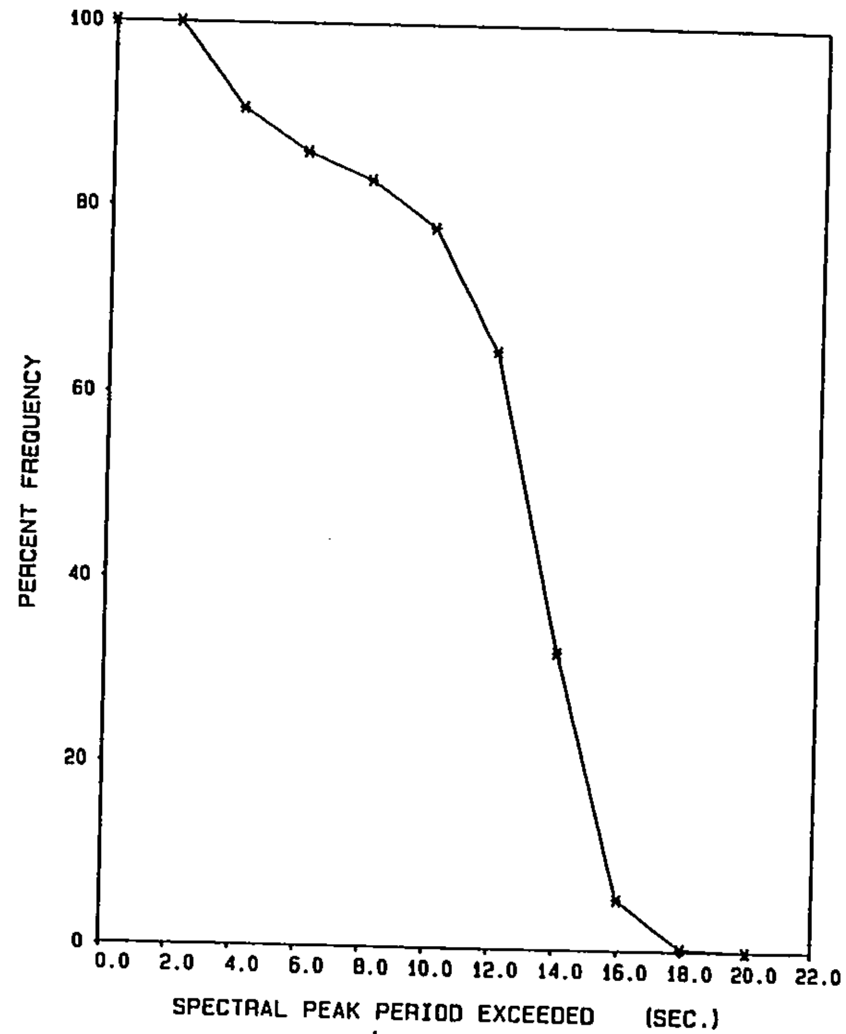


FIGURE 5c

CUMULATIVE SPECTRAL PEAK PERIOD DISTRIBUTION
HAUNA LANI, HAWAII
1/13/89 - 7/25/89

CURRENT MEASUREMENT METHODOLOGY AND RESULTS

The current meter was deployed at the 40-foot depth seaward of the proposed marina entrance, with the meter at the 34-foot depth (i.e. 6 feet off the bottom). The meter was programed to record current speed and direction at 15-minute intervals. Data collection for the 6-month measurement period was again 100%. The data was recorded on magnetic tape, and the digital record was computer processed. The speed and direction vector for each record is broken down into alongshore and onshore/offshore components based on the orientation of the coastline. The coordinate system and the sign convection used are shown on Figure 6. The 15-minute interval data records are then vector averaged to provide hourly average speeds and directions for further analysis. The current meter data was analyzed and is presented in the following formats.

1) Percent frequency histograms of current speed and direction, overall and by ebb and flood tide, are presented on Tables 2 and 3 for the January 12 -April 13 and April 13 - July 25 measurement periods, respectively, and on Table 4 as a summary of the entire 6-month period. Current roses for the January 12 - April 13 and the April 13 - July 25 measurement periods are shown on Figures 7 and 8, respectively, and a summary current rose for the entire 6-month period is shown on Figure 9 .

2) Time series plots of alongshore and onshore/offshore components of the current vectors, along with the predicted tide curve, are presented on Figure 10. The tide used is the predicted tide for Kawaihae Harbor, located approximately 6.3 miles north of the study area.

The measured currents offshore of the Mauna Lani Resort were relatively slow, typically 4 to 7 cm/s (0.1 knot), with an overall net transport to the southwest of about 1 cm/s. The maximum measured speed was 33 cm/s (0.6 knot). No particular correlation with the tide is evident, however the net transport to the southwest weakens during the flood tide. The current direction and net transport was not well defined, as shown by the current rose. The slow current speed makes the meter susceptible to influence by wave motion, thus the current vectors indicating onshore/offshore movement are likely a result of wave motion rather than actual currents setting toward or away from shore.

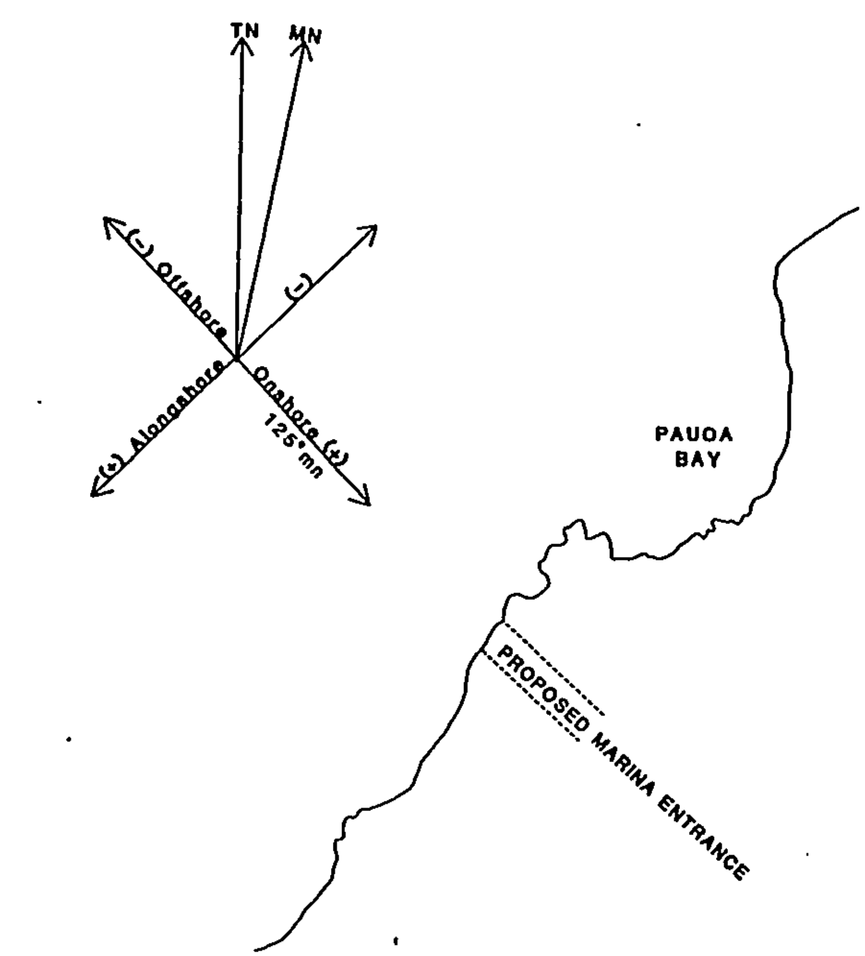


FIGURE 6

CURRENT DATA COORDINATE SYSTEM AND SIGN CONVENTION

TABLE 2

CURRENT SPEED AND DIRECTION HISTOGRAMS

MAUNA LANI RESORT

Station: A Depth (ft): 34 / 40 Deployment Period: 1/13/89 - 4/12/89
OVERALL RECORD CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	1.6	2.1	1.5	2.1	2.5	2.7	2.3	3.6	3.9	4.4	4.4	4.4	3.6	2.6	2.8	1.8
5- 9.9	1.2	1.2	1.2	2.3	2.1	2.4	2.4	2.2	2.0	2.5	4.5	5.3	3.8	3.3	2.5	1.4
10-14.9	0.4	0.2	0.1	0.5	1.0	0.9	0.7	0.8	0.6	0.2	0.9	1.6	1.4	0.7	0.5	0.2
15-19.9	0.0	0.0	0.3	0.2	0.1	0.1	0.2	0.0	0.0	0.0	0.2	0.3	0.2	0.3	0.1	0.0
20-24.9	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
25-29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	3.2	3.5	3.2	5.2	5.7	6.2	5.7	6.6	6.4	7.2	10.0	11.7	8.9	7.1	5.8	3.3
AVE SPD	5.45	4.80	6.92	6.76	6.44	6.52	6.53	5.61	5.01	4.66	5.84	6.84	6.53	7.12	5.96	5.42
MAX SPD	13.78	12.23	26.47	28.10	19.43	28.82	19.58	20.03	14.90	17.64	17.94	29.12	16.99	32.99	21.91	15.10

Station: A Depth (ft): 34 / 40 Deployment Period: 1/13/89 - 4/12/89
EBB TIDE CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	2.0	2.7	1.3	1.6	2.1	2.7	2.3	3.7	4.3	4.3	4.5	4.5	3.4	2.3	2.3	2.1
5- 9.9	1.1	1.0	1.4	2.0	1.6	2.1	2.8	2.6	1.9	2.4	5.1	5.8	3.7	3.4	2.1	1.5
10-14.9	0.5	0.3	0.2	0.4	0.7	0.5	0.6	0.8	0.7	0.3	1.0	1.4	1.0	0.8	0.6	0.4
15-19.9	0.0	0.0	0.3	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.3	0.4	0.2	0.3	0.2	0.0
20-24.9	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.1	0.0
25-29.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	3.6	4.0	3.2	4.4	4.5	5.4	5.8	7.1	7.0	7.1	10.9	12.3	8.3	7.0	5.3	4.0
AVE SPD	5.49	4.48	6.81	7.55	6.29	6.02	6.27	5.47	5.02	4.78	6.00	7.03	6.36	7.57	6.26	5.48
MAX SPD	13.64	12.23	18.63	28.10	16.07	20.87	19.58	13.68	14.44	17.64	17.94	29.12	16.99	24.92	21.91	13.84

Station: A Depth (ft): 34 / 40 Deployment Period: 1/13/89 - 4/12/89
FLOOD TIDE CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	1.3	1.4	1.9	2.5	3.0	2.7	2.4	3.4	3.4	4.5	4.2	4.3	3.7	3.0	2.8	1.5
5- 9.9	1.3	1.5	0.9	2.5	2.5	2.8	2.1	1.7	2.1	2.5	3.8	4.8	3.8	3.2	3.0	1.3
10-14.9	0.3	0.2	0.0	0.7	1.4	1.4	0.8	0.9	0.4	0.2	0.8	1.8	1.8	0.5	0.4	0.1
15-19.9	0.0	0.0	0.3	0.2	0.1	0.1	0.3	0.0	0.0	0.0	0.2	0.3	0.2	0.4	0.0	0.1
20-24.9	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29.9	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	2.8	3.0	3.3	6.0	7.0	7.1	5.6	6.1	5.9	7.2	9.0	11.1	9.5	7.2	6.3	2.9
AVE SPD	5.39	5.26	7.04	6.09	6.53	6.93	6.82	5.78	4.98	4.56	5.64	6.63	6.68	6.64	5.69	5.32
MAX SPD	13.78	11.92	26.47	16.47	19.43	28.82	18.05	20.03	14.90	10.68	17.39	17.50	16.47	32.99	14.95	15.10

TABLE 3

MAUNA LANI RESORT

Station: A Depth (ft): 34 / 40 Deployment Period: 4/12/89 - 7/25/89
OVERALL RECORD CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	2.4	2.9	2.9	3.6	2.9	2.3	2.0	2.8	3.8	5.2	6.1	5.8	3.9	3.1	3.6	2.9
5- 9.9	1.7	1.4	2.0	2.8	3.0	1.8	1.2	1.9	2.8	2.8	4.1	3.2	2.6	2.8	2.9	2.1
10-14.9	0.0	0.0	0.1	0.4	0.8	0.4	0.2	0.1	0.1	0.3	0.6	0.4	0.4	0.2	0.4	0.2
15-19.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
20-24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	4.1	4.3	5.0	6.7	6.7	4.5	3.4	4.8	6.7	8.2	10.8	9.4	7.0	6.1	6.9	5.3
AVE SPD	4.33	4.06	4.76	5.06	5.99	5.57	4.67	4.65	4.78	4.77	5.12	4.72	5.36	4.95	5.49	5.26
MAX SPD	9.13	8.85	11.61	15.91	16.60	20.92	13.38	13.84	10.78	13.59	15.26	13.51	15.84	11.20	15.86	15.78

Station: A Depth (ft): 34 / 40 Deployment Period: 4/12/89 - 7/25/89
EBB TIDE CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	2.5	2.6	2.5	2.8	2.9	2.1	1.8	2.6	3.2	5.8	7.4	6.4	4.1	2.8	3.1	3.0
5- 9.9	1.1	1.3	2.1	3.2	2.8	1.6	1.0	2.0	3.2	2.5	4.7	3.0	2.8	2.5	3.0	1.9
10-14.9	0.0	0.0	0.1	0.4	0.9	0.4	0.1	0.1	0.1	0.4	0.6	0.5	0.6	0.1	0.5	0.2
15-19.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.2	0.1
20-24.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	3.6	4.0	4.7	6.4	6.6	4.2	2.9	4.7	4.5	8.7	12.7	9.9	7.8	5.4	6.7	5.2
AVE SPD	3.88	3.91	4.98	5.31	5.96	5.99	4.53	4.67	5.00	4.39	5.00	4.51	5.55	5.01	5.74	5.32
MAX SPD	9.12	8.85	10.51	14.01	16.60	20.92	10.54	11.14	10.56	13.59	15.26	13.51	15.84	10.77	15.86	15.78

Station: A Depth (ft): 34 / 40 Deployment Period: 4/12/89 - 7/25/89
FLOOD TIDE CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	2.3	3.1	3.3	4.1	2.9	2.4	2.3	3.0	4.4	4.6	4.7	5.2	3.6	3.3	4.1	2.9
5- 9.9	2.3	1.5	1.9	2.4	3.3	2.0	1.4	1.8	2.4	3.0	3.4	3.3	2.4	3.2	2.7	2.4
10-14.9	0.0	0.0	0.2	0.4	0.7	0.3	0.2	0.2	0.2	0.2	0.7	0.4	0.2	0.2	0.4	0.2
15-19.9	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
20-24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	4.6	4.6	5.3	6.9	6.9	4.8	3.9	5.0	6.9	7.7	8.8	9.0	6.3	6.8	7.2	5.4
AVE SPD	4.69	4.19	4.56	4.81	6.02	5.19	4.77	4.64	4.56	4.97	5.30	4.95	5.11	4.91	5.25	5.20
MAX SPD	9.13	8.72	11.61	15.91	15.78	15.81	13.38	13.84	10.78	10.92	13.43	12.36	15.38	11.20	13.16	13.44

TABLE 4

MAUNA LANI RESORT

Station: A Depth (ft): 34 / 40 Deployment Period: 1/13/89 - 7/25/89
OVERALL RECORD CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	2.0	2.5	2.3	2.8	2.7	2.5	2.2	3.2	3.9	4.8	5.3	5.2	3.7	2.9	3.1	2.4
5- 9.9	1.5	1.3	1.4	2.6	2.6	2.1	1.8	2.0	2.4	2.6	4.3	4.2	3.1	3.1	2.7	1.8
10-14.9	0.2	0.1	0.1	0.5	0.9	0.6	0.4	0.5	0.3	0.3	0.7	1.0	0.9	0.4	0.5	0.2
15-19.9	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.0
20-24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
25-29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	3.7	3.9	4.2	6.0	6.3	5.3	4.5	5.6	6.6	7.7	10.4	10.5	7.9	6.6	6.6	4.5
AVE SPD	4.78	4.37	5.53	5.73	6.18	6.09	5.76	5.17	4.88	4.72	5.44	5.81	5.96	6.04	5.68	5.31
MAX SPD	13.78	12.23	26.47	28.10	19.43	28.82	19.58	20.03	14.90	17.64	17.94	29.12	16.99	32.99	21.91	15.78

Station: A Depth (ft): 34 / 40 Deployment Period: 1/13/89 - 7/25/89
EBB TIDE CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	2.2	2.7	1.9	2.2	2.5	2.4	2.0	3.1	3.8	5.1	6.0	5.5	3.8	2.6	2.7	2.6
5- 9.9	1.1	1.2	1.8	2.7	2.2	1.8	1.8	2.3	2.6	2.5	4.9	4.3	3.2	2.9	2.6	1.7
10-14.9	0.3	0.1	0.1	0.4	0.8	0.4	0.3	0.4	0.4	0.3	0.8	0.9	0.8	0.4	0.5	0.3
15-19.9	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.1	0.2	0.0
20-24.9	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
25-29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	3.6	4.0	4.0	5.5	5.7	4.8	4.2	5.8	6.7	8.0	11.9	11.0	8.0	6.2	6.1	4.6
AVE SPD	4.64	4.18	5.65	6.16	6.09	6.01	5.63	5.13	5.01	4.67	5.43	5.82	5.94	6.38	5.95	5.38
MAX SPD	13.64	12.23	18.63	28.10	16.60	20.92	19.58	13.68	14.44	17.64	17.94	29.12	16.99	26.92	21.91	15.78

Station: A Depth (ft): 34 / 40 Deployment Period: 1/13/89 - 7/25/89
FLOOD TIDE CALM: 0.0

CM/S	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0- 4.9	1.8	2.3	2.6	3.4	2.9	2.5	2.4	3.2	4.0	4.5	4.5	4.8	3.6	3.2	3.5	2.2
5- 9.9	1.8	1.5	1.4	2.4	2.9	2.4	1.7	1.7	2.2	2.8	3.6	4.0	3.0	3.2	2.8	1.9
10-14.9	0.1	0.1	0.1	0.5	1.0	0.8	0.5	0.5	0.3	0.2	0.7	1.0	0.9	0.4	0.4	0.1
15-19.9	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.0	0.0
20-24.9	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL %	3.8	3.9	4.4	6.5	6.9	5.8	4.7	5.5	6.4	7.5	8.9	10.0	7.7	7.0	6.8	4.3
AVE SPD	4.93	4.57	5.61	5.35	6.26	6.17	5.88	5.21	4.73	4.78	5.46	5.81	5.99	5.73	5.43	5.23
MAX SPD	13.78	11.92	26.47	16.47	19.43	28.82	18.05	20.03	14.90	10.92	17.59	17.50	16.47	32.99	16.95	15.10

MAUNA LANI RESORT 4/13/89 - 4/12/89
Station: A Meter/Water Depth: 34'/ 40'

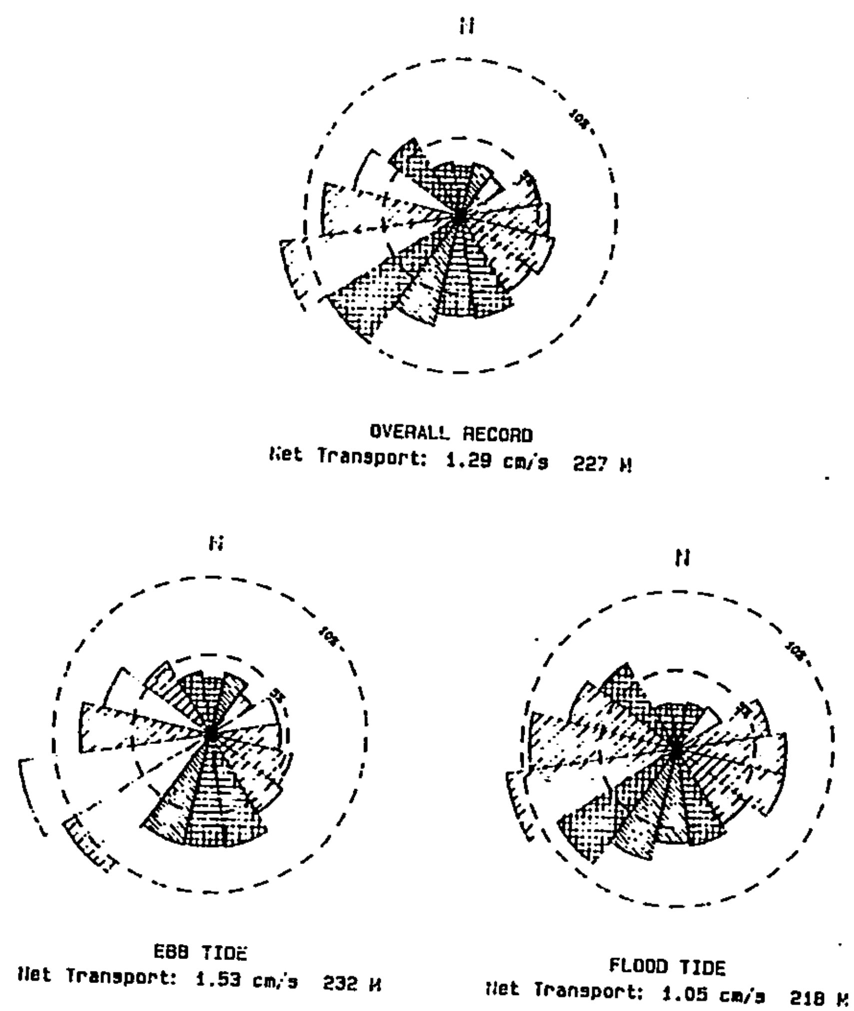


FIGURE 7
AVERAGE CURRENT SPEEDS (cm/s)

■ 3 - 4 4 - 5 5 - 6 6 - 7 > 7

MAUNA LANI RESORT 4/12/89 - 7/25/89
Station: A Meter/Water Depth: 34'/ 40'

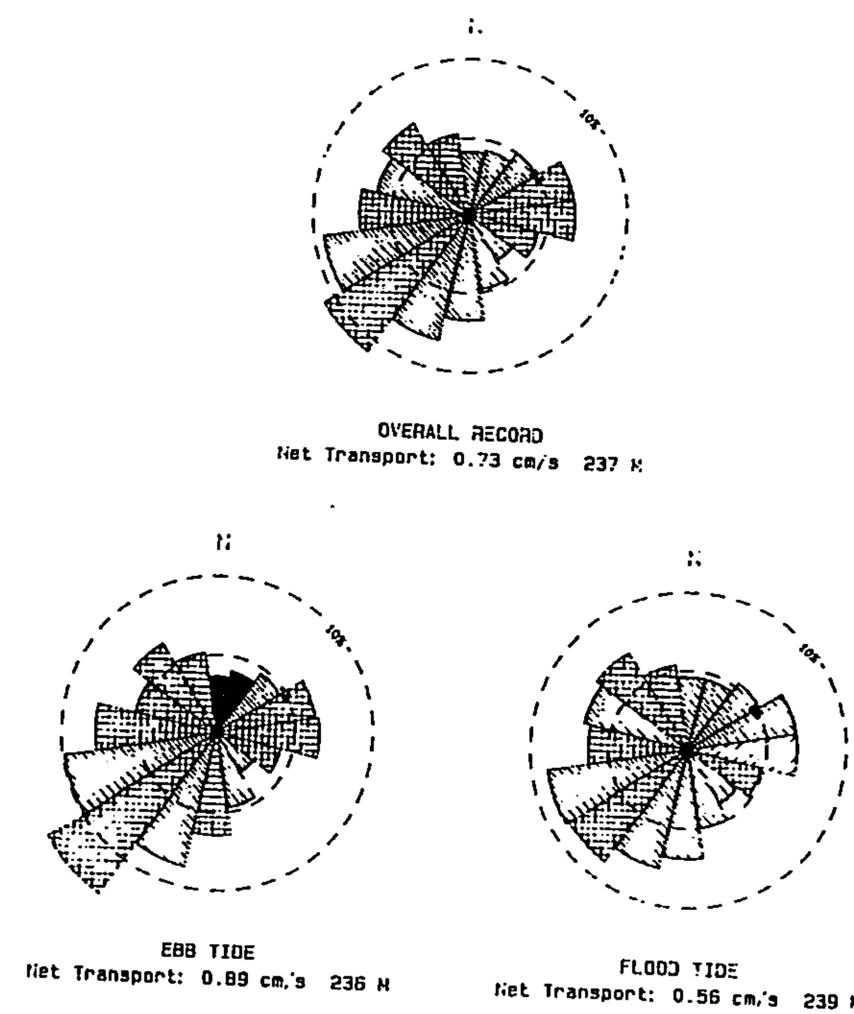


FIGURE 8
AVERAGE CURRENT SPEEDS (cm/s)

■ 3 - 4 4 - 5 5 - 6 6 - 7 > 7

23 24

KAUNA LANI RESORT 1/13/89 - 7/25/89

Station: A Meter/Water Depth: 34'/ 40'

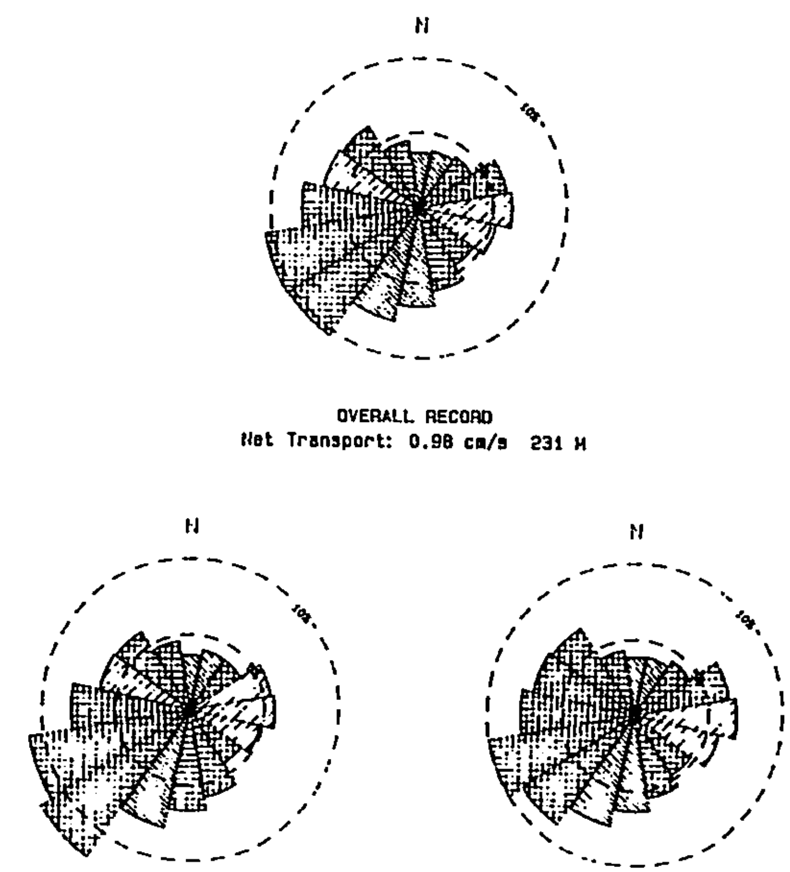


FIGURE 9

AVERAGE CURRENT SPEEDS (cm/s)

3 - 4 4 - 5 5 - 6 6 - 7 > 7

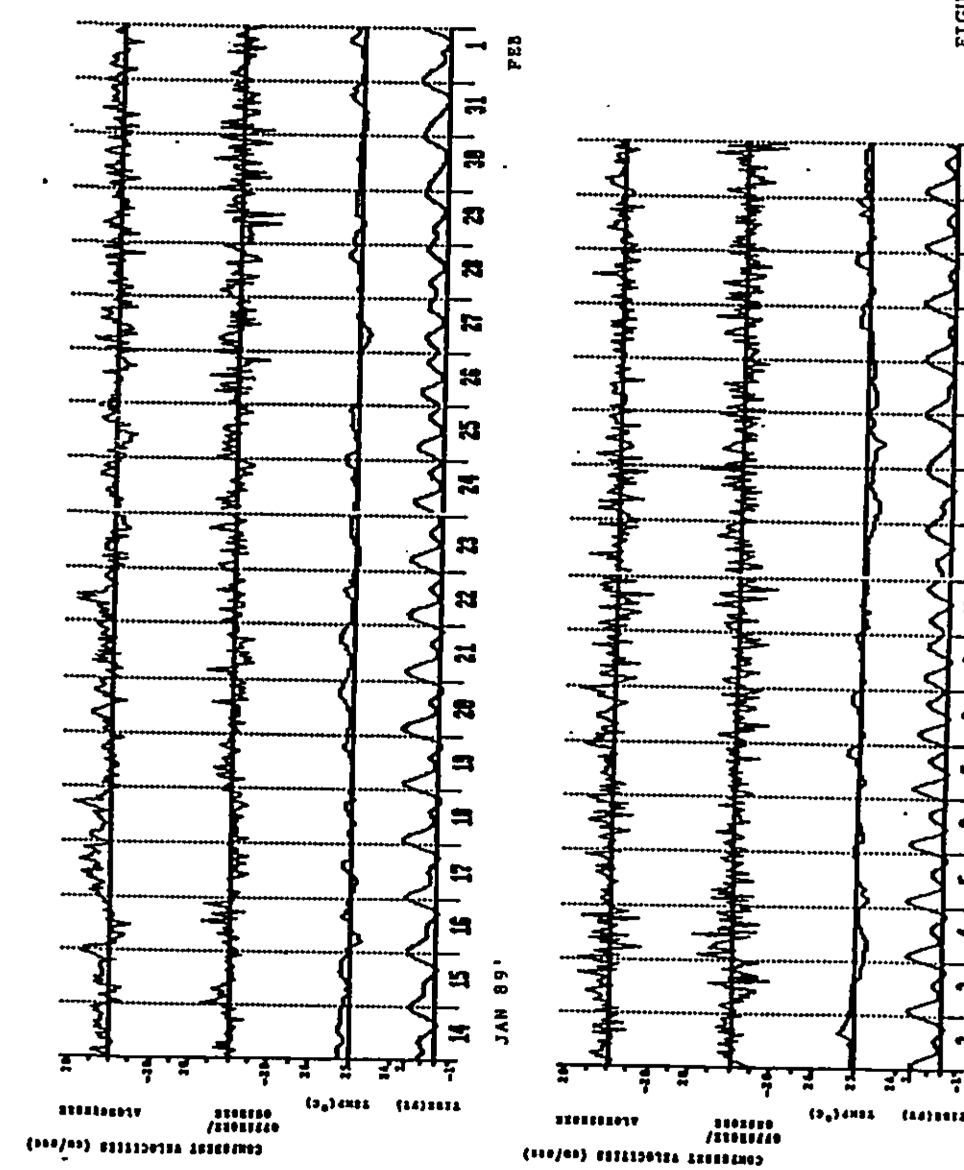
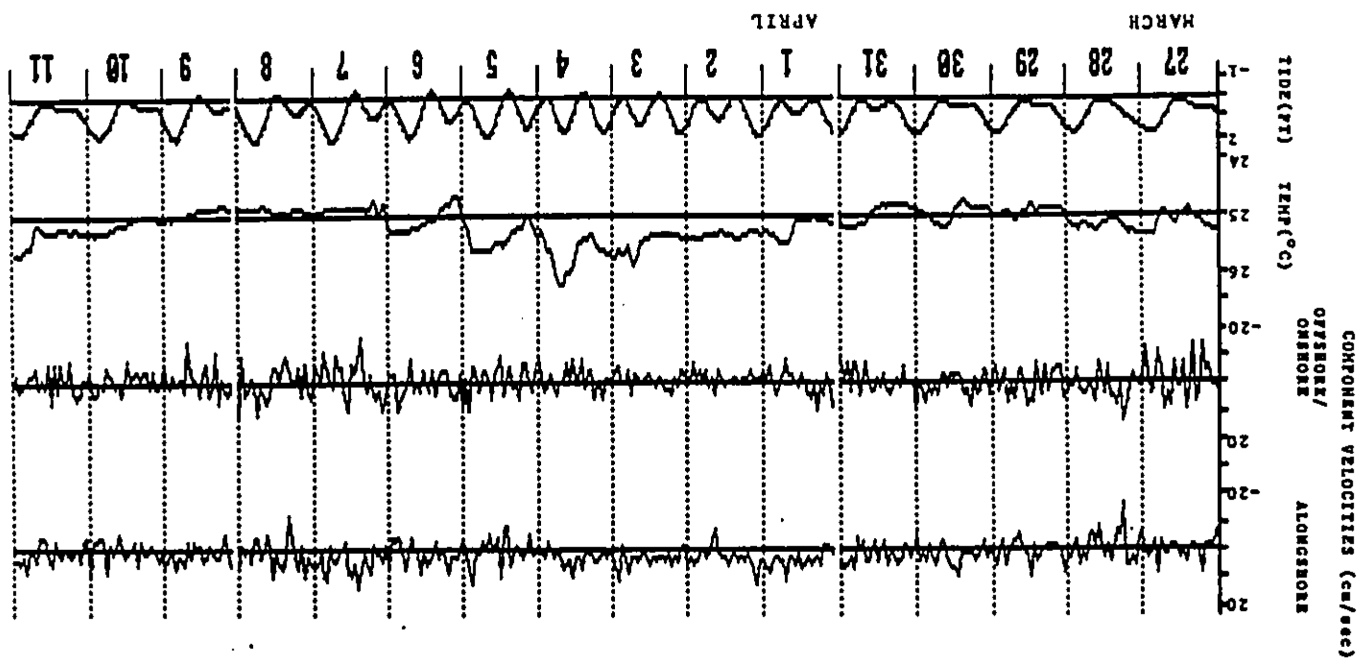


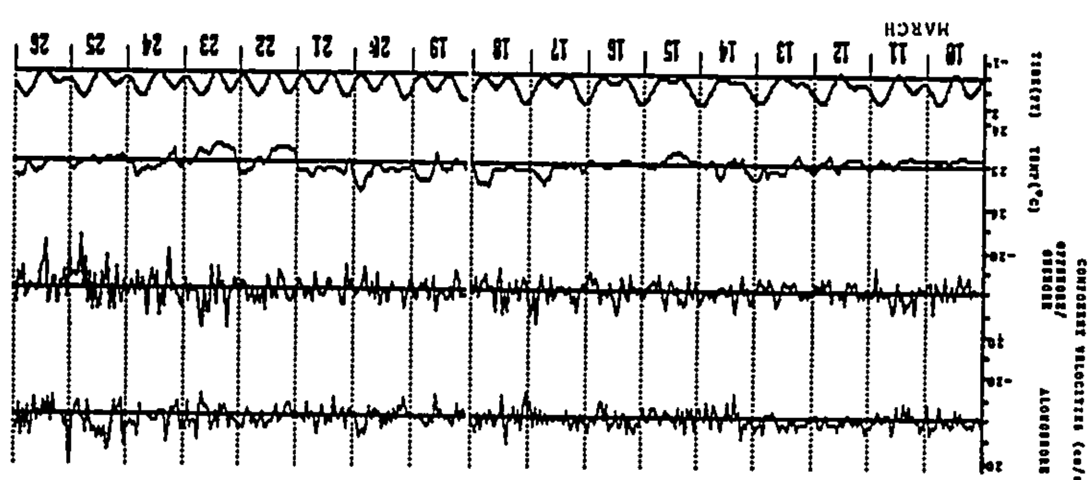
FIGURE 10
Current Velocity
Time Series

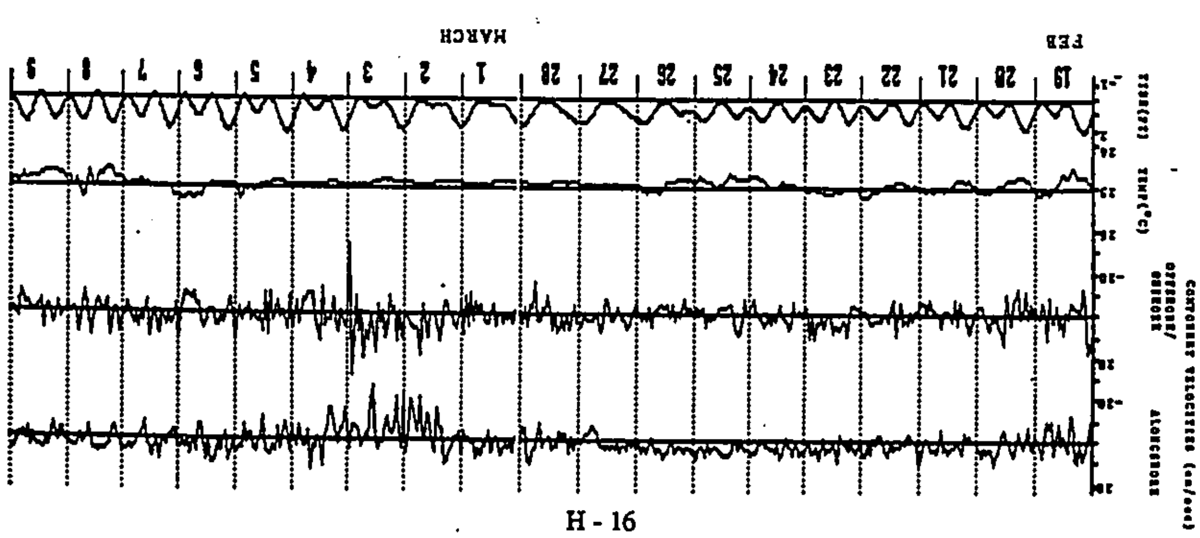
25

26

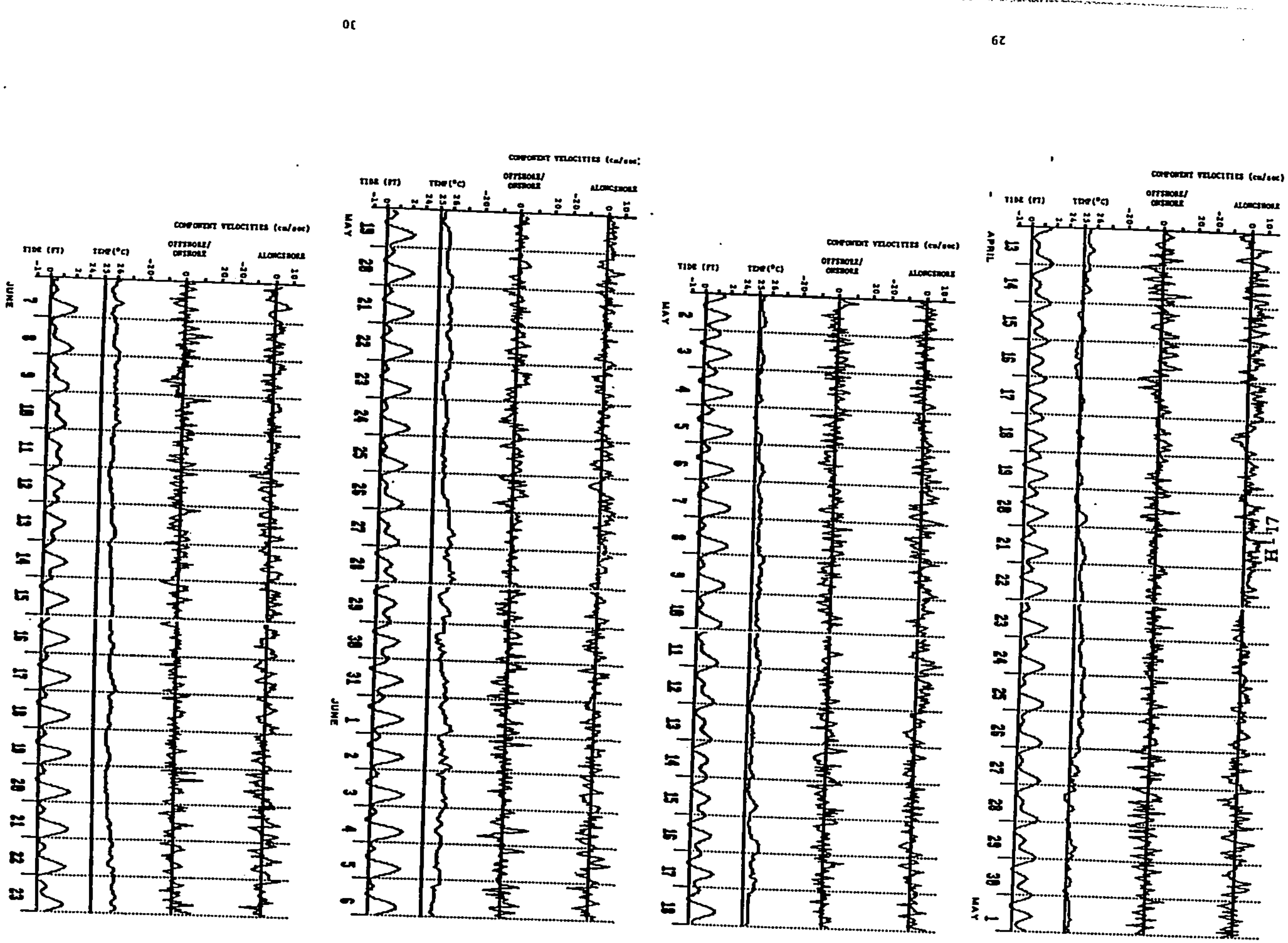

MARCH
APRIL
TIDE(FT)
TEMP(°C)
COMPONENT VELOCITIES (cm/sec)
OFFSHORE/ONSHORE
ALONGSHORE

28


MARCH
TIDE(FT)
TEMP(°C)
COMPONENT VELOCITIES (cm/sec)
OFFSHORE/ONSHORE
ALONGSHORE

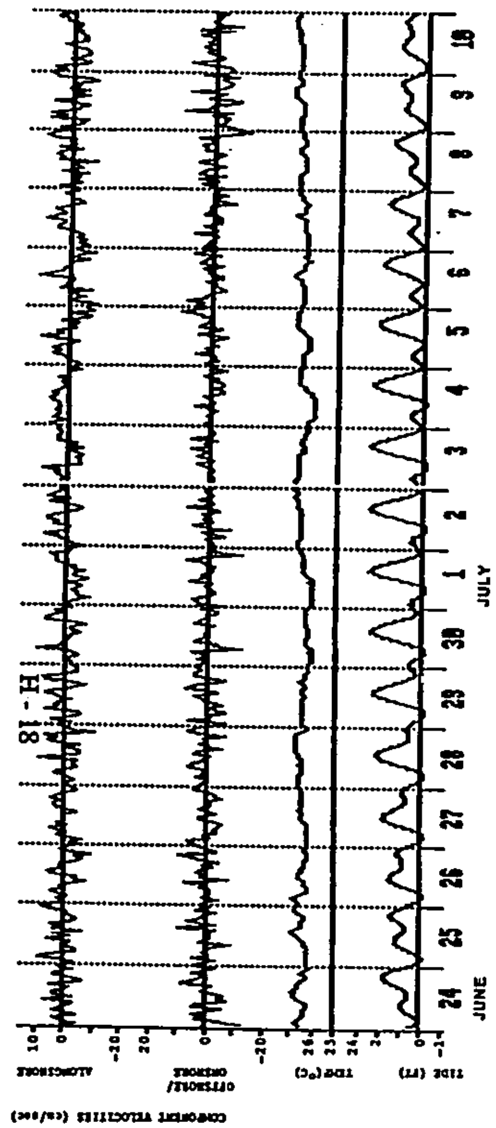

FEB
MARCH
TIDE(FT)
TEMP(°C)
COMPONENT VELOCITIES (cm/sec)
OFFSHORE/ONSHORE
ALONGSHORE

27


30
29
COMPONENT VELOCITIES (cm/sec)
TIDE (FT)
TEMP(°C)
OFFSHORE/ ONSHORE
ALONGSHORE
JUNE
MAY
APRIL
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1

APPENDIX

SPECTRAL WAVE ANALYSIS SUMMARY



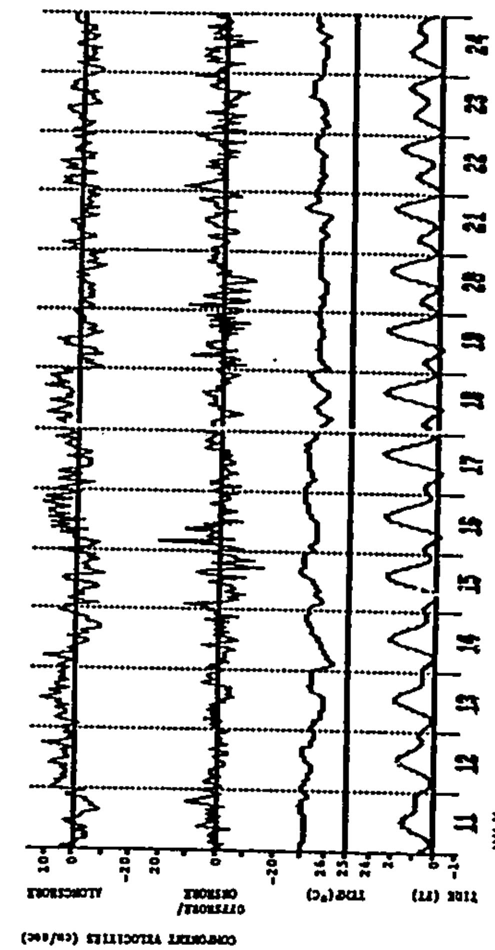


TABLE 1

Spectral Wave Analysis — Mauna Lani #1 — Page 1

time/ date	— pressure record data — mean psi	std dev psi	min psi	max psi	depth m	var m^2	— spectral analysis statistics — Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
89/01/13												
16:00	30.78	0.074	30.49	31.03	11.03	0.013	0.45	9.5	3.7	3.3	2.5	0.64
89/01/14												
00:00	31.39	0.059	31.19	31.63	11.45	0.010	0.39	2.1	3.4	3.1	2.5	0.60
08:00	31.46	0.064	31.22	31.66	11.49	0.009	0.38	10.2	3.9	3.4	2.5	0.67
16:00	30.73	0.060	30.52	30.92	10.99	0.009	0.39	3.3	3.6	3.2	2.5	0.62
89/01/15												
00:00	31.55	0.060	31.33	31.73	11.55	0.007	0.34	8.8	3.6	3.2	2.5	0.64
08:00	31.19	0.062	30.99	31.38	11.31	0.009	0.37	10.2	3.6	3.2	2.5	0.63
16:00	30.65	0.052	30.47	30.83	10.93	0.008	0.35	5.2	3.5	3.2	2.5	0.62
89/01/16												
00:00	31.59	0.057	31.43	31.78	11.58	0.007	0.34	10.2	3.6	3.2	2.5	0.63
08:00	30.97	0.050	30.82	31.16	11.16	0.007	0.32	7.8	3.5	3.1	2.5	0.61
16:00	30.68	0.049	30.52	30.84	10.96	0.008	0.35	3.2	3.4	3.1	2.5	0.58
89/01/17												
00:00	31.69	0.052	31.51	31.84	11.65	0.007	0.33	8.8	3.5	3.1	2.5	0.61
08:00	30.93	0.048	30.76	31.09	11.13	0.007	0.33	2.1	3.2	2.9	2.4	0.57
16:00	30.66	0.044	30.51	30.82	10.94	0.008	0.35	2.1	3.2	3.0	2.5	0.55
89/01/18												
00:00	31.67	0.046	31.54	31.81	11.64	0.009	0.37	2.6	3.1	2.9	2.4	0.52
08:00	30.90	0.047	30.74	31.05	11.11	0.007	0.34	2.2	3.2	3.0	2.4	0.57
16:00	30.80	0.052	30.62	30.97	11.04	0.011	0.42	4.1	3.5	3.2	2.6	0.58
89/01/19												
00:00	31.61	0.052	31.47	31.76	11.59	0.012	0.44	2.0	3.0	2.8	2.4	0.52
08:00	30.99	0.050	30.82	31.17	11.17	0.008	0.36	2.2	3.2	2.9	2.4	0.54
16:00	30.95	0.050	30.79	31.11	11.14	0.008	0.36	2.9	3.3	3.0	2.5	0.56
89/01/20												
00:00	31.49	0.071	31.21	31.70	11.51	0.011	0.43	9.5	3.5	3.1	2.5	0.61
08:00	31.07	0.080	30.82	31.33	11.22	0.010	0.40	13.5	4.0	3.4	2.5	0.68
16:00	31.06	0.072	30.77	31.30	11.22	0.009	0.37	13.5	4.0	3.4	2.5	0.69
89/01/21												
00:00	31.27	0.100	30.92	31.62	11.36	0.015	0.50	12.2	4.1	3.4	2.5	0.70
08:00	31.18	0.139	30.78	31.66	11.30	0.018	0.53	12.2	6.1	4.7	2.6	0.83
16:00	31.12	0.099	30.85	31.42	11.26	0.014	0.47	10.2	4.3	3.6	2.5	0.72
89/01/22												
00:00	31.06	0.091	30.76	31.38	11.22	0.011	0.42	11.1	4.6	3.9	2.6	0.75
08:00	31.26	0.109	30.96	31.57	11.35	0.013	0.46	11.1	5.1	4.1	2.6	0.79
16:00	31.16	0.092	30.80	31.45	11.29	0.012	0.44	11.1	4.4	3.7	2.5	0.73
89/01/23												
00:00	30.95	0.094	30.64	31.23	11.14	0.011	0.42	10.2	4.8	3.9	2.6	0.76
08:00	31.30	0.134	30.97	31.87	11.43	0.019	0.55	10.2	5.9	4.8	2.7	0.82
16:00	31.21	0.097	30.92	31.51	11.32	0.014	0.47	7.8	4.7	4.0	2.7	0.75
89/01/24												
00:00	30.91	0.120	30.53	31.27	11.11	0.018	0.54	12.2	4.9	4.1	2.6	0.77
08:00	31.45	0.107	31.09	31.84	11.49	0.014	0.40	11.1	4.8	3.9	2.5	0.76
16:00	31.15	0.093	30.82	31.47	11.28	0.011	0.42	11.1	4.8	4.0	2.6	0.75
89/01/25												
00:00	30.94	0.107	30.59	31.33	11.14	0.013	0.46	11.1	5.2	4.2	2.6	0.79

Spectral Wave Analysis — Mauna Lani #1 — Page 2

time/ date	— pressure record data — mean psi	std dev psi	min psi	max psi	depth m	var m^2	— spectral analysis statistics — Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
08:00	31.50	0.124	31.11	31.89	11.52	0.015	0.50	17.1	5.7	4.5	2.6	0.81
16:00	31.14	0.114	30.79	31.53	11.27	0.016	0.51	17.1	4.7	3.9	2.5	0.76
89/01/26												
00:00	30.97	0.132	30.49	31.43	11.16	0.018	0.54	15.1	5.5	4.3	2.6	0.80
08:00	31.47	0.175	30.91	32.05	11.50	0.023	0.60	13.5	8.0	5.9	2.7	0.89
16:00	31.07	0.242	30.36	31.76	11.22	0.045	0.85	13.5	7.9	6.1	2.9	0.88
89/01/27												
00:00	31.08	0.196	30.37	31.86	11.23	0.032	0.71	13.5	7.0	5.4	2.8	0.86
08:00	31.44	0.208	30.83	32.08	11.48	0.033	0.73	13.5	7.8	5.9	2.8	0.88
16:00	31.04	0.181	30.47	31.60	11.20	0.028	0.67	12.2	6.9	5.4	2.7	0.86
89/01/28												
00:00	31.25	0.171	30.71	31.89	11.35	0.026	0.65	12.2	6.5	5.2	2.8	0.85
08:00	31.43	0.147	30.98	31.81	11.47	0.021	0.58	19.7	5.9	4.6	2.6	0.82
16:00	30.99	0.196	30.38	31.61	11.37	0.028	0.67	17.1	8.3	6.1	2.8	0.89
89/01/29												
00:00	31.36	0.275	30.58	32.21	11.43	0.046	0.86	17.1	11.5	8.3	2.9	0.94
08:00	31.29	0.274	30.55	32.24	11.38	0.062	1.00	17.1	7.1	5.4	3.0	0.83
16:00	30.90	0.302	30.05	31.86	11.11	0.066	1.03	15.1	8.6	6.5	3.0	0.89
89/01/30												
00:00	31.50	0.276	30.74	32.36	11.52	0.061	0.99	17.1	8.1	6.4	3.1	0.87
08:00	31.16	0.265	30.30	32.15	11.29	0.056	0.95	15.1	7.7	6.1	2.9	0.88
16:00	30.82	0.244	29.98	31.73	11.06	0.045	0.85	15.1	8.3	6.5	3.0	0.89
89/01/31												
00:00	31.62	0.220	30.92	32.33	11.60	0.038	0.78	13.5	8.0	6.3	2.9	0.89
08:00	31.09	0.213	30.45	31.78	11.24	0.038	0.78	13.5	7.5	6.1	3.0	0.87
16:00	30.85	0.188	30.21	31.47	11.07	0.035	0.74	12.2	6.2	5.0	2.7	0.84
89/02/01												
00:00	31.68	0.158	31.21	32.16	11.64	0.025	0.63	10.2	6.2	5.0	2.7	0.84
08:00	31.04	0.123	30.62	31.37	11.20	0.016	0.51	11.1	5.4	4.4	2.6	0.81
16:00	30.83	0.082	30.51	31.12	11.06	0.010	0.39	9.5	4.4	3.7	2.6	0.73
89/02/02												
00:00	31.71	0.079	31.46	32.00	11.66	0.010	0.40	12.2	4.2	3.6	2.5	0.71
08:00	31.00	0.068	30.79	31.22	11.17	0.008	0.35	11.1	4.1	3.5	2.5	0.69
16:00	30.91	0.093	30.60	31.21	11.11	0.030	0.70	3.9	4.0	3.7	3.1	0.57
89/02/03												
00:00	31.75	0.161	31.31	32.22	11.69	0.023	0.61	15.1	6.6	5.1	2.8	0.84
08:00	31.00	0.211	30.31	31.71	11.17	0.041	0.81	15.1	6.9	5.6	3.1	0.84
16:00	30.95	0.337	29.94	32.15	11.14	0.081	1.14	15.1	9.0	7.0	3.1	0.90
89/02/04												
00:00	31.56	0.387	30.26	33.00	11.56	0.106	1.30	12.2	9.7	8.1	3.5	0.90
08:00	31.01	0.317	29.93	32.19	11.18	0.073	1.08	13.5	8.9	7.2	3.2	0.90
16:00	31.13	0.273	30.28	32.11	11.27	0.058	0.96	13.5	8.2	6.5	3.1	0.88
89/02/05												
00:00	31.44	0.209	30.73	32.09	11.48	0.037	0.77	12.2	7.3	5.9	3.0	0.86
08:00	31.11	0.165	30.61	31.65	11.25	0.025	0.63	12.2	6.2	4.8	2.6	0.84
16:00	31.29	0.131	30.87	31.71	11.37	0.017	0.53	12.2	5.8	4.6	2.7	0.82
89/02/06												
00:00	31.20	0.131	30.83	31.64	11.32	0.019	0.55	11.1	5.4	4.4	2.6	0.80

time/ date	mean psi	std dev psi	min psi	max psi	depth m	var m^2	Hsig m	Tpeak sec	TO sec	Tz sec	Tc sec	e
	-- pressure record data --						- spectral analysis statistics -					
08:00	31.20	0.110	30.81	31.54	11.31	0.014	0.48	13.5	4.8	4.0	2.6	0.76
16:00	31.32	0.120	30.89	31.75	11.40	0.021	0.58	11.1	4.9	4.2	2.9	0.73
89/02/07												
00:00	31.01	0.133	30.60	31.35	11.18	0.019	0.55	13.5	5.5	4.5	2.7	0.79
08:00	31.37	0.116	31.02	31.76	11.43	0.015	0.48	12.2	5.4	4.3	2.7	0.79
16:00	31.34	0.118	30.96	31.71	11.41	0.013	0.46	12.2	5.7	4.5	2.5	0.82
89/02/08												
00:00	30.82	0.114	30.47	31.17	11.05	0.013	0.46	12.2	5.4	4.3	2.6	0.80
08:00	31.41	0.141	30.97	31.93	11.46	0.018	0.54	12.2	6.1	4.7	2.6	0.84
16:00	31.29	0.161	30.79	31.87	11.37	0.025	0.64	11.1	5.6	4.4	2.6	0.82
89/02/09												
00:00	30.82	0.177	30.31	31.39	11.05	0.026	0.65	11.1	6.8	5.3	2.7	0.86
08:00	31.44	0.159	30.97	31.97	11.48	0.022	0.59	12.2	6.7	5.3	2.8	0.85
16:00	31.22	0.162	30.74	31.80	11.33	0.027	0.66	11.1	6.0	4.9	2.8	0.82
89/02/10												
00:00	31.00	0.174	30.51	31.53	11.17	0.031	0.71	11.1	6.0	5.0	2.9	0.81
08:00	31.43	0.132	30.97	31.85	11.47	0.035	0.75	5.2	4.9	4.5	3.3	0.68
16:00	31.10	0.140	30.58	31.55	11.24	0.047	0.87	5.2	4.9	4.5	3.5	0.64
89/02/11												
00:00	31.18	0.123	30.76	31.58	11.30	0.029	0.68	6.0	4.9	4.4	2.9	0.74
08:00	31.34	0.109	30.98	31.68	11.41	0.021	0.57	10.2	4.9	4.3	2.9	0.74
16:00	30.95	0.130	30.50	31.40	11.15	0.026	0.64	6.2	5.2	4.6	3.0	0.76
89/02/12												
00:00	31.44	0.224	30.69	32.09	11.48	0.047	0.86	10.2	7.3	6.2	3.3	0.85
08:00	31.25	0.237	30.61	32.10	11.35	0.052	0.92	11.1	7.1	6.0	3.2	0.85
16:00	30.92	0.225	30.19	31.60	11.12	0.051	0.90	11.1	6.8	5.8	3.2	0.83
89/02/13												
00:00	31.61	0.188	30.93	32.28	11.59	0.030	0.78	9.5	6.3	5.3	2.9	0.83
08:00	31.16	0.164	30.64	31.63	11.28	0.026	0.65	11.1	6.5	5.3	2.8	0.85
16:00	30.83	0.147	30.41	31.35	11.06	0.022	0.59	15.1	6.1	4.9	2.8	0.82
89/02/14												
00:00	31.74	0.131	31.31	32.14	11.68	0.018	0.53	10.2	5.8	4.7	2.7	0.82
08:00	31.01	0.118	30.67	31.43	11.19	0.015	0.49	15.1	5.3	4.2	2.5	0.80
16:00	30.84	0.098	30.46	31.16	11.07	0.012	0.44	9.5	4.6	3.8	2.5	0.75
89/02/15												
00:00	31.79	0.096	31.49	32.06	11.72	0.011	0.42	15.1	4.7	3.8	2.5	0.76
08:00	30.93	0.126	30.49	31.32	11.13	0.016	0.51	15.1	5.3	4.2	2.6	0.79
16:00	30.89	0.189	30.22	31.60	11.10	0.025	0.63	15.1	8.3	6.0	2.7	0.90
89/02/16												
00:00	31.73	0.223	31.01	32.45	11.68	0.035	0.75	13.5	8.8	6.6	2.8	0.91
08:00	30.94	0.190	30.36	31.55	11.13	0.031	0.70	12.2	6.4	4.9	2.6	0.85
16:00	30.95	0.159	30.45	31.44	11.15	0.022	0.59	12.2	6.3	4.9	2.6	0.85
89/02/17												
00:00	31.66	0.139	31.14	32.11	11.63	0.018	0.53	12.2	6.3	4.9	2.7	0.84
08:00	30.97	0.128	30.57	31.40	11.16	0.014	0.48	13.5	6.3	4.9	2.6	0.84
16:00	31.08	0.115	30.67	31.42	11.23	0.014	0.47	11.1	5.2	4.1	2.5	0.79
89/02/18												
00:00	31.53	0.135	31.15	31.93	11.54	0.017	0.53	11.1	5.8	4.5	2.6	0.83

time/ date	mean psi	std dev psi	min psi	max psi	depth m	var m^2	Hsig m	Tpeak sec	TO sec	Tz sec	Tc sec	e
	-- pressure record data --						- spectral analysis statistics -					
08:00	30.99	0.150	30.60	31.51	11.17	0.019	0.55	17.1	6.5	4.8	2.6	0.85
16:00	31.20	0.262	30.41	32.03	11.32	0.044	0.84	15.1	10.0	7.1	2.7	0.93
89/02/19												
00:00	31.34	0.276	30.54	32.28	11.41	0.052	0.91	15.1	9.2	6.8	2.8	0.91
08:00	31.03	0.248	30.14	31.88	11.20	0.043	0.83	15.1	9.0	6.8	2.8	0.91
16:00	31.32	0.234	30.62	32.11	11.40	0.038	0.78	15.1	8.8	6.5	2.7	0.91
89/02/20												
00:00	31.20	0.184	30.70	31.79	11.32	0.027	0.66	13.5	6.9	5.2	2.6	0.87
08:00	31.14	0.181	30.61	31.73	11.27	0.027	0.65	13.5	7.3	5.7	2.8	0.87
16:00	31.40	0.139	30.91	31.87	11.45	0.020	0.56	12.2	5.6	4.5	2.6	0.81
89/02/21												
00:00	31.11	0.134	30.72	31.54	11.25	0.018	0.54	11.1	5.7	4.5	2.6	0.82
08:00	31.23	0.136	30.81	31.72	11.33	0.019	0.55	10.2	5.9	4.7	2.7	0.83
16:00	31.47	0.095	31.16	31.76	11.50	0.012	0.43	15.1	4.7	3.9	2.5	0.76
89/02/22												
00:00	31.05	0.092	30.76	31.34	11.21	0.011	0.42	11.1	4.5	3.7	2.6	0.73
08:00	31.27	0.086	30.97	31.53	11.36	0.012	0.45	13.5	3.9	3.3	2.4	0.68
16:00	31.52	0.100	31.16	31.88	11.53	0.014	0.47	10.2	4.9	4.1	2.6	0.77
89/02/23												
00:00	31.08	0.090	30.80	31.37	11.23	0.011	0.42	10.2	4.4	3.7	2.5	0.73
08:00	31.31	0.074	31.09	31.58	11.39	0.010	0.39	11.1	3.9	3.4	2.5	0.68
16:00	31.45	0.066	31.25	31.66	11.49	0.009	0.38	12.2	4.0	3.5	2.6	0.67
89/02/24												
00:00	31.08	0.069	30.87	31.30	11.23	0.009	0.38	11.1	4.1	3.6	2.6	0.70
08:00	31.32	0.059	31.14	31.48	11.40	0.010	0.40	9.5	3.5	3.2	2.5	0.61
16:00	31.37	0.057	31.17	31.53	11.43	0.010	0.39	9.5	3.4	3.1	2.5	0.60
89/02/25												
00:00	31.09	0.071	30.83	31.35	11.24	0.012	0.44	2.4	3.7	3.3	2.5	0.64
08:00	31.30	0.061	31.09	31.50	11.38	0.009	0.39	2.0	3.6	3.2	2.5	0.63
16:00	31.29	0.066	31.10	31.51	11.38	0.011	0.43	15.1	3.6	3.2	2.5	0.63
89/02/26												
00:00	31.20	0.058	30.97	31.38	11.31	0.008	0.35	12.2	3.7	3.3	2.6	0.62
08:00	31.29	0.056	31.11	31.48	11.37	0.008	0.35	2.0	3.3	3.0	2.4	0.59
16:00	31.17	0.059	30.95	31.36	11.29	0.009	0.37	15.1	3.4	3.1	2.5	0.59
89/02/27												
00:00	31.37	0.055	31.21	31.59	11.43	0.008	0.35	17.1	3.4	3.0	2.5	0.58
08:00	31.26	0.058	31.07	31.43	11.36	0.008	0.35	15.1	3.4	3.0	2.4	0.61
16:00	31.09	0.063	30.91	31.29	11.24	0.008	0.35	15.1	3.5	3.1	2.4	0.63
89/02/28												
00:00	31.56	0.074	31.35	31.81	11.56	0.008	0.36	15.1	4.0	3.4	2.4	0.69
08:00	31.18	0.118	30.77	31.59	11.30	0.017	0.52	12.2	4.6	3.8	2.5	0.75
16:00	30.99	0.199	30.31	31.74	11.17	0.032	0.72	11.1	7.1	5.5	2.7	0.87
89/03/01												
00:00	31.67	0.171	31.11	32.23	11.64	0.026	0.64	11.1	6.9	5.5	2.8	0.86
08:00	31.06	0.146	30.60	31.54	11.22	0.023	0.60	12.2	5.6	4.6	2.7	0.81
16:00	30.94	0.129	30.51	31.45	11.14	0.017	0.52	10.2	6.0	4.9	2.8	0.82
89/03/02												
00:00	31.83	0.096	31.49	32.14	11.74	0.016	0.50	10.2	4.3	3.7	2.6	0.71

time/ date	— pressure record data — mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	TO sec	Tz sec	Tc sec	e
08:00	31.04	0.113	30.65	31.40	11.20	0.031	0.71	3.8	4.5	4.1	3.1	0.66
16:00	31.00	0.253	30.10	31.75	11.18	0.074	1.09	8.3	6.4	5.7	3.5	0.78
89/03/03												
00:00	31.90	0.296	30.97	32.84	11.79	0.099	1.26	10.2	6.6	5.8	3.5	0.80
08:00	30.96	0.301	30.10	31.86	11.15	0.090	1.20	9.5	7.2	6.4	3.8	0.81
16:00	31.03	0.285	30.15	31.98	11.20	0.104	1.29	9.5	6.1	5.5	3.7	0.75
89/03/04												
00:00	31.85	0.280	30.94	32.76	11.76	0.109	1.32	8.8	6.0	5.4	3.7	0.73
08:00	30.96	0.246	30.09	31.91	11.15	0.089	1.19	8.3	5.7	5.1	3.4	0.74
16:00	31.19	0.210	30.48	31.86	11.31	0.053	0.92	8.3	6.3	5.6	3.4	0.80
89/03/05												
00:00	31.73	0.178	31.11	32.34	11.68	0.043	0.83	8.3	5.7	4.9	3.0	0.79
08:00	30.95	0.164	30.46	31.45	11.14	0.028	0.67	12.2	6.1	4.9	2.8	0.83
16:00	31.34	0.138	30.87	31.82	11.41	0.022	0.59	11.1	5.5	4.5	2.6	0.81
89/03/06												
00:00	31.56	0.151	31.10	32.03	11.56	0.029	0.68	11.1	5.4	4.6	2.8	0.79
08:00	31.03	0.110	30.64	31.39	11.20	0.021	0.57	12.2	4.6	4.0	2.7	0.73
16:00	31.55	0.088	31.29	31.82	11.56	0.015	0.48	11.1	4.1	3.6	2.7	0.68
89/03/07												
00:00	31.32	0.127	30.96	31.72	11.40	0.017	0.52	15.1	5.6	4.5	2.7	0.79
08:00	31.06	0.108	30.71	31.43	11.22	0.014	0.48	15.1	5.1	4.2	2.7	0.77
16:00	31.65	0.071	31.38	31.88	11.62	0.009	0.38	15.1	4.0	3.5	2.6	0.68
89/03/08												
00:00	31.07	0.083	30.81	31.33	11.23	0.013	0.45	13.5	4.2	3.7	2.7	0.69
08:00	31.12	0.088	30.84	31.37	11.26	0.019	0.55	15.1	3.8	3.3	2.5	0.65
16:00	31.72	0.076	31.46	31.98	11.67	0.011	0.43	12.2	3.9	3.4	2.6	0.66
89/03/09												
00:00	31.00	0.075	30.74	31.27	11.18	0.011	0.42	13.5	3.9	3.4	2.5	0.67
08:00	31.23	0.088	30.95	31.51	11.34	0.015	0.49	11.1	3.9	3.4	2.5	0.67
16:00	31.71	0.099	31.41	32.04	11.66	0.013	0.46	10.2	4.7	4.0	2.6	0.75
89/03/10												
00:00	31.00	0.085	30.72	31.31	11.18	0.010	0.40	13.5	4.3	3.6	2.5	0.73
08:00	31.27	0.091	31.02	31.54	11.36	0.011	0.41	13.5	4.4	3.6	2.5	0.74
16:00	31.61	0.090	31.34	31.96	11.59	0.012	0.43	11.1	4.2	3.6	2.5	0.71
89/03/11												
00:00	31.15	0.097	30.86	31.52	11.28	0.011	0.41	10.2	5.0	4.1	2.6	0.77
08:00	31.32	0.118	30.97	31.75	11.40	0.014	0.47	15.1	5.4	4.3	2.6	0.80
16:00	31.47	0.102	31.17	31.80	11.50	0.013	0.45	15.1	4.6	3.7	2.5	0.74
89/03/12												
00:00	31.31	0.088	31.02	31.60	11.39	0.009	0.39	15.1	4.4	3.6	2.4	0.73
08:00	31.29	0.097	30.92	31.62	11.38	0.010	0.41	13.5	4.7	3.8	2.5	0.76
16:00	31.25	0.074	31.02	31.46	11.35	0.008	0.35	15.1	4.1	3.4	2.4	0.70
89/03/13												
00:00	31.50	0.062	31.31	31.69	11.52	0.010	0.40	13.5	3.2	2.9	2.4	0.56
08:00	31.23	0.049	31.04	31.38	11.33	0.007	0.35	2.2	3.1	2.9	2.4	0.53
16:00	31.13	0.055	30.97	31.33	11.26	0.007	0.34	2.2	3.3	3.0	2.4	0.58
89/03/14												
00:00	31.65	0.064	31.46	31.84	11.62	0.007	0.34	13.5	3.7	3.2	2.5	0.64

time/ date	— pressure record data — mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	TO sec	Tz sec	Tc sec	e
08:00	31.11	0.128	30.71	31.58	11.25	0.014	0.48	13.5	6.0	4.6	2.6	0.83
16:00	31.03	0.135	30.62	31.44	11.20	0.017	0.52	12.2	5.6	4.3	2.5	0.81
89/03/15												
00:00	31.75	0.125	31.39	32.10	11.69	0.016	0.50	12.2	5.4	4.2	2.5	0.80
08:00	31.00	0.112	30.66	31.35	11.18	0.012	0.45	13.5	5.3	4.2	2.5	0.80
16:00	31.01	0.099	30.65	31.33	11.18	0.011	0.41	13.5	5.0	4.0	2.5	0.77
89/03/16												
00:00	31.82	0.093	31.48	32.19	11.74	0.010	0.41	15.1	4.6	3.7	2.5	0.74
08:00	30.96	0.078	30.71	31.19	11.15	0.008	0.36	15.1	4.3	3.6	2.5	0.71
16:00	31.02	0.075	30.80	31.23	11.19	0.008	0.36	10.2	4.1	3.5	2.5	0.70
89/03/17												
00:00	31.76	0.069	31.53	32.01	11.70	0.010	0.40	10.2	3.7	3.2	2.5	0.63
08:00	30.95	0.094	30.69	31.23	11.14	0.009	0.39	15.1	4.8	3.8	2.5	0.76
16:00	31.09	0.164	30.50	31.66	11.24	0.021	0.57	13.5	7.0	5.1	2.5	0.87
89/03/18												
00:00	31.64	0.212	31.04	32.21	11.61	0.032	0.72	13.5	8.5	6.4	2.8	0.90
08:00	30.92	0.200	30.38	31.53	11.12	0.030	0.69	13.5	7.8	5.9	2.7	0.89
16:00	31.23	0.146	30.75	31.80	11.34	0.019	0.55	12.2	6.3	4.9	2.6	0.85
89/03/19												
00:00	31.52	0.136	31.14	31.98	11.53	0.019	0.55	11.1	5.6	4.5	2.6	0.82
08:00	30.96	0.128	30.54	31.45	11.15	0.016	0.51	10.2	5.8	4.6	2.6	0.83
16:00	31.37	0.083	31.09	31.63	11.43	0.010	0.39	11.1	4.2	3.5	2.5	0.71
89/03/20												
00:00	31.39	0.091	31.09	31.65	11.45	0.011	0.41	13.5	4.6	3.8	2.5	0.75
08:00	30.99	0.096	30.70	31.30	11.17	0.012	0.43	10.2	4.7	3.9	2.6	0.75
16:00	31.49	0.086	31.18	31.80	11.52	0.011	0.42	12.2	4.3	3.6	2.5	0.72
89/03/21												
00:00	31.30	0.090	31.01	31.62	11.38	0.012	0.44	12.2	4.2	3.6	2.5	0.71
08:00	31.01	0.072	30.74	31.28	11.18	0.008	0.36	12.2	4.0	3.4	2.5	0.69
16:00	31.58	0.079	31.32	31.84	11.58	0.010	0.41	11.1	4.0	3.4	2.5	0.69
89/03/22												
00:00	31.15	0.092	30.86	31.45	11.28	0.010	0.41	17.1	4.6	3.7	2.5	0.74
08:00	30.99	0.127	30.60	31.42	11.17	0.013	0.46	15.1	6.2	4.6	2.5	0.84
16:00	31.60	0.140	31.21	32.10	11.59	0.017	0.52	15.1	6.1	4.6	2.6	0.83
89/03/23												
00:00	31.03	0.165	30.57	31.51	11.20	0.021	0.58	13.5	7.3	5.4	2.7	0.87
08:00	31.02	0.162	30.58	31.63	11.19	0.021	0.58	13.5	6.9	5.1	2.5	0.86
16:00	31.63	0.185	31.13	32.16	11.61	0.028	0.67	12.2	6.9	5.2	2.7	0.85
89/03/24												
00:00	31.01	0.169	30.50	31.54	11.19	0.023	0.60	12.2	6.9	5.2	2.6	0.87
08:00	31.05	0.190	30.53	31.67	11.21	0.027	0.66	13.5	7.6	5.6	2.6	0.89
16:00	31.64	0.169	31.05	32.25	11.62	0.024	0.62	13.5	6.5	4.9	2.6	0.85
89/03/25												
00:00	31.02	0.204	30.41	31.60	11.19	0.029	0.68	13.5	8.8	6.6	2.8	0.91
08:00	31.10	0.258	30.25	32.06	11.25	0.044	0.84	13.5	9.5	7.1	2.9	0.92
16:00	31.54	0.335	30.52	32.79	11.55	0.075	1.10	13.5	9.7	7.4	2.9	0.92
89/03/26												
00:00	31.06	0.265	30.32	31.85	11.22	0.050	0.89	13.5	8.6	6.5	2.8	0.90

ime/ ate	— pressure record data — mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	TO sec	Tz sec	Tc sec	e
8:00	31.10	0.331	30.09	32.21	11.24	0.074	1.09	13.5	10.0	8.1	3.3	0.91
6:00	31.45	0.258	30.60	32.30	11.48	0.048	0.88	12.2	8.8	6.9	3.0	0.90
9/03/27												
0:00	31.15	0.213	30.48	31.91	11.28	0.035	0.75	12.2	7.7	5.9	2.7	0.89
8:00	31.06	0.214	30.47	31.73	11.22	0.037	0.77	11.1	7.1	5.4	2.6	0.87
6:00	31.30	0.193	30.69	31.93	11.38	0.028	0.67	15.1	7.8	5.9	2.7	0.89
9/03/28												
0:00	31.27	0.195	30.75	31.90	11.36	0.029	0.68	12.2	7.8	5.9	2.7	0.89
8:00	31.07	0.205	30.48	31.66	11.22	0.033	0.72	12.2	7.7	6.0	2.8	0.89
6:00	31.20	0.167	30.70	31.71	11.31	0.025	0.63	9.5	6.6	5.2	2.7	0.86
9/03/29												
0:00	31.40	0.134	31.01	31.93	11.45	0.018	0.54	13.5	5.6	4.5	2.6	0.81
8:00	31.05	0.117	30.64	31.50	11.21	0.014	0.48	13.5	5.5	4.4	2.6	0.81
6:00	31.06	0.126	30.65	31.51	11.22	0.019	0.55	9.5	5.1	4.2	2.7	0.78
9/03/30												
0:00	31.52	0.095	31.19	31.79	11.53	0.012	0.44	9.5	4.5	3.7	2.5	0.74
8:00	30.97	0.086	30.60	31.29	11.16	0.011	0.42	11.1	4.2	3.6	2.5	0.70
6:00	30.99	0.111	30.68	31.31	11.17	0.018	0.53	15.1	4.7	4.0	2.8	0.72
9/03/31												
0:00	31.59	0.122	31.18	32.01	11.58	0.014	0.48	15.1	5.7	4.4	2.6	0.81
8:00	30.95	0.137	30.58	31.39	11.14	0.017	0.53	13.5	5.9	4.6	2.6	0.82
6:00	30.95	0.140	30.51	31.42	11.14	0.020	0.57	13.5	5.7	4.6	2.7	0.81
9/04/01												
0:00	31.71	0.099	31.42	32.02	11.66	0.013	0.45	13.5	4.7	3.9	2.6	0.75
8:00	30.91	0.086	30.63	31.20	11.12	0.010	0.40	13.5	4.5	3.8	2.5	0.74
6:00	31.01	0.069	30.78	31.25	11.19	0.010	0.39	12.2	3.9	3.4	2.6	0.65
9/04/02												
0:00	31.73	0.068	31.52	31.95	11.68	0.009	0.38	11.1	4.0	3.5	2.6	0.67
8:00	30.89	0.063	30.70	31.10	11.10	0.008	0.35	11.1	3.7	3.2	2.4	0.65
6:00	31.18	0.063	31.01	31.38	11.30	0.009	0.39	15.1	3.4	3.0	2.5	0.59
9/04/03												
0:00	31.66	0.067	31.45	31.89	11.63	0.008	0.35	13.5	3.8	3.3	2.5	0.66
8:00	30.86	0.063	30.66	31.03	11.08	0.009	0.37	12.2	3.4	3.0	2.4	0.62
6:00	31.35	0.070	31.10	31.57	11.42	0.010	0.40	13.5	3.5	3.1	2.4	0.62
9/04/04												
0:00	31.47	0.073	31.23	31.71	11.50	0.008	0.36	15.1	3.9	3.3	2.4	0.68
8:00	30.70	0.071	30.57	31.00	11.02	0.009	0.38	15.1	3.7	3.2	2.4	0.64
6:00	31.58	0.071	31.38	31.79	11.58	0.009	0.38	11.1	3.7	3.2	2.4	0.65
9/04/05												
0:00	31.26	0.100	30.93	31.57	11.36	0.012	0.44	11.1	4.6	3.8	2.5	0.75
8:00	30.72	0.118	30.31	31.06	10.98	0.015	0.49	10.2	5.4	4.4	2.6	0.80
6:00	31.77	0.127	31.35	32.20	11.70	0.045	0.85	4.3	4.7	4.4	3.4	0.62
9/04/06												
0:00	31.02	0.111	30.50	31.34	11.19	0.024	0.62	5.4	4.7	4.2	2.9	0.71
8:00	30.72	0.154	30.14	31.20	10.99	0.043	0.83	4.8	4.9	4.4	3.1	0.71
6:00	31.89	0.166	31.35	32.44	11.79	0.048	0.88	10.2	5.4	4.9	3.4	0.71
9/04/07												
0:00	30.89	0.143	30.37	31.35	11.10	0.032	0.71	15.1	5.3	4.7	3.2	0.74

time/ date	— pressure record data — mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	TO sec	Tz sec	Tc sec	e
08:00	30.84	0.116	30.49	31.26	11.07	0.025	0.64	4.8	4.5	4.0	2.8	0.72
16:00	31.91	0.182	31.31	32.53	11.80	0.070	1.06	7.8	4.7	4.2	2.9	0.72
89/04/08												
00:00	30.85	0.112	30.51	31.27	11.08	0.037	0.77	4.8	4.5	4.2	3.1	0.66
08:00	30.87	0.092	30.60	31.19	11.09	0.017	0.52	17.1	4.1	3.6	2.7	0.68
16:00	31.73	0.223	30.92	32.54	11.68	0.054	0.93	9.5	6.6	5.7	3.3	0.82
89/04/09												
00:00	30.95	0.236	30.10	31.72	11.14	0.049	0.89	15.1	7.3	6.0	3.1	0.86
08:00	31.02	0.173	30.49	31.49	11.19	0.029	0.68	15.1	6.4	5.1	2.9	0.83
16:00	31.59	0.159	31.01	32.12	11.58	0.027	0.66	15.1	6.2	5.1	3.1	0.80
89/04/10												
00:00	31.09	0.099	30.79	31.39	11.24	0.015	0.48	15.1	4.6	3.9	2.6	0.73
08:00	31.05	0.090	30.79	31.33	11.21	0.010	0.39	15.1	4.9	4.0	2.6	0.76
16:00	31.33	0.083	31.08	31.62	11.40	0.015	0.49	8.3	3.9	3.5	2.6	0.67
89/04/11												
00:00	31.26	0.064	31.02	31.47	11.36	0.013	0.46	2.2	3.4	3.1	2.5	0.59
08:00	31.10	0.063	30.92	31.32	11.25	0.009	0.38	13.5	3.6	3.2	2.5	0.61
16:00	31.17	0.070	30.94	31.37	11.29	0.012	0.44	13.5	3.8	3.4	2.6	0.64
89/04/12												
00:00	31.41	0.081	31.12	31.70	11.46	0.013	0.42	15.1	3.9	3.4	2.5	0.68
08:00	31.08	0.070	30.87	31.29	11.23	0.008	0.36	13.5	3.9	3.4	2.5	0.67
16:00	0.13	0.792	-0.38	10.18	-9.99	0.295	2.17	256.0	11.9	6.7	2.9	0.90

Spectral Wave Analysis   Mauna Lani #2

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
89/04/12												
18:30	31.36	0.078	31.12	31.60	11.45	0.014	0.47	11.1	4.1	3.6	2.7	0.67
89/04/13												
02:30	31.11	0.080	30.85	31.34	11.28	0.011	0.42	15.1	3.9	3.3	2.5	0.67
10:30	31.09	0.074	30.84	31.32	11.26	0.015	0.49	4.8	3.9	3.6	2.7	0.65
18:30	31.15	0.073	30.87	31.43	11.30	0.022	0.59	5.2	4.0	3.8	3.0	0.59
89/04/14												
02:30	31.19	0.087	30.88	31.49	11.33	0.022	0.59	4.3	4.3	3.9	2.9	0.66
10:30	31.13	0.095	30.80	31.40	11.28	0.038	0.78	5.2	4.3	4.0	3.3	0.59
18:30	30.96	0.095	30.61	31.33	11.17	0.055	0.94	5.2	3.4	3.2	2.6	0.57
89/04/15												
02:30	31.32	0.060	31.10	31.51	11.42	0.016	0.51	3.9	3.6	3.3	2.6	0.61
10:30	31.14	0.073	30.86	31.36	11.29	0.027	0.66	4.5	4.1	3.9	3.1	0.60
18:30	30.92	0.055	30.73	31.07	11.14	0.012	0.43	4.7	3.8	3.5	2.7	0.63
89/04/16												
02:30	31.40	0.054	31.20	31.58	11.47	0.011	0.42	5.7	3.5	3.2	2.6	0.60
10:30	31.12	0.064	30.90	31.32	11.28	0.015	0.49	4.3	3.8	3.5	2.7	0.62
18:30	30.99	0.055	30.79	31.19	11.19	0.010	0.41	4.2	3.7	3.4	2.7	0.62
89/04/17												
02:30	31.46	0.066	31.24	31.72	11.52	0.016	0.51	4.2	3.9	3.6	2.8	0.63
10:30	31.13	0.082	30.86	31.44	11.29	0.019	0.54	13.5	4.0	3.6	2.8	0.64
18:30	31.01	0.064	30.78	31.25	11.21	0.014	0.47	5.2	3.9	3.6	2.6	0.63
89/04/18												
02:30	31.43	0.051	31.26	31.60	11.50	0.011	0.42	4.3	3.5	3.2	2.6	0.59
10:30	31.04	0.063	30.85	31.25	11.22	0.010	0.41	6.2	3.8	3.4	2.6	0.64
18:30	31.13	0.050	30.97	31.30	11.29	0.009	0.38	2.2	3.3	3.0	2.5	0.57
89/04/19												
02:30	31.46	0.043	31.32	31.60	11.51	0.007	0.32	2.6	3.4	3.1	2.6	0.57
10:30	31.02	0.087	30.73	31.30	11.21	0.014	0.47	17.1	4.3	3.7	2.6	0.70
18:30	31.31	0.108	30.93	31.67	11.41	0.016	0.51	15.1	4.5	3.7	2.6	0.72
89/04/20												
02:30	31.40	0.139	30.97	31.88	11.47	0.023	0.61	15.1	5.1	4.1	2.7	0.76
10:30	30.95	0.127	30.54	31.41	11.17	0.017	0.52	15.1	5.3	4.2	2.6	0.80
18:30	31.46	0.118	31.05	31.82	11.52	0.016	0.51	13.5	5.1	4.1	2.6	0.77
89/04/21												
02:30	31.32	0.101	31.04	31.65	11.42	0.015	0.49	13.5	4.4	3.7	2.6	0.72
10:30	30.93	0.080	30.70	31.21	11.15	0.012	0.43	13.5	3.9	3.4	2.5	0.67
18:30	31.68	0.068	31.48	31.88	11.66	0.010	0.40	13.5	3.9	3.5	2.6	0.66
89/04/22												
02:30	31.25	0.057	31.06	31.42	11.37	0.007	0.35	13.5	3.5	3.1	2.4	0.62
10:30	30.85	0.056	30.66	31.03	11.10	0.008	0.35	15.1	3.5	3.1	2.5	0.61
18:30	31.75	0.056	31.57	31.94	11.72	0.008	0.36	15.1	3.5	3.1	2.5	0.61
89/04/23												
02:30	31.14	0.054	30.94	31.30	11.29	0.007	0.34	15.1	3.3	3.0	2.4	0.59
10:30	30.83	0.050	30.67	31.02	11.08	0.008	0.35	13.5	3.3	3.0	2.5	0.57
18:30	31.84	0.053	31.68	32.02	11.78	0.006	0.32	15.1	3.6	3.2	2.5	0.62
89/04/24												
02:30	31.06	0.063	30.84	31.30	11.24	0.008	0.36	13.5	3.6	3.2	2.5	0.63

Spectral Wave Analysis   Mauna Lani #2

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	30.84	0.054	30.67	31.01	11.09	0.007	0.34	12.2	3.4	3.0	2.4	0.59
18:30	31.83	0.053	31.67	32.00	11.77	0.008	0.35	2.2	3.3	3.0	2.4	0.58
89/04/25												
02:30	30.97	0.056	30.78	31.13	11.18	0.007	0.32	12.2	3.5	3.1	2.4	0.53
10:30	30.88	0.065	30.66	31.07	11.12	0.009	0.37	11.1	3.5	3.1	2.4	0.62
18:30	31.76	0.073	31.55	31.99	11.72	0.007	0.34	17.1	4.2	3.5	2.5	0.70
89/04/26												
02:30	30.94	0.077	30.71	31.18	11.15	0.010	0.39	17.1	3.9	3.3	2.5	0.66
10:30	30.95	0.102	30.64	31.26	11.17	0.013	0.46	15.1	4.2	3.5	2.5	0.71
18:30	31.64	0.111	31.29	32.00	11.64	0.012	0.44	15.1	5.4	4.2	2.5	0.80
89/04/27												
02:30	30.93	0.139	30.47	31.46	11.15	0.018	0.53	13.5	5.8	4.4	2.5	0.82
10:30	30.99	0.131	30.55	31.46	11.19	0.018	0.54	11.1	5.1	4.1	2.5	0.78
18:30	31.43	0.100	31.07	31.76	11.49	0.013	0.46	12.2	4.5	3.7	2.5	0.74
89/04/28												
02:30	30.97	0.090	30.65	31.30	11.18	0.014	0.47	6.9	4.2	3.6	2.5	0.71
10:30	31.07	0.095	30.78	31.39	11.25	0.013	0.46	13.5	4.6	3.9	2.6	0.75
18:30	31.28	0.087	31.00	31.66	11.39	0.014	0.48	8.3	4.2	3.6	2.6	0.70
89/04/29												
02:30	31.11	0.080	30.85	31.34	11.28	0.010	0.40	12.2	4.3	3.6	2.5	0.72
10:30	31.24	0.079	30.98	31.51	11.36	0.010	0.41	15.1	4.4	3.8	2.6	0.71
18:30	31.11	0.166	30.63	31.57	11.27	0.023	0.61	17.1	6.8	5.1	2.8	0.84
89/04/30												
02:30	31.19	0.132	30.71	31.60	11.33	0.024	0.62	17.1	4.8	4.0	2.7	0.74
10:30	31.27	0.146	30.81	31.74	11.39	0.026	0.64	17.1	5.0	4.1	2.7	0.75
18:30	30.91	0.158	30.46	31.41	11.13	0.023	0.60	15.1	6.3	4.9	2.8	0.82
89/05/01												
02:30	31.33	0.157	30.84	31.74	11.42	0.025	0.64	15.1	5.5	4.4	2.7	0.79
10:30	31.26	0.136	30.83	31.69	11.38	0.024	0.62	15.1	5.1	4.3	2.8	0.76
18:30	30.89	0.135	30.46	31.33	11.12	0.021	0.57	13.5	5.4	4.4	2.8	0.78
89/05/02												
02:30	31.30	0.185	30.70	32.01	11.41	0.032	0.72	13.5	6.7	5.4	3.1	0.83
10:30	31.15	0.160	30.68	31.68	11.30	0.028	0.66	15.1	5.8	4.7	2.8	0.80
18:30	30.89	0.135	30.38	31.33	11.13	0.026	0.65	12.2	4.8	[illegible]	2.8	0.73
89/05/03												
02:30	31.32	0.125	30.89	31.76	11.42	0.016	0.50	15.1	5.6	4.4	2.6	0.80
10:30	30.98	0.136	30.47	31.52	11.19	0.021	0.58	15.1	5.3	4.3	2.7	0.77
18:30	31.11	0.150	30.54	31.62	11.27	0.024	0.61	15.1	5.6	4.5	2.7	0.80
89/05/04												
02:30	31.27	0.171	30.72	31.74	11.38	0.023	0.61	15.1	6.8	5.0	2.6	0.86
10:30	30.83	0.192	30.30	31.51	11.08	0.031	0.71	13.5	6.6	5.1	2.7	0.85
18:30	31.33	0.170	30.89	31.87	11.43	0.026	0.64	13.5	6.0	4.6	2.6	0.83
89/05/05												
02:30	31.17	0.156	30.74	31.65	11.32	0.020	0.56	13.5	6.9	5.1	2.6	0.86
10:30	30.69	0.142	30.28	31.21	10.99	0.018	0.53	13.5	6.1	4.7	2.6	0.83
18:30	31.59	0.118	31.26	31.99	11.60	0.014	0.47	12.2	5.5	4.3	2.6	0.80
89/05/06												
02:30	31.07	0.083	30.77	31.32	11.25	0.011	0.41	13.5	4.0	3.4	2.5	0.68

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	30.66	0.130	30.29	31.04	10.97	0.014	0.47	19.7	6.1	4.5	2.5	0.83
18:30	31.79	0.110	31.39	32.20	11.74	0.018	0.54	17.1	3.9	3.3	2.4	0.68
89/05/07												
02:30	30.94	0.112	30.63	31.30	11.16	0.013	0.46	15.1	4.9	3.6	2.4	0.77
10:30	30.65	0.126	30.30	31.06	10.96	0.013	0.46	15.1	6.0	4.4	2.5	0.83
18:30	31.87	0.159	31.43	32.34	11.80	0.020	0.57	13.5	6.8	5.0	2.6	0.85
89/05/08												
02:30	30.89	0.168	30.38	31.44	11.12	0.021	0.58	13.5	7.4	5.4	2.6	0.88
10:30	30.67	0.151	30.19	31.16	10.97	0.018	0.54	13.5	6.5	4.8	2.5	0.85
18:30	31.86	0.134	31.47	32.27	11.79	0.017	0.52	12.2	5.6	4.3	2.5	0.81
89/05/09												
02:30	30.84	0.134	30.39	31.32	11.09	0.016	0.50	13.5	6.1	4.6	2.5	0.84
10:30	30.76	0.109	30.43	31.10	11.03	0.012	0.44	15.1	5.1	4.0	2.5	0.79
18:30	31.71	0.080	31.44	31.97	11.69	0.009	0.38	15.1	4.3	3.6	2.5	0.71
89/05/10												
02:30	30.86	0.081	30.58	31.15	11.10	0.010	0.39	15.1	4.1	3.5	2.5	0.69
10:30	30.87	0.066	30.68	31.10	11.11	0.008	0.35	15.1	3.6	3.1	2.4	0.63
18:30	31.58	0.057	31.39	31.75	11.60	0.008	0.37	2.1	3.3	3.0	2.4	0.58
89/05/11												
02:30	30.87	0.060	30.67	31.07	11.11	0.006	0.32	13.5	3.7	3.2	2.4	0.65
10:30	31.02	0.066	30.84	31.20	11.21	0.007	0.33	15.1	3.9	3.3	2.5	0.67
18:30	31.42	0.074	31.17	31.62	11.49	0.008	0.35	15.1	4.0	3.4	2.5	0.68
89/05/12												
02:30	30.93	0.075	30.73	31.18	11.15	0.007	0.33	15.1	4.3	3.5	2.4	0.72
10:30	31.13	0.070	30.93	31.37	11.29	0.009	0.38	12.2	3.6	3.2	2.4	0.64
18:30	31.29	0.081	31.04	31.54	11.40	0.010	0.39	9.5	4.1	3.5	2.5	0.70
89/05/13												
02:30	31.00	0.080	30.77	31.25	11.20	0.009	0.39	15.1	4.1	3.5	2.5	0.69
10:30	31.20	0.060	30.99	31.40	11.33	0.007	0.34	11.1	3.6	3.1	2.5	0.62
18:30	31.15	0.063	30.98	31.36	11.30	0.009	0.39	9.5	3.5	3.1	2.4	0.61
89/05/14												
02:30	31.06	0.079	30.80	31.30	11.24	0.011	0.41	17.1	3.9	3.3	2.4	0.67
10:30	31.23	0.068	30.97	31.46	11.35	0.011	0.41	6.6	3.8	3.4	2.5	0.65
18:30	31.09	0.077	30.85	31.33	11.26	0.012	0.44	15.1	3.9	3.5	2.6	0.67
89/05/15												
02:30	31.09	0.098	30.79	31.39	11.26	0.010	0.40	15.1	5.3	4.2	2.6	0.79
10:30	31.22	0.077	30.94	31.46	11.35	0.015	0.48	15.1	3.9	3.5	2.6	0.67
18:30	31.04	0.061	30.84	31.23	11.23	0.009	0.37	15.1	3.7	3.3	2.6	0.62
89/05/16												
02:30	31.11	0.069	30.90	31.32	11.27	0.009	0.38	15.1	3.7	3.3	2.5	0.65
10:30	31.20	0.087	30.95	31.50	11.33	0.014	0.48	15.1	4.0	3.5	2.6	0.67
18:30	31.05	0.089	30.76	31.33	11.24	0.011	0.42	11.1	4.3	3.6	2.5	0.72
89/05/17												
02:30	31.09	0.073	30.84	31.33	11.26	0.009	0.37	15.1	3.9	3.3	2.5	0.67
10:30	31.12	0.096	30.83	31.43	11.28	0.012	0.43	17.1	4.3	3.5	2.5	0.71
18:30	31.08	0.086	30.80	31.38	11.25	0.009	0.37	15.1	4.9	4.0	2.6	0.75
89/05/18												
02:30	31.07	0.073	30.85	31.25	11.25	0.008	0.36	15.1	4.0	3.4	2.5	0.68

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	31.00	0.076	30.75	31.26	11.20	0.009	0.38	15.1	4.1	3.5	2.5	0.69
18:30	31.20	0.063	31.01	31.40	11.34	0.009	0.38	15.1	3.7	3.3	2.6	0.63
89/05/19												
02:30	31.08	0.053	30.91	31.24	11.26	0.006	0.32	15.1	3.4	3.1	2.5	0.59
10:30	30.94	0.053	30.79	31.11	11.16	0.010	0.40	9.5	3.2	3.0	2.5	0.55
18:30	31.32	0.050	31.15	31.48	11.42	0.009	0.37	13.5	3.2	2.9	2.5	0.55
89/05/20												
02:30	31.00	0.040	30.85	31.15	11.20	0.006	0.30	3.4	3.2	2.9	2.5	0.54
10:30	30.82	0.045	30.65	30.99	11.08	0.006	0.36	2.0	3.1	2.9	2.4	0.53
18:30	31.49	0.063	31.31	31.71	11.54	0.010	0.40	15.1	3.7	3.3	2.6	0.62
89/05/21												
02:30	31.01	0.063	30.79	31.24	11.20	0.010	0.40	15.1	3.8	3.4	2.6	0.65
10:30	30.77	0.066	30.59	30.98	11.04	0.014	0.47	2.3	3.5	3.2	2.5	0.59
18:30	31.65	0.063	31.43	31.83	11.64	0.011	0.42	17.1	3.7	3.3	2.6	0.62
89/05/22												
02:30	30.91	0.066	30.66	31.12	11.14	0.011	0.42	15.1	3.5	3.1	2.5	0.61
10:30	30.68	0.076	30.42	30.92	10.98	0.010	0.39	15.1	4.0	3.5	2.5	0.66
18:30	31.69	0.058	31.50	31.85	11.67	0.011	0.43	15.1	3.3	3.1	2.5	0.57
89/05/23												
02:30	30.81	0.055	30.62	31.01	11.07	0.006	0.35	15.1	3.4	3.1	2.4	0.61
10:30	30.68	0.049	30.52	30.84	10.98	0.007	0.33	13.5	3.4	3.1	2.5	0.58
18:30	31.72	0.048	31.54	31.88	11.69	0.008	0.36	13.5	3.5	3.2	2.6	0.59
89/05/24												
02:30	30.78	0.060	30.56	30.99	11.05	0.009	0.38	13.5	3.7	3.3	2.5	0.64
10:30	30.74	0.051	30.59	30.89	11.02	0.008	0.35	2.8	3.4	3.1	2.5	0.56
18:30	31.70	0.048	31.52	31.84	11.68	0.007	0.34	13.5	3.4	3.1	2.5	0.58
89/05/25												
02:30	30.75	0.051	30.55	30.94	11.03	0.007	0.34	12.2	3.5	3.2	2.5	0.60
10:30	30.82	0.045	30.67	30.96	11.08	0.006	0.32	10.2	3.3	3.0	2.5	0.56
18:30	31.63	0.045	31.46	31.76	11.63	0.008	0.37	3.3	3.3	3.1	2.6	0.56
89/05/26												
02:30	30.78	0.044	30.64	30.92	11.05	0.008	0.36	2.2	3.3	3.0	2.5	0.55
10:30	31.00	0.045	30.85	31.13	11.20	0.008	0.37	2.1	3.2	3.0	2.5	0.55
18:30	31.50	0.045	31.35	31.65	11.54	0.010	0.40	2.3	3.3	3.1	2.5	0.53
89/05/27												
02:30	30.79	0.039	30.66	30.92	11.06	0.006	0.31	2.0	3.2	2.9	2.5	0.55
10:30	31.14	0.037	30.99	31.28	11.29	0.006	0.32	2.6	3.1	2.9	2.5	0.52
18:30	31.30	0.041	31.16	31.43	11.40	0.006	0.35	2.4	3.1	2.9	2.5	0.51
89/05/28												
02:30	30.85	0.039	30.73	30.96	11.09	0.008	0.35	2.2	2.9	2.8	2.4	0.49
10:30	31.29	0.035	31.18	31.39	11.40	0.006	0.30	2.1	3.0	2.8	2.4	0.51
18:30	31.17	0.046	31.03	31.33	11.31	0.008	0.37	2.2	3.1	2.9	2.4	0.52
89/05/29												
02:30	30.99	0.057	30.82	31.17	11.19	0.009	0.38	17.1	3.3	3.0	2.4	0.58
10:30	31.40	0.058	31.21	31.60	11.47	0.007	0.32	15.1	3.8	3.3	2.5	0.65
18:30	31.06	0.063	30.86	31.24	11.24	0.009	0.38	15.1	3.5	3.1	2.5	0.60
89/05/30												
02:30	31.04	0.072	30.82	31.28	11.23	0.011	0.41	11.1	3.5	3.1	2.5	0.52

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	31.43	0.063	31.21	31.60	11.49	0.009	0.39	11.1	3.6	3.2	2.5	0.62
18:30	30.99	0.061	30.76	31.20	11.19	0.008	0.36	13.5	3.6	3.2	2.5	0.62
89/05/31												
02:30	31.09	0.055	30.89	31.27	11.26	0.009	0.38	2.0	3.3	3.0	2.4	0.60
10:30	31.36	0.065	31.15	31.56	11.44	0.012	0.44	8.3	3.4	3.1	2.5	0.60
18:30	31.08	0.050	30.91	31.26	11.26	0.008	0.35	2.9	3.2	2.9	2.4	0.55
89/06/01												
02:30	31.13	0.052	30.96	31.31	11.29	0.008	0.35	2.5	3.2	2.9	2.4	0.56
10:30	31.21	0.075	30.92	31.41	11.34	0.011	0.43	17.1	3.6	3.2	2.5	0.63
18:30	31.27	0.077	31.02	31.55	11.38	0.010	0.40	15.1	4.0	3.4	2.5	0.67
89/06/02												
02:30	31.15	0.096	30.88	31.45	11.30	0.012	0.44	10.2	4.5	3.7	2.6	0.73
10:30	31.03	0.144	30.50	31.48	11.22	0.020	0.57	10.2	5.9	4.7	2.6	0.83
18:30	31.47	0.084	31.19	31.71	11.52	0.012	0.44	15.1	3.8	3.2	2.4	0.66
89/06/03												
02:30	31.11	0.066	30.87	31.37	11.28	0.008	0.35	13.5	3.8	3.3	2.5	0.66
10:30	30.93	0.090	30.66	31.20	11.15	0.011	0.41	15.1	4.4	3.6	2.5	0.73
18:30	31.67	0.087	31.39	31.95	11.66	0.013	0.45	13.5	3.8	3.3	2.5	0.67
89/06/04												
02:30	30.97	0.078	30.69	31.28	11.18	0.010	0.40	13.5	4.1	3.5	2.6	0.69
10:30	30.77	0.077	30.52	31.02	11.04	0.011	0.42	10.2	3.9	3.4	2.5	0.67
18:30	31.85	0.080	31.55	32.12	11.79	0.012	0.44	12.2	4.1	3.6	2.6	0.66
89/06/05												
02:30	30.92	0.076	30.69	31.17	11.15	0.011	0.41	11.1	3.8	3.3	2.5	0.66
10:30	30.74	0.077	30.46	30.98	11.02	0.010	0.39	12.2	4.1	3.5	2.5	0.70
18:30	31.91	0.064	31.72	32.12	11.82	0.008	0.36	13.5	3.8	3.3	2.5	0.66
89/06/06												
02:30	30.86	0.057	30.67	31.03	11.10	0.007	0.32	13.5	3.8	3.3	2.5	0.64
10:30	30.77	0.055	30.56	30.94	11.04	0.007	0.34	9.5	3.6	3.3	2.5	0.62
18:30	31.87	0.052	31.68	32.04	11.80	0.007	0.34	8.8	3.4	3.1	2.4	0.61
89/06/07												
02:30	30.83	0.048	30.67	30.98	11.08	0.007	0.33	15.1	3.2	3.0	2.5	0.56
10:30	30.87	0.053	30.69	31.05	11.11	0.007	0.34	15.1	3.5	3.2	2.5	0.61
18:30	31.80	0.060	31.62	32.04	11.75	0.007	0.34	15.1	3.7	3.2	2.5	0.64
89/06/08												
02:30	30.86	0.061	30.65	31.06	11.10	0.009	0.39	15.1	3.4	3.0	2.4	0.59
10:30	31.00	0.062	30.79	31.18	11.20	0.009	0.39	13.5	3.4	3.0	2.4	0.60
18:30	31.67	0.070	31.44	31.92	11.66	0.012	0.45	6.0	4.1	3.7	2.7	0.67
89/06/09												
02:30	30.92	0.051	30.74	31.09	11.14	0.008	0.35	13.5	3.2	2.9	2.4	0.56
10:30	31.16	0.058	31.00	31.35	11.31	0.009	0.37	13.5	3.5	3.1	2.5	0.60
18:30	31.55	0.056	31.33	31.75	11.57	0.013	0.45	2.0	3.2	3.0	2.5	0.56
89/06/10												
02:30	30.93	0.053	30.76	31.11	11.15	0.007	0.34	15.1	3.6	3.2	2.5	0.61
10:30	31.30	0.057	31.14	31.49	11.41	0.007	0.33	15.1	3.5	3.1	2.4	0.62
18:30	31.43	0.061	31.26	31.61	11.49	0.010	0.40	15.1	3.4	3.1	2.5	0.57
89/06/11												
02:30	30.93	0.069	30.69	31.13	11.15	0.011	0.42	13.5	3.4	3.1	2.5	0.60

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	31.42	0.109	31.07	31.74	11.48	0.012	0.44	15.1	5.2	4.1	2.5	0.78
18:30	31.33	0.080	31.11	31.60	11.43	0.010	0.41	13.5	4.0	3.4	2.5	0.68
89/06/12												
02:30	30.96	0.086	30.70	31.21	11.17	0.012	0.43	13.5	4.2	3.6	2.6	0.71
10:30	31.47	0.066	31.28	31.72	11.52	0.011	0.43	17.1	3.9	3.5	2.7	0.63
18:30	31.28	0.108	30.88	31.67	11.39	0.019	0.56	15.1	4.1	3.5	2.6	0.69
89/06/13												
02:30	31.05	0.111	30.67	31.43	11.23	0.014	0.48	15.1	4.8	3.9	2.6	0.75
10:30	31.50	0.108	31.21	31.82	11.54	0.013	0.46	15.1	4.8	3.9	2.5	0.76
18:30	31.24	0.098	30.95	31.51	11.36	0.010	0.40	15.1	5.0	3.9	2.5	0.77
89/06/14												
02:30	31.09	0.069	30.87	31.31	11.26	0.007	0.34	15.1	4.0	3.4	2.4	0.68
10:30	31.47	0.067	31.25	31.67	11.52	0.009	0.38	15.1	3.7	3.3	2.5	0.65
18:30	31.17	0.063	30.95	31.36	11.31	0.011	0.41	15.1	3.5	3.1	2.5	0.60
89/06/15												
02:30	31.11	0.062	30.93	31.30	11.27	0.008	0.35	15.1	3.7	3.3	2.5	0.65
10:30	31.37	0.060	31.20	31.59	11.45	0.011	0.42	3.5	3.5	3.2	2.6	0.59
18:30	31.20	0.052	31.02	31.37	11.34	0.013	0.45	4.7	3.2	3.0	2.5	0.55
89/06/16												
02:30	31.11	0.044	30.97	31.25	11.27	0.007	0.32	2.6	3.3	3.0	2.5	0.55
10:30	31.27	0.063	31.06	31.48	11.39	0.012	0.43	2.3	3.4	3.1	2.5	0.58
18:30	31.32	0.062	31.11	31.55	11.42	0.011	0.42	17.1	3.3	3.0	2.5	0.57
89/06/17												
02:30	31.11	0.068	30.90	31.35	11.28	0.009	0.38	17.1	3.6	3.1	2.4	0.63
10:30	31.14	0.085	30.88	31.39	11.29	0.012	0.43	15.1	4.1	3.5	2.6	0.68
18:30	31.49	0.106	31.19	31.81	11.54	0.013	0.45	15.1	4.8	3.9	2.6	0.75
89/06/18												
02:30	31.12	0.089	30.77	31.43	11.28	0.011	0.43	15.1	4.1	3.4	2.5	0.69
10:30	30.99	0.094	30.65	31.25	11.19	0.010	0.40	15.1	4.7	3.8	2.5	0.75
18:30	31.63	0.075	31.39	31.87	11.63	0.011	0.41	15.1	3.8	3.4	2.6	0.65
89/06/19												
02:30	31.07	0.076	30.78	31.34	11.24	0.009	0.38	17.1	4.0	3.4	2.5	0.68
10:30	30.87	0.093	30.61	31.14	11.11	0.011	0.43	15.1	4.4	3.6	2.5	0.72
18:30	31.73	0.111	31.33	32.14	11.70	0.015	0.48	15.1	4.6	3.7	2.5	0.74
89/06/20												
02:30	30.99	0.138	30.56	31.43	11.19	0.019	0.55	15.1	5.2	4.0	2.5	0.78
10:30	30.77	0.129	30.44	31.15	11.04	0.015	0.49	15.1	5.6	4.2	2.5	0.81
18:30	31.85	0.140	31.42	32.27	11.78	0.017	0.52	15.1	6.1	4.5	2.5	0.83
89/06/21												
02:30	30.93	0.100	30.66	31.23	11.15	0.011	0.42	13.5	4.8	3.9	2.5	0.76
10:30	30.78	0.106	30.49	31.07	11.05	0.012	0.43	15.1	4.9	3.9	2.5	0.77
18:30	31.90	0.091	31.61	32.17	11.82	0.013	0.45	13.5	4.0	3.4	2.5	0.66
89/06/22												
02:30	30.90	0.094	30.66	31.16	11.13	0.013	0.46	13.5	4.0	3.4	2.4	0.69
10:30	30.87	0.072	30.66	31.10	11.11	0.005	0.36	15.1	4.0	3.4	2.5	0.66
18:30	31.90	0.092	31.59	32.18	11.82	0.010	0.39	13.5	4.7	3.5	2.5	0.76
89/06/23												
02:30	30.89	0.098	30.58	31.22	11.12	0.011	0.42	15.1	4.6	3.7	2.5	0.75

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	31.04	0.120	30.62	31.50	11.23	0.014	0.47	15.1	5.4	4.2	2.5	0.80
18:30	31.78	0.133	31.37	32.22	11.73	0.014	0.48	15.1	6.7	4.9	2.6	0.85
89/06/24												
02:30	30.85	0.134	30.36	31.36	11.09	0.016	0.50	15.1	6.0	4.5	2.5	0.83
10:30	31.21	0.150	30.77	31.69	11.34	0.017	0.52	15.1	7.5	5.5	2.6	0.88
18:30	31.71	0.140	31.31	32.13	11.68	0.019	0.56	13.5	5.5	4.3	2.6	0.80
89/06/25												
02:30	30.88	0.113	30.52	31.30	11.12	0.012	0.44	13.5	5.5	4.3	2.5	0.61
10:30	31.37	0.174	30.92	31.90	11.46	0.025	0.63	13.5	6.9	5.2	2.6	0.86
18:30	31.48	0.103	31.15	31.87	11.53	0.013	0.45	13.5	4.8	3.9	2.6	0.75
89/06/26												
02:30	30.84	0.076	30.56	31.08	11.09	0.008	0.37	10.2	4.1	3.5	2.5	0.71
10:30	31.54	0.057	31.38	31.71	11.57	0.008	0.36	8.8	3.4	3.1	2.4	0.60
18:30	31.30	0.066	31.06	31.53	11.40	0.008	0.36	17.1	3.7	3.2	2.5	0.64
89/06/27												
02:30	30.89	0.061	30.70	31.12	11.12	0.007	0.35	17.1	3.5	3.1	2.4	0.62
10:30	31.67	0.092	31.35	31.93	11.66	0.008	0.36	15.1	5.3	4.1	2.5	0.79
18:30	31.17	0.128	30.71	31.61	11.31	0.016	0.51	15.1	5.1	3.9	2.4	0.78
89/06/28												
02:30	30.91	0.161	30.40	31.55	11.13	0.019	0.55	13.5	7.8	5.7	2.6	0.89
10:30	31.66	0.158	31.21	32.12	11.65	0.021	0.58	15.1	6.1	4.5	2.5	0.84
18:30	31.14	0.109	30.83	31.50	11.29	0.012	0.44	15.1	5.2	4.1	2.6	0.77
89/06/29												
02:30	31.02	0.141	30.67	31.38	11.21	0.017	0.52	15.1	6.1	4.6	2.5	0.83
10:30	31.57	0.107	31.31	31.88	11.59	0.015	0.49	13.5	4.5	3.7	2.5	0.73
18:30	31.15	0.093	30.84	31.42	11.30	0.011	0.43	13.5	4.4	3.6	2.5	0.72
89/06/30												
02:30	31.05	0.103	30.74	31.42	11.23	0.010	0.40	13.5	5.3	4.1	2.5	0.79
10:30	31.41	0.105	31.08	31.74	11.48	0.013	0.45	13.5	4.6	3.7	2.5	0.75
18:30	31.24	0.090	30.98	31.52	11.37	0.011	0.41	13.5	4.3	3.5	2.5	0.72
89/07/01												
02:30	31.06	0.059	30.86	31.26	11.24	0.007	0.33	15.1	3.5	3.1	2.4	0.62
10:30	31.25	0.077	31.03	31.53	11.37	0.013	0.45	15.1	3.5	3.1	2.5	0.61
18:30	31.47	0.075	31.19	31.71	11.52	0.012	0.43	13.5	3.7	3.2	2.5	0.63
89/07/02												
02:30	31.06	0.085	30.81	31.39	11.25	0.009	0.38	13.5	4.5	3.7	2.5	0.74
10:30	31.06	0.067	30.84	31.27	11.24	0.013	0.45	15.1	3.2	3.0	2.4	0.56
18:30	31.62	0.068	31.41	31.85	11.63	0.012	0.44	13.5	3.5	3.1	2.5	0.61
89/07/03												
02:30	31.09	0.060	30.90	31.32	11.26	0.010	0.39	13.5	3.4	3.1	2.5	0.60
10:30	30.85	0.058	30.67	31.03	11.10	0.008	0.36	13.5	3.4	3.1	2.5	0.59
18:30	31.71	0.059	31.54	31.88	11.68	0.012	0.44	13.5	3.2	2.9	2.5	0.54
89/07/04												
02:30	31.05	0.061	30.86	31.25	11.23	0.007	0.34	13.5	3.6	3.2	2.4	0.64
10:30	30.79	0.048	30.66	30.96	11.05	0.008	0.35	2.2	3.1	2.9	2.4	0.54
18:30	31.77	0.074	31.49	32.04	11.73	0.012	0.43	15.1	3.7	3.2	2.5	0.63
89/07/05												
02:30	30.97	0.080	30.72	31.24	11.18	0.009	0.39	15.1	4.0	3.4	2.5	0.69

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	30.76	0.087	30.50	31.03	11.04	0.009	0.37	15.1	4.7	3.8	2.5	0.75
18:30	31.76	0.089	31.48	32.05	11.72	0.013	0.46	13.5	3.9	3.4	2.5	0.67
89/07/06												
02:30	30.93	0.078	30.65	31.23	11.15	0.009	0.39	13.5	4.1	3.5	2.5	0.69
10:30	30.86	0.067	30.62	31.07	11.10	0.007	0.34	13.5	3.9	3.3	2.5	0.68
18:30	31.74	0.076	31.47	32.01	11.71	0.008	0.35	15.1	4.3	3.6	2.5	0.72
89/07/07												
02:30	30.91	0.068	30.71	31.14	11.14	0.009	0.39	13.5	3.7	3.3	2.5	0.64
10:30	31.02	0.082	30.73	31.25	11.21	0.010	0.40	13.5	4.2	3.5	2.5	0.70
18:30	31.69	0.088	31.44	31.98	11.68	0.010	0.40	17.1	4.5	3.7	2.5	0.72
89/07/08												
02:30	30.85	0.107	30.53	31.16	11.09	0.013	0.45	15.1	4.7	3.8	2.5	0.76
10:30	31.18	0.119	30.85	31.56	11.32	0.014	0.47	13.5	5.4	4.2	2.5	0.80
18:30	31.58	0.107	31.20	31.94	11.60	0.011	0.43	17.1	5.4	4.2	2.6	0.79
89/07/09												
02:30	30.87	0.136	30.48	31.25	11.11	0.015	0.49	15.1	6.3	4.7	2.5	0.84
10:30	31.32	0.142	30.85	31.84	11.42	0.019	0.55	15.1	5.6	4.3	2.5	0.81
18:30	31.41	0.148	30.97	31.84	11.48	0.017	0.53	15.1	6.7	4.9	2.5	0.86
89/07/10												
02:30	30.83	0.129	30.46	31.22	11.08	0.014	0.48	15.1	6.0	4.5	2.5	0.82
10:30	31.44	0.133	30.98	31.86	11.50	0.017	0.52	15.1	5.4	4.1	2.5	0.79
18:30	31.29	0.081	31.05	31.55	11.40	0.011	0.42	13.5	3.9	3.4	2.5	0.65
89/07/11												
02:30	30.81	0.074	30.57	31.02	11.06	0.009	0.38	13.5	3.7	3.2	2.4	0.65
10:30	31.51	0.068	31.29	31.71	11.55	0.007	0.34	13.5	3.9	3.3	2.5	0.67
18:30	31.20	0.050	31.03	31.36	11.34	0.008	0.35	13.5	3.4	3.1	2.5	0.58
89/07/12												
02:30	30.81	0.048	30.66	30.98	11.07	0.007	0.33	13.5	3.3	3.0	2.5	0.56
10:30	31.52	0.040	31.36	31.64	11.55	0.006	0.30	13.5	3.2	2.9	2.4	0.55
18:30	31.09	0.046	30.92	31.23	11.26	0.007	0.34	3.4	3.5	3.2	2.6	0.57
89/07/13												
02:30	30.83	0.046	30.66	30.97	11.08	0.007	0.34	2.2	3.3	3.0	2.5	0.56
10:30	31.49	0.046	31.34	31.64	11.53	0.009	0.37	2.4	3.1	2.9	2.4	0.54
18:30	31.05	0.047	30.88	31.21	11.23	0.008	0.35	3.4	3.6	3.3	2.7	0.58
89/07/14												
02:30	30.87	0.048	30.71	31.04	11.11	0.007	0.33	2.3	3.4	3.1	2.5	0.59
10:30	31.44	0.058	31.25	31.66	11.50	0.011	0.42	15.1	3.5	3.1	2.5	0.59
18:30	31.08	0.057	30.89	31.26	11.25	0.009	0.37	15.1	3.6	3.2	2.6	0.61
89/07/15												
02:30	30.91	0.051	30.75	31.08	11.14	0.007	0.33	15.1	3.3	2.9	2.4	0.57
10:30	31.33	0.073	31.11	31.55	11.43	0.012	0.45	15.1	3.8	3.3	2.5	0.66
18:30	31.15	0.078	30.91	31.42	11.30	0.014	0.47	7.8	4.2	3.7	2.7	0.68
89/07/16												
02:30	30.98	0.085	30.68	31.27	11.18	0.014	0.47	7.8	4.4	3.9	2.7	0.72
10:30	31.24	0.088	30.98	31.54	11.36	0.027	0.65	4.5	4.0	3.7	2.9	0.63
18:30	31.28	0.082	30.98	31.56	11.39	0.014	0.47	13.5	4.1	3.6	2.6	0.69
89/07/17												
02:30	31.05	0.061	30.84	31.27	11.23	0.011	0.42	6.2	3.8	3.4	2.5	0.54

time/ date	-- pressure record data -- mean psi	std dev psi	min psi	max psi	depth m	var m^2	- spectral analysis statistics - Hsig m	Tpeak sec	T0 sec	Tz sec	Tc sec	e
10:30	31.04	0.059	30.86	31.22	11.23	0.015	0.49	2.3	3.3	3.1	2.6	0.55
18:30	31.40	0.065	31.20	31.59	11.47	0.012	0.43	13.5	3.5	3.2	2.5	0.60
89/07/18												
02:30	31.00	0.048	30.81	31.14	11.20	0.007	0.34	2.0	3.3	3.0	2.5	0.57
10:30	30.77	0.066	30.54	31.00	11.04	0.014	0.48	5.4	3.6	3.3	2.6	0.62
18:30	31.52	0.079	31.27	31.77	11.56	0.018	0.54	4.3	3.9	3.6	2.8	0.64
89/07/19												
02:30	31.01	0.072	30.73	31.24	11.20	0.010	0.40	13.5	3.9	3.5	2.5	0.67
10:30	30.72	0.088	30.38	30.99	11.01	0.021	0.57	4.2	4.3	3.9	2.9	0.67
18:30	31.69	0.071	31.44	31.89	11.67	0.014	0.48	13.5	3.7	3.3	2.6	0.63
89/07/20												
02:30	31.02	0.083	30.74	31.27	11.21	0.016	0.51	7.3	4.2	3.8	2.8	0.68
10:30	30.72	0.075	30.47	30.96	11.01	0.011	0.42	7.3	4.4	3.8	2.7	0.71
18:30	31.79	0.059	31.63	31.99	11.74	0.008	0.37	13.5	3.6	3.2	2.5	0.62
89/07/21												
02:30	30.96	0.083	30.72	31.22	11.17	0.014	0.48	13.5	4.0	3.5	2.6	0.68
10:30	30.79	0.048	30.61	30.96	11.06	0.008	0.36	2.2	3.0	2.8	2.4	0.52
18:30	31.71	0.050	31.56	31.87	11.68	0.007	0.34	13.5	3.4	3.1	2.5	0.60
89/07/22												
02:30	30.94	0.061	30.73	31.14	11.16	0.010	0.40	13.5	3.7	3.3	2.6	0.64
10:30	30.97	0.107	29.34	31.22	11.18	0.021	0.59	8.3	4.5	3.9	2.7	0.72
18:30	31.64	0.063	31.41	31.85	11.64	0.009	0.39	6.2	4.0	3.5	2.6	0.67
89/07/23												
02:30	30.85	0.067	30.64	31.10	11.09	0.012	0.44	6.2	3.7	3.4	2.6	0.64
10:30	31.24	0.068	31.04	31.46	11.36	0.011	0.43	7.8	4.0	3.6	2.7	0.66
18:30	31.56	0.049	31.39	31.73	11.59	0.007	0.33	13.5	3.7	3.4	2.6	0.62
89/07/24												
02:30	30.75	0.063	30.52	30.95	11.02	0.010	0.39	13.5	3.7	3.3	2.6	0.63
10:30	31.41	0.049	31.27	31.58	11.48	0.007	0.32	13.5	3.5	3.2	2.5	0.60
18:30	31.38	0.045	31.24	31.52	11.46	0.010	0.40	2.4	3.1	2.9	2.5	0.52
89/07/25												
02:30	30.76	0.049	30.59	30.91	11.04	0.008	0.36	13.5	3.6	3.3	2.6	0.62
10:30	4.54	7.462	0.00	23.36	-6.98	26.283	20.51	256.0	****	40.7	3.2	1.00
18:30	59.82	******	-20.87	624.97	31.00	******	*****	5.2	5.1	4.5	3.4	0.65

APPENDIX I

DEEPWATER WAVE CLIMATE SUMMARY FOR THE MAUNA LANI RESORT, ISLAND OF HAWAII

DEEPWATER WAVE CLIMATE SUMMARY

for the

MAUNA LANI RESORT

ISLAND OF HAWAII

Prepared for:
Peratrovich, Nottingham & Drage, Inc.
Seattle, Washington

Prepared by:
Sea Engineering, Inc.
Waimanalo, Hawaii

April 1989

INTRODUCTION

This report summarizes existing available deepwater wave data pertinent to the design and assessment of a small boat marina at the Mauna Lani Resort, located in the vicinity of Makaiwa and Pauoa Bays on the northwest coast of the island of Hawaii. The prevailing deepwater wave climate and extreme (storm) wave conditions are discussed based on actual wave measurements, storm wave hindcasts and hypothetical hurricane storm events.

The majority of the existing data is wave height and period information, with very little direction data, and is general for the Hawaiian Islands and not specific to the west coast of Hawaii Island or the project site. The limited wave direction data, coupled with the somewhat sheltered location of the project site, makes it difficult to be quantitative about the deepwater wave climate as it specifically pertains to the Mauna Lani Resort. The limitations and applicability of the existing wave data is discussed in the report.

The wave data presented in this report, with the exception of nearshore wave measurements at Kaunaoa Beach, are deepwater waves. Waves are considered to be in deepwater, and thus unaffected by the ocean bottom conditions and bathymetry, when the water depth is greater than one-half the wave length. Deepwater waves which approach the project site would be altered by the processes of refraction, diffraction, shoaling and ultimately wave breaking as they propagate into shallow water nearshore. Wave transformation from deep to shallow water and the nearshore wave climate at the project site is not addressed in this report.

PREVAILING DEEPWATER WAVES

General Hawaiian Wave Types

The general Hawaiian wave climate can be described by four primary wave types; the northeast tradewind waves, southern swell, Kona storm waves and North Pacific swell. These wave types and their general approach directions are shown on Figure 1.

Tradewind waves may be present in Hawaiian waters throughout the year, but are most frequent in the summer season, between April and September, when they usually dominate the Hawaiian wave climate. They result from the strong and steady tradewinds blowing from the northeast quadrant over long fetches of open ocean. The typical deepwater tradewind waves have periods of 5 to 8 seconds and heights of 4 to 10 feet.

I-2

Southern swell is generated by Antarctic winter storms and is most prevalent during the months of April through October. These long, low waves approach from the southeast through southwest, with typical periods of 12 to 22 seconds and deepwater heights of 1 to 4 feet.

Kona storm waves are generated by intense winds associated with local fronts or low pressure systems and typically have periods ranging from 6 to 10 seconds and heights up to 10+ feet. These waves can occur anytime during the year, but they are most common in late winter and early spring. The waves approach from the south to west, with the largest waves usually from the southwest. Deepwater wave heights during a severe Kona storm in January 1980 were hindcasted by Sea Engineering, Inc. to be about 17 feet with a period of 9 seconds.

North Pacific swell is produced by severe winter storms in the Aleutian area of the North Pacific Ocean and by mid-latitude low pressure areas. North swell may arrive in the Hawaiian Islands throughout the year but is largest and most frequent during the winter months of October through March. North Pacific swell typically has periods of 12 to 20 seconds and heights of 5 to 15 feet.

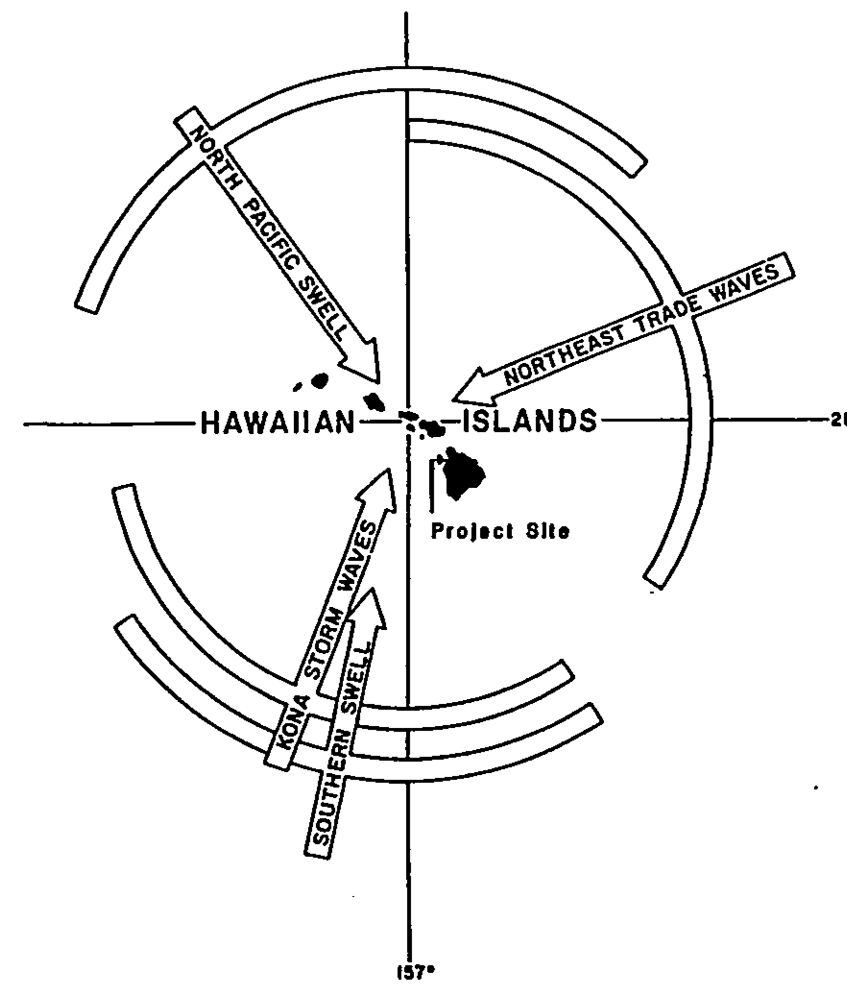


FIGURE 1

GENERALIZED WAVE TYPES

In addition to the primary wave types, infrequent tropical storms and hurricanes may generate large waves which affect the west coast of Hawaii island.

These general deepwater wave types follow different paths to reach the project area in the vicinity of the Mauna Lani Resort. The project area is well sheltered from northeast tradewind waves by the island of Hawaii itself, and is partially sheltered from North Pacific swell by the Hawaiian Islands which are located to the northwest of the study site. North Pacific swell diffracts and refracts around the islands with only a portion of their deepwater energy reaching the project area. North swell can reach the project site two ways. If the wave approach is very west-northwesterly the swell can propagate south of the islands of Kauai, Oahu and Maui to approach the project site fairly directly. If the waves come from a very northerly direction they approach the project site through the gap between the east end of Maui and the northwest coast of Hawaii island. Northwest swell has a difficult time reaching the project site. Kona storm waves and southern swell, on the other hand, approach the coast in the project area directly.

Wave Data Sources

SSMO Data - Open ocean (deepwater) wave statistics have been compiled by the U.S. Naval Weather Service Command in the summary of Synoptic Meteorological Observations (SSMO) - Hawaiian and Selected North Pacific Island Coastal Marine Areas.

The SSMO data was obtained through direct synoptic observations of ships in passage and represents average conditions recorded during the 8-year period from 1963 to 1970. Sea waves generated by local winds in the vicinity of the observer are presented as percent frequency of sea height versus surface wind speed and direction (8 compass points), and the percent frequency of wave height versus wave period. For the latter presentation when both sea and swell waves are present, the higher of the two is used.

Sea is defined as waves generated by winds in the vicinity of the observer, and swell as waves generate by winds distant from the local area of observation. It should be noted that ships tend to avoid bad weather when possible, thus biasing the SSMO data toward good weather samples (and thus lower wave heights). In addition, longer period swells may be masked from visual observation by shorter period local wind waves superimposed on the top of the swell. The SSMO data for the leeward Hawaiian Islands (south and west of the island) is considered most appropriate for the project area. The boundary of the SSMO Hawaiian Leeward area is shown in Figure 2, and a summary of the data is provided in Table 1. According to the SSMO data, deepwater waves will approach the project area from the south clockwise to the north approximately 15 percent of the time, assuming wind direction coincides with wave approach direction (i.e., this is a measure of sea conditions, not swell waves).

CDIP Data - Deepwater wave data in the Hawaiian Islands is collected by the Coastal Data Information Program (CDIP), a coastal wave data collection and analyses program conducted by Scripps Institution of Oceanography under the sponsorship of the U.S. Army Corps of Engineers. Wave height and period data is measured by a network of Waverider buoys connected to a central data acquisition and analysis station at Scripps Institution.

Hawaii has three buoys which are monitored by the program, one located east of Makapuu Point, Oahu, one located west of Barbers Point, Oahu and one located west of Barking Sands, Kauai. The three wave buoy locations are shown on Figure 2. The Makapuu buoy is partially sheltered from westerly waves and the Barbers Point buoy is partially sheltered from northerly and easterly waves, both sheltered by the island of Oahu, and the Barking Sands buoy is sheltered from easterly waves by the Island of Kauai.

Among the three wave data sets, the Barbers Point data is considered to be most applicable to the project area because the sheltered wave conditions at this location are most similar (of the three buoys) to the wave exposure at the project site.

TABLE 1
SSMO DEEPWATER WAVE STATISTICS FOR LEEWARD HAWAII

a) PERCENT FREQUENCY OF WIND DIRECTION VERSUS WAVE HEIGHT

WIND DIR. HEIGHT(FT)	N	NE	E	SE	S	SW	W	NW	TOTAL
<1 (FT)	0.9	1.4	1.8	0.7	0.7	0.4	0.5	0.4	6.8
1-2	2.7	6.4	10.9	2.9	1.9	1.1	1.2	1.2	28.3
3-4	2.8	9.2	15.9	2.8	1.5	0.6	0.8	0.6	34.2
5-6	1.6	4.5	8.8	1.2	0.5	0.1	0.3	0.3	17.3
7	0.8	2.5	4.0	0.4	0.3	0.1	0.1	0.1	8.3
8-9	0.3	1.1	1.6	0.1	*	*	0.1	0.1	3.3
10-11	0.1	0.4	0.5	0.1	*	*	*	*	1.1
12	0.1	0.1	0.1	*	0.0	0.0	*	0.0	0.3
13-16	*	0.1	0.1	*	*	0.0	0.0	0.0	0.2
17-19	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	*
>20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	9.2	25.5	43.8	8.4	4.9	2.5	3.0	2.7	100.0

(b) PERCENT FREQUENCY OF WAVE PERIOD VERSUS WAVE HEIGHT

PERIOD(SEC) HEIGHT(FT)	<6	6-7	8-9	10-11	12-13	<13	INDET	TOTAL
<1	1.5	0.1	*	0.0	0.0	0.0	3.6	5.3
1-2	12.5	2.1	0.4	0.1	*	0.0	1.1	16.2
3-4	21.2	8.1	2.2	0.5	*	0.0	1.0	33.1
5-6	8.3	8.6	2.8	0.7	0.2	0.1	0.6	21.2
7	3.2	6.2	2.8	0.7	0.3	0.1	0.2	13.6
8-9	1.0	2.2	1.6	0.6	0.2	0.1	0.1	5.9
10-11	0.3	0.9	1.0	0.4	0.1	*	0.1	2.8
12	0.1	0.3	0.4	0.2	*	*	*	0.9
13-16	0.1	0.2	0.2	0.2	0.1	*	*	0.7
17-19	0.0	*	*	*	0.0	*	0.0	0.1
20-22	0.0	*	*	*	0.0	*	0.0	0.1
23-25	0.0	*	*	*	*	0.0	0.0	0.1
26-32	0.0	0.0	0.0	0.0	*	0.0	0.0	*
>33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	48.5	28.6	11.5	3.3	1.0	0.4	6.7	100.0

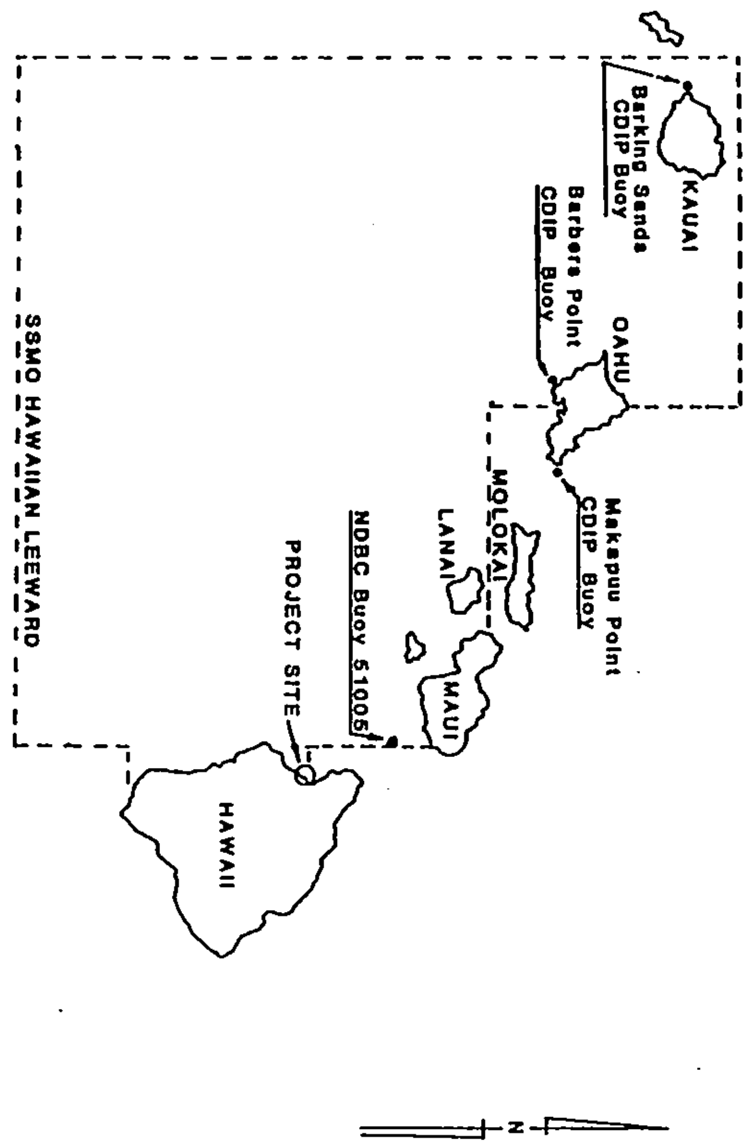


FIGURE 2
DEEPWATER WAVE BUOY LOCATIONS IN HAWAII AND BOUNDARIES OF THE SSMO HAWAIIAN LEEWARD AREA.

The Barbers Point buoy is moored in 600 feet of water, thus wave data from the buoy with periods less than about 16 seconds would technically be considered deepwater waves. Unfortunately, no wave direction data is obtained by the waverider system.

A summary of the percent frequency of wave height versus period for a one-year period (1987) as measured by the Barbers Point CDIP Buoy is given on Table 2. The height is the spectral based significant height and the period is that associated with the spectral peak. For the Barbers Point data, wave heights ranged from 1.3 to 9.5 feet and wave periods ranging from 5 to 20 seconds. Based on the data in Table 2, wave height exceedances at Barbers Point for a 50%, 10% and 1% frequency of occurrence are 3 feet, 4.6 feet and 7.2 feet respectively, with typical wave periods of 6 to 16 seconds.

<u>NDBC Data</u> - The National Oceanic and Atmospheric Administration, National Data Buoy Center (NDBC), operates four moored deepwater weather observation buoys for National Weather Service support in the general vicinity of the Hawaiian Islands. Along with meteorological data these buoys record wave height data, but no wave period or direction information. These buoys are located 200 to 500 miles from the project site, and their data is not very applicable to the project site.

The NDBC also, however, deployed a test buoy in the Alenuihaha Channel between the islands of Hawaii and Maui for the two-year period from December 1985 through December 1987 (NDBC 51005, located at 20°24' N. latitude and 156°06' W. longitude). The location of the buoy is shown on Figure 2. Wave height data for this buoy is available as summaries of the hourly mean significant wave height and daily (24 hour) mean significant wave height.

A summary of the daily mean significant wave height as measured by NDBC Buoy 51001 for the years 1986 and 1987 is given on Tables 3A and 3B, respectively, and a summary of the percent frequency of occurrence of wave heights for the two years combined is shown on Figure 3.

TABLE 2

CDIP PROGRAM DEEPWATER WAVE STATISTICS

FOR BARBERS POINT , OAHU

PERCENT FREQUENCY (%)
(1/1/87 - 12/29/87)

HEIGHT	WAVE PERIOD (SEC.)									
(FEET)	4.0- 6.0	6.0- 8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	16.0-18.0	18.0-20.0	20.0-22.0	TOTAL
0.0- 1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0- 2.0	0.4	1.0	1.4	2.2	2.3	0.7	0.1	0.0	0.0	8.0
2.0- 3.0	1.2	10.5	8.5	7.5	12.8	6.5	1.5	0.0	0.4	48.9
3.0- 4.0	0.5	5.8	3.2	4.4	5.2	4.7	1.9	0.0	0.4	26.2
4.0- 5.0	0.1	1.1	1.3	1.2	2.8	2.7	0.8	0.0	0.0	10.0
5.0- 6.0	0.0	0.7	0.3	0.9	1.0	0.6	0.2	0.0	0.1	3.8
6.0- 7.0	0.1	0.4	0.2	0.2	0.3	0.3	0.0	0.0	0.1	1.7
7.0- 8.0	0.0	0.2	0.1	0.1	0.2	0.2	0.2	0.0	0.1	1.0
8.0- 9.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3
9.0-10.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2
TOTAL	2.3	19.8	15.0	16.5	24.9	15.8	4.7	0.0	1.0	100.0

THE TOTAL NUMBER OF DATA = 1239
THE RANGE OF WAVE HEIGHTS (FEET) : 1.3 - 9.5
THE RANGE OF WAVE PERIODS (SEC.) : 5.0 - 20.0

THE WAVE HEIGHT IS THE SPECTRALLY BASED SIGNIFICANT WAVE HEIGHT.
THE WAVE PERIOD IS THE PERIOD ASSOCIATED WITH THE SPECTRAL PEAK.

TABLE 3A

SIGNIFICANT WAVE HEIGHT
RECORDED BY NDBC BUOY 51005
(1986, DAILY MEAN, FEET)

Day	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	9.8	3.9	2.6	6.6	7.2	5.6	4.6	5.9	5.3	7.2	4.9	8.5
2	8.9	4.6	3.0	6.6	5.6	5.3	5.6	5.6	4.9	6.6	5.9	8.5
3	7.6	4.9	4.3	6.9	7.2	4.9	5.9	5.6	4.9	6.9	6.9	8.9
4	5.3	4.9	3.9	8.5	6.9	4.6	6.9	5.9	4.9	5.9	6.6	7.2
5	4.3	5.3	3.6	9.2	6.9	5.6	6.2	6.9	4.6	6.2	5.6	4.6
6	3.6	5.3	4.3	8.2	6.6	6.2	5.3	6.9	4.6	6.2	5.6	6.6
7	6.2	5.6	3.6	7.9	6.9	6.2	6.2	6.2	4.3	6.2	7.2	4.3
8	5.9	4.9	4.3	9.2	6.6	6.2	7.6	5.9	4.3	5.3	7.6	3.6
9	6.2	4.3	4.6	12.1	7.6	5.3	8.5	5.9	5.3	4.3	7.6	4.3
10	5.3	3.6	4.3	15.1	10.5	4.9	8.5	5.9	4.9	3.9	9.2	4.9
11	4.6	3.6	4.6	13.5	9.2	4.3	8.2	5.6	4.6	3.3	7.9	5.3
12	4.3	3.6	4.6	10.8	9.5	3.9	6.6	7.2	4.3	3.3	8.9	5.3
13	5.9	5.6	5.3	10.2	8.9	4.6	6.2	7.5	3.9	4.3	10.8	6.2
14	5.9	4.9	7.2	8.9	8.5	6.2	5.6	7.5	3.9	4.6	9.2	6.9
15	4.9	4.9	8.2	8.2	8.5	7.2	6.2	6.9	3.3	5.6	7.2	6.6
16	3.6	6.6	8.5	6.9	7.6	7.6	5.9	5.3	3.0	6.6	7.6	6.6
17	3.3	5.9	7.2	5.9	6.9	7.6	6.2	4.3	2.6	7.2	8.5	7.9
18	3.9	5.3	5.9	4.9	6.2	8.2	6.2	3.3	3.6	5.9	7.2	8.5
19	4.9	3.9	5.9	4.6	5.9	8.2	5.6	3.9	3.6	5.6	6.9	7.2
20	5.9	3.0	7.6	5.3	5.6	7.2	4.9	3.9	3.0	6.9	7.6	5.3
21	5.6	3.3	7.2	7.2	4.6	7.2	4.3	5.3	3.6	7.2	7.2	4.9
22	6.6	5.3	8.2	7.2	3.6	7.9	5.6	5.3	3.9	5.9	6.9	5.6
23	5.3	4.9	7.2	7.6	3.0	6.9	9.2	5.6	5.9	5.3	6.2	6.2
24	3.9	6.6	5.6	8.5	3.0	6.9	6.6	5.9	8.2	4.3	8.2	5.3
25	3.6	5.9	4.3	9.5	3.3	5.9	6.6	5.9	8.9	4.3	9.2	5.3
26	4.6	4.6	4.6	9.2	3.6	5.9	6.2	5.9	6.9	6.9	9.8	4.6
27	3.2	3.9	5.6	9.8	3.6	4.6	6.2	6.6	6.6	6.9	10.5	3.9
28	3.9	2.6	.5.6	10.2	3.3	4.6	5.9	6.6	5.9	6.2	10.5	4.3
29	3.3		6.6	9.5	3.9	4.3	6.6	4.9	6.6	5.3	11.2	4.6
30	3.9		7.2	7.9	6.6	4.6	6.6	6.2	6.9	3.9	8.9	4.6
31	3.6		7.2		7.2		8.2	5.3		2.6		5.3

TABLE 3B

SIGNIFICANT WAVE HEIGHT
RECORDED BY NDBC BUOY 51005
(1987, DAILY MEAN, FEET)

Day	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	5.3	4.9	4.3	10.8	6.6	4.9	5.6	4.9	2.3	5.9	7.2	9.2
2	5.3	5.3	4.9	11.8	6.2	3.3	6.2	4.9	2.3	7.2	7.6	6.9
3	7.2	5.3	6.9	9.5	5.6	3.3	6.6	4.6	2.6	7.2	5.9	5.6
4	7.6	4.3	6.9	6.9	5.6	4.6	6.2	4.3	4.3	5.3	5.3	4.9
5	6.6	5.9	6.2	6.2	5.3	5.6	5.3	4.3	4.9	4.6	5.3	4.6
6	6.2	5.9	5.3	6.9	4.6	5.6	5.3	4.9	5.6	4.6	5.3	6.9
7	5.6	4.9	4.3	6.9	6.9	5.3	5.9	5.6	4.6	4.3	4.9	7.2
8	4.3	3.3	4.6	5.6	7.2	4.9	5.6	4.9	4.6	5.9	5.6	7.6
9	3.9	3.6	3.9	6.9	5.9	5.3	5.9	4.6	4.9	7.9	5.6	5.9
10	6.6	3.6	3.3	7.2	7.2	5.6	5.9	5.3	4.6	5.9	5.9	5.6
11	10.5	3.9	3.0	7.6	6.6	5.6	5.6	6.6	5.9	4.6	6.6	5.3
12	12.1	3.0	4.6	6.6	6.2	4.6	6.2	6.9	7.2	5.6	6.2	7.2
13	12.5	3.3	6.2	5.9	4.3	5.6	6.2	6.9	6.6	4.3	7.6	7.2
14	11.2	5.3	7.2	6.6	3.9	6.6	5.9	5.9	6.6	3.9	6.6	7.9
15	8.2	4.9	7.9	8.2	3.6	7.2	5.6	5.9	6.9	4.9	4.9	9.2
16	8.9	5.9	7.6	5.3	4.6	7.2	6.2	5.6	6.9	5.3	5.9	7.9
17	6.9	7.2	7.6	8.5	5.9	5.6	4.9	5.9	7.2	4.9	5.3	5.6
18	6.9	7.6	6.9	8.2	4.6	5.3	4.9	5.3	7.9	4.6	6.6	6.2
19	9.8	8.5	6.9	6.2	4.3	5.3	6.6	5.6	6.2	5.3	7.2	8.5
20	8.9	7.6	8.9	6.6	4.9	5.3	7.2	5.9	4.9	5.3	7.6	7.9
21	7.2	7.2	9.5	4.3	5.6	6.6	6.6	5.9	3.6	5.3	10.2	6.6
22	7.2	7.8	7.6	4.3	4.9	5.6	6.2	5.9	3.9	5.3	9.5	6.6
23	7.6	8.2	5.9	5.3	5.3	4.9	5.9	5.3	5.3	6.6	8.5	6.9
24	6.2	7.9	5.9	5.6	8.2	3.9	4.9	5.3	4.9	6.2	8.9	6.6
25	6.9	7.9	4.9	4.6	9.5	3.9	4.3	5.6	5.3	6.2	8.9	6.9
26	8.2	6.2	4.3	3.6	8.5	3.9	4.3	6.2	4.6	5.9	10.2	7.2
27	6.6	5.6	4.6	6.9	7.9	4.9	4.3	8.9	*	5.9	10.8	7.9
28	5.3	4.9	6.2	7.6	6.2	5.3	4.3	5.6	3.9	5.6	10.8	7.9
29	5.3		6.9	6.2	6.2	4.9	4.6	4.6	3.6	5.9	10.5	6.2
30	4.3		6.2	5.6	6.6	4.9	5.3	3.3	5.6	6.2	10.2	5.9
31	3.9		7.6		6.6		5.6	2.6		5.9		5.3

* DENOTES MISSING DATA

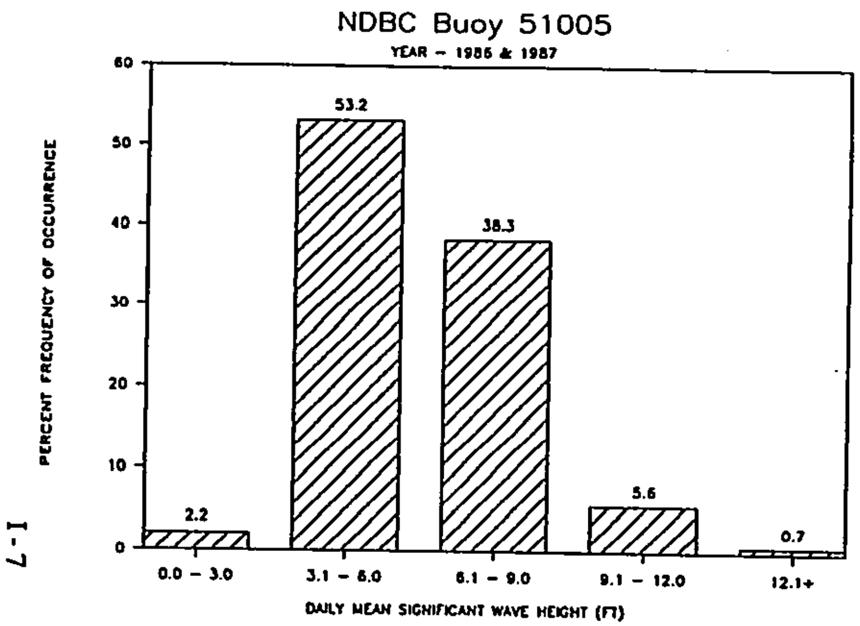


FIGURE 3

The maximum short duration wave heights as indicated by the hourly mean wave heights were generally 10 to 20 percent greater than the daily 24-hour mean wave heights on any given day. Periods of larger than typical wave heights generally occurred during the winter months (November through March), presumably as a result of North Pacific swell. There were two instances when the mean significant wave height exceeded about 14 feet for a 24-hour period (April 1986 and January 1987), and the maximum measured one-hour mean significant wave height was 17.7 feet.

The Alenuihaha Channel is generally the roughest channel in the Hawaiian Islands. The prevailing tradewind speed is increased as the winds are funneled between the tall mountains on the islands of Maui and Hawaii, resulting in high, steep seas in the channel. These high waves typically propagate northeast to southwest without very much of the wave energy refracting in the deep channel to reach the shoreline at the project site.

Kaunaoa Beach Data - Sea Engineering, Inc. conducted wave measurements in Kawaihae Bay (Kaunaoa Beach), about 5 miles north of the project site, at a location shown on Figure 4. A wave gauge was deployed in a water depth of 43 feet during the period between September 1983 and March 1984. The measured waves were altered from their deepwater characteristics as a result of refraction and shoaling effects due to the relatively shallow water depth at the wave gauge location, however the relatively close proximity of the measurement site to the Mauna Lani Resort and a similar exposure to deepwater waves makes this data useful for assessing possible nearshore conditions at the project site. A summary of the wave measurements is provided on Table 4. Wave heights ranged from 0.5 feet to 6.2 feet and the periods ranged from 5 to 28 seconds for the six-month winter period. Based on the measurements wave height exceedances for 50%, 10% and 1% frequency of occurrence are 2.6 feet, 3.3 feet, and 5.1 feet, respectively, with typical wave periods of 10 to 18 seconds.

TABLE 4

MEASURED WAVE STATISTICS AT KAUNAOA BEACH, HAWAII
PERCENT FREQUENCY OF WAVE PERIOD vs. HEIGHT

PERCENT FREQUENCY (%)
(9/16/83 - 3/26/84)

HEIGHT (FEET)	WAVE PERIOD (SEC.) 4.0- 6.0	6.0- 8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	16.0-18.0	18.0-20.0	20.0-22.0	22.0-24.0	24.0-26.0	26.0-28.0	28.0-30.0	TOTAL
0.0- 1.0	0.0	0.0	1.6	6.2	5.8	3.8	3.2	0.4	0.0	0.0	0.1	0.0	0.1	21.2
1.0- 2.0	0.1	0.0	1.6	11.3	15.0	9.5	5.1	0.5	0.0	0.3	0.0	0.0	0.0	43.4
2.0- 3.0	0.0	0.5	1.2	3.6	9.0	4.9	2.4	0.7	0.3	0.0	0.0	0.0	0.0	22.6
3.0- 4.0	0.1	0.3	0.5	0.7	2.2	2.9	0.8	0.4	0.0	0.0	0.0	0.0	0.0	7.9
4.0- 5.0	0.0	0.0	0.1	1.1	1.6	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	3.9
5.0- 6.0	0.0	0.0	0.0	0.0	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
6.0- 7.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
TOTAL	0.2	0.8	5.0	22.9	34.2	22.2	11.9	2.0	0.3	0.3	0.1	0.0	0.1	100.0

THE TOTAL NUMBER OF DATA = 758
THE RANGE OF WAVE HEIGHTS (FEET) : 0.5 - 6.2
THE RANGE OF WAVE PERIODS (SEC.) : 5.1 - 28.4

THE WAVE HEIGHT IS THE SPECTRALLY BASED SIGNIFICANT WAVE HEIGHT.
THE WAVE PERIOD IS THE PERIOD ASSOCIATED WITH THE SPECTRAL PEAK.

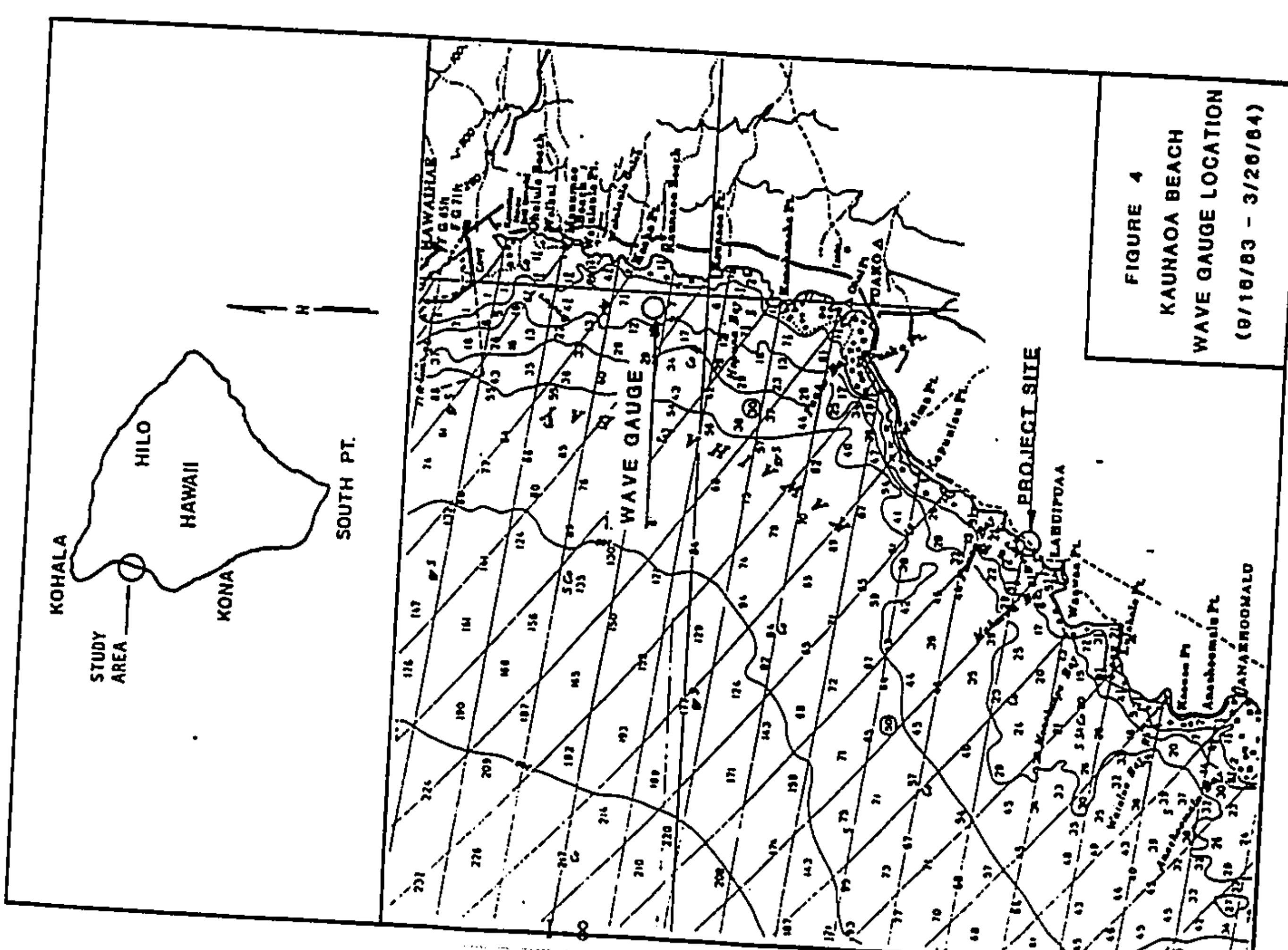


FIGURE 4
KAUNAOA BEACH
WAVE GAUGE LOCATION
(9/16/83 - 3/26/84)

EXTREME DEEPWATER WAVES

Extrapolation of Deepwater Wave Data

High wave heights with long recurrence intervals or return periods can be statistically estimated from a relatively short term wave record. The return period is the average expected duration between occurrences of a given wave height. Applying a Weibull distribution to the Barbers Point CDIP (Table 2) and the NDBC (Table 3A & 3B) wave data, high waves for given return periods were estimated as follows:

RETURN PERIOD IN YEARS	WAVE HEIGHT IN FEET CDIP	WAVE HEIGHT IN FEET NDBC
10	13	20
25	14	21
50	15	22

These results assume that a high wave occurrence lasts at least 24 hours.

Extreme storm wave conditions can also be predicted by analyzing the large waves reported in the SSHO data. Extreme wave conditions can be predicted using Gumbel's distribution function. Taking the smallest annual maxima of interest as 16.5 feet, 34 waves in the SSHO data were used to determine wave height versus return period as follows:

RETURN PERIOD IN YEARS	WAVE HEIGHT IN FEET
10	29
25	31
50	33

This analysis of SSHO data estimates the possible occurrence of extreme deepwater waves in the waters off Leeward Hawaii, but it does not mean that these waves would necessarily reach the project area since this analysis is based on extreme waves from all directions.

Storm Wave Hindcasts

The project area is also exposed to severe wave attack from passing tropical storms and hurricanes. The U.S. Army Corps of Engineers (1967) hindcasted wave heights generated by 17 severe storms during the period from 1947 - 1965, and seven of these affected the south and/or west shores of the islands. Marine Advisers (1963) also hindcasted deepwater wave conditions off the west coasts of Lanai and Molokai produced by the ten worst storms during the 15-year period from 1947 - 1961. Sea Engineering, Inc. hindcasted the deepwater wave characteristics for the Kona storm of January 1980, and the Hurricane Iwa (1982) deepwater wave heights near the project area. Storm wave data from these sources are summarized in Table 5.

TABLE 5.

HISTORIC STORM WAVE CHARACTERISTICS

Date	Deepwater Wave Height (feet)	Deepwater Wave Period (seconds)	Approach Direction
12/20/55	14.8	11	West
09/05/57 (Della)	18.9	21	West
12/02/57 (Nina)	20.0	13	South & West
01/18/59	14.0	10	South & West
08/06/59 (Dot)	22.5	12	South & West
01/07/62	13.6	11	South & West
01/17/63	12.0	10	Southwest
01/11/80	17.0	9	Southwest
11/23/82 (Iwa)	14.0	14	Southwest

CORRECTION

THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

EXTREME DEEPWATER WAVES

Extrapolation of Deepwater Wave Data

High wave heights with long recurrence intervals or return periods can be statistically estimated from a relatively short term wave record. The return period is the average expected duration between occurrences of a given wave height. Applying a Weibull distribution to the Barbers Point CDIP (Table 2) and the NDBC (Table 3A & 3B) wave data, high waves for given return periods were estimated as follows:

RETURN PERIOD IN YEARS	WAVE HEIGHT IN FEET CDIP	NDBC
10	13	20
25	14	21
50	15	22

These results assume that a high wave occurrence lasts at least 24 hours.

Extreme storm wave conditions can also be predicted by analyzing the large waves reported in the SSMO data. Extreme wave conditions can be predicted using Gumbel's distribution function. Taking the smallest annual maxima of interest as 16.5 feet, 34 waves in the SSMO data were used to determine wave height versus return period as follows:

RETURN PERIOD IN YEARS	WAVE HEIGHT IN FEET
10	29
25	31
50	33

This analysis of SSMO data estimates the possible occurrence of extreme deepwater waves in the waters off Leeward Hawaii, but it does not mean that these waves would necessarily reach the project area since this analysis is based on extreme waves from all directions.

Storm Wave Hindcasts

The project area is also exposed to severe wave attack from passing tropical storms and hurricanes. The U.S. Army Corps of Engineers (1967) hindcasted wave heights generated by 17 severe storms during the period from 1947 - 1965, and seven of these affected the south and/or west shores of the islands. Marine Advisers (1963) also hindcasted deepwater wave conditions off the west coasts of Lanai and Molokai produced by the ten worst storms during the 15-year period from 1947 - 1961. Sea Engineering, Inc. hindcasted the deepwater wave characteristics for the Kona storm of January 1980, and the Hurricane Iwa (1982) deepwater wave heights near the project area. Storm wave data from these sources are summarized in Table 5.

TABLE 5.

HISTORIC STORM WAVE CHARACTERISTICS

Date	Deepwater Wave Height (feet)	Deepwater Wave Period (seconds)	Approach Direction
12/20/55	14.8	11	West
09/05/57 (Della)	18.9	21	West
12/02/57 (Nina)	20.0	13	South & West
01/18/59	14.0	10	South & West
08/06/59 (Dot)	22.5	12	South & West
01/07/62	13.6	11	South & West
01/17/63	12.0	10	Southwest
01/11/80	17.0	9	Southwest
11/23/82 (Iwa)	14.0	14	Southwest

Hurricane Storm Waves

Hurricanes form near the equator, and in the central North Pacific usually move toward the west or northwest. During the primary hurricane season of July, August and September, hurricanes generally form off the west coast of Mexico and move westward across the Central Pacific. These tropical storms or hurricanes usually pass south of the Hawaiian Islands, with a northward curvature near the islands. However, they generally stay far enough offshore to only cause high surf or heavy rainfall as they pass. Late season tropical storms and hurricanes follow a somewhat different track, forming south of Hawaii and moving north toward the islands.

There are many recorded tropical storms or hurricanes which have approached the Hawaiian Islands during the past 35 years. Most of these storms passed well south or west of the islands, or weakened in intensity as they reached Hawaii, but there have been notable exceptions. Hurricanes Hiki, Della, Nina and Fico passed within about 200 miles of the islands, Dot passed over Kauai, and Iwa passed within 30 miles (25 NM) of Kauai. Hurricane Susan, with sustained wind speeds estimated at 120 knots was pointed directly at the island of Hawaii approaching from the southwest but died before coming within 200 miles of the islands. It is interesting to note that during the past 35 years only two hurricanes have actually struck the Hawaiian Islands, and both of these passed over or near Kauai. Fortunately, both hurricanes, Dot and Iwa, were weakening before reaching Kauai and were barely hurricane strength at the island.

The report Hurricanes in Hawaii (Haraguchi, 1984), prepared for the U.S. Army Corps of Engineers presents hypothetical model hurricanes for the Hawaiian Islands. The model Hawaiian Hurricane is defined as the probable hurricane that will strike the Hawaiian Islands in the future. The characteristics of the model hurricane are based on the characteristics of hurricanes Dot and Iwa.

Based on the characteristics of these model hurricanes, the hypothetical deepwater hurricane wave conditions were determined using the following equations:

$$Ho = 16.5 \exp (R\Delta P/100)\ (1 + 0.208\ \lambda V/\sqrt{U})$$
$$T = 8.6 \exp (R\Delta P/200)\ (1 + 0.104\ \lambda V/\sqrt{U})$$

where,

U = the maximum sustained wind speed in knots (U = 67 knots)

ΔP = Pn - Po in inches of mercury and Pn is the normal central pressure of 29.92 inches of mercury and Po is the central pressure of the hurricane. (Po = 28.8 inches of mercury)

V = hurricane forward speed in knots (V = 20 knots)

R = radius of maximum wind in nautical miles (R = 19 n.m.)

λ = a coefficient depending on the hurricane forward speed. (Use λ = 1.0)

The predicted wave height and period for the model hurricane are calculated to be 31 feet and 12.0 seconds.

This is a worst case condition, assuming that the hurricane passes very near to the west coast of Hawaii and the project site. The actual likelihood of this is estimated to be very low. It is more likely that the storm would pass some distance from the island, thus the wave height at the project site would depend on the storm track and decay distance over which the waves travel.

REFERENCES

Haraguchi, Paul. 1979. "Hurricanes in Hawaii." Prepared for USACOE, Pacific Ocean Division.

Marine Advisors, Inc. 1963. "Severe Storm Wave Characteristics in the Hawaiian Islands (1947-1961)." Prepared for the Department of Transportation, State Hawaii

Sea Engineering, Inc. 1986. "Hurricane Vulnerability Study for Kauai, Poipu and Vicinity and Waimea - Kekaha." Prepared for USACOE, Pacific Ocean Division.

Sea Engineering, Inc. 1984. "Wave Data Collection and Analysis." Prepared for Mauna Kea Beach Hotel, Island of Hawaii.

U.S. Army Engineer District, Honolulu. 1967. "Report on Survey of the Coasts of the Hawaiian Islands, Harbors for Light-Draft Vessels."

U.S. Army Corps of Engineers and State of California Department of Boating and Waterways. 1987. "Coastal Data Information Program." Monthly Report, January 1987 to December 1987.

CORRECTION

THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY

SEE FRAME(S)

IMMEDIATELY FOLLOWING

<u>REFERENCES</u>

Haraguchi, Paul. 1979. "Hurricanes in Hawaii." Prepared for USACOE, Pacific Ocean Division.

Marine Advisors, Inc. 1963. "Severe Storm Wave Characteristics in the Hawaiian Islands (1947-1961)." Prepared for the Department of Transportation, State Hawaii

Sea Engineering, Inc. 1986. "Hurricane Vulnerability Study for Kauai, Poipu and Vicinity and Waimea - Kekaha." Prepared for USACOE, Pacific Ocean Division.

Sea Engineering, Inc. 1984. "Wave Data Collection and Analysis." Prepared for Mauna Kea Beach Hotel, Island of Hawaii.

U.S. Army Engineer District, Honolulu. 1967. "Report on Survey of the Coasts of the Hawaiian Islands, Harbors for Light-Draft Vessels."

U.S. Army Corps of Engineers and State of California Department of Boating and Waterways. 1987. "Coastal Data Information Program." Monthly Report, January 1987 to December 1987.

APPENDIX J

GREEN TURTLES (CHELONIA MYDAS) AT MAUNA LANI RESORT, SOUTH KOHALA, HAWAII: AN ANALYSIS OF IMPACTS WITH THE DEVELOPMENT OF A SMALL BOAT MARINA

GREEN TURTLES (*CHELONIA MYDAS*) AT MAUNA LANI RESORT, SOUTH KOHALA, HAWAII: AN ANALYSIS OF IMPACTS WITH THE DEVELOPMENT OF A SMALL BOAT MARINA

Prepared For:

Mauna Lani Resort
P.O. Box 4959
Kawaihae, Hawaii 96743-4959

By:

Richard E. Brock, Ph.D.
Environmental Assessment Co.
1804 Paula Drive
Honolulu Hawaii 96816

October 1989

INTRODUCTION

Because of declining population sizes the green sea turtle (*Chelonia mydas*) was granted protection under the federally mandated Endangered Species Act in 1977-78. Green turtles as adults are known to forage and rest in the shallow waters around the main Hawaiian Islands. Reproduction in the Hawaiian population occurs primarily during the summer months in the Northwest Hawaiian Islands with adults migrating during the summer months to these isolated atolls and returning in late summer or early fall. In the main Hawaiian Islands green turtles will rest along ledges or in caves in coastal waters usually from 40 to 80 feet in depth during the day. Under the cover of darkness turtles will travel inshore to shallow subtidal and intertidal habitats to forage on algae or limu (Balazs *et al*. 1987). The normal range of these daily movements between resting and foraging areas is about one kilometer (Balazs 1980; Balazs *et al*. 1987). Thus from the present state of knowledge, an ideal green turtle habitat would have the presence of appropriate offshore resting areas (caves, ledges or undercuts) being located within a kilometer or less of a sufficient abundance of appropriate forage algal species situated in shallow water. Selectivity of algal species consumed by Hawaiian green turtles appears to vary with the locality of sampling but stomach content data show *Acanthophora spicifera* and *Amansia glomerata* to be quantitatively the most important (Balazs *et al*. 1987); the preferences may be due to the ubiquitous distributions of these algal species.

The proposed development of a marina on the grounds of the Mauna Lani Resort, South Kohala, Hawaii has raised a number of environmental concerns; among these is the potential impact that may occur to green turtles resident to the coastline affronting the resort. Green turtles are known to frequent the reefs offshore of the Mauna Lani Resort as well as along reefs at Puako to the north and the Kapalaoa area to the south (Brock 1988c). Indeed, one green turtle resting site offshore of Mauna Lani is well known and used as a dive tour destination; this site is locally called "Turtles".

This study was undertaken to assess the impact that the construction of the proposed marina and later the vessel operation might have on the green turtles resident to the reefs offshore of the Mauna Lani Resort. Specifically the objectives of this study were to:

1. Determine the extent of green turtle resting habitat in the vicinity of the proposed marina entrance channel;

2. Quantify the abundance of green turtles in this resting habitat;

Environmental Consultants, Inc. 1975. Preliminary environmental impact studies on the marine environment at Maunalua Bay.. Prepared for Kentron Hawaii, Ltd. 65p.

Hubbs, C.L. and A.B. Rechnitzer. 1952. Report on experiments designed to determine effects of underwater explosions on fish life. Calif. Fish & Game 38:333-366.

Water Resources Research Center. 1973. The quality of coastal waters, second annual progress report. WRRC Tech. Rept. No. 31. Univ. Hawaii, Honolulu.

Wright, D.G. 1982. A discussion paper on the effects of explosions on fish and marine mammals in the waters of the Northwest Territories. Canadian Tech. Rept. of Fisheries and Aquatic Sciences No. 1052. 16p.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders and E.R. Fletcher. 1975. The relationship between fish size and their response to underwater blast. Prepared for Defense Nuclear Agency. Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico. Rept. No. DNA 3767T. 44p.

(Mr. Larry Kaipaka, Mr. Norman Aninee, Mr. Francis Ruddle and Mr. Craig Hunter) pinpointed two resting sites: one just offshore of the Mauna Lani Resort (popularly known as "Turtles") and a second seaward of the fringing reef at Puako; these locations are shown

According to dive tour operators, this is the primary resting site for green turtles in the area. Some shelter exists under this mound (caves up to 1.2m in diameter) and the knoll is covered with P. compressa. Five turtles were seen at this site (Table

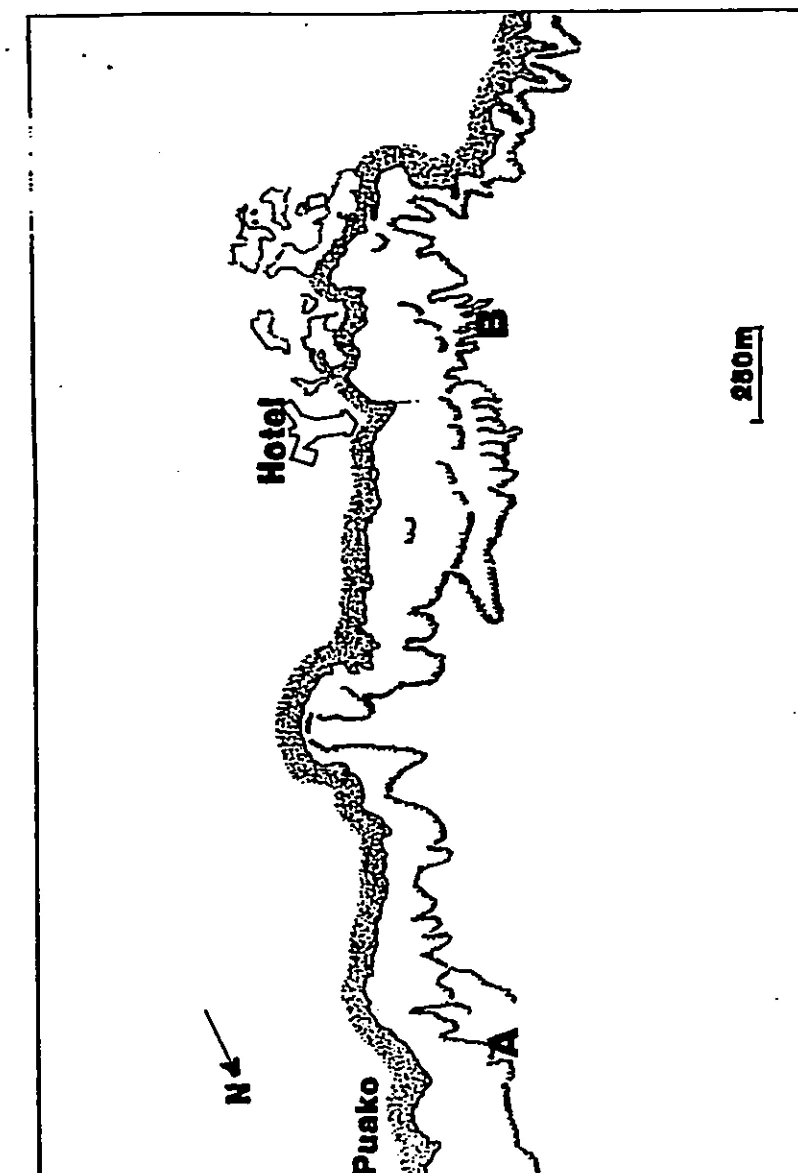


FIGURE 1. Map depicting the reef area encompassed by this survey affronting the Mauna Lani Resort and Puako area to the north. The seaward edge of the shallow fringing reef is shown and the shoreline is stippled. Twop major green turtle resting habitat sites examined in this study are depicted: site "A" is offshore of Puako and "B" is approximately 2.3km to the south. The latter resting area is locally called "Turtles". Figure drawn from an aerial photograph taken in 1984.

Table 1. Summary of the number and percentage (in parentheses) of green turtles observed in two resting sites (Puako and "Turtles") offshore of the Mauna Lani Resort and environs in underwater surveys by 10cm size classes (estimated straight line carapace lengths) from the 3 October 1989 survey.

Resting Location	Visibility (m)	Size Class (cm)	Number	Percentage
Puako	24	40-49	1	12.5
		50-59	5	62.5
		60-69	1	12.5
		70-79	1	12.5
		Total	8	
"Turtles"	20	50-59	8	80
		60-69	2	20
		Total	10	

1); three were resting on the top of the mound and two adjacent along one side but none were taking advantage of the existing shelter under the knoll. Water depth at the top of the mound is about 10m.

On an adjacent ridge of coral (about 30m to the north and approximately 50m seaward of the first knoll) is a second resting site identified by the dive tour operators. Here a Porites compressa mound rises about 3m from the substratum and water depth is about 12m. Four turtles were encountered resting on top of this mound (Table 1). A third area on the same ridge approximately 35m shoreward of the second site was identified as a turtle resting area. Here the Porites compressa mound (and ridge) is not as well developed and rises about a meter from the surrounding bottom. At the time of our sampling, no turtles were seen in this third area. Upon return to the dive vessel anchored about 60m inshore, we encountered one additional turtle (about 60cm carapace length) on the surface, making the total number seen in our survey of "Turtles" to be 10 individuals.

In an effort to find turtles not associated with either of these two resting sites described above as well as to identify additional concentration of resting turtles, a diver was slowly towed behind a vessel over much of the area between the Puako and "Turtles" resting sites; additionally towing was done from "Turtles" to the south across Makaiwa Bay to Waiakumalae Point (See Figure 2). The strategy in towing a diver was to meander the vessel in an out over substratum in 3 to 20m in depth; when a green turtle was sighted, the vessel was stopped and an estimate of its size and condition was made. The results of this towing are given Figure 2 and are described below. In total, 7 turtles were encountered in this towing; as part of the tow, the diver was taken over the primary resting site at "Turtles" and 3 turtles were seen at that location. Eliminating these three turtles (which were subsequently counted an hour later along with others in the SCUBA survey of "Turtles"), only four turtles were noted away from the two primary resting sites. These four turtles were all encountered resting on Porites compressa and their locations are given in Figure 2. the green turtle seen at point 1 (Figure 2) about 420m offshore of the north side of the Hotel building in 13m of water. This turtle had an estimated carapace length of 60cm; at point 2 about 160m to the south in 14m of water a second turtle (estimated 50cm carapace length) was encountered. A third turtle (about 55cm carapace length) was found about 650m offshore and slightly south of the hotel in 16m of water and the last turtle seen in the towing survey (point 4) encountered about 200m offshore of the small-boat ramp that services Mauna Lani Resort. This turtle was estimated to have a straight line carapace length of about 50cm and was in about 3.5m of water.

Local divers reported one sighting of a turtle offshore of Waiakumalae Point several weeks previously, thus a third SCUBA

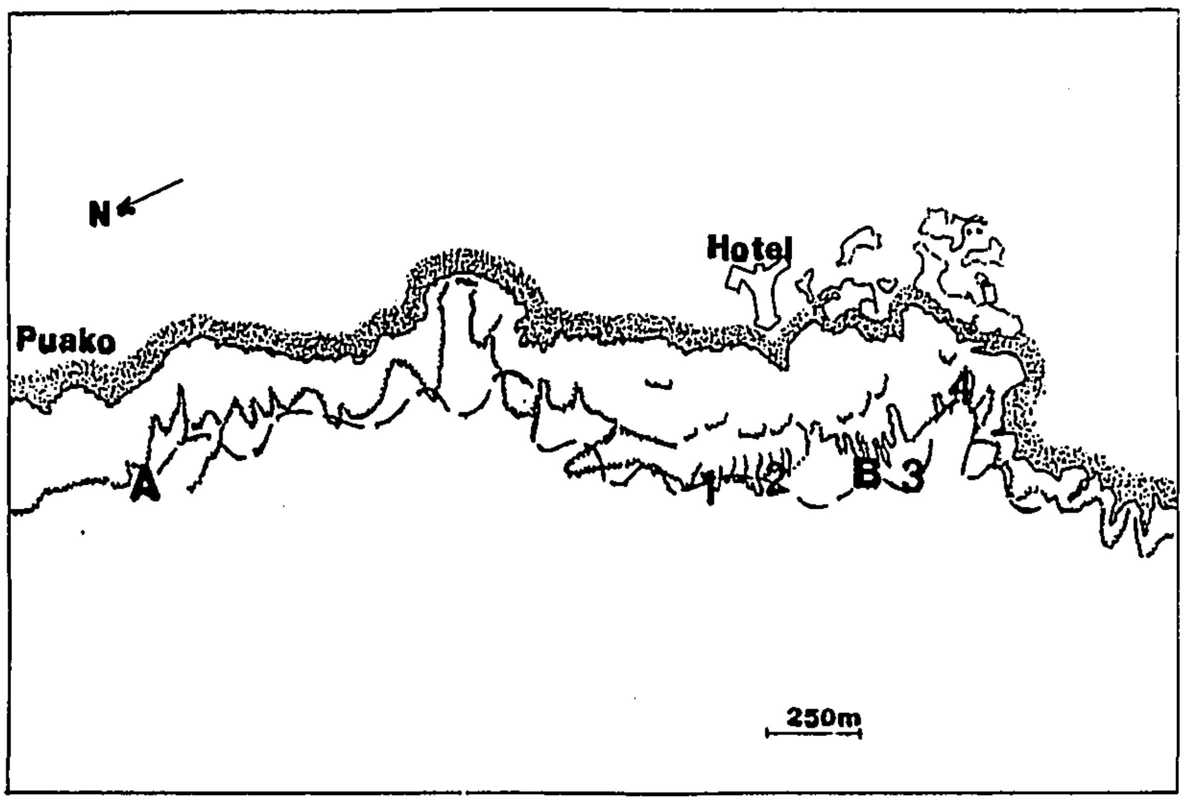


FIGURE 2. Approximate track of the vessel-assisted visual reconnaissance for green turtle resting sites (dashed line). Shown are the two major resting areas at Puako (A) and at "Turtles" (B). Numbers 1 through 4 show the approximate locations of four turtles encountered away from either of the major resting areas. Figure drawn from an aerial photograph taken in 1984.

dive was conducted in the area of the point (Figure 2). The substratum in this area is basalt dropping steeply away from about 2m to over 10m in depth. Below this depth the substratum slopes at about a 20 degree angle until sand is met with at 20m. On the slope are areas of Porites lobata and P. compressa. No turtles were encountered in this area.

Because of the interest in developing a marina, a visual reconnaissance was carried out at the site of the proposed marina and entrance channel from depth of 11m (about 250m offshore) to the shoreline and at about 80m to either side of the entrance channel. The mouth of the marina will be situated about 480m north of the resort building. The purpose of this survey was to determine the presence (or lack of) turtles and their forage in the vicinity of the proposed development. This effort found no turtles in the area but noted a fine mat of the alga, Grateloupia phuquoensis (maximum blade length 3mm) occurring in patches adjacent to shore on the basalt substratum in 0.5 to 1m in depth. It is not known if green turtles forage on G. phuquoensis; no evidence of browsing on this mat was seen. Grateloupia phuquoensis occurs in subtidal patches throughout the Mauna Lani shoreline.

During all underwater work an effort was made to locate any possible macrothalloid algae that may serve as forage for green turtles. Other than the small amount of G. phuquoensis noted above adjacent to the basalt shoreline and a single monospecific stand of Galaxaura acuminata found at the base of a vertical wall in 12m of water offshore of Waiakumalae Point, no macrothalloid algae were encountered subtidally. A careful search of the rocky intertidal from Makaiwa Bay north to the site of the Ritz Carlton (under construction) was made to note any possible sources of forage appropriate for green turtles.

Dispersed along the intertidal basalt rocks were found small patches (covering $100cm^2$ to $2m^2$) of several algal species including Ahnfeltia concinna, Ulva fasciata, Giffordia breviarticulata and Chaetomorpha antennina; these algae were usually less than 3mm in blade length unless they were located well back into a crevice into which grazing fish or browsing turtles had no access. These algal patches are widely scattered along the intertidal at Mauna Lani.

In an effort to determine where resident green turtles are feeding, a shoreline survey was conducted at last light on 3 October (tide height about +1 foot) and at first light on 4 October (tide height approximately +2 feet). One small turtle was encountered in the evening survey about 10m from shore approximately inshore of the "Turtles" resting site; no turtles were seen in the early morning survey.

No green turtles were encountered in this survey with tags

or noticeable deformities (tumors or fibropapillomas). The local divers did say that occasionally they see an individual turtle that has lost one of its foreflippers; this turtle was not seen in this survey.

DISCUSSION

The results of this study suggest that there is a resident population of green turtles offshore of the Mauna Lani Resort and nearby at Puako; our censuses on 3 October 1989 found 22 individuals. The majority of these turtles appeared to have selected one of two specific resting localities. A common point among all resting turtles encountered in this survey is their apparent use of Porites compressa as a preferred substratum; the reason(s) for this are unknown.

One interesting observation made on this survey was the apparent small size of the turtles encountered. Of the 22 turtles censused, one turtle was estimated to be in the 40-49cm size class, 16 in the 50-59cm size class (73% of the total), 4 in the 60-69cm size class and one in the 70-79cm size class. The calculated mean size for this sample is 57.3cm. As a comparison, green turtles censused in the West Beach, Oahu area had an estimated mean size close to 80cm (Brock 1988b) and at Hawaii Kai, Oahu a mean size of 58cm (Brock 1988a). In the author's experience, the green turtles encountered in West Hawaii are usually juveniles or subadults (similar to those at Mauna Lani). The estimation of length in the field on free swimming turtles is fraught with potential errors; but attempting to make some estimate on size provides some information that would otherwise not be available. In any case, no turtles were encountered in our survey that were estimated to be greater than 79cm in straight line carapace length. Balazs (1980) defined green turtle growth in the following way: juvenile - to 65cm straight line carapace length; subadult - 65 to 81cm straight line carapace length and adult (i.e., reproductively active) - 81cm and greater. Thus none of the turtles in the present survey were adults suggesting that the Mauna Lani and Puako habitats are appropriate for juveniles.

Potential impacts to green turtles by the construction of the marina facilities relate primarily to the proposed dredging of an entrance channel because of proximity to resident turtles. The results of this survey suggest that the closest resting aggregation of green turtles is at "Turtles" about 675m south of the proposed channel alignment. One potentially adverse condition could occur with the generation of turbidity with channel dredging.

Dredging will generate fine sedimentary material which will be carried about by currents creating a plume of turbid water.

Turtles may not favor turbid water and the increased turbidity caused by dredging could impact algal species on which the turtles forage. However as noted by Brock (1988b), the abundance of green turtles in an inshore resting habitat at West Beach, Oahu showed a significant inverse relationship with water clarity; when water clarity was high, few turtles were present in the resting area. Additionally, much of the turbid water at West Beach generated by that project or the adjacent Barbers Point Deep Draft Harbor is tidally influenced, flowing adjacent to the shoreline up and down the coast. Most of the known algal resources available to the West Beach turtles is found near the shore in the areas influenced by turbid water. Turbid water conditions at West Beach have been chronic since the commencement of the harbor expansion in the early 1980's, yet the green turtle population persists in the area.

At Hawaii Kai, Oahu Brock (1988a) noted that turbid water from the Hawaii Kai Small Boat Marina is often encountered on falling tide in the area where green turtles reside. Despite the poor clarity (sometimes less than one meter), turtles were often seen in the low visibility areas. High turbidity has been present in the Hawaii Kai area for years (WRRC 1973, ECI 1975, AECOS 1979) yet the turtles and their algal forage species are abundant in the area (Brock 1988a). These data suggest that turbid water is not a particular hinderance to green turtles, especially if it were transitory as associated with construction.

The lack of known significant amounts of algal forage resources for green turtles at Mauna Lani presents a perplexing picture. Juvenile and subadult turtles reside in the area and have done so for years (Mr. F. Ruddle, pers. comm.) yet our survey found that algal resources are nowhere abundant in shallow water. Short of taking stomach samples from turtles at Mauna Lani, the question of what they are feeding on will probably remain unanswered. Without further hard evidence, we suspect that the resident turtles at Mauna Lani are foraging on the thin algal mat that exists in the intertidal and shallow subtidal region adjacent to the rocky shoreline affronting the entire resort. Support for this hypothesis comes from the observation made by local divers that they occasionally see turtles adjacent to the shoreline. Our own shoreline survey at dusk found one turtle in this area. The fine algal mats referred to above occur in patches along the entire study site; greatest concentrations were in the vicinity of the hotel.

Marina entrance channel construction may require the use of explosives which, if improperly used could kill nearby turtles. Underwater explosions produce two types of pressure waves, the initial compression or shock wave and later the bubble-pulse or negative pressure wave (Cole 1948). The primary disturbance to the water during an explosion is the arrival of the compression wave from the reacting explosive. This disturbance is propagated

through the water as a pulse of compression with a leading front which carries the greatest energy. In an uniform medium this peak pressure wave undergoes an exponential decay that is a function of the type of charge, its size and distance from the site of detonation. The peak pressure from a given charge decreases with increasing distances and the rate of energy dissipation varies with environmental conditions. Thus in open water, the peak pressure from dynamite varies inversely as the 1.15 power of distance (Hubbs and Rechnitzer 1952). The peak pressure does not bear a linear relationship to the weight of the charge but varies as the one-third power of the charge size. Therefore, a 2.2kg (5 lb) charge yields about one-third the peak pressure that a 57kg (125 lb) charge does. Hubbs and Rechnitzer (1952) found that the greatest mortality to fish exposed to explosive charges was with the negative pressure wave.

When a fish with a swimbladder or an air breathing animal with lungs swimming underwater is exposed to the compression wave of an underwater explosion, the pressure increases reducing the volume of gas in the lung or swimbladder. As the external pressure is returned to ambient, the bladder or lung expands to its previous volume; however, as the later arriving negative or decompression wave impinges on the fish or animal, the pressure drops below ambient and the gas in the organ rapidly expands and in the case of fish, creates tensile stresses in the bladder wall. If the pressure decrease is great enough, the bladder membrane will be ruptured (Yelverton et al. 1975, Wright 1982). Since the compression and decompression waves from a blast arrive within a period of a few milleseconds, the organism does not have the opportunity to adjust the gas volume to compensate for the sudden pressure changes.

If explosives are to be used in developing the marina entrance channel, some precautions could be undertaken to lessen the impact to resident turtles. To minimize the chances of the propagation of a significant shockwave with any explosives, mitigating measures could include (1) the use of drilled holes in setting charges which would serve to direct the shockwave vertically in the watercolumn, (2) the use of small charges individually detonated with microsecond delays which lessen the magnitude of the shockwave, (3) and a program of careful searching and removal of turtles from the nearfield (within several hundred yards of the detonation site) just prior to the detonation. These methods were recently and successfully used in shoreline explosives work at West Beach, Oahu (Brock 1988b).

A potential negative impact to green turtles resident to the reefs at Mauna Lani and Puako may come through the operation of high speed vessels in the area. In the high speed movement of a vessel through a known turtle resting area, turtles could be possibly run over causing mortality. We have no information regarding the number of collisions between power craft and green turtles in Hawaiian waters or even if they do occur. Brock (1988a) noted that despite the heavy use of the Hawaii Kai Marina entrance channel by craft moving at excessive speeds, there was no evidence of turtles having been hit (i.e., none with marks to suggest collision with a propeller). Brock (1988a) also found that on the approach of a vessel at Hawaii Kai, turtles on the surface would immediately dive to avoid the boat. The primary resting site at Mauna Lani ("Turtles") is used by dive tour operators; the presence of divers and dive flags should serve to deter many vessels from moving at excessive speeds in the area and most of these boaters will probably give the site a wide berth.

With marina development could come a host of environmental pollutants derived from marina operations (e.g., oils, grease, gasoline accidently spilled) as well as from runoff from private homes (pesticides, herbicides, etc. and their breakdown products). Presently there are no quantitative data supporting or denying the existence of such pollutants from small boat harbors impacting Hawaiian green turtles. However, the marina development at Hawaii Kai may offer some insight to the problem. Marina construction at Hawaii Kai commenced in 1959 and urban growth as well as boat use has continued unabated since that time. Presumably, urban and marina pollution has been ongoing at Hawaii Kai for at least 25 years yet the green turtle population is quite large, has persisted and appears to be in a reasonably good state of health. Indeed, Brock (1988a) found 81 turtles on the reefs affronting the Hawaii Kai Marina.

A potential for negative impact on green turtles exists with the use of the primary resting site ("Turtles") as a dive tour destination. Use of the area by dive tour operators on the our one survey day (3 October 1989) was light relative to that at Hawaii Kai. Two boats with divers (number undetermined but probably no more than 6 per boat) conducted dives at the site. At Hawaii Kai, Brock (1988a) estimated that about 80 divers view the turtles on a daily basis with no defineable negative impacts. In the main resting site at "Turtles" we censused five individuals; three of these turtles were quite wary, leaving as we approached suggesting that either the carrying capacity of the site with respect to divers has been reached or that out of ignorance, some divers intimidate the turtles. If the latter hypothesis is correct, the illegality of harassing a federally protected species should be made known to the users.

In conclusion, the data gathered on the resident green turtle population offshore of the Mauna Lani Resort suggests that these juvenile and subadult turtles are apparently coexisting with man in an area that has received a moderate level of development over the last ten years. There is nothing to suggest that the population of green turtles at Mauna Lani is declining albiet the lack of a historical database. If further development

(i.e., creating an entrance channel and marina) at Mauna Lani is of concern with respect to green turtles, one only has to compare the proposed Mauna Lani Marina to that at Hawaii Kai on Oahu. The massive nature of change at Hawaii Kai (dredging, habitat alteration, increased runoff, etc.) commencing 30 years ago has not caused green turtles to abandon the habitat. High use by private boaters and commercial dive tour operators focusing on the green turtle resting habitat has not caused turtles to leave the area. In the case of Hawaii Kai, green turtles are one of the few larger vertebrate species to persist in the face of considerable environmental change. If what has occurred at Hawaii Kai provides a reasonable database, the small proposed marina development at Mauna Lani should not significantly impact the resident turtle population.

LITERATURE CITED

AECOS, Inc. 1979. Oahu coral reef inventory. Part B - sectional map descriptions. Prepared for U.S. Army Corps of Engineers, Pacific Ocean Division, Honolulu. 552p.

Balazs, G.H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. NOAA Tech. Memorandum NMFS, NOAA-TM-NMFS-SWFC-7. 141p.

Balazs, G.H., R.G. Forsyth and A.K.H. Kam. 1987. Preliminary assessment of habitat utilization by Hawaiian green turtles in their resident foraging pastures. NOAA Tech. Memorandum NMFS, NOAA-TM-NMFS-SWFC-71. 107p.

Brock, R.E. 1988a. Green turtles (Chelonia mydas) at Hawaii Kai, Hawaii: An analysis of the impacts with the development of a ferry system. Prepared for Sea Engineering, Inc., Makai Research Pier, Waimanalo, Hawaii. Environmental Assessment Co., 1804 Paula Drive, Honolulu, Hawaii. 26p.

Brock, R.E. 1988b. Green sea turtle population monitoring during blasting work at West Beach, Oahu. Final Report. Prepared for Alfred A. Yee, Division of Leo A. Daly, 500 Ala Moana Blvd., Honolulu, Hawaii. Environmental Assessment Co., 1804 Paula Drive, Honolulu, Hawaii. 15p.

Brock, R.E. 1988c. Proposed small-boat moorings for Anaehoomalu Bay, Hawaii: an assessment of biological impacts. Prepared for Transcontinental Development Co., P.O. Box 3028, Waikoloa Village Station, Waikoloa, Hawaii. Environmental Assessment Co., 1804 Paula Drive, Honolulu, Hawaii. 39p.

Cole, R.H. 1948. Underwater explosions. Princeton University Press, Princeton, N.J. 437p.

Environmental Consultants, Inc. 1975. Preliminary environmental impact studies on the marine environment at Maunalua Bay. Prepared for Kentron Hawaii, Ltd. 65p.

Hubbs, C.L. and A.B. Rechnitzer. 1952. Report on experiments designed to determine effects of underwater explosions on fish life. Calif. Fish & Game 38:333-366.

Water Resources Research Center. 1973. The quality of coastal waters, second annual progress report. WRRC Tech. Rept. No. 31. Univ. Hawaii, Honolulu.

Wright, D.G. 1982. A discussion paper on the effects of explosions on fish and marine mammals in the waters of the Northwest Territories. Canadian Tech. Rept. of Fisheries and Aquatic Sciences No. 1052. 16p.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders and E.R. Fletcher. 1975. The relationship between fish size and their response to underwater blast. Prepared for Defense Nuclear Agency. Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico. Rept. No. DNA 3767T. 44p.

APPENDIX K

IMPACTS ASSESSMENT FOR THE MAUNA LANI COVE DEVELOPMENT WITH REGARD TO HUMPBACK WHALES

AECOS 588

IMPACTS ASSESSMENT FOR THE MAUNA LANI COVE DEVELOPMENT WITH PEGARD TO HUMPBACK WHALES

Prepared For:

Mauna Lani Resort, Inc.
P.O. Box 4959
Kohala Coast
Island of Hawaii 96743-4959

Prepared By:

AECOS, Inc.
970 N. Kalaheo Ave., Suite A300
Kailua, Hawaii 96734

November 1989

Introduction

The site for the proposed Mauna Lani Cove is inland of the shore and a proposed entrance channel traverses a very shallow, nearshore basalt shelf -- neither will directly alter habitat utilized by marine cetaceans (whales and porpoises). However, deeper waters offshore of the marina are, at times, utilized by these animals. Of the greatest concern would be any potential impacts of the project on humpback whales (Megaptera novaeangliae), an endangered species which migrates into Hawaiian waters each November. A significant portion of the Northern Pacific humpback population resides until about April or May in the ocean around Penguin Bank, Molokai, Lanai, west Maui, and Kaho'olawe (Shallenberger, 1979; Tinney, 1988). Waters surrounding the Island of Hawaii are utilized to a lesser extent (McSweeny, personal communication), with the waters north of Kailua-Kona to Upolu Point (northwest coast) the area where humpbacks are seen most often around the Big Island (J. Mobley, pers. communication; Herman, Forestell, and Antinoja, 1980). Calving and breeding take place in State waters.

Impacts on Humpback Whales

The potential impacts on humpback whales of any proposed boating facility in Hawaii requires a multifaceted assessment. The Mauna Lani Cove, considering the physical facility by itself, will be carved out of low-lying coastal land -- thus, the location per se will not have any direct impacts on whales. Even construction related impacts could be lacking or minor, and can be mitigated through selection of methods and timing of certain major construction events. Blasting and perhaps other forms of submerged materials removal could represent a threat to whales in the near vicinity (see Impacts Associated with Blasting), although one which can be completely mitigated by limiting this activity to the months between April and October when the humpbacks are absent from Hawaiian waters.

Long-term environmental effects of the facility placement and general marina operation are unlikely to adversely impact whales or other cetaceans. Clearly, any demonstrable impact on these animals has to do with the use of the proposed facility by marine vessels, and not the facility itself. Here, the degree of impact will depend upon a variety of factors, including numbers of vessels using the facility, types of vessels, and the nature of activities that these vessels engage in after they leave the marina. While it is believed, or at least presumed, that harassment of humpback whales by boats in these waters is harmful to the well-being of an endangered population, there is less agree-

ment on the impact of boating generally (that is, boating activities conducted without any special orientation to the presence of humpback whales) on marine mammals. Regulations (National Marine Fisheries Service) have been formulated to control human/whale interactions, but these pertain to vessel/whale encounters, deliberate attempts to observe whales at sea, and a fairly broadly defined harassment of whales by boaters.

The evidence that vessel traffic has a negative effect on the distribution of humpback whales is variable and conflicting. Observations in the northwest Atlantic and northeast Pacific (e.g., off Newfoundland, Prince William Sound, Cape Cod) indicate behavioral changes by whales in response to vessels, but generally high fidelity to particular feeding areas despite considerable vessel activity. These studies included areas of major shipping, trawler activity, and commercial whale-watching from boats (Brodie, 1981; Hatkin and Hatkin, 1981; Hall, 1982; Mayo, 1982). On the other hand, Jurasz and Jurasz (1980) attributed the sharp decline in humpback whale numbers in Glacier Bay, Alaska in the late 1970's to an increase in boat traffic in that area. Nishiwaki and Sasao (1977) postulated that increasing maritime shipping activities around Tokyo Bay and northern Kyushu was the only explanation for the decline in catches by whalers seeking Baird's beaked whale (Berardius bairdi) and minke whale (Balaenoptera acutorostrata) respectively in each area.

Over the longer term, humpbacks tend to be found in regions remote from human activities, a reason cited for the relatively fewer numbers of whales seen off of Oahu as compared with the other Hawaiian Islands (Herman, 1979); although Norris and Reeves (1978) suggest natural cycles and whaling activities may actually be responsible for the decline off Oahu. In a short-term study, Bauer (1986) found no correlation between vessel and whale numbers, and no net movement offshore at Olowalu, Maui between 1983 and 1984. A six-year study by Glockner-Ferrrari and Ferrari (1985, 1987) off Maui suggests that a major offshore movement of mother-calf pods occurred during the late 1970's and early 1980's. These researchers attribute the decline to increases in boat traffic (vessel registrations in Maui County have risen sharply in the last decade), although their study alone cannot be used to determine whether the observed reductions in sightings is, in fact, correlated with vessel traffic. Further, no consistent baseline information or comparative studies on humpback whale habitat utilization around Maui is available to corroborate the trends reported by Glockner-Ferrari and Ferrari (Tinney, 1988; E. A. Mathews, personal communication).

Sufficient evidence from Hawaii and elsewhere demonstrates that boating (and other human) activity does have an impact on behavior of individual whales. Although much research remains to be done, the behavioral responses of humpbacks to vessels approaching within a kilometer or even several kilometers, are strongly suggestive that these mammals regard vessels as a threat (Bauer and Herman, 1986). Studies designed to establish the nature of the relationship between various kinds of boating activities and humpback whale behaviors are just starting (Forestell, pers. communication). Whether or not human activity short of whale hunting constitutes a threat to the whale population cannot be answered directly. Current assumptions are that behavioral responses to potentially disturbing human activities might be stressful to the individual whales; and stress can have a variety of adverse effects on growth, mating behavior, and reproductive success (Bauer and Herman, 1986).

From a practical standpoint, the problem of boating activities, boating facilities, and popular destinations and routes used by boaters is the focusing of human activities and attendant noise in areas which may be critical habitat for humpback whales. For the region surrounding Maui, Molokai, and Lanai, where most studies on humpback distribution and behavior are conducted, and where the populations of whales tend to concentrate, these animals are nearly always found inside the 100-fathom (182-meter) depth curve and mostly on the lee side of the islands (Herman and Antinoja, 1977; Wolman and Jurasz, 1977; Forestell, 1986). Shallower waters (in to about 10 fathoms or 18 meters) seem preferred, particularly by mother-calf pairs (Glockner-Ferrari and Ferrari, 1985; Forestell in Tinney, 1988). These waters generally are the more popular for most kinds of recreational and commercial boating (but not major shipping and most commercial fishing). The bottom topography off the West Hawaii coast provides less area of this preferred habitat as defined by depth range, than the Maui-Lanai-Molokai region where humpbacks are more abundant. The most notable areas off West Hawaii where mother-calf pairs are known to spend time nearshore are the waters off "Red Hill" and the old Kona Airport. However, humpback whales seasonally transit the West Hawaii coastal waters, and may be observed very close to shore in areas where the bottom falls away steeply, such as off Wa'awa'a Point (at the south end of the Mauna Lani Resort).

Baker and Herman (1981) have suggested that the humpbacks migrate through the island chain, appearing first off the Big Island, then moving northwestward past Maui, Penguin Bank, and then Oahu before leaving Hawaiian waters. Darling and Morowitz (1986) dispute this claim, providing evidence that at least some individual whales move back and forth between Maui and Hawaii during their stay in local waters.

The development of any kind of boating facility on a coast will have an effect of focusing boating activity in the immediate

area considering that the number of vessels transiting directly adjacent parcels of open water will increase. The focusing of human activities at destination sites (which are very widely scattered off West Hawaii) is largely independent of shore facilities location (although connecting routes would be effected). Thus, boating facilities development must be viewed as contributing to the an already recognized trend of increasing traffic in local waters. The effect of this trend on the humpback whales is poorly understood, although caution dictates that an adverse impact be assumed.

In this respect, it is clear that the impact of a boat harbor or marina on the humpback whale will be no more than, and probably much less than, the impact of a boat launch ramp facility alone. The impact of a public boat ramp will be greater because it represents an almost "unlimited" source of focused boating activity. The vast majority (more than 80%) of registered vessels in Hawaii are stored on land and enter coastal waters via a launch ramp facility. Further, the kinds of craft which are daily launched from ramps are more likely to be disturbing to local whale pods because of greater noise and speed (mostly power boats as opposed to sail craft, and mostly smaller craft with less experienced pilots as opposed to commercial operators) and type of activity engaged in (mostly recreational fishing and water sports in nearby waters as opposed to longer range, steady transient passages). These statements are generalizations because the collection of craft moored in the small boat harbors as well as the boats launched from ramps obviously represent a mixture of types engaged in the full range of activities to which recreational and small- to medium-sized commercial vessels are put in Hawaiian waters. Nonetheless, the distinctions are as important in assessing the impact potential represented by various types of facilities as is the facility's location relative to "essential" whale habitat.

With respect to the number of craft and their frequency and patterns of use, the Mauna Lani Cove will have relatively low impact potential as compared to comparable-sized public harbor and/or ramp facilities. Although a public boat ramp will be provided at Mauna Lani Cove, this ramp will not see heavy public launching traffic for several reasons. First, an established public boat ramp is located at Puako, only 3 miles northeast from the Mauna Lani project. This ramp is more suitably located for general public use and more accessible from most North Kona/South Kohala population centers. The ramp at Mauna Lani Cove will be provided with only limited parking and a use fee will be charged. The ramp at the proposed boat-landing is intended for the use of the Mauna Lani complex residents and hotel activities at the Mauna Lani Resort. A "private" ramp presently exists at Makaiwa Bay, about 1/2 mile south of the proposed new facility. The

Mauna Lani Cove slips and the boat-landing slips are intended for residents of interior parcels at Mauna Lani and transient sailors (inter-island and trans-Pacific). Most of the proposed facility is an inland waterway providing on-site boat slips for the owners of upscale private houselots.

Conclusions

Thus, while the Mauna Lani Cove will contribute to an increase in boating activity off the North Kona/South Kohala coast of the Big Island by virtue of providing docking facilities beyond what is presently available in the area, limitations imposed by the kind of facility that is planned, would also limit the magnitude of the increase. Proximity to an existing public boat ramp (Puako - 3 miles distant) and potentially expanding commercial facilities 7 miles northeast along the coast (at Kawaihae Harbor), place the proposed marina close to areas of existing foci of boating activity and suggest that the Mauna Lani Cove will not be a major contributor to boating traffic in this area.

Mitigations

As indicated above, the potential negative impacts of a boating facility on humpback whales resides primarily in the activities undertaken in offshore waters by the vessels porting at that facility. Negative impacts can be at least reduced through educational efforts and/or educational programs directed at marina users. These efforts should be the responsibility of the facility operator and could include signage erected during the seasonal appearance of humpbacks in local waters that remind boaters to exercise suitable caution outside the harbor. The signs might also include a list of the rules promulgated by National Marine Fisheries Service for vessels approaching whales and whale pods. Brochures for distribution and displays for viewing might also be prepared by the facility operator.

Bibliography

Baker, C., and L. Herman. 1984. Aggressive behavior between humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters. Can. J. Zool., 62: 1922-1937.

Bauer, G.B. 1986. The Behavior of Humpback Whales in Hawaii and Modifications of Behavior Induced by Human Interventions. PhD. dissertation, Dept. of Psychology, University of Hawaii. 314 p.

_____, and L.M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawaii. Prep. for National Marine Fisheries Service, Honolulu, Hawaii. 140+ p.

Brodie, P.F. 1981. Marine mammals in the ecosystem of the Canadian east coast. Proc. Offshore Environment in the 80s, St. John's Newfoundland. 10 p.

Chmura, G.L., and N.W. Ross. 1978. The environmental impacts of marinas and their boats. A literature review with management considerations. Marine Advisory Service, Univ. Rhode Island, Narragansett. 32 p.

Darling, J., and H. Morowitz. 1986. Census of "Hawaiian" humpback whales (Megaptera novaeangliae) by individual identification. Can. J. Zool., 64: 105-111.

Forestell, P.H. 1986. Assessment and verification of abundance estimates, seasonal trends, and population characteristics of the humpback whale in Hawaii. Final Report to the Marine Mammal Commission. 43 p.

Glockner-Ferrari, D.A., and M.J. Ferrari. 1985. Individual identification, behavior, reproduction, and distribution of humpback whales, Megaptera novaeangliae, in Hawaii. Marine Mammal Commissiuon, Rept. No. MMC-83/06.

_____ and _____. 1986. Identification, reproduction, and distribution of humpback whales in Hawaiian waters, 1984 and 1985. Final Report submitted to National Marine Mammal Laboratory, Natl. Mar. Fish. Serv., Seattle. 33 p.

_____ and _____. 1987. Report on the behavior of cow-calf pairs off west Maui, Hawaii. Abstract for the Sixth Biennial conference on the Biology of Marine Mammals. Miami, Florida, December 5-9, 1987.

Hall, J.D. 1982. Prince William Sound, Alaska -- humpback whale population and vessel traffic study, Seattle. National Marine Fisheries Service, final report. 14 p.

Herman, L.M. 1979. Humpback whales in Hawaiian waters: a study in historical ecology. Pac. Sci., 33: 1-15.

______, and R. Antinoja. 1977. Humpback whales in the Hawaiian breeding waters: population and pod characteristics. Sci. Rep. Whales Res. Inst., 29: 59-85.

______, P.H. Forestell, and R.C. Antinoja. 1980. The 1976/77 migration of humpback whales into Hawaiian waters: composite description. Rept. to the Marine Mammal Commission. NTIS Rept. MMC-77/19.

Jurasz, C., and V. Jurasz. 1980. Whale-vessel interactions in Glacier Bay National Monument, Alaska. p. 66, In: San Diego Workshop on the Interaction Between man-made noise and vibration and Arctic marine wildlife, 25-29 February 1980, a report and recommendations. Acoustical Society of America.

Matkin, C.O., and D.R. Matkin. 1981. Marine mammal survey of southwestern Prince William Sound 1979-1980. Rept. to the U.S. Fish and Wildlife Service, Anchorage.

Mayo, C.A. 1982. Observations of cetaceans: Cape Cod Bay and southern Stellwagen Bank, Massachusetts, 1975-1979. U.S. Dept. of Commer., NTIS PB82-186263, 68 p.

Nishiwaki, M., and A. Sasao. 1977. Human activity disturbing natural migration routes of whales. Sci. Rep. Whales Res. Inst., 29: 113-120.

Norris, K.S., and R.R. Reeves (eds.). 1978. Report on a workshop on problems related to humpback whales (Megaptera novaeangliae) in Hawaii. U.S. Dept. Commer., NTIS PB-280 794, 90 p.

Shallenberger, E.W. 1979. The status of Hawaiian cetaceans. Manta Corp., prep. for U.S. Marine Mammal Commission, Washington, D.C. 103 p.

Tinney, R.T., Jr. 1988. Review of information bearing upon the conservation and protection of humpback whales in Hawaii. Prep. for Marine Mammal Commission, Washigton, D.C. 56 p.

U.S. Dept. of the Interior, Fish and Wildlife Service. 1986. Planning aid letter, Olowalu navigation improvements study, Olowalu, Maui. Prep. for U.S. Army Corps of Engineer Division, Pacific Ocean, Fort Shafter, Hawaii. 35 p.

Wolman, A., and C. Jurasz. 1977. Humpback whales in Hawaii: vessel census, 1976. Mar. Fish. Rev., 39: 1-5.

APPENDIX L

ARCHAEOLOGICAL INVENTORY SURVEY, MAUNA LANI COVE PROJECT AREA, MAUNA LANI RESORT

Report 588-060589

Archaeological Inventory Survey
Mauna Lani Cove Project Area
Mauna Lani Resort

Lands of Kalahuipuaa and Waikoloa
South Kohala District, Island of Hawaii

PHRI
Paul H. Rosendahl, Ph.D., Inc.
Archaeological • Historical • Cultural Resource Management Studies & Services
305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 • FAX (808) 961-6998

Report 588-060589

Archaeological Inventory Survey
Mauna Lani Cove Project Area
Mauna Lani Resort

Lands of Kalahuipuaa and Waikoloa
South Kohala District, Island of Hawaii

by

Peter M. Jensen, Ph.D.
Associate Senior Archaeologist

Prepared for

Belt, Collins & Associates
680 Ala Moana Blvd., Suite 200
Honolulu, Hawaii 96813

November 1989

PHRI
Paul H. Rosendahl, Ph.D., Inc.
Archaeological • Historical • Cultural Resource Management Studies & Services
305 Mohouli Street • Hilo, Hawaii 96720 • (808) 969-1763 • FAX (808) 961-6998

SUMMARY

At the request of Ms. Anne Mapes of Belt, Collins & Associates (BCA), for their client, Mauna Lani Resort, Inc., Paul H. Rosendahl, Ph.D., Inc. (PHRI) has conducted an archaeological inventory survey of the approximately 130 ac Mauna Lani Cove project area at the Mauna Lani Resort in the Lands of Kalahuipuaa and Waikoloa, South Kohala District, Island of Hawaii. The field work was conducted April 10-19, 1989, and involved a 100% coverage pedestrian survey of all lands to be affected by the proposed new cove complex (c. 88 acres) and the adjacent relocated golf course holes (and enclosed area) (c. 45 acres). The objectives of the survey were to (a) identify all sites and site complexes present within the project area, including relocating and evaluating previously recorded sites, (b) evaluate the potential significance of all identified archaeological remains, (c) determine the possible impacts of any proposed development upon the identified remains, and (d) define the general scope of any subsequent archaeological work that might be deemed necessary or appropriate. Ultimately the study was designed to provide information appropriate to and sufficient for preparation of both Draft and Final Environmental Impact Statements (DEIS, FEIS).

Eighteen archaeological sites containing 46 component features were located within the 130-acre project area. Of the 18 sites, none could be unequivocally linked with previously recorded resources. Formal feature types present at the sites include caves, surface habitation features including C-shape enclosures and short linear wall segments, cairns, petroglyphs, abrader basins, one modified bedrock outcrop, and a historic rock fence. Functional types present include temporary habitation, markers, recreation, historic ranching operations, and production activities related to the manufacture of abraders.

Of the 18 identified sites, all have been assessed as significant for information content. For 17 of these 18 sites, no further work is considered necessary as the present inventory-level recording is considered adequate mitigation of potential project effects. For the remaining one site, additional data collection in the form of subsurface excavation of a portion of a cave floor deposit is recommended prior to finalizing a determination of the site's full information potential. No unusual, one-of-a-kind, or otherwise unique or especially well-preserved features were encountered within the project area, and preservation is not being recommended for any of the recorded resources. No sites possessing potential cultural value were identified during the field work nor in conjunction with background historic documentary research.

CONTENTS

ILLUSTRATIONS

TABLES

INTRODUCTION

BACKGROUND

At the request of Ms. Anne Mapes of Belt, Collins & Associates (BCA), for their client, Mauna Lani Resort, Inc., Paul H. Rosendahl, Ph.D., Inc. (PHRI) has conducted an archaeological inventory survey of the approximately 130-ac Mauna Lani Cove project area at the Mauna Lani Resort in the Lands of Kalahuipuaa and Waikoloa, South Kohala District, Island of Hawaii. The basic objective of this survey was to provide information appropriate to and sufficient for preparation of both Draft and Final Environmental Impact Statements (DEIS, FEIS).

Field work for the project was conducted April 6-19, 1989, under the supervision of PHRI Senior Associate Archaeologist Dr. Peter M. Jensen, assisted by PHRI Supervisory Archaeologist Robert Noah and PHRI Field Archaeologists Eric Pearthree, Mark Roe, and Eric Johnson. Approximately 225 man-hours of labor were expended conducting the survey fieldwork.

The present report comprises the final report of the current project. The report includes a scope of work, a description of the project area, a discussion of previous investigations relevant to the project area, a brief overview of Kalahuipuaa and Anaehoomalu prehistory, historical documentary research, a section on field methods and procedures, and site descriptions. The report concludes with evaluations and recommendations for all recorded sites.

SCOPE OF WORK

The basic purpose of an archaeological inventory survey, formerly referred to as a reconnaissance survey, is to identify—to discover and locate on available maps—all sites and features of potential archaeological significance present within a specified project area. An inventory survey constitutes the initial level of archaeological investigation. It is extensive rather than intensive in scope, and is conducted basically to determine the presence or absence of archaeological resources within a specified project area. This level of survey indicates both the general nature and variety of archaeological remains present, and the general 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 subsequent mitigation work as might be necessary or appropriate. Such work could include intensive data collection involving detailed recording of sites and features, and selected test excavations; and possibly subsequent 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 project area inventory survey was carried out in accordance with the standards for inventory-level survey recommended by the Hawaii State Department of Land and Natural Resources-Historic Sites Section/State Historic Preservation Office (DLNR-HSS/SHPO). These standards are currently being used by the Hawaii County Planning Department as guidelines for the review and evaluation of archaeological reconnaissance survey reports submitted in conjunction with various development permit applications.

The specific objectives of the present inventory survey were to (a) identify (find and locate) all sites and features present within the project area (including previously identified and as yet unidentified sites and features), (b) evaluate the potential general significance of all identified archaeological remains, (c) determine the possible impacts of any proposed development upon the identified remains, and (d) define the scope of any subsequent intensive data collection and/or other mitigation work that might be necessary or appropriate.

Based on a review of available background literature and records, and based on discussions with Ms. Virginia Goldstein and Mr. Tim Lui-Kwan— staff planner/historic sites specialist and deputy director, respectively, in the Hawaii County Planning Department, and with Dr. Ross Cordy—chief archaeologist with DLNR-HSS/SHPO, the following specific tasks were determined to constitute an adequate and appropriate scope of work for the present project area:

1. **Background Research.** Review available archaeological and historic literature and documentary resources (books, maps, journals, archival records, and other materials) relevant to the project area. In addition, assess the potential for any further more detailed historical research that might be appropriate in connection with any subsequent archaeological work;

2. **Archaeological Inventory Survey Field Work.** Conduct 100 % coverage variable intensity (10-30 m intervals) surface reconnaissance of the approximately 130-acre project area, with emphasis upon (a) relocation and evaluation of all previously identified sites, and (b) identification, recording, and evaluation of all previously unidentified sites;

3. **Limited Subsurface Testing.** Undertake limited subsurface testing at selected site(s) to recover suitable volcanic glass and charcoal samples for dating analyses; and,

4. **Data Analysis and Reports.** Analyze all field data, and prepare appropriate reports. The Final Report to include (a) a full descriptive account of survey findings, (b) interpretation and evaluation of the findings, and (c) specific recommendations for any further archaeological work that might be appropriate and/or required.

To facilitate management decisions regarding the subsequent treatment of resources, and to ensure achieving the ultimate objectives of the project, the significance of each identified archaeological site has been assessed in terms of (a) the National Register criteria contained in the Code of Federal Regulations (36 CFR Part 60), and (b) the criteria for evaluation of traditional cultural values prepared by the national Advisory Council on Historic Preservation. DLNR-HSS/SHPO uses these criteria to evaluate eligibility for both the State of Hawaii as well as the National Register of Historic Places.

PROJECT AREA DESCRIPTION

The Mauna Lani Cove project area consists of approximately 130 acres of land located on the dry, leeward coast of the Island of Hawaii. The project area extends from the shoreline between Pauoa Bay to the north and Makaiwa Bay to the south, inland to a point located several hundred meters east of the project alignment of the Mamalahoa Trail (Figure 1). The existing Mauna Lani Bay Hotel forms the southern boundary of the project parcel, while the future Ritz-Carlton Mauna Lani Hotel will be constructed immediately north of the project area. That portion of the project area located west of the Mamalahoa Trail is situated within Kalahuipuaa, while the land located on the east side of the Trail is within Waikoloa. Kalahuipuaa is an historically designated 'Ili subdivision of Waikoloa ahupua'a.

The project area is located within basaltic lava flows belonging to the Prehistoric Member of Mauna Loa's Kau Volcanic Series (Stearns and Macdonald 1946: Plate 1). The specific geologic formation which dominates the project area consists of an older, heavily weathered pahoehoe. This material dominates much of the landscape inland from and north of the fishponds at Kalahuipuaa, and south into and beyond Anaehoomalu. Travel in any direction across the smooth, occasionally ropey surface of the pahoehoe is unimpeded. Intact as well as collapsed and partially collapsed lava tubes and blisters are common occurrences, many of which provided excellent habitation shelters and natural crypts for the placement of burials. Moreover, while these vesicular lavas were not exploitable as material for adzes or other prehistoric tools which required a fine-grained texture, the scoriaceous material was suited to, and extensively used as, raw material for the manufacture of a variety of abraders. Such activity areas were documented in the early 1970s by Kirch within the project area (Kirch 1973; 1975), and occur in abundance immediately to the south at Anaehoomalu and adjacent portions of Waikoloa (see Jensen 1988 for recently completed in-depth archaeological analyses of Waikoloa abrader production areas).

The climate of this portion of western Hawaii Island is hot and arid, with annual rainfall averaging less than 10 inches (Stearns and Macdonald 1946: Figure 36). Since there are no exotic sources of water within the area, streams and watercourses are entirely lacking and hydrologic erosion has been minimal except along the shoreline.

Vegetation reflects the heat and aridity of the region as well as the general absence of well-developed soils. The Kaniku A'a flow, located south of the present project area, is nearly devoid of plants. Vegetation on the older pahoehoe substrate within the present project area is dominated by a few species of low grass and several varieties of creeping weeds. Pockets of stunted kiawe (*Prosopis pallida* [Humb. and Bonpl. ex Willd.]) have also taken root on the pahoehoe, but are interspersed at intervals ranging from a few meters to over one hundred meters. The inland terrestrial fauna is likewise restricted in types and numbers, being dominated by insects, lizards, rats, and introduced species including pheasant, quail, mongoose and goats.

The area around the nearby Kalahuipuaa Fishponds, located to the south, contrasts sharply with the present project area. Unlike the stark inland vegetation, vegetation at the fishponds consists of abundant coconuts (*Cocos nucifera* L.), milo (*Thespesia populnea* L.), dense grasses (ringing the Kalahuipuaa fishponds), and economically important plants such as sweet potato (*Ipomea batatas* [L.]), naupaka (*Scaevola sericea* [Vahl]), noni (*Morinda citrifolia*), and pandanus (*Pandanus odoratissimus* [L.f.]). Pond fauna is also quite diverse and, of course, provided much of the incentive for human habitation at this locale. Edible species of molluscs, crustacea, and fish abound in the open ponds,

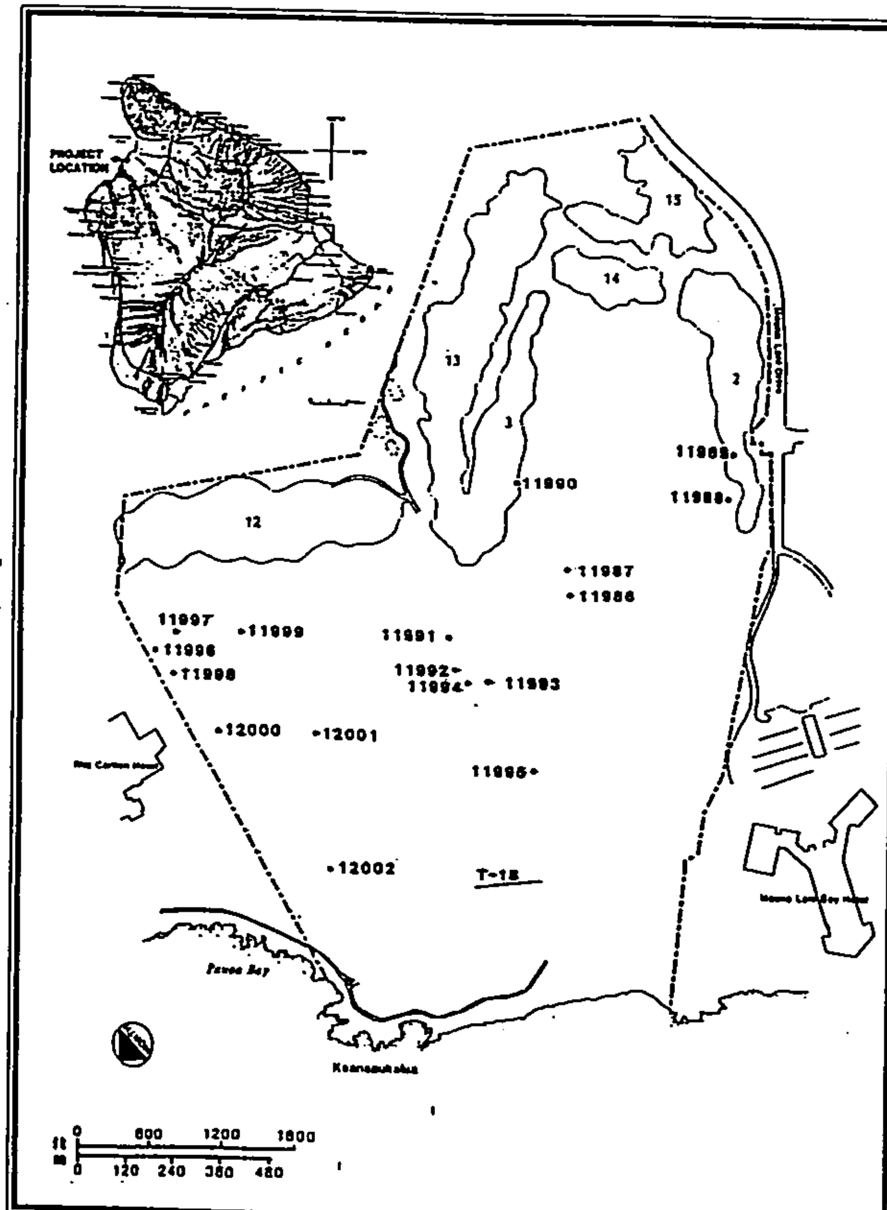


Figure 1. PROJECT AREA AND SITE LOCATION MAP

while brackish water molluscs, shrimp and bivalves predominate the smaller, closed systems. None of the present project area involved ponds or adjacent land segments, however, and the reader is referred to Kirch's excellent works (1973; 1975; 1979) for additional detail concerning the exploitation of pond resources and the specific nature of prehistoric habitation at and around these features.

As noted by Kirch (1975:10) and others (e.g., Bonk 1986; Hommon 1982), littoral and marine habitats vary considerably along the Kalahuipuaa shoreline. The rocky shore and steep cliffs fronting the ocean along the western-most portion of the present project area provided only limited areas suitable for habitation, and the reef system here is poorly developed. Nevertheless, Kirch did locate several archaeological sites within this area, including Sites E1-307, -308, -310, and -324* (Kirch 1973:23), all of which are discussed below. Even so, Kirch's earlier findings indicated that this section of shoreline did not contain a significant concentration of prehistoric cultural resources, especially in view of the better developed resource base which existed around Pauoa Bay immediately north, and Makaiwa Bay to the south. Again the reader is referred to Kirch's work (1975; 1979) for a summary and analysis of the local marine environment/resources, coupled with detailed findings concerning the technological and behavioral aspects of marine resource exploitation at Kalahuipuaa.

PREVIOUS ARCHAEOLOGICAL WORK

All of the land contained within the present project area has been subjected to previous archaeological reconnaissance survey. However, none of this land has been subjected to the level of scrutiny presently required for archaeological inventory by Hawaii State and County regulations. Cognizant of this situation, the County of Hawaii required that all project area lands be reexamined in conformity with today's standards for cultural resource inventory and assessment.

During the course of assembling pertinent background information, the following summary of previous archaeological work was compiled. This presentation includes a summary of Kirch's 1975 research at Kalahuipuaa, and appropriate modifications based on the results of more recent research within the area (e.g., Welch 1989; Jensen 1989). The summary of previous research concludes by selectively presenting pertinent background information from adjacent portions of southwestern Waikoloa and Anaehoomalu.

The earliest recorded archaeological investigations at Kalahuipuaa were conducted in 1929-30 by Reinecke (1930), who visited the area as part of a BPBM survey of the coast between Kailua, Kona, and Kalahuipuaa, South Kohala. Reinecke observed three clusters of sites beginning at a point on the high a'a cliffs opposite Nawahine Rock, proceeding northward past Honokoape Bay, and terminating at the main fishpond at Kalahuipuaa. Reinecke's Site 144 was described as located "...along this high coast of rough a'a; ten shelters at various intervals" (Reinecke 1930:28). Proceeding north, Reinecke (1930:28) made two additional observations at Honokoape Bay: "At Honokoape Bay, white sand drifted among the a'a...one shelter between [the pond] and the sea...[Site 145]" A second shelter was identified along the path leading from the Bay "...toward Kalahuipua'a." Reinecke's final observation of cultural material at Kalahuipuaa was at his Site 146, which he described as "A few shelters where the path descends from the a'a to the masonry breakwater of the chief pond at Kalahuipua'a" (1930:28). Reinecke concluded his observations by noting that "From here [at the pond] the growth of kiawe along the shore is so dense that it was useless to attempt any survey of sites unless one had a base near; nor is it likely that a painstaking search would reveal much." It seems fairly clear that Reinecke did not continue his coastal survey as far north as the present project area.

There are no known records of archaeological work within the project area between 1930 and 1955, when Kenneth P. Emory of the BPBM conducted test excavations in a large shelter cave site E1-342 (BPBM Number H100) (Emory Ms.). In addition to this work, Emory also undertook test excavations at a second cave shelter located c. 1,500 meters northeast of Pauoa Bay, and north of the present project area. The findings were never published, although fishhooks recovered from both sites were utilized in the island-wide analysis and typology of prehistoric Hawaiian fishing gear written by Emory, Bonk, and Sinoto (1959).

In 1962-3, BPBM returned to the area in order to conduct limited test excavations at a coastal midden site (HA-E3-2) at Puako Bay (Smart 1964). Although no age determinations were achieved, 29 portable artifacts and a quantity of faunal remains were recovered and analyzed. In 1964 BPBM recorded the extensive Puako petroglyph fields located north of the present project area (B.P. Bishop Museum 1964; Cox 1971).

During the latter part of 1970, the Hawaii Department of Land and Natural Resources (DLNR), Division of Parks

* B.P. Bishop Museum (BPBM) site designation: all site numbers prefixed by 50-Ha-E1- (50=State of Hawaii, Ha=Island of Hawaii, E=District of North Kona, 1=Kalahuipua'a).

and Historic Sites, conducted a reconnaissance survey of the 23-mile-long construction corridor for the proposed Queen Kaahumanu Highway between Kailua and Kawaihae. This survey, under the direction of Ching (1971), was focused on the 2,000-ft-wide study corridor. The corridor entered Waikoloa from the south at a point approximately 0.5 km east of the Kiholo-Puako trail, and proceeded northward through Waikoloa following a broad eastward arc. That portion of the corridor passing by Kalahuipuaa was located in excess of 1500 meters east of the shore, and over 300 meters east of the present project area.

Ching recorded a large number of sites along the highway corridor, and salvage excavations were undertaken by Rosendahl at several of those located within Waikoloa (Rosendahl 1972). Rosendahl's work focused primarily on defining the nature of aboriginal Hawaiian residential occupation and exploitation within "...the barren and seemingly inhospitable environment between the narrow, coastal habitation- and marine-resources exploitation zone and the more extensive, upland, habitation- and agricultural-exploitation zone." Although Rosendahl's work involved sites situated outside of the present project area, his findings are nevertheless relevant to the present undertaking because a portion of the present project area is also located between these two major resource exploitation zones. Rosendahl's findings confirm that the primary focus of occupation within the barren "intermediate" zone involved (a) use of temporary shelters by people travelling between the coastal and upland habitation zones, (b) temporary and extended residential occupation by people engaged in marine and other exploitation activities, and (c) storage facilities for marine exploitation gear and other recurrently used possessions. In terms of exploitation, Rosendahl's findings suggested (a) seasonal marginal agriculture in conjunction with coastal occupation and marine exploitation, (b) raw material procurement and initial fabrication of lava abrading tools, and possibly (c) bird catching (Rosendahl 1972:iii-iv). The results of limited dating suggested that these activities were undertaken between AD 1500 through the post-1778 contact period. One of the most significant findings was the possibility that a form of flood-water farming or dryland-irrigation horticultural crops dependent on intermittent seasonal flows of surface water took place in this barren area. The evidence for this activity was encountered in the form of several short terraces associated with temporary habitation areas and features. Rosendahl's findings were reviewed prior to undertaking the present survey in order to familiarize the project director and the survey crew with the full range of feature types which might be encountered within the area.

In 1972, BPBM conducted reconnaissance surveys for seven proposed construction areas within Waikoloa (Bevacqua 1972). Bevacqua's survey areas excluded all present project area lands (see Bevacqua 1972: Figure 1). Nevertheless, his findings, like Rosendahl's, have helped characterize the range and density of cultural material which might be expected to occur within the project area.

In 1973, Kirch directed a comprehensive survey of approximately 3,800 acres of land located within Kalahuipuaa, Lalamilo and Waikoloa. The survey was designed to assess the cultural resources of this large and diverse region, and resulted in the location and recording of 179 archaeological sites containing 449 separate features (Kirch 1973). Following the initial survey, several additional field examinations were undertaken in order to more accurately locate some of the previously recorded sites, and in 1975, intensive survey and excavation was undertaken at selected previously recorded sites (Kirch 1975).

A total of 1,152 man-hours was spent in the initial field survey of 1973 (Kirch 1975:5). Field work involved examining predetermined areas by walking transects of unspecified width. In 1975, a number of the 179 recorded sites were field checked in order to ensure locational accuracy. Volcanic glass was collected from six of the open sites during this period, and burials were removed from two burial caves and placed into a third. The latter was then sealed to prevent vandalism. In 1975, ten sites, all shelter caves with midden deposits, were excavated to bedrock. These sites represent both coastal and inland environments and large as well as small examples. This excavation sample is believed to represent c. 70% of all midden-bearing cave sites which exist within the entire 3,800-acre project area which Kirch had previously examined. Excavation, which proceeded in arbitrary 10-cm levels at all but one of the sites (where 5-cm levels were utilized), revealed relatively homogenous midden deposits mixed with rubble and aeolian dust. Screening was accomplished utilizing 1/4" mesh, and single floral and faunal analysis samples were recovered from each excavated site. As Kirch noted (1975:6), "...there is every reason to believe that the size of the excavated sample of archaeological deposits at Kalahuipua'a is fully representative of the total universe of existing sites."

The results of the survey and excavations formed the basis for Kirch's synthesis of areal prehistory, outlined below in the section of this report entitled "Overview of Kalahuipua'a Prehistory."

In 1982, Robert J. Hommon undertook data recovery excavations at a large cave site located near the Kalahuipuaa ponds (Site 342) (Hommon 1982). This site had originally been excavated in 1955 by Kenneth P. Emory, who excavated seven three-foot-square pits through the cultural deposit during three days of field work. However, Emory had recovered only a portion of the deposit, while the artifacts and other cultural materials were never analyzed or described. Subsequently, Kirch excavated an additional 10 sq m of surface area during his 1975 project. Included in Kirch's report was the recommendation that any future impacts to the site be preceded by additional data recovery, as significant data remained buried within the deposit. Eventually Kirch's recommendation was incorporated into a management plan for the site (Anonymous [Ahlo and Hommon] 1982:30-31). In 1981-82, Mauna Lani Resort, Inc., proposed to stabilize the cave roof at Site 342 by filling the interior with rocks. Since such action would have destroyed all or most of the remaining cultural deposit, it was necessary for the Mauna Lani Resort to implement provisions of the cultural resources management plan. Accordingly, Mauna Lani Resort, Inc., recruited the services of Science Management, Inc. to undertake the required additional data recovery. Dr. Robert J. Hommon was designated Project Manager, and the field work, involving excavation of an additional 7.5 sq m of surface area, was undertaken in 1982 (Hommon 1982). The work plan specified (1) excavation of the remainder of all significant deposits within the cave, (2) qualitative and quantitative analysis of all materials recovered, and (3) preparation of a final report which included a synthesis of previously unreported excavation results (i.e., Emory's 1955 unpublished excavation data).

Hommon's research expanded the data base concerning prehistoric use of the site, which in turn tended to support Kirch's earlier finding (Kirch 1975) that (1) the majority of the artifacts relate directly or indirectly to the exploitation of marine resources, and (2) the shallow inshore areas and the fishponds provided most of the food species of fish, molluscs and echinoderms which were being consumed by the local residents. The most significant aspects of Hommon's research, however, derived not from the artifactual, but rather from the botanical material. A significant percentage of the 20 identifiable genera and/or species recovered in his 1/8-in mesh screens suggested that the site's occupants arrived, or maintained close contacts with, inland areas, including some as far away as Waimea (Hommon 1982:48-50). In effect, Hommon was able to confirm the establishment in prehistoric times of a pattern of inland-to-coastal economic interdependence which either gave rise to, or had already acquired the essential attributes of, the classic ahupua'a pattern.

In September of 1984, the BPBM conducted an archaeological reconnaissance of c. 60 acres of state (c. 90%) and private (10%) lands located immediately south of the Puako petroglyph fields and north of Pauoa Bay (Welch 1984). Although the entire area was included within the 3,800 acres previously examined by Kirch (1975), unspecified levels of survey coverage required re-examination of the entire area in order to ensure compliance with new state and county regulations. The field work, supervised by Dr. David J. Welch, resulted in identifying one modern and six possibly prehistoric sites, all located on pahoehoe lava. Component features include cairns, basalt alignments (surface shelters), and a possible burial cave. None of these sites was located within the present project area, although Welch's findings tend to highlight the restricted range of site and feature types within some inland areas. Welch recommended intensive reconnaissance, data recovery and possible preservation of some of the component features in the event that future development is proposed at any of the sites.

A second reconnaissance was undertaken in 1984 which also involved lands adjacent to the Puako petroglyph fields. The survey, which involved two small parcels totaling c. 15,000 sq ft (Tomonari-Tuggle 1982:1), was undertaken in conjunction with a proposal by Mauna Lani Resort, Inc. to improve access to the large Puako petroglyph fields. Two sites were identified during the course of field work, one of which was an isolated petroglyph figure, and the second a 75-m-long section of low rubble wall (believed to be historic in age). Avoidance of direct impacts was recommended for the petroglyph panel. Additional reconnaissance was recommended for a silt-covered portion of the project area prior to any construction activity involving heavy equipment. None of the Tomonari-Tuggle project is located within the bounds of the present project area.

In October of 1985, two burials were encountered in coastal a'a during trenching for a sewer line servicing Mauna Lani Resort facilities. The human remains were disinterred by William J. Bonk and analyzed by Pietrusewsky (Bonk and Pietrusewsky 1986). Burial #1 was identified as that of a young adult Polynesian female, essentially free of pathology. Burial #2, represented by very incomplete remains, is believed to be remains of a pathology-free young adult Polynesian male. No additional evidence of habitation was observed within the vicinity of the two burials, and the land areas involved are not part of the present project area.

In May of 1988, William J. Bonk undertook excavations at previously recorded Site E1-323, located near the center of existing Mauna Lani Resort developments. The site, which consists of a collapsed blister with four small, shallow chambers, remained intact through May of 1988 due to Kirch's earlier preservation recommendations (Kirch 1985). Bonk's crew excavated a total of six 1-m-sq units within three of the chambers, with a surface collection undertaken in the remaining chamber. No artifacts were recovered, and a cultural deposit was encountered within only one of the test units, and hence within only one of the four chambers (Chamber A). Bonk interprets the site as a "...'way station', a temporary rest stop, a transient shelter for one or a small group seeking protection for but a brief period..." In view of the removal of all significant cultural material during the course of excavation, Bonk recommended archaeological clearance for proposed resort developments in relation to this site.

In January and February of 1988, David Welch completed intensive archaeological reconnaissance and data recovery research at the site of the proposed Ritz-Carlton Hotel site which is located immediately south of the present project area (Welch 1988a). Two sites had been previously identified within the hotel site area proper (50-10-11-11055* and -11058), and one additional site had been recorded along the route of the proposed access road (50-10-11-11057). Fieldwork involved intensive survey, mapping, dismantling, and excavation at the ahu cluster (Site 11058), mapping and coring at Keanapou fishpond and its vicinity (Site 11056), and data recovery excavations at two features associated with Site 11058. Upon completion of the fieldwork, Welch recommended additional survey around the pond edges following vegetation clearing, removal of some of the large petroglyph panels at Site 11057, and excavation at Site E1-304, depending on the actual level of impacts which might result from road construction near the site area. Since Welch's research involved data recovery at previously recorded sites, no new information was generated concerning site types and densities within the general project area.

In June and July of 1988, Welch undertook additional archaeological research at Mauna Lani (1988b) in order to supplement research undertaken and recommendations advanced earlier in the year (Welch 1988a). Additional survey and mapping was conducted in the vicinity of Keanapou Fishpond (Site 11056); at Site 11057 two test pits were expanded and four additional test pits were excavated; and at Site 11058, Feature 1 (cairn) was reconstructed. The completed field work met all requirements of the mitigation plan which had been developed for the project by the DLNR/HSS-SHPO and the County of Hawaii Planning Department. Welch's preliminary report (1988b) included a review of the July 1988 fieldwork, an overview of the work completed to date within the project area, and a set of final recommendations for further mitigation work and preservation of archaeological sites and features located within the area of potential effect for the proposed Ritz Carlton Hotel resort. A draft of the final report for the investigations at Sites 11056-11058 was issued in November of 1988, and the final report was completed in early 1989 (Welch 1989).

Welch's work provided little new information concerning site types and densities within the general project area, as archaeological survey constituted only a small component of his research. However, Welch has developed significant new information with respect to existing assumptions concerning hydration rates for volcanic glass. Specifically, Welch concludes that future dating results must more carefully consider the source of volcanic glass, as well as relevant temperature data, since both significantly affect rates of hydration and hence the age estimates derived from volcanic glass. As a consequence of using the traditional age calculations developed by Morgenstein and Michels, notes Welch, several problems exist with reconstructions of regional prehistory. Specifically, the earliest generally accepted dates for initial human use of Kalahuipuaa remain uncertain since existing hypotheses are based largely, and in some cases solely, on volcanic glass dates. Moreover, there is at present no way to substantiate the generally accepted hypotheses, also largely based on age estimates derived from volcanic glass, that the local population ceased to increase during the 18th century and that sites in west Hawaii were generally abandoned at this time as a result of population decline (Welch 1989:100). Welch is, in fact, more inclined to accept the notion that population growth probably continued uninterrupted during the 18th century, contrary to the existing hypothesis, with significant population decline probably not occurring until after western contact (i.e., after about AD 1800).

In concluding this review of previous archaeological research, it is important to consider some of the recent findings from areas located immediately south of the Mauna Lani Resort and the present project area. Considerable research has been undertaken during the past 15 years at Anaehoomalu and contiguous portions of western- and southern-most Waikoloa. The reader is referred to Donham's recent reconnaissance survey report (Donham 1987) for a

* State Inventory of Historic Places (SIHP) site designation system: all four-digit site numbers prefixed by 50-10-10 (50=State of Hawaii, 10=Island of Hawaii, 10=USGS 7.5 series quad map ["Anaehoomalu, Hawaii"]).

detailed summary of previous research within this area and for an overview of Anaehoomalu prehistory. Specifically relevant to the present project is an archaeological reconnaissance survey conducted by PHRI in November of 1986 (Donham 1987). This survey involved c. 820 acres of Waikoloa Beach Resort Expansion Areas and other selected parcels located between the Kiholo-Puako Trail and Queen Kaahumanu Highway. Two major terrain/lava types were discovered to exist within this large area. Kaniku aa flow dominates the northern two-thirds of that project area, while the southern and southwestern portion is dominated by an older, heavily weathered pahoehoe (Donham 1987: Figure 1). This weathered pahoehoe extends uninterrupted northward into, and in fact dominates, the surface geologic formation of the present project area. In consideration of this correspondence, Donham's findings were expected to be instructive with respect to the present survey. Nearly all (98%) of the sites located by Donham were found to occur within approximately 25% of the total area examined at Waikoloa, and most of this percentage was concentrated on the weathered pahoehoe within the southern and southwest-most portion of her project area. Moreover, within this formation, only a fairly narrow range of site types was represented, consisting primarily of areas of quarried scoria, abrader basins created during the manufacture of abraders, and small, temporarily-occupied habitation areas (surface features and small caves and overhangs) presumably associated with abrader manufacturing activities.

The Donham findings at Waikoloa suggested the following with respect to the present Mauna Lani Cove project area. Prehistoric and historic sites would likely be represented by small, temporarily-occupied habitation features (including small caves, overhangs, and surface structures such as C-shapes), quarried crevices and blisters from which scoriaceous pahoehoe was extracted, and abrader basins and associated debitage resulting from abrader manufacture. Additionally, however, Rosendahl's findings (Rosendahl 1972) had indicated that a minor agricultural component might also be present, consisting of low walls constructed to block erosion of shallow soil lenses which could be utilized for agricultural activities; such features should be encountered at the mouths of ephemeral (surface) drainages across the pahoehoe.

BRIEF SUMMARY OF KALAHUIPUAA AND ANAEHOOMALU PREHISTORY

The results of Kirch's 1973-75 survey and excavations at Kalahuipuaa formed the basis for his synthesis of areal prehistory. This synthesis had been developed in part on Barrera's previous work at Anaehoomalu (Barrera 1971). Both areas were clearly interrelated, and thus the previous research from both is relevant to the present project area. The results of previous research within these areas may be summarized briefly, as follows.

Chronology

For both Kalahuipuaa and Anaehoomalu, the evidence suggests initial human occupation by single extended families sometime between about AD 900-1000 at Anaehoomalu, and AD 1100-1200 at Kalahuipuaa. For both areas, population gradually increased, achieving a maximum permanent population at Anaehoomalu of between 35-50 persons, and between 100-150 at Kalahuipuaa. Lastly, for both areas, the dating results suggested one or more possible breaks in the sequence. Aside from these general correspondences, however, the two sequences may have been somewhat different.

At Kalahuipuaa, the most widely utilized model of local prehistory suggests that the period between about AD 1200 and 1600 was characterized by a continuous expansion in the number, and in the typological range, of occupied sites (Kirch 1979). This trend becomes particularly evident at around AD 1500, according to Kirch, and appears to confirm an increase through time in the local population, either through internal population growth, or through immigration. Moreover, while the earliest period of occupation at Kalahuipuaa (i.e., between AD 1100-1300) appears to have been marked by exclusive use of shelter cave sites, the period of "expansion" saw a wider range of feature types called into use for habitation, including specifically surface structural features. Kirch has interpreted these latter findings not only as signaling an increase in the resident population, but perhaps also a greater degree of permanence (Kirch 1975:180-182). After about AD 1650, however, the number of occupied features at Kalahuipuaa (both cave as well as surface features) is believed to have decreased. This event, also thought to have occurred at Anaehoomalu, may suggest a number of operative mechanisms, according to Kirch (1975:183): population growth in west Hawaii may have reached an equilibrium peak by c. AD 1600; competition for arable land or other resources had led to significant internal stress; and/or there was an increase in open conflict and competition during the two to three centuries preceding European contact.

As noted above, however, Welch's recent work at the Ritz Carlton hotel site (Welch 1989) suggests that the earliest use of the area remains uncertain since much of the early speculation was based solely on volcanic glass dates. Welch also observes that, until the problems with volcanic glass dating are at least partially resolved, there is no way to substantiate the generally accepted hypotheses that the local population ceased to increase during the 18th century. In fact, Welch is more inclined to accept the notion that population growth probably continued uninterrupted during the 18th century, and that decline did not set in until after western contact (i.e., after about AD 1800). This issue obvoulsy remains an area for continued research.

On final point concerning the area's chronology. In January of 1989, PHRI conducted data recovery excavations at a small, inland cave shelter site (Site 11267) in conjuction with proposed golf course expansion at the Mauna Lani Resort (Jensen 1989b). The excavation program resulted in recovery of approximately 85% of the entire deposit within the small cave, including three bulk samples containing datable charcoal. The midden suggested primary reliance on marine resources during temporary, short-term use of the cave site. Assay of the charcoal extracted from one of the bulk dating samples suggested that the cave was occupied between about AD 780-1420. While the midden and artifact fragments recovered support existing hypothese relating seaward Waikoloa's material culture to expolitative and settlement patterns emphasizing marine resources, the C-14 dating suggested much earlier use of small inland shelters than had been generally hypothesized, as use of such sites during the earliest period of prehistoric occupation within west Hawaii appeared clearly to have been documented at Site 11267. The implications of these findings for existing models of regional prehistory will remain unclear until additional examples of such inland shelters have been evaluated. The findings suggest, however, that the existing chronological framework and the most widely accepted model of regional settlement patters are both likely to be modified in conjuction with data recovery at sites which at one time were considered essentially devoid of any useful information.

The Prehistoric Population

Based on his analysis of the contents of 14 midden-bearing cave shelters at Kalahuipuaa, Kirch hypothesized the following: initial occupation was by a single extended family (c. ten persons) at site E1-355 which increased over the subsequent 300 years to a maximum of between 100-150 persons simultaneously utilizing several shelters. After c. AD 1650, the number of occupied caves/features decreased, indicating a concomitant decrease in the resident/visitor population.

The skeletal population recovered from E2-56 cave indicated an unskewed male/female ratio. The population's age profile could not, however, be accurately reconstructed in view of the under-representation of sub-adults. Metrical and discrete trait analysis of the Kalahuipuaa crania indicated a high correlation with the male burials from Anaehoomalu, with a lesser degree of correlation apparent between the female occupants of these two areas.

Settlement Patterns and Social Organization

Kirch proposed a model of prehistoric settlement pattern and social organization which accommodated most of the Kalahuipuaa data and which was consistent with ethnohistoric information. Noting that agricultural pursuits were generally not feasible at Kalahuipuaa, Kirch argued (1975:186) that either the prehistoric population also utilized upland arable lands for agricultural activities, or "...the population was in the unique position of being totally dependent on marine resources." Kirch felt that it was unlikely that the native population subsisted without a significant vegetable (carbohydrate) component. Moreover, the presence of upland plant remains at occupied coastal shelters seemed to document extensive prehistoric contacts between these two ecological zones (Kirch 1975). Since arable uplands exist only a few hours' walk from the coast, Kirch argued that "...a pattern of upland residence and agricultural activity, with repeated intermittent occupation of coastal sites in order to exploit marine (principally protein) resources, would be a maximizing strategy in the West Hawai'i ecosystem." Hommon (1982) subsequently obtained additional botanical evidence for a significant upland agricultural contribution to the diet of the coastal Kalahuipuaa occupants.

In Kirch's model, the shelter cave sites at Kalahuipuaa served as "...temporary residences for small groups exploiting the marine environment, for periods of a few days to perhaps several weeks or even months." He further interpreted the Kalahuipuaa site distribution pattern as representing a single integrated social unit, with each of the various sites/features representing minimal domestic units—i.e., households and extended families. Evidence for this, according to Kirch, is the presence of but a single shrine and only one main burial cave. Such features are known to have been traditionally associated with individual social groups.

It is interesting to note in this regard that at Anaehoomalu, Barrera (1971) had identified three main burial caves and documented a number of shrines. This would suggest the presence of more than a single social group within this area.

Site and Assemblage Variability, Material Culture and Technology

Utilizing a variant of the standard product-moment correlation coefficient, Kirch evaluated the relative homogeneity among the 14 midden-bearing caves at Kalahuipuaa, in terms of portable artifacts and midden constituents. Two Q-mode analyses were performed, one involving 25 major artifact categories, the second utilizing 11 midden categories. The results suggested a high degree of correspondence in the relative proportions of portable artifacts and midden categories at all 14 sites, with only a single possible exception.

With respect to the artifactual component, Kirch recovered a total of 1,361 portable artifacts (excluding volcanic glass flakes and volcanic glass and basalt cores); the sample included a variety of wooden objects. In excess of 75% of this artifact assemblage relates directly or indirectly to marine exploitation. The fishing gear tends to support the fishhook typology initially proposed by Emory, Bonk and Sinoto (1959), as well as temporal changes in fishhook head types which had subsequently been proposed by Sinoto (1962). However, unlike the sequence uncovered at South Point on Hawaii Island, the sequence at Kalahuipuaa (and at Anaehoomalu) suggested that there was an increase in rotating hooks over time with a concomitant decrease in jabbing hooks. Possible ecological implications of this change required additional midden data, and thus constitutes an important area for future west Hawaii research.

Diet and Economy

Kirch (1975) undertook detailed analyses of midden samples recovered from excavated cave deposits, and arrived at several tentative conclusions concerning possible changes in exploitative strategy and aspects of prehistoric settlement and occupation at Kalahuipuaa:

1. The relative percentage of major shellfish genera did not correlate positively with a site's proximity to fishponds. That is, regardless of distance from the Kalahuipuaa fishponds, all excavated deposits contained approximately equal proportions of shellfish in relation to other exploited food resources;

2. There appears to have been considerable consistency in relative species exploitation over the 500 year span during which Site E1-355 was occupied, although there was some evidence of a trend toward a decreasing representation of labrids and increasing representation of scarids; and,

3. Shellfish represented approximately 90% of the total meat and energy value of the midden. This figure correlated closely with other temporary marine exploitation sites for which similar midden data was available, and contrasts with available midden data from sites associated with permanent agricultural fields (such as exist at Halawa Valley, Molokai).

Collectively, these are the findings which led Kirch to conclude that Kalahuipuaa represented the marine component of a much larger system, analogous to the ethnohistoric ahupua'a, in which coastal and inland environments were linked in a pattern of economically- and socially-induced transhumance.

Specialized Activities Documented at Kalahuipuaa, Anaehoomalu and Waikoloa

Exposed at Waikoloa, Anaehoomalu, and Kalahuipuaa are extensive fields of an old (c. 3,000+ year old) scoriaceous pahoehoe which was well suited for numerous abrading and shaping tasks which confronted prehistoric Hawaiians. Not only do these exposures appear to represent the single most concentrated source of such material throughout all of the Hawaiian Islands, but the material is located adjacent to an abundant food resource (the coastal marine environment and the pond complexes at Anaehoomalu and Kalahuipuaa) as well as the Pacific Ocean (which would have enhanced the potential for movement of finished products). As earlier observed by Ching, the exploitation of this raw material clearly represents one of the most important specialized activities undertaken within all three of these areas.

In 1987, Jensen undertook detailed recording and data collection at several sites located within the "core" area of pahoehoe quarrying and abrader manufacture. This research, designed to formally evaluate several existing hypotheses which had been developed by Donham (1987), produced the following tentative conclusions (Jensen 1988:137-144).

Dating - Excavation at three small cave habitation shelters indicated that temporary occupation of small cave shelters associated with quarry/workshop activities began around AD 1400 and continued uninterrupted through AD 1801. A relatively large number of the volcanic glass samples dated to the latter portion of the date range—to between about AD 1700 and AD 1800—suggesting that the shelters were probably used more frequently during the latter period, which in turn implied an increase in the intensity of quarrying and abrader manufacturing activities during that period as well.

Production sequence and spatial patterning of associated features - The entire production sequence was represented—i.e., there was no significant spatial patterning in the several discrete processes beginning with quarrying and culminating in abrader production, except patterning which reflected certain environmental constraints. Reduction of quarried scoria to block-like, triangular, circular, and oval preform shapes all occurred on site, and it did not appear that initial reduction was an end in itself. Lastly, there was no evidence that the sequence of production processes had undergone significant evolution over time.

Political organization of production - Ching had originally (1971) suggested the possibility that Area Omega may have been set aside as an 'ili kupono, a land unit possessing unique attributes, with the occupants owing immediate allegiance to the chief of the 'ili rather than to the chief of any one of the several ahupua'a through which quarrying and abrader production activities were eventually extended. However, the 1988 project revealed no appropriate chiefly residency, nor any permanent habitation sites directly associated with quarrying and abrader production. There is at present, then, no evidence that labor within the Anaehoomalu area was conducted by a designated work force. Rather, the area appears to have been accessible to non-designated visitors, who in turn engaged in production primarily for their own use and/or for trade.

IMPLICATIONS OF PREVIOUS ARCHAEOLOGICAL RESEARCH FOR THE PRESENT PROJECT

So far as the present inventory project was concerned, the primary implications of prior regional research include the following:

1. Geomorphologically, the present project area represents an extension of the type of 3,000 year-old pahoehoe which characterizes much of Temporary Management Area (TMU) A at Waikoloa (land which is located immediately east of the Kiholo-Puako Trail) and which was the focus of the "Area Omega" quarries and workshops. Consequently, it might be expected that the types of features likely to be encountered within this portion of Kalahuipuaa would generally duplicate those documented elsewhere (e.g., in Jensen 1988) as being related to specialized abrader manufacturing. If true, at least some of the shelters (caves and surface features) would therefore likely contain only a restricted range of artifact types and should indicate temporary occupation by from one-three persons. On the other hand, the present project area also includes coastal lands, in consideration of which more intensive occupation of some of the habitation complexes could also be expected;

2. The chronological summaries presented above for Anaehoomalu and Kalahuipuaa suggested that most of the smaller cave and surface shelters which exist within the project area were most likely utilized between about AD 1400 and 1800. Midden deposits in larger habitation complexes, particularly along the coast, may date to latter part of this range, contain relatively thicker deposits, and exhibit a wider range and higher frequency of artifact types. Lastly, some inland caves might date the earliest period of occupation in west Hawaii (i.e., to between c. AD 800-1200; and,

3. As noted above, the Mauna Lani Cove project area had been subjected to previous survey work by Kirch (1973, 1975). Kirch's original site location map (1975: Figure 10, p. 23) was scaled to match an existing project area map, and the Cove project area was then drawn onto Kirch's site distribution/location map. This resulted in confirming that 28 sites had at one time been identified within the approximate bounds of the present project survey area (Table 1).

A summary of previously recorded sites within the Cove Project Area is as follows:

East Side of Trail: Total of ten sites, including six areas of abrader basin concentration without associated midden or portable artifact concentrations; two C-Shape surface shelters without associated midden or portable artifact concentrations; one storage cave without associated cultural deposits; one historic trail (King's Trail).

West Side of Trail: Total of 18 sites, including seven shelter caves without associated midden or other cultural deposits except light surface scatters of marine shell fragments; five C-Shape surface habitation shelters without associated midden accumulations; five areas of abrader basin concentration without associated midden or portable artifact concentrations; one burial cave without associated cultural deposits except for the burial remains, which were removed and reinterred at another cave site.

Kirch subjected none of these previously recorded sites to excavation or other data collection, save the work undertaken at El-321 burial cave in order to remove and reinter the remains. Kirch's previous findings within the present Cove project area closely reflect the set of expectations as to what might be found within the present project area, as generated from previous work within generally similar terrain at Anaehoomalu and southernmost Waikoloa. That is, most of the small shelters which Kirch had identified within the Cove project area were probably occupied in conjunction with abrader manufacturing activities, on a very short-term, temporary basis. As a consequence, these sites accumulated little if any habitation refuse.

Many of the sites no longer exist, having been destroyed in conjunction with golf course, landscaping and other construction activities associated with development of the Mauna Lani Resort. The only Kirch sites that were reidentified during the current project are El-320 (11987), El-326 (11988), El-43 (11989), El-39 (11990), and El-313 (11992). While approximately 30% of the Cove project area has already been developed and/or extensively disturbed in conjunction with previous Resort developments, the archaeological information losses have actually been minimal. This relates to the fact that none of the previously recorded sites located within the Cove project area contained midden or artifactual accumulations.

HISTORICAL DOCUMENTARY RESEARCH

Historical documentary research was conducted by Helen Smith, B.A., who examined and analyzed available archaeological and historical literature, and other documentary resources relating to the project area. Potential sources of information for the project area included early historical accounts by native and foreign residents of the Hawaiian kingdom, written descriptions by visitors, land records, and historic maps. Of these, several yielded information relevant to the Kalahuipuaa project area.

In general, documentary information on the project area is limited, mainly due to the project area's location. The project area is within the 'ili (land divisions) of Anaehoomalu and Kalahuipuaa, Waimea Ahupua'a, District of South Kohala. These are relatively isolated 'ili circumscribed by barren lava flows, thus not much was written about them. This is not to say the 'ili were unimportant. Anaehoomalu and Kalahuipuaa, compared to surrounding lands, are oasis-like, and in prehistoric times they were valuable for fishing, aquaculture, and other shoreline activities. Both ili include small strips of sand beach backed by brackish-water anchialine ponds that sustain a wide variety of marine life. Apparently, limited agriculture also took place in the 'ili. G.S. Handy writes:

> The coastal section of Waimea, now called South Kohala, has a number of small bays with sandy shores where fishermen used to live, and where they probably cultivated potatoes in small patches. Anaehoomalu, Waialua, Honokaope, Kalahuipua'a and Puaoa all have sandy strips along the sea; and there is an area of black cinder in this section where sweet potatoes might be grown in rainy seasons (Handy 1940:163).

According to Barrere, it was the scarcity of water rather than the poor rocky soils that was the most limiting factor, for crops such as sweet potatoes and gourds can be grown in exceedingly stony ground (Barrere, 1983).

Research into myths and legends concerning the project area turned up a few legends. In Pukui and Elbert's Place Names of Hawaii (1974), two submerged stones in Anaehoomalu Bay, known as Pohaku-ku-lua (stones standing double), are cited. One of the stones is said to be in the Kona district and the other in Kohala, which places the stones in the far southern portion of Anaehoomalu. Larry Kimura, Hawaiian cultural specialist and language instructor at the University of Hawaii at Manoa, has written a paper on these stones, from which the following legend concerning the stones, Legend of Kapalaoa, has been taken (Kimura 1964). Kimura learned of the legend from a local informant:

> Pele appears to residents as an elderly woman with a cane. She asks for some fish or salt and is refused even when requesting the gills/scales. She is told that "na ke ali'i no na mea a pau loa!" (Everything is for the king!) She left them and returned to Mauna Loa. Not long after, returning in the form of lava, destroying the royal family and those who denied her (sic).
>
> The chief, Pohakuloa and chiefess, Kuaiwa had nowhere to run but to the sea. Pele heaped lava upon them turning them into huge rocks visible today. As Kuaiwa fled, her niho palaoa fell. Pele immediately covered it. A semicircular stone still

Table 1.

PREVIOUSLY RECORDED BPBM SITES AND SITE TYPES

Previously Recorded BPBM Site Number		Site Type
EAST OF KING'S TRAIL		
E2	-36	C-Shape
	-37	Abrader Basins
	-38	Abrader Basins
	-39	"Storage" Cave (no hab. debris)
	-40	Abrader Basins
	-41	Abrader Basins
	-42	Abrader Basins
	-43	Abrader Basins
	-44	C-Shape
	-79	Mamalahoa Trail
WEST OF KING'S TRAIL		
E1	-306	Shelter Cave
	-307	Shelter Cave
	-308	Scattered Surface Midden
	-309	C-Shape
	-310	Shelter Cave
	-311	Shelter Cave w/ basins & petroglyphs
	-312	C-Shape
	-313	C-Shape
	-314	C-Shape w/ basins
	-315	Shelter Cave, w/ basins
	-316	Abrader Basins
	-317	Abrader Basins
	-318	Shelter Cave
	-319	Abrader Basins
	-320	Abrader Basins
	-321	Burial Cave, remains removed to E2-56
	-322	C-Shape
	-323	Shelter Cave (labeled "chambers")

visible at low tide represents Kuaiwa's lei. This is why the area is named Kapalaoa. Kapuaokalaulani, also known as Kalpukai fled carrying her food calabash. Her rock form has a shallow cave representing this ipukai (food calabash). This is why she is also known as Kaipukai.

Meko, another rock, is seldom visible because it is right below the surface of the water. Sources insisted (with no reason for such) that Hawaiian women of the old days wove mats in a cave at the base of Meko.

There is also a shark hole called Ka Lua o Ka 'Ehu. This shark [within the shark hole] guarded the people who entered waters from Kapalaoa to Keawewai, South Kohala.

Another legend concerning the project area is also about the boundary between Kohala and Kona. This legend, found in Barrere (1971), concerns Lonoikamakahiki, the 16th-century ruling chief of Hawaii Island. Lonoikamakahiki is credited with the erection of the boundary marker called Ahu-a-Lono, situated between the districts of North Kona and South Kohala. Ahu-a-Lono is indicated on most survey maps. According to the story, Lonoikamakahiki was deserted by his followers while on a visit on Kauai, and he was befriended by a Kauai man by the name of Kapaihi-a-Hilina. Kapaihi accompanied Lono when the latter returned to Hawaii, and Kapaihi became the chief's closest advisor. In jealousy, other chiefs poisoned Lono's mind against Kapaihi, to whom Lono eventually denied admittance to his presence while at Kahaluu, Kona. Kapaihi then left Kona to return to Kauai, and Lono, almost immediately repenting for his action, went in search of Kapaihi:

> When Lonoikamakahiki set sail on his search for his friend, Kapaihiahilina had already arrived at 'Anaeho'omalu and soon afterwards was followed by Lonoikamakahiki and others. Lonoikamakahiki saw Kapaihiahilina sitting on the sand beach when the canoes were being hauled ashore...When they came together...Lonoikamakahiki made a covenant between them...built a temple of rocks (he wahi ahu pohaku) as a place for the offering of their prayers and the making of oaths to Lonoikamakahiki's god to fully seal the covenant (Barrere 1971).

According to Fornander, the temple of rocks (or mound [he ahu] of rocks [pohaku]) was named Keauhualono, signifying its erection by Lonoika- makahiki (Fornander 1916-1917:360-362).

S.M. Kamakau, Hawaiian scholar and historian, provides two accounts from legends which mention the Anaehoomalu-Kalahuipuaa area. Kamakau cites the waters of Kalahuipuaa as a favorite of Umi-a-Liloa, son of the first unifier of Hawaii Island:

> He [Umi-a-Liloa] was noted for his skill in fishing and was called Pu'ipu'i a ka lawai'a (a stalwart fisherman). Aku fishing was his favorite occupation, and it often took him to the beaches from Kalahuipua'a to Kamaula. He also fished for 'ahi and for kala. He was accompanied by famed fishermen such as Pae, Kahuna, and all the chiefs of his kingdom (Kamakau 1961).

Kamakau also cites Kalahuipuaa as he tells of how Kamehameha I prevented lava flows from entering the fishpond at Kiholo:

> The fishpond at Kiholo, North Kona was constantly being threatened by lava flows when Kamehameha was the ruler of the kingdom of Hawai'i. A flow came down close to the pond at Kiholo; Kamehameha brought a pig and cast it in; the "fires" stopped...It was a time, perhaps, when the fires had ears and would listen to the words of men. Today...Kalahuipua'a in South Kohala...[is] covered with lava...and [in] lands that have never known the desolation of lava flows, there are places where lava has overrun the land (Kamakau 1964:67).

A search through missionary accounts and the writings of early historians uncovered only the above indirect legendary references to the project area; however, two early historic references directly concerning the project area were found in Clark (1985), who quotes George Bowser writing in 1880, and in Hommon (1981), who quotes J.S. Emerson. Bowser writes:

> From Puako to Kalahuipua'a is about four miles. The traveler cannot mistake the road in this district, as the paths are always plainly marked. The road to Kalahuipua'a is along the beach, and is in good order. A few shrubs are growing along the route, but on my left are several waterholes and two small groves of coconut trees (Clark 1985).

According to Barrere (1971), most if not all of the trails in Anaehoomalu were marked out by the prehistoric inhabitants of the land.

J.S. Emerson noted, while surveying Kalahuipuaa for the government in 1880, that Kamehameha I "had" a small village at Keawanui (in back of a small cove northeast of Lahuipuaa Pond). He writes that Keawanui Landing "...was the landing of Kamehameha I" (Hommon 1981). Kamehameha is said to have rewarded Isaac Davis, one of his foreign advisors, for his services with a large tract of Waikoloa, which had been previously held by the branch of Waimea chiefs represented by Papa, wife of Isaac's son George He'eu Davis. But Anaehoomalu and Kalahuipuaa with their valuable fishponds were detached from the gift (Hommon 1981).

Land Use Information

Although some historical documents refer to Anaehoomalu as an 'ili (land division) of Waikoloa ahupua'a, this is disputed by other documents. During 1865 hearings to determine the boundaries between Waimea and Waikoloa, a witness named Kanehailua testified that "Waikoloa is an 'ili of Waimea ahupua'a..." (Barrere 1983). In addition, several maps at the Department of Land and Natural Resources Survey Office indicate this latter division to be the most common. Of the references consulted during the current project, all except one cite Anaehoomalu and Kalahuipuaa as 'ili designated during the Great Mahele to the alii. The exception is Marion Kelly's citation of Waikoloa (of which Anaehoomalu and Waikoloa are part) as an 'ili kupono (land division paying tribute to the ruling chief): "The other of these 'ilikupono, namely Waikoloa, was given by Kamehameha as a separate property to Isaac Davis..."(Kelly 1956).

Much of the documentary information concerning land use in the vicinity of the project area refers to the fishponds of the area. Malcom Love, caretaker of Kalahuipuaa during the 1940s, 1950s and 1960s was interviewed by a man named Tommy Holmes in 1981 (Hommon 1981). Love told Holmes that an old man named Akau (now deceased) of Kawaihae told him that the ponds of Kalahuipuaa long ago belonged to Kamehameha I and that they were strictly managed. According to Akau, the fish raised in the ponds were carried by runner to Kamehameha when he was in Kohala, and people were not allowed to remain in the vicinity of the ponds as they passed through the area (Hommon 1981). In 1987, an evaluation of ancient Hawaiian fishponds was conducted by Russ Apple and William Kikuchi for the National Park Service. Their intent was to determine which ponds were worthy of historical preservation. Out of 56 fishponds listed statewide, Lahuipuaa Pond in Kalahuipuaa was considered the second most important. Besides it being maintained continuously throughout the centuries, they cited it as being owned by alii through the 1970s.

The fact that Anaehoomalu and Kalahuipuaa were selected by alii during the Great Mahele reflects the importance of the fishing grounds and the producing fishponds of the two 'ili. With an 'ili went konohiki fishing rights—which extended one mile out to sea (or to an offshore reef where there was one) for the full length of the 'ili; the chief of the 'ili reserved either one species of fish or one-third of each seasonal catch as his own, and made the rest free to the dwellers of the land.

It is possible that, except for pond caretakers, commoners were not allowed to live at Kalahuipuaa after the ponds became the exclusive property of high ranking chiefs (Clark 1985). This is supported by Barrera (1974:3) who write:

> ...utilization of adjacent land units may have differed quite radically...for example, the upper Lalamilo are contains nearly 3,500 features, while Waikoloa, separated from Lalamilo by a stone wall, contains only 240 features.

Later, following the time of Kamehameha I, Kalahuipua and Anaehoomalu descended to Kamehameha III, who later gave the 'ili to Kalama, his queen (Cox 1970). Queen Kalama Hakaleleponi's lands descended to her uncle, Charles Kanaina, in Native Testimony (LCA 4452:4 for Anaehoomalu and 4452:3 for Kalahuipuaa). Upon Kalama's death in 1870, Kanaina claimed the estate and it was distributed to him as the sole heir (Estate of Queen Dowager H.K. Kapahuhaili, Probate No. 1562, Order Appointing Accounts and Decree of Distribution, R. 103-105). In the inventory of Kalama's estate, Anaehoomalu was appraised at $300 for its 869 acres and Kalahuipuaa's 359 acres were appraised at $800. This equals about $.35 an acre for Anaehoomalu and $2.23 an acre for Kalahuipuaa. Clearly, at this time Anaehoomalu was considered quite worthless; land values in this era were based not only on the productivity of the soil but also on that of the sea, and sea coast and inland fishponds (Barrere 1971). Kanaina died intestate in 1877. Many claimed to be heirs of his estate. The probate court determined that 25 persons were rightful heirs, but they could not agree upon division of Kanaina's properties and asked the court to appoint a commissioner to sell the lands, with the proceeds going to the heirs (Estate of Charles Kanaina, Probate No. 2426, Order Approving Accounts and Decree of Distribution, R. 1107-1118).

Samuel Parker (grandson of John Palmer Parker, founder of Parker Ranch) purchased Kalahuipuaa for $1,500 and Anaehoomalu for $1,000 at public auction in 1882 (Bu. Conveyances, Bk.91:243). Perhaps from the time of its original purchase by Samuel Parker, Anaehoomalu has served as a recreation and fishing area for Parker Ranch

employees; it also served as a place from which to get pond fish for Parker Ranch luaus (Barrere 1971). According to Barrere, from early on, from perhaps before the time of Samuel Parker's purchase, there was a caretaker who lived near the fishponds. A "hut" depicted on a Government Survey Map of 1880 (see Figure 2) was probably the resident of the caretaker(s) of Kuualii and Kahapapa ponds. Marion Kelly, while investigating Kaloko Fishpond in Kona (in Jan. 1970), was told by her informant, Keanaaina, that he and his father used to go to Anaehoomalu in the late 1930s and early 1940s to get fry from the ponds with which to restock Kaloko Pond (Kelly 1956). The ponds were partially demolished by the tsunamis of 1946 and 1960, and Parker Ranch restored them to use. Since the last caretaker retired, in 1965 or 1966, the ponds have no longer been maintained (Barrere 1971).

Francis I'i Brown bought Kalahuipuaa from members of the Woods family (Parker heirs) and Richard Smart in 1932 and 1936. Brown is credited for upgrading and modifying the ponds, and keeping them functional after his purchase.

The ponds and the fish they held were immortalized by Helen Desha Beamer in her song "Ke Keawaiki Hula," written c. 1940:

'Au'au i ka wai
O kahi punawai o ka'aina
Ia wai aniani hu'ihu'i
Lamalama ke kino ke ea mai.

Ua inu a kena
I na wai o ka'aina
Ua'ai i na i'a ono loa
Mai Kalahuipua'a a ke kai.

Bathe in the fresh water
of that spring in the lava hollow
This water glassy and chill
Glowing the body on emerging.

Drink till satisfied
of the waters of the land.
Eat the most delicious fishes
From Kalahuipua'a by the sea.

In 1972 Brown sold Kalahuipuaa to Orchid Island Resort, Inc. and subsequently to Mauna Lani Resort, Inc.

FIELD METHODS AND PROCEDURES

Survey fieldwork was conducted April 6-19, 1989, under the supervision of PHRI Associate Senior Archaeologist Dr. Peter M. Jensen, assisted by PHRI Field Archaeologists Robert Noah, Mark Roe, and Eric Johnson. The field work consisted of an inventory survey and detailed recording of sites and features.

Inventory Survey and Recording

The field survey was conducted by walking systematic transects across 100% of the undeveloped and ungraded portions of the project area parcels, with transect spacing maintained at 10- to 30-meter intervals. Ground surface visibility was excellent throughout the project area, with vegetation limited to occasional clumps of Fountain grass and kiawe thickets. No obstacles were encountered during the course of the field survey, and all survey objectives were satisfactorily achieved.

Detailed recording was completed for all sites encountered; the recording included site and feature dimensions, delineation of surface and subsurface midden deposits where present, and preparation of scaled maps and drawings of individual features. Sites were described on standard PHRI site and feature record forms, and distinctive features were mapped to scale and were photographed using 35 mm black-and-white film (PHRI Roll Nos. 89-588: Rolls 1-2).

Once identified and recorded, the locations of all archaeological sites and features were determined using a combination of aerial photographs and metric tape and compass, and the locations were then plotted onto a master project area map and the aerial photograph. Each recorded site and/or the primary feature within each site complex was marked with pink and blue flagging tape, as well as an aluminum tag bearing the site number, date, the letters "PHRI," and the PHRI project number (89-588). PHRI temporary site numbers (prefixed by "T-") were assigned to all recorded sites located within the project parcels; subsequently, T- sites were assigned permanent SIHP site numbers, as indicated in Table 2.

Table 2.

CORRELATION OF SITE NUMBERS

PHRI (1989) Site Number	BPBM (Kirch 1973) Site Number	SIHP Number
T-1	-	11986
T-3	E1-320	11987
T-4	E1-326	11988
T-5	E1-43	11989
T-6	E1-39	11990
T-7	-	11991
T-8	E1-313	11992
T-9	-	11993
T-10	-	11994
T-11	-	11995
T-12	-	11996
T-13	-	11997
T-14	-	11998
T-15	-	11999
T-16	-	12000
T-17	-	12001
T-19	-	12002

FINDINGS

A total of 18 archaeological sites containing 46 component features was located within the 130-acre project area. Only five previously recorded sites could be linked these 18 sites; however, these linked sites represent only tentative assignments. No sites could be unequivocally linked with previously identified sites, but estimations have been made based on the available site descriptions and the locational information contained in Kirch's original survey report.

Formal feature types at the 18 recorded sites include caves, surface habitation features including C-shape enclosures and short linear wall segments, cairns, petroglyphs, abrader basins, one modified bedrock outcrop, and a historic rock fence. Functional types include temporary habitation, markers, recreation, historic ranching operations, and production activities related to the manufacture of abraders. No burials, or burial remains, are believed to exist at project area sites. Previously recorded trail Site E2-79 could not be relocated, as discussed more fully in the conclusion section of this report.

Table 3 provides a summary of the distribution of all 18 sites and their associated features. Included in the table are temporary site designations, deleted and/or subsumed site numbers, the types and numbers of features present, and appropriate totals. At sites which possessed basins and petroglyphs, a number appears in parentheses next to the number "1." The number in parentheses represents the approximate number of individual basins present, or the number of individual petroglyph figures observed. Regardless of the number of individual basins or petroglyphs represented, however, each occurrence of basins or petroglyphs at a particular site has been counted as a single feature representation in the totals calculated in Table 3.

SITE DESCRIPTIONS

Site 11986 (T-1) - Caves (2), Cairn, Abrader Basins (112)

This site consists of two small caves (Features A and B), one cairn (Feature C), and approximately 112 abrader basins (Feature D) distributed over an area measuring c. 11 m east-west by 14 m north-south. The complex is located within a fairly isolated area near the center of the project area, several hundred meters northeast of the existing Mauna Lani Resort complex parking lot. Both caves were formed within circular blisters, when the centers of which collapsed exposing an overhanging ledge of varying depth. The sheltered portion of Feature A cave measures approximately 4 m wide by 2 m deep. For Feature B, three sheltered areas are situated around the periphery of the collapsed blister, including a primary chamber measuring c. 7 m wide and 3 m deep, and two smaller chambers flanking both sides of the primary chamber, each measuring approximately 2 m wide by 1.5 m deep. No subsurface accumulation of midden or other cultural material exists within either cave feature, and the only indications of prior human use and activity are the abrader basins which occur in abundance on top of and between the two shelters, and a light surface scattering of marine shell fragments located immediately in front of, and scattered about the surface on top of, the two small caves. The scatter was not collected as it was deemed archaeologically insignificant.

Feature C cairn is located 2 m southeast of Feature B cave, and consists of c. 20-30 small pahoehoe cobbles piled so as to form a marker (probably for the adjacent cave feature) measuring 0.72 m in diameter at the base, and 0.4 m in height. Scattered about the immediate area, and on top of the two caves, are 112 well-developed abrader basins. However, no additional cultural materials were observed anywhere in association with these bedrock features.

Site T-2

T-2 components were subsequently incorporated into Site T-1.

Site 11987 (T-3) - Abrader Basins (215)

Site 11987 represents a cluster of approximately 215 abrader basins occupying an expanse of smooth pahoehoe roughly circular in plan view and measuring c. 20 m in diameter. Occasional marine shell fragments were observed on the surface within the area, as were several small collapsed lava blisters which might have functioned as temporary habitation shelters. However, none of the blister overhangs contained any direct evidence of prior use or occupation, and thus none were recorded as separate cultural features. This site may represent previously recorded Site E1-320, described in Kirch's original survey report as a concentration of well-developed abrader basins (Kirch 1973: Table 3).

Table 3.

SUMMARY OF IDENTIFIED SITES AND FEATURES

Field Site No.	Notes/ Comments	SIHP* Site No.	Overhang/ Caves	Surface Habitation	Cairns	Petroglyph (Fig. Rep.)	Abrader Basins	Modifed Outcrop	Historic Fence	Total at Site
T-1	No deposit	11986	2	--	1	--	1(112)	--	--	4
T-2	Now in Site T-1	N/A	--	--	--	--	--	--	--	N/A
T-3	--	11987	--	--	--	--	1(215)	--	--	1
T-4	No surface deposit	11988	--	1(c), 1(lin.)	--	--	1 (55)	--	--	3
T-5	No deposit	11989	1	--	--	--	1 (15)	--	--	2
T-6	No deposit	11990	1	--	--	--	1 (23)	--	--	2
T-7	--	11991	--	--	1	1(2)	1 (25)	--	--	3
T-8	No surface deposit	11992	--	1(c), 1(lin.)	1	--	--	1	--	4
T-9	No surface deposit	11993	--	6(c)	2	--	--	--	--	8
T-10	No surface deposit	11994	--	1(c), 1(lin.)	--	--	--	--	--	2
T-11	--	11995	--	--	--	1(3)	--	--	--	1
T-12	No surface deposit	11996	--	4(c)	--	--	--	--	--	4
T-13	No surface deposit	11997	--	2(c)	--	--	1 (5)	--	--	3
T-14	--	11998	--	--	1	--	--	--	--	1
T-15	No surface deposit	11999	--	3(c)	--	--	--	--	--	3
T-16	No surface deposit	12000	--	1(c)	--	--	--	--	--	1
T-17	No surface deposit	12001	--	2(c)	--	--	--	--	--	2
T-18	--	12402	--	--	--	--	--	--	1	1
T-19	Deposit present	12002	1	--	--	--	--	--	--	1
	Total:		5	24	6	2(5)	7(450)	1	1	46
	% of Total:		11	52	13	5	15	2	2	100

* SIHP Numbers prefixed by 50-10-10- (c) = C-shape (lin.) = Linear surface habitation feature

Numbers in parentheses represent estimate of individual figures/basins present

Site 11988 (T-4) - C-Shape, Linear Wall, Abrader Basins (55)

Site 11988 consists of two surface habitation features (C-shape and linear wall) directly associated with c. 55 well-developed abrader basins, and may correspond to previously recorded Site E1-326 (Kirch 1973: Table 3). Feature A C-shape was constructed on the smooth pahoehoe surface by stacking cobbles four to six courses high and wide, forming a shelter wall measuring 4 m in length, 0.75 m maximum width, and 0.25 m maximum height. The interior of the C-shape consists of roughly 2.0 sq m. Feature B wall is dimensionally nearly identical to Feature A, although the rock alignment is not curved. No cultural deposits have accumulated behind either of these surface habitation features. Immediately northeast of these two features are a 55 abrader basins. The existing Mauna Lani Golf Course is located approximately 3 meters to the south of Feature B wall.

Site 11989 (T-5) - Cave, Abrader Basins (15)

This site appears to correspond with previously recorded Site E1-43, and consists of a single small habitation cave directly associated with approximately 15 abrader basins. The cave has formed in a large lava blister which measures c. 25 m in diameter; the center of the blister has collapsed, and a habitable space exists under a portion of the intact ledge of the blister on the blister's northeast side. This shelter area measures 9 m in width, extends 7 m back from the dripline, and averages 1.25 m in height. Although the available space was suitable for habitation, no significant cultural deposit is within the sheltered area or in front of the opening. The only evidence that the feature may have been utilized is the presence of a very light surface scattering of marine shell fragments, and the c. 15 abrader basins scattered around the surface of the intact portions of the blister. The scatter was not collected as it was deemed archaeologically insignificant.

Site 11990 (T-6) - Cave, Abrader Basins (23)

This site may correspond with previously recorded Site E1-39, described as "a storage cave" (Kirch 1973: Table 3). The site, located close to the northern boundary of the eastern portion of the project area, consists of a small blister cave which has formed in a largely collapsed lava blister. The sheltered space under the intact portion of the blister's ceiling, which contains a sparse surface scattering of marine shell fragments, measures 6.5 m in width and extends 4.25 m from front to back. Interior head room averages nearly 2 m throughout the feature. Scattered about the intact blister roof section are approximately 23 well-developed abrader basins.

Site 11991 (T-7) - Cairn, Petroglyphs (2), Abrader Basins (15)

Site 11991 (Figure 2) is located near the center of the present project area, within the vicinity of previously recorded Site E1-311. The site, which occupies an area measuring approximately 11 m in diameter, consists of a cairn constructed of stacked pahoehoe boulders and cobbles to a maximum dimension of 0.6 m diameter and 0.43 m in height. The cairn lies at the south end of a very rough alignment of rubble, which could represent collapsed C-shaped structures (not recorded during the present project). Petroglyph figures at the site consists of an anthropomorphic figure with a raised arm at the end of which is a pecked circle, and a second figure of an incompletely formed circle; two additional pecked areas adjacent to these figures may be fishhook representations. Scattered about the area between the Feature A cairn and the petroglyph figures are c. 15 abrader basins.

Site 11992 (T-8) - Modified Outcrop, Linear Surface Feature, C-Shape, Cairn

This site consists of four separate features located near the center of the project area and within the general vicinity of previously recorded Site E1-313, which the site may possibly represent. Feature A consists of from 30-40 pahoehoe cobbles and boulders stacked adjacent to a slightly uplifted section of bedrock, forming a small sheltered area behind the pile of boulders and adjacent to the bedrock outcrop. Feature B consists of a straight alignment of stacked pahoehoe cobbles and boulders, with a maximum length of 3.15 m, an average width of 1 m, and an average height of 0.45 m. Feature C consists of a C-shaped surface habitation feature measuring 2.85 m in length, averaging 0.9 m in width and 0.40 m in height. The C-shape encloses an area roughly 1.0 m sq. All three of these features provided temporary shelter and a modicum of protection from winds which would have derived from the north-northeast. Feature D consists of a small cairn constructed of 20-30 pahoehoe cobbles and boulders piled to a maximum basal diameter of 1.75 m, and a maximum height of 0.7 m. This feature may have served to mark the location of the Features A-C. No midden deposits or portable artifacts are at or within the immediate vicinity of any of the surface features at this site.

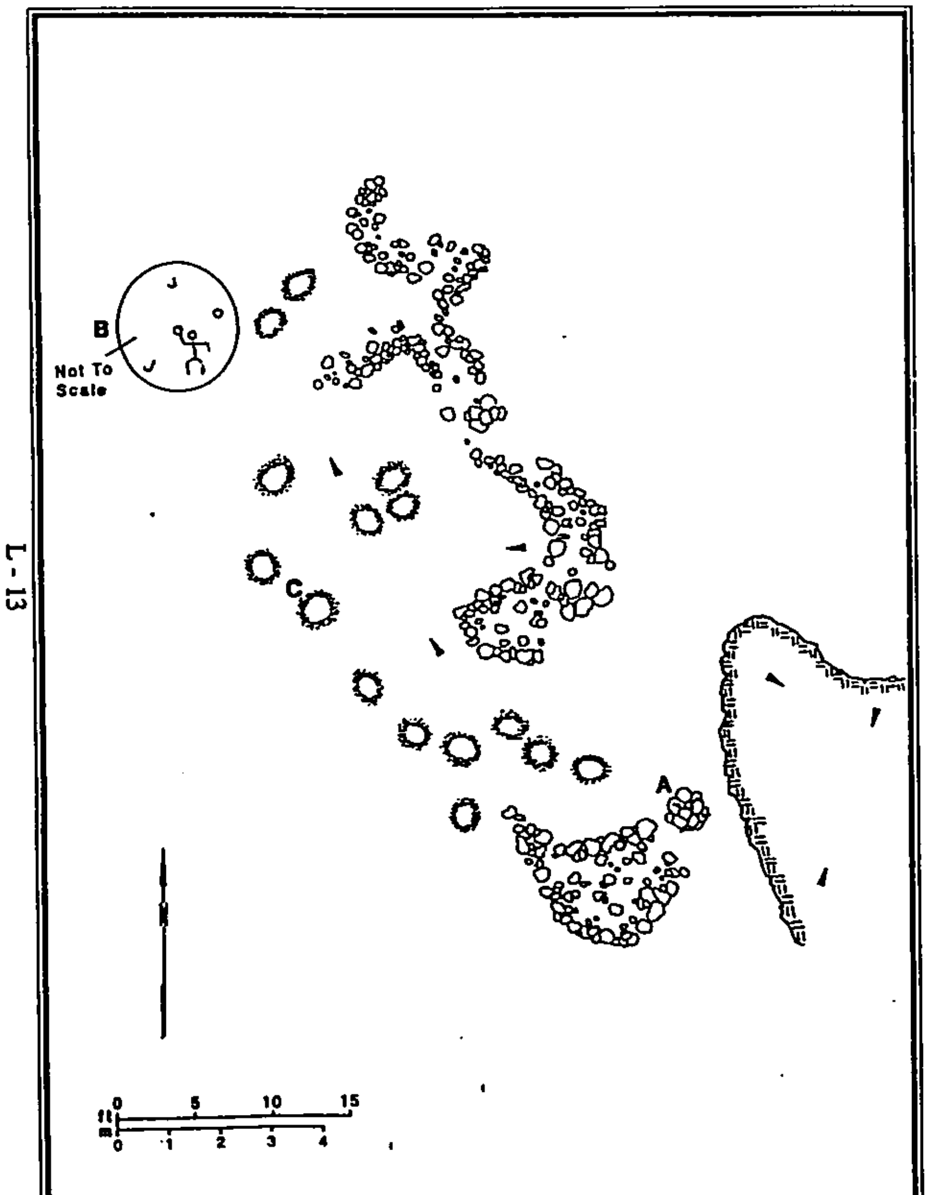


Figure 2. SITE 11991 (T-7)

Site 11993 (T-9) - C-Shapes (6), Cairns (2)

This site, located near the center of the project area within the vicinity of Sites 11991, 11992, and 11994, consists of six surface habitation features and two cairns (Figure 3). Based on available descriptive and locational information, this site may represent previously recorded Site E1-313 or -314. Except for differences caused by erosion or other disturbance, all six C-shapes are roughly equivalent in construction details and size, averaging 3.5 m wall length, 0.8 m wall thickness, and 0.4 m in height. The interior areas of the C-shapes average roughly 2.2 sq m. However, while the apex of five of the features is oriented at approximately 180 degrees (south), one is oriented c. due north. No cultural deposits—either marine shell fragments or portable artifacts—are at any of the six features. The remaining features at this site consists of two cairns, centrally located with respect to the six C-shapes, separated from each other by 8 meters, and located along an axis which dissects the site roughly east-west. As with the surface habitation features, no cultural deposits were found in association with the two cairns.

Site 11994 (T-10) - C-Shape, Linear Wall

This site consists of two surface features located near the center of the project area. Fairly recent bulldozer tracks dissect the site area from north to south. Feature A alignment consists of a 1-m-wide wall constructed by stacking pahoehoe cobbles and boulders from four to five courses high and from three to four courses wide, yielding an average height of 0.2 m. Apparently representing but a segment of a once longer feature, only nine linear meters of wall remain within the project area. Feature B consists of a C-shaped surface habitation feature measuring 3.1 m in length, 1 m maximum width, and 0.50 m maximum height. The C-shape encloses an area roughly 3.5 sq m. No cultural deposits were found in association with either the C-shaped shelter area or the wall segment.

Site 11995 (T-11) - Petroglyphs (3)

This site consists of three separate figures pecked into the pahoehoe surface, distributed over an area measuring 0.24 by 0.48 m. The three figures include the same elements represented at Site 11991—an anthropomorphic figure with one raised arm at the end of which is a small circle, an adjacent circle or concentric circles, and a single pecked fishhook representation. No additional cultural materials, such as midden shell remains or portable artifacts, were observed within the immediate or general vicinity of this site.

Site 11996 (T-12) - C-Shapes (4)

This site is located within the northernmost portion of the project area within an area where no sites were previously recorded. The site consists of four surface habitation features. All four are equivalent in construction detail and size, and average 3.15 m wall length, 0.75 m wall thickness, and 0.3 m wall height. Two of the features were constructed adjacent to one another, so that the overall appearance of the two is of an E-shaped surface feature. The remaining two were separated by approximately 1.5 meters. The apex of each of the features is oriented at 45 degrees Az. No cultural deposits were found in association with any of the four surface habitation features.

Site 11997 (T-13) - C-Shapes (2), Abrader Basins (5)

This site consists of two surface habitation features directly associated with at least five abrader basins. Feature A is a well-constructed and classic-shaped C-shape surface feature, with maximum dimensions of 4.0 m length, 0.95 m width, and 0.45 m height. Feature B, located c. 5 m southeast, is less well-defined and constructed, with maximum dimensions of 2.5 m length, 1.0 m width, and 0.52 m height. Feature C at this site consists of five well-developed abrader basins located in the space between the two C-shapes. The apex of each of the features is oriented at 45 degrees Az. Although a light scattering of marine shell fragments occurs on the surface at and about the site area, no significant accumulation of cultural deposits are anywhere within the immediate or general site vicinity. The scatter was not collected as it was deemed archaeologically insignificant.

Site 11998 (T-14) - Cairn

This site consists of a single isolated cairn, represented by 30-40 stacked pahoehoe cobbles and boulders, yielding a maximum basal diameter of 3.8 m and a maximum height of 0.85 m. The absence of cultural material makes it impossible to determine whether the feature is prehistoric/protohistoric in age, or representative of more recent activities within the project area.

Site 11999 (T-15) - C-Shapes (3)

This site is relatively isolated, within the northernmost portion of the project area. The site consists of three surface habitation features (C-shapes) distributed over an area which extends 10 m north-south by 9 m east-west. All three were constructed by stacking pahoehoe cobbles and boulders

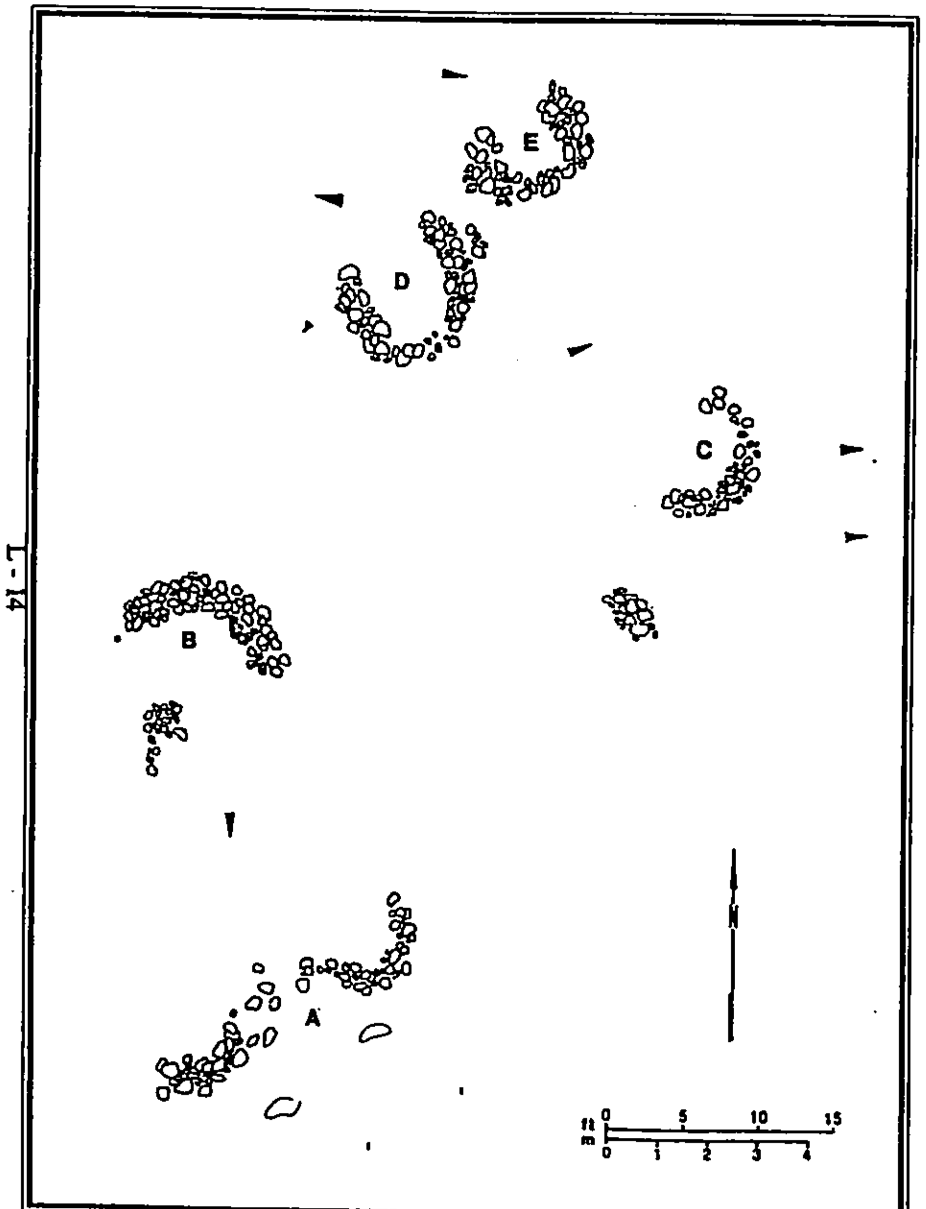


Figure 3. SITE 11993 (T-9)

from two to four courses high and wide. The maximum dimensions of the three vary considerably, as follows: Feature A - 3.25 m (l), 0.90 m (w), 0.53 m (h); Feature B - 5.00 (l), 0.75 (w), 0.45 (h); Feature C - 2.00 (l), 0.3 (w), 0.3 (h). Feature A encloses an area roughly 2.0 sq m; Feature B encloses roughly 4.0 sq m; Feature C encloses roughly 1.0 sq m. Two of the two are oriented 90 degrees Az, while the remaining example is oriented approximately 135 degrees Az. Additional cultural deposits consist of a light surface scattering of marine shell fragments at and between all three of these surface shelters. The scatters were not collected as they were deemed archaeologically insignificant.

Site 12000 (T-16) - C-Shape

This site, located within an area of dense kiawe, consists of a single C-shaped surface habitation feature measuring 2.3 m in length, 0.65 m in width, and 0.58 m in height. The C-shape encloses an area roughly 1.0 m sq. An organic matt has accumulated at and within the vicinity of the feature due to the presence of dense vegetation. An examination (with hand trowels) of this material failed to substantiate the presence of a significant accumulation of cultural material, such as portable artifacts and/or marine shell midden.

Site 12001 (T-17) - C-Shapes (2)

This site consists of two surface habitation features located within the general vicinity of previously recorded Site EI-317, itself described as an abrader manufacturing area. As presently recorded, the site consists of two poorly defined C-shaped surface features, separated by approximately 6 m of smooth pahoehoe. One feature measures 5.75 m in length, 1.0 m in width, and 0.40 m in height, and encloses an area of roughly 2.5 m sq. The second feature measures 2.0 m in length, 0.75 m in width, and 0.35 m in height, and encloses an area of roughly 0.5 sq m. The apex of each feature is oriented approximately 80 degrees Az. A light surface scattering of marine shell fragments was observed at and on the pahoehoe surface between the two features.

Site T-18 - Historic Fence and Associated Wall

This site, located c. 100 meters inland from and paralleling the coastline, consists of a 150-meter-long segment of historic-era fence (Figure 4). The fence consists of two primary components, one of which is a series of Ohia posts, the second is a discontinuous rubble wall. The posts are set on top of and occasionally into the pahoehoe surface, they are spaced at c. 2 m intervals. Occasional staples in the posts indicate the use of at least two strands of barbed wire, although none of the wire remains between the posts. The discontinuous rubble wall was constructed across low areas in the pahoehoe in order to block passage underneath the stretched wire portion of the fence. The wall was constructed along the inland side of the post-supported wire portion of the fence. No portable artifacts or other historic-era features were observed along the remaining segment of fence within the present project area.

Site 12002 (T-19) - Cave

This site, located near the northwest corner of the project area, consists of a single relatively isolated cave formed in a collapsed lava blister (Figure 5). The collapsed center portion of the blister has left a sheltered area under the blister's overhang which averages 1 m in ceiling height and which measures 6.5 m in width (north-south) and extends under the dripline an average of 2.5 m. Within this surface area of c. 13 square meters, a potentially significant accumulation of cultural material consists of marine shell midden and portable artifacts. Minor probing during the present project revealed at least 20 cm maximum deposit over 3-4 square meters of surface area. This site represents the only remaining site within the project area at which a potentially significant accumulation of cultural material has been deposited. Before concluding that the deposit is not potentially important to our understanding of local or regional prehistory, the resource should be formally evaluated through a program of subsurface archaeological excavation.

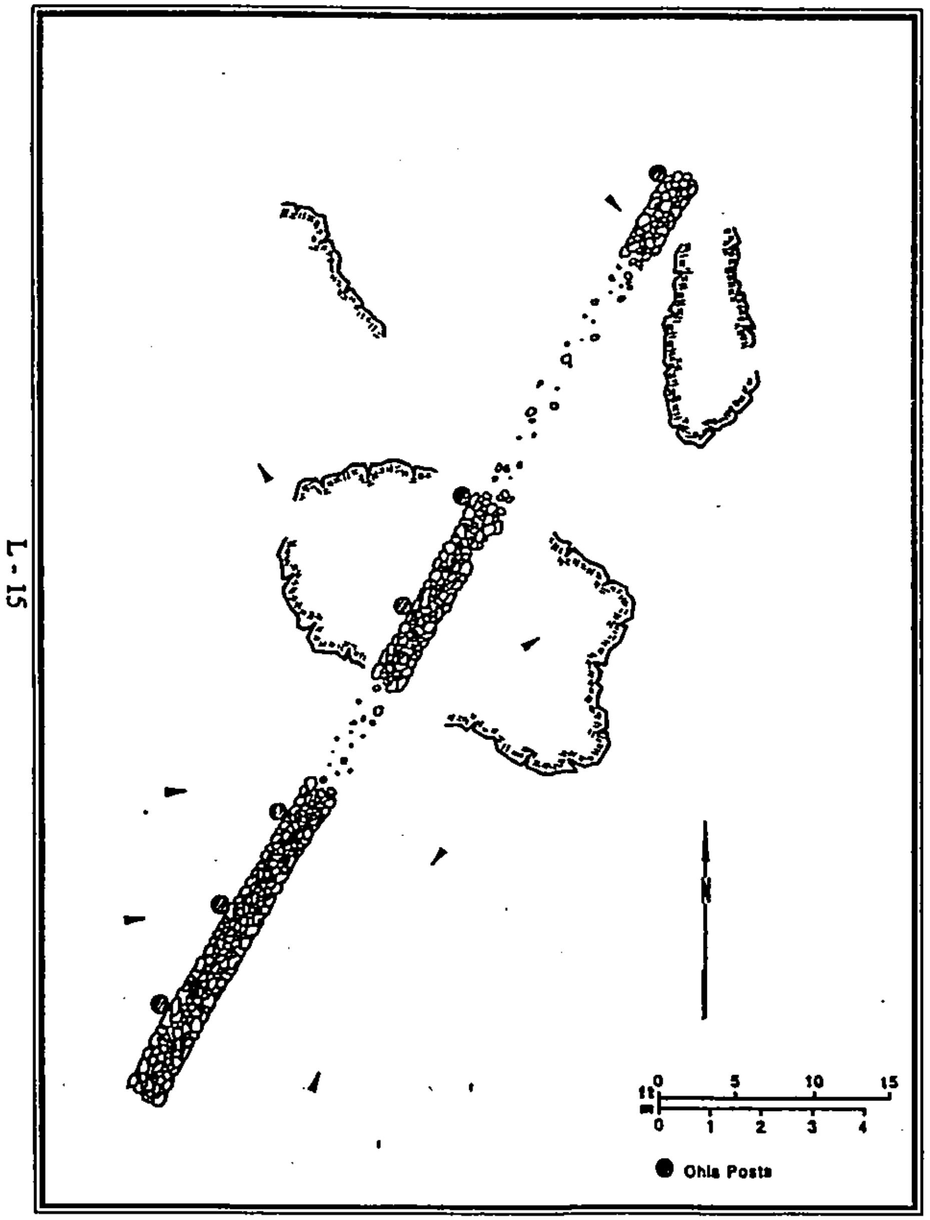


Figure 4. SITE 12402 (T-18)

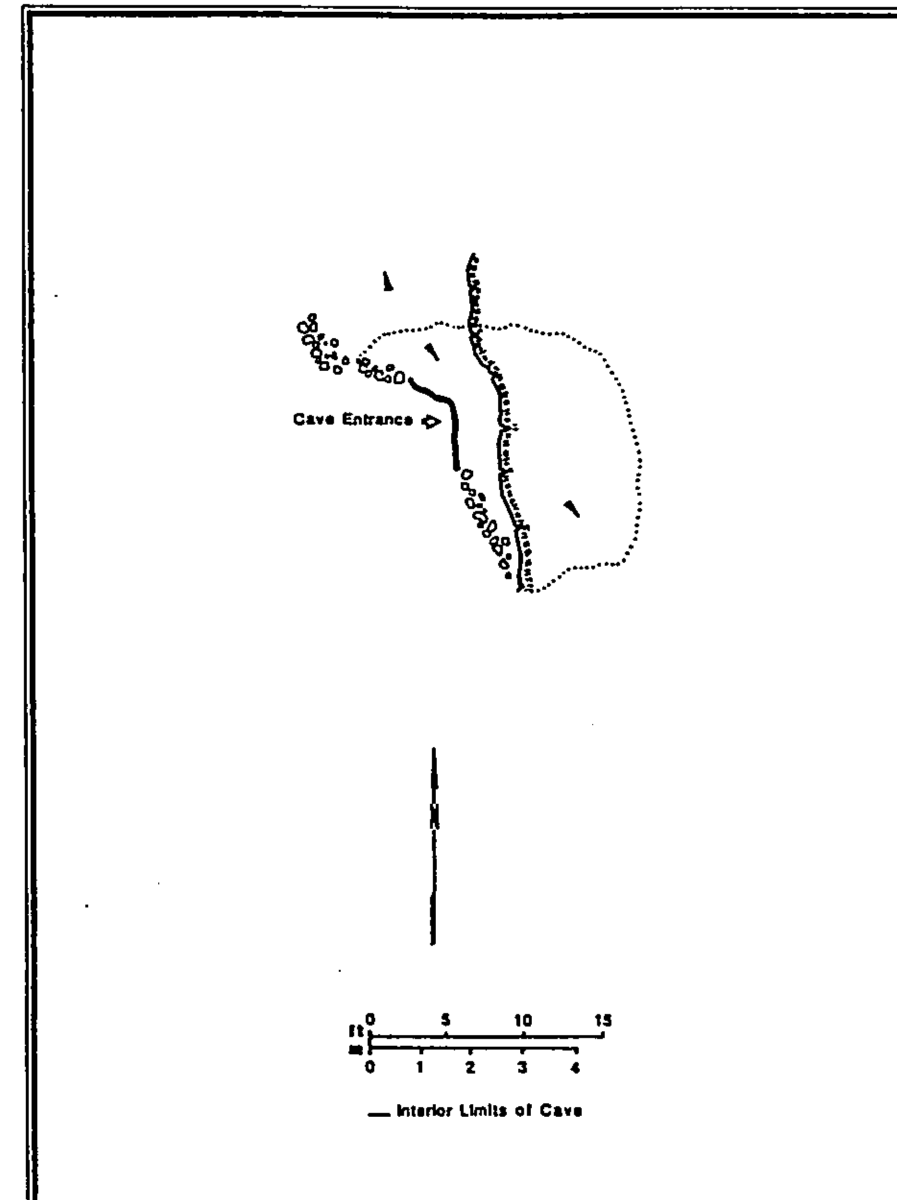


Figure 5. SITE 12002 (T-19)

CONCLUSION

DISCUSSION

Prior to initiating survey field work for the present project, all of the sites which had been previously recorded by Kirch within the present project area were plotted onto project area maps. This procedure resulted in identifying 28 sites which appeared to have once existed within the overall project area. However, previously recorded sites could only be linked with five of these (see Table 2).

As noted, these linked sites represent only tentative assignments, for which there are several explanatory factors. First, the site location map available in Kirch's report was generally inadequate for relocating sites in the field. Based on the distance scale, the site number designations printed on the map are probably in excess of ten times the actual size of most of the individual sites themselves. Second, very few landmarks which might have been useful in relocating individual sites in the field, are identified on the existing location maps. Third, for many of the previously recorded sites, particularly those considered "insignificant" or of limited research value, the written descriptions consist of simple phrases, such as "C-shapes," or "area of abrader basins." It may be that the present project's 18 sites incorporate many of the features originally identified by Kirch's survey crew; however, the brief site descriptions, combined with the absence of site maps for many of these, have impeded subsequent field identification. Lastly, much of the land comprising the present project area has in fact been bulldozed or developed, and it is obvious that many of the sites or site components originally recorded by Kirch no longer exist. Even the Mamalahoa Trail through the project area could not be relocated; an examination of aerial photos indicates that c. 80-90% of the alignment has been developed. That portion of the projected alignment through undeveloped sections of the project area could not be identified on the ground.

Despite the discrepancies between Kirch's original site count and the results of the present project, a number of intact sites still exist within the project area and these were recorded during the present project. As noted in Table 3, surface habitation features, principally C-shapes, are the most prominent features represented within the project area, representing 25 (c. 83%) of the total of 30 habitation components, and c. 54% of all of the feature components identified within the project area. As expected, the cultural deposits observed at these surface habitation features consist predominantly of very light surface scatters of marine shell fragments. In this and all other respects, these findings are in conformity with expectations which had been generated from Kirch's and others' previous findings within the immediate and general project vicinity. Specifically, the present project has confirmed previous researchers' findings that substantial deposits of marine shell midden, portable artifacts, and datable charcoal do not exist at most of the inland surface features located within this portion of Kalahuipuaa.

In addition to the 25 surface habitation features, five caves/overhangs exhibiting evidence of use/occupation were recorded within the project area. Four of the five lack accumulated cultural deposits, and native use has been inferred on the basis of the presence of a surface scattering of marine shell midden, virtually identical to the scattering of marine shell fragments observed at most of the surface habitation features. Again, these findings conform with Kirch's model of prehistoric settlement and resource exploitation at Kalahuipuaa. Arguing that cave sites were essentially "...temporary residences for small groups exploiting the marine environment, for periods of a few days to perhaps several weeks or even months", Kirch had predicted (1) an inverse relationship between the distance from shore of a particular habitable cave and the quantity of cultural material likely to be present, and (2) a positive relationship between a cave's distance from shore and the likelihood that the deposit dated to the late prehistoric period, between about AD 1500-1600. These predictions were based on his demonstration that virtually all of the midden-containing caves at Kalahuipuaa exhibited (1) a high degree of correspondence in the relative proportions of portable artifacts and midden categories, (2) that these portable artifacts and midden components clearly suggested that exploitation of marine resources was the primary objective of areal habitation, and (3) that the areal population was steadily increasing through about AD 1600, resulting in a gradual increase through time in the demand for suitable living areas. This gradual increase in demand would have translated into an expansion over time in the area within which marine-exploitation bases would have been established, with a concomitant incorporation through c. AD 1600 of less desirable (i.e., more inland) locales.

The single midden-bearing cave identified among the five recorded examples accommodates Kirch's predictions in that this site (Site 12002) was situated closer to the shore than of any of the recorded examples. None of the inland caves contained significant accumulations of cultural material.

Additional aspects of Kirch's settlement pattern and exploitative model are testable on the basis of the data believed to be present at Site 12002. First, the deposit at Site 12002 should be much shallower than most of the cave deposits which Kirch had examined closer to the shoreline and to the fishponds. Second, the site's artifact inventory and midden composition should demonstrate primary subsistence reliance on the exploitation of marine resources. Third, the deposit should date to the late prehistoric or early historic period. As demonstrated during the present project, a deposit exists at this site which appears to contain midden, artifacts and dating samples directly relevant to the above research issues. It is this possibility which justifies concluding that the site possesses potentially significant information value. What remains to be further evaluated at Site 12002 is the full range of artifacts and midden constituents actually present, as well as the age of the site's deposit.

Combining surface habitation features (25 components) with cave/overhang shelters (five components) indicates that approximately 65% of all of the recorded archaeological components identified with the project area reflect temporary, short-duration occupation. Moreover, all six of the cairns appear also to have served as markers for either surface or cave habitation features, which brings the percentage of features directly related to temporary occupation to approximately 78%. For both the habitation caves and surface habitation features, a predominantly prehistoric to early historic/protohistoric age is indicated on the basis of observations of artifacts both present and lacking at these features. This hypothesis is generally supported by the fact that none of the few petroglyphs observed within the area appear to be historic in age, although associations of individual petroglyphs with particular caves or surface features cannot be easily established.

Of the remaining 22% of the recorded feature components, nine (or approximately 20%) consist of petroglyphs (two components containing only five individual elements) and abrader basins directly associated with temporary habitation areas (seven examples were recognized, containing a total of c. 450 individual basins). Additional examples of abrader basins, some also associated with shallow excavations (representing quarrying for scoriaceous pahoehoe), were observed to be distributed more or less evenly throughout the project area. These feature types (basins and shallow excavations) and their distribution within the present project area were also observed to essentially duplicate the observations recently made elsewhere at Kalahuipuaa (see Jensen 1989a) and at nearby Waikoloa (Jensen 1988). In consideration of the comparability of the examples within the present project area to those extensively evaluated in adjacent parcels (Jensen 1989a) and at Waikoloa's TMU A (Jensen 1988), and based on the specific findings with regard to such features at Waikoloa, these features were not individually recorded during the present project, nor have additional data recovery or preservation been recommended for these feature types.

Lastly, a segment of an historic-era barbed wire fence with associated rock wall was located within the project area. Most of the wooden components have deteriorated, only a short segment of the original alignment remains intact, and the remnant feature is without additional associated features or artifact concentrations.

EVALUATIONS

Significance categories used in the evaluation process for the present project area sites follow definitions derived from the National Register criteria for evaluation, as outlined in the Code of Federal Regulations (36 CFR Part 60). The Hawaii State Historic Preservation Office also employs these criteria for evaluating cultural resources. Sites determined here to be potentially significant for information content (Category A in Table 4) are assessed under Criterion D, which defines significant resources as those which "have yielded, or may be likely to yield, information important in prehistory or history" (36 CFR Sec. 60.4). Sites determined to be potentially significant as excellent examples of site types (Category B) are assessed under Criterion C, which defines significant resources as those which "embody the distinctive characteristics of a type, period, or method of construction,...or that represent a significant and distinguishable entity whose components may lack individual distinction" (36 CFR Sec. 60.4).

Sites determined to be (potentially) culturally significant (Category C) are assessed under guidelines prepared by the Advisory Council on Historic Preservation, entitled "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (Draft Report, August 1985). Cultural value is defined in the guidelines 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 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). Both religious and nonreligious cultural values are specified, and examples include burial sites, loci of traditional economic activities, and loci that are symbolic of a group's identity or history (1985:11).

Table 4.

SUMMARY OF GENERAL SIGNIFICANCE ASSESSMENTS AND RECOMMENDED GENERAL TREATMENTS

Site or Feature No.	Significance Category				Recommended Treatment			
	A	X	B	C	FDC	NFW	PID	PAI
11986 (T-1)	-	+	-	-	-	+	-	-
11987 (T-3)	-	+	-	-	-	+	-	-
11988 (T-4)	-	+	-	-	-	+	-	-
11989 (T-5)	-	+	-	-	-	+	-	-
11990 (T-6)	-	+	-	-	-	+	-	-
11991 (T-7)	-	+	-	-	-	+	-	-
11992 (T-8)	-	+	-	-	-	+	-	-
11993 (T-9)	-	+	-	-	-	+	-	-
11994 (T-10)	-	+	-	-	-	+	-	-
11995 (T-11)	-	+	-	-	-	+	-	-
11996 (T-12)	-	+	-	-	-	+	-	-
11997 (T-13)	-	+	-	-	-	+	-	-
11998 (T-14)	-	+	-	-	-	+	-	-
11999 (T-15)	-	+	-	-	-	+	-	-
12000 (T-16)	-	+	-	-	-	+	-	-
12001 (T-17)	-	+	-	-	-	+	-	-
12402 (T-18)	-	+	-	-	-	+	-	-
Subtotal: 17	0	17	0	0	0	17	0	0
12002 (T-19)	+	-	-	-	+	-	-	-
Subtotal: 1	1	0	0	0	1	0	0	0
Total: 18	1	17	0	0	1	17	0	0

General Significance Categories:

A=Important for information content, further data collection necessary (PHRI=research value);
X=Important for information content, no further data collection necessary (PHRI=research value, SHPO=not significant);
B=Excellent example of site type at local, region, island, State, or National level (PHRI=interpretive value); and
C=Culturally significant (PHRI=cultural value).

Recommended General Treatments:

FDC=Further data collection necessary (intensive 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.

To further facilitate client management decisions regarding the subsequent treatment of resources, the general significance of all archaeological remains identified during the present survey was evaluated in terms of potential scientific research, interpretive, and/or cultural values. **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 for the preservation and promotion of cultural and ethnic identity and values.

Information Content

In evaluating information content (Category A) (scientific research value), all of the sites located within the project area were examined in light of the major research issues identified during background research. The areas of potential research revolved primarily around questions of chronology, settlement and exploitative patterns, site and assemblage variability, material culture and technology, and diet and economy.

Chronology - Determining the period of use for sites within the project area is contingent upon recovery and assay of datable materials, such as volcanic glass and charcoal. Only a single cave shelter in the project area (Site 12002) was discovered to contain such material. The fact that only a single site contains such information in no way diminishes the importance of this site to regional prehistory, however, as the site may possess various additional attributes (e.g., artifacts, midden, dating samples, and location) which render it potentially significant in evaluating existing hypotheses concerning prehistoric and early historic use and occupation within the area.

Settlement and Exploitative Patterns - Further evaluation of areal settlement and exploitative patterns requires evaluation of accumulated deposits of artifacts and associated midden. Some information concerning exploitation of scoriaceous pahoehoe for production of abraders could be recovered within the project area. However, the comparability of the material observed within the present project area to that which has recently been extensively examined at Anaehoomalu and Waikoloa (Jensen 1988) suggests that additional data collection with respect to such features is not likely to further our understanding of the process itself, nor of possible socio-political correlates. Again, the only project area site likely to add to our information base concerning settlement and exploitative patterns is Site 12002, where artifacts and food remains (midden) appear to have accumulated in conjunction with datable charcoal.

Site and Assemblage Variability, Material Culture and Technology, and Diet and Economy - Virtually all of the project area sites are simple single- or dual-component sites, limiting the applicability of complex questions which require relating assemblage variability, diet, material culture, and technology to one another over relatively long periods of time. By contrast, a small artifact inventory has apparently accumulated at Site 12002, and further evaluation of this deposit could be expected to shed some light on the general applicability of existing hypotheses which relate site and assemblage variability with prehistoric diet and economy at Kalahuipuaa.

Interpretive Value

At this stage of analysis (inventory-level reconnaissance), archaeological sites with potentially high value as excellent examples of site types (Category B) (excellent example of type site), are identified by considering those attributes which, if occurring together at one site, would provide a representative example of particular kinds of behaviors, activities or conditions. In the present project area, none of the recorded sites is believed to exhibit qualities which would render its preservation especially meaningful or appropriate. The several C-shapes and the isolated caves are neither especially distinctive nor unique. Neither are the few widely scattered petroglyphs. The petroglyphs have been documented adequately, having been sketch-mapped to approximate scale and having been photographed. Moreover, many of the surface habitation features (C-shapes) are partially collapsed, implying that exhibition would necessitate reconstruction which in itself would diminish the authenticity of the preserved components. While the abrader basins reflect what was obviously an important industry in prehistoric West Hawaii, an excellent type site has already been preserved at the Mauna Lani Resort (Site 11267) (Jensen 1989b), while numerous additional examples of these features and associated temporary habitation areas have already been preserved at adjacent portions of Waikoloa (at TMU A's Site 5694, immediately east of the Kiholo-Puako Trail). In consideration of these factors, preservation of additional examples within the present project area is not deemed necessary.

Cultural Value

Sites with cultural significance (Category C) (cultural value) would include those with traditional uses and those that have significant meaning in the context of a traditional way of life. The most prominent features are the C-shapes widely scattered across, but not clustered at specific locales, within the project area. Advancement of technical knowledge concerning these features could theoretically enhance their cultural value, although none of the features is associated with significant accumulations of cultural material (midden or artifacts), and additional data collection is thus not possible. Moreover, these features are ubiquitous throughout West Hawaii, and there is no evidence that their construction or use had acquired extraordinary meaning or significance in the context of traditional Hawaiian life styles. The other feature types represented within the project area include abrader basins, a very few scattered petroglyphs, five small cave habitation features, and six small cairns which appear to represent habitation feature markers. These components are also extensively represented within the immediate and general project vicinity, and are not believed to possess extraordinary cultural value, as per the definition of "cultural value" provided above.

RECOMMENDATIONS

Based on the findings of significance and potential significance and cultural value as outlined above and summarized in Table 4, the following recommendations have been developed and are here offered. All 46 site components at the 18 recorded sites are tentatively assessed as significant for information content. For 17 of the 18 sites, however, no further data collection is recommended as the present site recording is seen as adequate preservation of the sites' information values. The sites included in this category are Sites 11986 through 12001. For these same 17 sites, no additional consideration, such as preservation or possible interpretive development, is warranted or recommended, and none of these 17 sites is considered to possess significant cultural value.

One of the 18 sites is believed to retain potentially significant information (data) in relation to research questions and issues which remain important in local and regional prehistory. This is Site 12002, a small blister cave located near the northwest corner of the project area. Additional data collection has been recommended in order to formally evaluate the remaining scientific/information potential of the site's cultural deposit in relation to National Register of Historic places eligibility Criterion D (information value). Site 12002 is not, however, also considered significant or potentially significant for interpretive or for cultural value.

It should be noted that the above evaluations and recommendations are based on the findings of an inventory-level surface survey. There is always the possibility, however remote, that potentially significant unidentified cultural remains might be encountered in the course of future development activities. In such a situation, archaeological consultation should be sought immediately.

REFERENCES CITED

ACHP (Advisory Council on Historic Preservation)

1985 Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review. Washington, D.C.: Advisory Council on Historic Preservation. (Draft Report, August)

Anonymous (Ahlo, H.M., Jr., and R.J. Hommon)

1982 Mauna Lani Resort: An Interpretive and Management Plan for its Historic Resources. Science Management, Inc.

Barrera, W., Jr.

1971 Anaehoomalu: A Hawaiian Oasis. Preliminary Report of Salvage Research in South Kohala, Hawaii. Pacific Anthropological Records No. 15. Department of Anthropology, B.P. Bishop Museum.

1974 Archaeological Survey. IN Archaeological and Historical Surveys of the Waimea to Kawaihae Road Corridor, Island of Hawaii. Department of Anthropology, B.P. Bishop Museum. Prepared for Department of Transportation, State of Hawaii.

Barrere, D.B.

1971 Appendix A. Anaehoomalu: A Reconstruction of Its History. IN, Anaehoomalu: A Hawaiian Oasis. Preliminary Report of Salvage Research in South Kohala, Hawaii. Pacific Anthropological Records No. 15. Department of Anthropology, B.P. Bishop Museum.

1983 Notes on the Lands of Waimea and Kawaihae. IN Clark and Kirch 1983:25-51.

B.P. Bishop Museum

1964 Report on the Puako Petroglyph Field in the Proposed State Historic Petroglyph Park, Puako, South Kohala. Mimeo.

Bevacqua, R.F.

1972 Archaeological Survey of Portions of Waikoloa, South Kohala District, Island of Hawaii. Departmental Report Series 72-4. Department of Anthropology, B.P. Bishop Museum.

Bonk, W.

1986 Archaeological Investigations at Site E1-323, Kalahuipua'a, South Kohala, Island of Hawaii. Department of Anthropology, University of Hawaii-Hilo. Prepared for Mauna Lani Resorts, Inc.

Bonk, W., and M. Pietrusewsky

1986 An Archaeological Report of Two Burials From the Ahupua'a of Kalahuipua'a, South Kohala, Hawaii. Papers in Ethnic and Cultural Studies 86-1. Department of Anthropology, University of Hawaii-Hilo. Prepared for Mauna Lani Development Corporation.

Ching, F.K.W.

1971 The Archaeology of South Kohala and North Kona: From the ahupua'a of Lalamilo to the ahupua'a of Hamanamana. Surface Survey Kailua-Kawaihae Road Corridor (Section III). Hawaii State Archaeological Journal 71-1. Department of Land and Natural Resources, Division of State Parks, State of Hawaii.

Clark, J.R.K

1985 Beaches of the Big Island. Honolulu: University of Hawaii Press.

Clark, J.T., P.V. Kirch

1983 Archaeological Investigations of the Mudland-Waimea-Kawaihae Road Corridor, Island of Hawaii. Departmental Report Series 83-1. Department of Anthropology, B.P. Bishop Museum.

Cordy, R.

1981 A Study of Prehistoric Social Change: The Development of Complex Societies in the Hawaiian Islands. New York: Academic Press.

Cox, J.H.

1971 Appendix B: Results of a Preliminary Investigation of the Anaehoomalu Petroglyphs, IN, Anaehoomalu: A Hawaiian Oasis. Preliminary Report of Salvage Research in South Kohala, Hawaii. Pacific Anthropological Records No. 15. Department of Anthropology, B.P. Bishop Museum.

Cox, J.H., with E. Stasack

1970 Hawaiian Petroglyphs. B.P. Bishop Museum Special Publication 60.

Donham, T.

1986 Preliminary Report Upon Completion of Field Work: Archaeological Data Recovery Within a Proposed Powerline Corridor along the Kiholo-Puako Trail, Waikoloa Beach Resort, Land of Waikoloa, South Kohala, Island of Hawaii. PHRI Report 282-121186. Prepared for Transcontinental Development Company.

1987 Archaeological Reconnaissance Survey, Resort Expansion Area and Selected Undeveloped Resort Parcels, Waikoloa Beach Resort, Land of Waikoloa, South Kohala, Island of Hawaii. PHRI Report 268-021187. Prepared for Transcontinental Development Company.

Emory, K.P.

Ms. Field Notes on the Excavation of Sites H100 and H101 (1955). On file, Department of Anthropology, B.P. Bishop Museum.

Emory, K.P., W.J. Bonk, and Y. Sinoto

1959 Hawaiian Archaeology: Fishhooks. B.P. Bishop Museum Special Publication 47.

Fornander, A.

1918 Hawaiian Antiquities and Folk-Lore. Memoirs, Vol. 4. B.P. Bishop Museum.

Handy, E.S.C.

1940 The Hawaiian Planter. B.P. Bishop Museum 161. Vol. I.

Hommon, R.J.

1981 Archaeological Data Recovery at Site 342, Kalahuipuaa. Science Management, Inc. Prepared for Mauna Lani Resorts.

1982 Archaeological Data Recovery at Site 342, Kalahuipuaa. Science Management, Inc. Unpublished Report Prepared for Mauna Lani Resorts.

Jensen, P.M.

1988 Archaeological Data Recovery and Intensive Survey, Resort Expansion Area and Selected Undeveloped Resort Parcels, Waikoloa Beach Resort, Lands of Waikoloa and Anaehoomalu, South Kohala, Island of Hawaii. PHRI Report 371-031488. Prepared for Transcontinental Development Company.

1989a Archaeological Inventory Survey, Mauna Lani Resort New Golf Course, Lands of Kalahuipuaa and Waikoloa, South Kohala District, Island of Hawaii. PHRI Report 496-120988. Prepared for Transcontinental Development Company.

1989b Archaeological Inventory Survey, Waikoloa Beach Resort Parcels 20, 21, 22, and 23, Land of Waikoloa, North Kohala District, Island of Hawaii. PHRI Report 512-022289. Prepared for Transcontinental Development Company.

1989 (In Prep) Mitigation of Potential Project Effects to Site HRHP 5694, TMU A, Waikoloa, North Kohala District, Island of Hawaii. In Prep.

Kamakau, S.M.

1961 Ruling Chiefs of Hawaii. Honolulu: Kamehameha School Press.

1964 Ka Po'e Kahiko: The People of Old. B.P. Bishop Museum.

Kelly, M.

1956 Changes in Land Tenure in Hawaii, 1778-1850. Ms. Hawaiian-Pacific Collection, University of Hawaii-Manoa.

Kimura, L.

1964 Kapalaoa Homestead Life. Ms. University of Hawaii-Manoa.

Kirch, P.V.

1973 Archaeological Reconnaissance Survey of Kalahuipua'a and Portions of Waikoloa, Lalamilo, and Anaehoomalu, South Kohala, Hawaii Island. Unpublished Manuscript. Department of Anthropology, B.P. Bishop Museum.

1975 Preliminary Report on Phase II Archaeological Investigations at Kalahu'ipua'a, South Kohala, Hawaii Island. Department of Anthropology, B.P. Bishop Museum. Prepared for Maunaloa Land, Inc.

1979 Marine Exploitation in Prehistoric Hawaii: Archaeological Investigations at Kalahuipua'a, Hawaii Island. Pacific Anthropological Records No. 29. Department of Anthropology., B.P. Bishop Museum.

1985 Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory. Honolulu: University of Hawaii Press.

Pukui, M.K.

1974 Place Names of Hawaii. Honolulu: University of Hawaii Press.

Reinecke, J.E.

1930 Survey of Hawaiian Sites: From Kailua, Kona to Kalahuipuaa, Kohala. Department of Anthropology, B.P. Bishop Museum.

Rosendahl, P.H.

1972 Archaeological Salvage of the Hapuna-Anaehoomalu Section of the Kailua-Kawaihae Road, Island of Hawaii. Departmental Report Series 72-5, Department of Anthropology., B.P. Bishop Museum.

Sinoto, Y.H.

1962 Chronology of Hawaiian Fishhooks. Journal of Polynesian Society 71(2):162-166.

Smart, C.D.

1964 A Report of Excavations on Site H22, Puako, Hawaii Island. B.P. Bishop Museum.

Stearns, H.T., and G.A. Macdonald

1946 Geology and Ground Water Resources of the Island of Hawaii. Hawaii Division of Hydrology, Bulletin No. 9. Honolulu.

Tomonari-Tuggle, M.J.

1982 An Archaeological Reconnaissance Survey of a Parcel Adjoining the Puako Petroglyph Fields, Puako, Hawai'i. Prepared for Waimea Hawaiian Civic Club and Mauna Lani Resort.

Walker, Alan T. and Paul H. Rosendahl

1986 Intensive Survey and Test Excavations, Waikoloa Beach Resort Off-Site Electrical Work Project Area, Lands of Anaehoomalu and Waikoloa, South Kohala, Island of Hawaii. PHRI Report 258-082586. Prepared for Transcontinental Development Company.

Welch, D.

1984 Archaeological Reconnaissance of the Area South of the Puako Petroglyph Archaeological District, South Kohala, Hawaii Island. Department of Anthropology, B.P. Bishop Museum. Prepared for Mauna Lani Resort, Inc.

1988a Field Summary Report. Archaeological Investigations at the Site of the Ritz-Carlton Hotel, Mauna Lani Resort. International Archaeological Research Institute, Inc. Prepared for Belt, Collins & Associates and Mauna Lani Resort, Inc.

1988b Field Summary Report. Mauna Lani Project Phase 2. International Archaeological Research Institute, Inc. Prepared for Belt, Collins & Associates and Mauna Lani Resorts, Inc.

1989 Archaeological Investigations at Pauoa Bay, Ritz-Carlton Mauna Lani Resort, South Kohala, Hawaii, Final Report. Unpublished Report. Prepared for Belt, Collins and Associates.

APPENDIX M

TRAFFIC IMPACT STUDY
MAUNA LANI COVE
SOUTH KOHALA, HAWAII

TRAFFIC IMPACT STUDY

MAUNA LANI COVE

South Kohala, Hawaii

Prepared for:

Mauna Lani Resort, Inc.

Prepared by:

Belt Collins & Associates

Honolulu, Hawaii

October 1989

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TRAFFIC IMPACT STUDY

MAUNA LANI COVE

TMK: 6-8-22:1, 3 & 9

INTRODUCTION

Mauna Lani Resort, Inc. originally proposed a 1,100-unit resort hotel on a 35 acre portion of the total 88 Mauna Lani Cove site. However, the plan for the hotel zoned site has been changed to a water oriented residential project consisting of approximately 90 to 140 single family residential dwelling units and 175 to 250 boat slips. For purposes of analysis, 140 single family dwelling units and 250 boat slips are assumed in this study. The proposed Mauna Lani Cove project would also include a restaurant, retail, and marina support facilities. This study evaluates the potential weekday peak hour traffic impacts for future conditions without and with the project and compares the impacts of the Cove project with the impacts of the original proposed hotel project.

EXISTING CONDITIONS

The project site is located in the South Kohala district on the island of Hawaii. The site would be located between the existing Mauna Lani Bay Hotel and the future Ritz-Carlton Mauna Lani Hotel at Mauna Lani Resort as shown in Figure 1. Vehicular access to the project site would be from Queen Kaahumanu Highway and Mauna Lani Drive.

Roadway System

Queen Kaahumanu Highway is the major north-south arterial roadway on the Kona/Kohala coast and links Kawaihae (north of the project) to Kailua-Kona (south of the project). The pavement structure on Queen Kaahumanu Highway consists of a single traffic lane in each direction and paved shoulders on both sides of the roadway. In the vicinity of Mauna Lani Drive, the posted speed limit on Queen Kaahumanu Highway is generally 55 miles per hour.

Mauna Lani Drive is a two-lane roadway which serves the Mauna Lani Resort. Mauna Lani Drive intersects Queen Kaahumanu Highway at an unsignalized T-intersection with Mauna Lani Drive forming the stem of the intersection.

The northbound approach on Queen Kaahumanu Highway at the Queen Kaahumanu Highway/Mauna Lani Drive intersection consists of a separate left turn lane and a through traffic lane while the southbound approach provides a through traffic lane and a channelized deceleration lane for right turn traffic. The Mauna Lani Drive or eastbound approach is striped for a separate left turn lane and provides a channelized acceleration lane for right turn movements. Eastbound left turn movements from Mauna Lani Drive are controlled by a stop sign while eastbound right turn movements are controlled by a yield sign.

Existing Traffic Conditions

The description of existing traffic conditions at the Queen Kaahumanu Highway/Mauna Lani Drive intersection are from manual traffic count data collected in July 1988 by Project Planners Hawaii[1]. The traffic count data indicates that the morning peak hour occurs from 6:15 AM to 7:15 AM and that the afternoon peak hour occurs from 3:30 PM to 4:30 PM. Existing traffic volumes for the morning (AM) and afternoon (PM) peak hours are shown in Figure 2.

The method of analysis used for unsignalized intersections and two-lane highways are described in the 1985 Highway Capacity Manual[2]. Levels of Service (LOS) for unsignalized intersections, two-lane highways, and signalized intersections are described in the Appendix.

At the Queen Kaahumanu/Mauna Lani Drive intersection, eastbound traffic on Mauna Lani Drive executing a left turn onto Queen Kaahumanu Highway experiences LOS C during both peak hours. Eastbound traffic on Mauna Lani Drive executing a right turn onto Queen Kaahumanu Highway operates at LOS A during both peak hours. The northbound left turn movement on Queen Kaahumanu Highway presently operates at LOS A during the AM and PM peak hours.

Existing two-way traffic volumes on Queen Kaahumanu Highway are greater to the north of Mauna Lani Drive. Analyses of these highway volumes yield LOS B conditions during the AM peak hour and LOS C conditions during the PM peak hour.

FUTURE CONDITIONS WITHOUT PROJECT

Year 1998 is the expected date of completion for the proposed project. A review of traffic projections for the Mauna Lani Resort area indicates that traffic on Queen Kaahumanu Highway would be expected to increase at a rate of 15 percent per year[3]. This growth rate includes traffic from other resort developments along the South Kohala coastline. Traffic on Mauna Lani Drive would also be expected to increase due to completion of the Ritz-Carlton Mauna Lani Hotel and residential/resort single family units in the area. Figure 3 shows the traffic assignment for future conditions without the proposed project.

The increase of traffic volumes at the Queen Kaahumanu Highway/Mauna Lani Drive intersection would cause a reduction of capacity resulting in LOS E conditions for the eastbound left turn movements from Mauna Lani Drive during the AM peak hour and over-capacity or LOS F conditions during the PM peak hour. The eastbound right turn movements would continue to experience LOS A conditions during both peak hours. The northbound left turns on Queen Kaahumanu Highway would operate at LOS B during the AM peak hour and at LOS A during the PM peak hour.

Levels of Service for traffic on Queen Kaahumanu Highway would also be affected as LOS E conditions would prevail during AM and PM peak hours.

TRAFFIC GENERATION

Traffic generation is composed of trip generation, trip distribution, and traffic assignment. Trip generation estimates the number of trips produced or attracted by the project, trip distribution determines the origins or destinations of these trips, and traffic assignment places these trips onto the roadway network.

Trip Generation

The trip generation for the proposed project is based on 140 single family dwelling units and 250 boat slips. The Economic Impact Analysis[4] for the project estimated that approximately 90 percent of the single family units would be used by part-time residents or part-time visitors. However, for worst-case analysis, this study assumes that only 50 percent of these units would be used as resort units (part-time use). The conceptual plan estimates a maximum of 250 boats: 75 boat slips would be included with house lots, 110 boat slips would be in the boat basin, and the space for 65 additional boats would be provided by rafting and boat size variability. The trip generation for the 75 boat slips with house lots is included in the projection for the single family units. Therefore, the trip generation for the marina was based on 175 boat slips. This study also assumes a quality-restaurant with a floor area of 9,000 square feet and a general store with a floor area of 4,000 square feet. The trip generation rates used for the cove project are from the Institute of Transportation Engineers', Trip Generation[5], Fourth Edition.

The trip generation estimate was also performed for the original project, a 1,100-

unit resort hotel. Peak hour trip rates for resort hotels in the South-Kohala and Kona areas were determined in the Ritz-Carlton Mauna Lani Environmental Impact Statement[3] and are used in this study. Tables 1 and 2 show the trip generation estimate for the project.

Trip Distribution/Traffic Assignment

Project traffic was distributed to/from the north (Kawaihae) and to/from the south (Kailua-Kona). Based on traffic count data taken at the Waikoloa Beach Resort, the Mauna Kea Resort, and the Mauna Lani Resort, 60 percent of traffic would be distributed to/from the north while the remaining 40 percent would be to/from the south[6]. Project traffic was assigned to the Queen Kaahumanu Highway/Mauna Lani Drive intersection according to these distribution factors. For analysis of worst-case conditions, the study assumed that all project trip ends would have an external destination or origin. Figure 4 shows the traffic assignment for project traffic while Figure 4a shows the traffic assignment for the original project.

TABLE 1
TRIP GENERATION RATES

Land Use (Parameter)	Daily	AM PEAK HOUR Trip Rate	AM PEAK HOUR %In	PM PEAK HOUR Trip Rate	PM PEAK HOUR %In
Single Family (dwelling units)	10.062	0.773	28%	1.012	64%
Resort (dwelling units)	3.162	0.160	67%	0.262	41%
Marina (boat berths)	3.000	0.090	50%	0.170	50%
Restaurant (1,000 square feet)	95.620	0.909	90%	7.250	69%
Store (1,000 square feet)	71.160	0.792	50%	6.109	52%
Resort Hotel (units)	---	0.420	86%	0.760	41%

TABLE 2
TRIP GENERATION FOR THE PROJECT

Land Use (Parameter)	Daily (vpd)	AM PEAK HOUR Enter (vph)	AM PEAK HOUR Exit (vph)	PM PEAK HOUR Enter (vph)	PM PEAK HOUR Exit (vph)
Single Family (70 dwelling units)	704	15	39	45	26
Resort (70 dwelling units)	221	8	3	8	10
Marina (175 boat berths)	525	8	8	15	15
Restaurant (9,000 square feet)	861	7	1	45	20
Store (4,000 square feet)	285	2	1	13	11
Cove Project Total:	2,596	40	52	126	82*
Resort Hotel (1,100 units)	---	397	65	341	495

vpd = vehicles per day
vph = vehicles per hour
* Discrepancies are due to rounding.

PROJECT IMPACTS

Traffic from the Cove Project was added to year 1998 volumes (without project) and is shown in Figure 5. The addition of project traffic would increase traffic volumes at the Queen Kaahumanu Highway/Mauna Lani Drive intersection by 5 percent during the AM peak hour and by 9 percent during the PM peak hour.

Cove Project

Eastbound left turn traffic on Mauna Lani Drive at the Queen Kaahumanu Highway/Mauna Lani Drive intersection would experience over-capacity or LOS F conditions during the AM and PM peak hours. The eastbound right turn movements would also remain unchanged at LOS A during both peak hours. The northbound left turn traffic would continue to experience LOS B conditions during the AM peak hour and would change to LOS B during the PM peak hour.

Traffic on Queen Kaahumanu Highway would continue to experience LOS E conditions during both peak hours. Table 3 compares the Levels of Service for existing, future without project, and future with project conditions.

Original Project

The original hotel project would have increased traffic volumes at this intersection by 25 percent during the AM peak hour and by 38 percent during the PM peak hour. The traffic assignment for year 1998 with the hotel project is shown in Figure 5a.

In comparison with the Cove project, the Queen Kaahumanu Highway/Mauna Lani Drive intersection, the eastbound left turn movements would also experience LOS F conditions during both peak hours. However, the eastbound right turn traffic would encounter longer delays as they would operate at LOS C during the AM peak hour and at LOS E during the PM peak hour. Northbound left turn traffic on Queen Kaahumanu Highway would operate at LOS D and LOS B during the AM and PM peak hours, respectively. The additional traffic would cause LOS F or over-capacity conditions on Queen Kaahumanu Highway during the AM and PM peak hours.

TABLE 3
LEVELS OF SERVICE

	Existing		Future Conditions (Year 1998) w/o project		w/ project	
Unsignalized Intersection	AM	PM	AM	PM	AM	PM
Mauna Lani Drive						
Eastbound Left	C	C	E	F	F	F
Eastbound Right	A	A	A	A	A	A
Queen Kaahumanu Highway						
Northbound Left	A	A	B	A	B	B
Highway						
Queen Kaahumanu Highway	B	C	E	E	E	E

MITIGATION MEASURES

For the year 1998 without project, the capacity of the eastbound left turn movements at the Queen Kaahumanu Highway/Mauna Lani Drive unsignalized intersection would be exceeded even without the addition of the Cove project traffic. There are several alternatives that could improve the situation at this intersection:

1. Signalization of this intersection would be warranted according to Warrant 11 (peak hour volume) in the Manual on Uniform Traffic Control Devices[7]. A three-phase traffic signal at the Queen Kaahumanu Highway/Mauna Lani Drive is estimated to operate at LOS C conditions or better during the AM and PM peak hours for year 1998 without and with the proposed project.

2. A grade separated interchange could be constructed at the Queen Kaahumanu Highway/Mauna Lani Drive intersection. This alternative involves constructing Mauna Lani Drive over or under Queen Kaahumanu Highway and constructing ramps from Mauna Lani Drive to/from Queen Kaahumanu Highway in order to eliminate conflicting turn movements on Queen Kaahumanu Highway.

3. A second unsignalized T-intersection on Queen Kaahumanu Highway could be provided for access to the Mauna Lani Resort area. This second access road and Mauna Lani Drive could provide the necessary capacity for the projected eastbound left turn movements from the Mauna Lani Resort area.

RECOMMENDATIONS AND CONCLUSIONS

The analysis of the Queen Kaahumanu Highway/Mauna Lani drive intersection indicates that the eastbound left turn capacity at this intersection would experience over-capacity conditions even without the proposed Cove project. If the traffic volumes for future year 1998 are realized, all developments on the South Kohala-Kona coast with unsignalized intersections on Queen Kaahumanu Highway are expected to encounter similar problems. Improvements for year 1998 at this intersection would be required even without considering traffic from the proposed project which is estimated to increase traffic volumes at this intersection by 5 percent during the AM peak hour and by 9 percent during the PM peak hour.

Signalization of the Queen Kaahumanu Highway/Mauna Lani Drive intersection is not recommended. Queen Kaahumanu Highway is a rural, high-speed facility that has only one signalized intersection, Queen Kaahumanu at Palani Road, near the highway's end in Kona where the character of the area changes from open area to commercial and where the speed limit is reduced. A traffic signal at the Queen Kaahumanu Highway/Mauna Lani Drive intersection would be unexpected to motorists and would increase the potential for rear-end accidents at this intersection.

A grade separated interchange could be a possible long-term solution. An interchange would provide adequate capacity for all turn movements at the Queen Kaahumanu Highway/Mauna Lani Drive intersection as all turn movements would be facilitated by on-ramps or off-ramps at this interchange. However, an interchange would

not reduce traffic volumes on Queen Kaahumanu Highway and would not be fully utilized unless it served an access roadway to development on the east side of Queen Kaahumanu Highway directly across from Mauna Lani Drive.

The most feasible and realistic short-term solution to reduce traffic delays for the eastbound left turn movement at the Queen Kaahumanu Highway/Mauna Lani Drive intersection would require the construction of a second access roadway connecting Queen Kaahumanu Highway to the Mauna Lani Resort area. If 40 percent of the Mauna Lani Resort traffic diverts to this new intersection, LOS E conditions are estimated at for the eastbound left turn movements the two intersections.

This second unsignalized T-intersection with Queen Kaahumanu Highway should be located at least 1,200 feet from the Mauna Lani Drive intersection[8]. A northbound left turn lane on Queen Kaahumanu Highway would be warranted[9] and should be provided for storage of left turning vehicles and for use as a refuge area for eastbound left turn traffic. This refuge area would allow eastbound left turn traffic to cross the southbound traffic lane before merging with northbound traffic and would create more opportunities for eastbound left turns across Queen Kaahumanu Highway traffic. Separate left and right turn lanes are recommended for the eastbound approach to prevent left turning traffic from blocking this approach. Since Queen Kaahumanu Highway is a high-speed facility, acceleration and deceleration lanes should also be provided on the highway for right turns onto the access road and for right turns onto Queen Kaahumanu Highway.

REFERENCES

1. Project Planners Hawaii, Traffic Count - Queen Kaahumanu Highway At Mauna Lani Drive, July 1988.

2. Transportation Research Board, National Research Council, Highway Capacity Manual, Special Report 209, Washington, D.C., 1985.

3. Belt Collins & Associates, Final Environmental Impact Statement - The Ritz Carlton Mauna Lani, July 1987.

4. Natelson-Levander-Whitney, Inc., Mauna Lani Marina Economic Impact Analysis, May 1989.

5. Institute of Transportation Engineers, Trip Generation, Fourth Edition, Washington, D.C., 1987.

6. Belt Collins & Associates, Final Environmental Impact Statement - Revised Master Plan For Mauna Lani Resort, June 1985.

7. U.S. Department of Transportation, Federal Highway Administration, Manual On Uniform Traffic Control Devices For Streets and Highways, 1978, as amended.

8. State of Hawaii, Department of Transportation, Highways Division, Statewide Uniform Design Manual For Streets and Highways, October 1980, as amended.

9. Harmelink, M.D.,"Volume Warrants For Left Turn Storage Lanes At Unsignalized Grade Intersections," Highway Research Record No. 211, Washington, D.C., 1967.

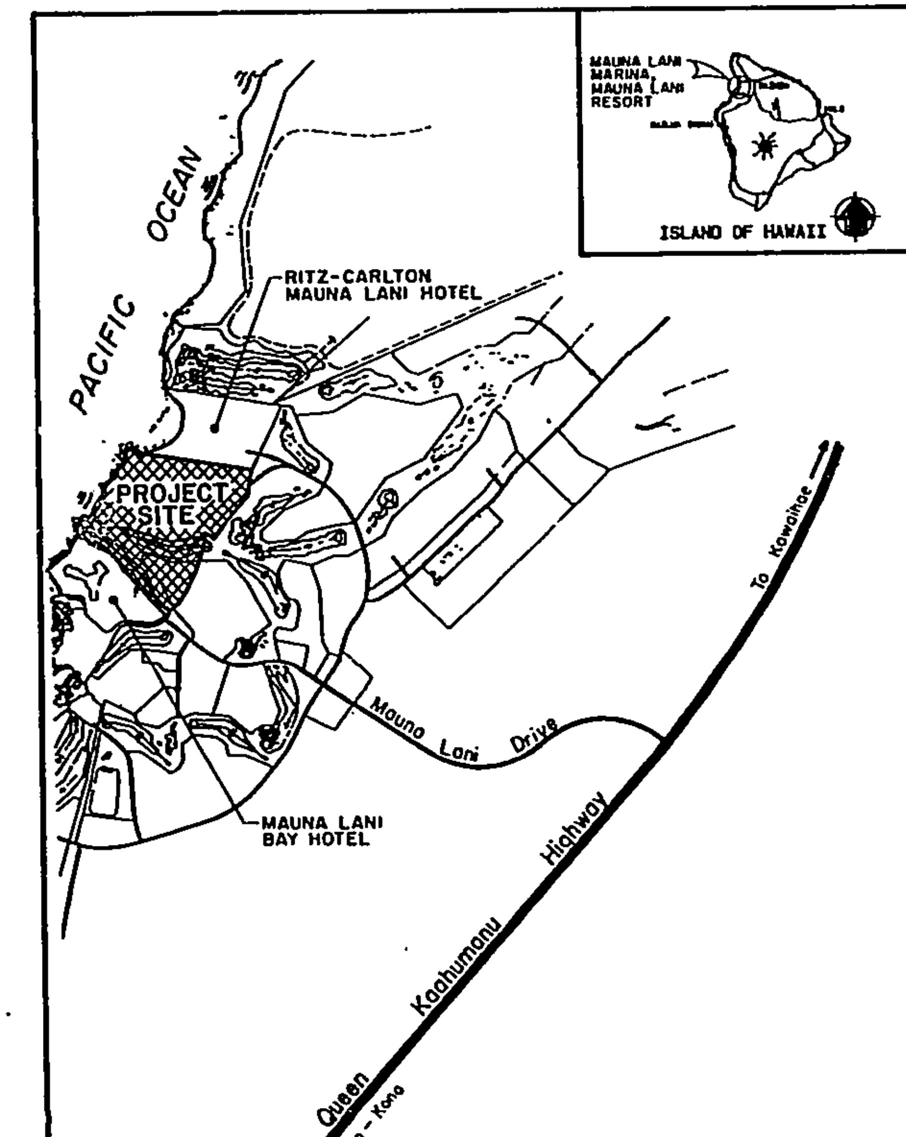


FIGURE 1
PROJECT LOCATION MAP

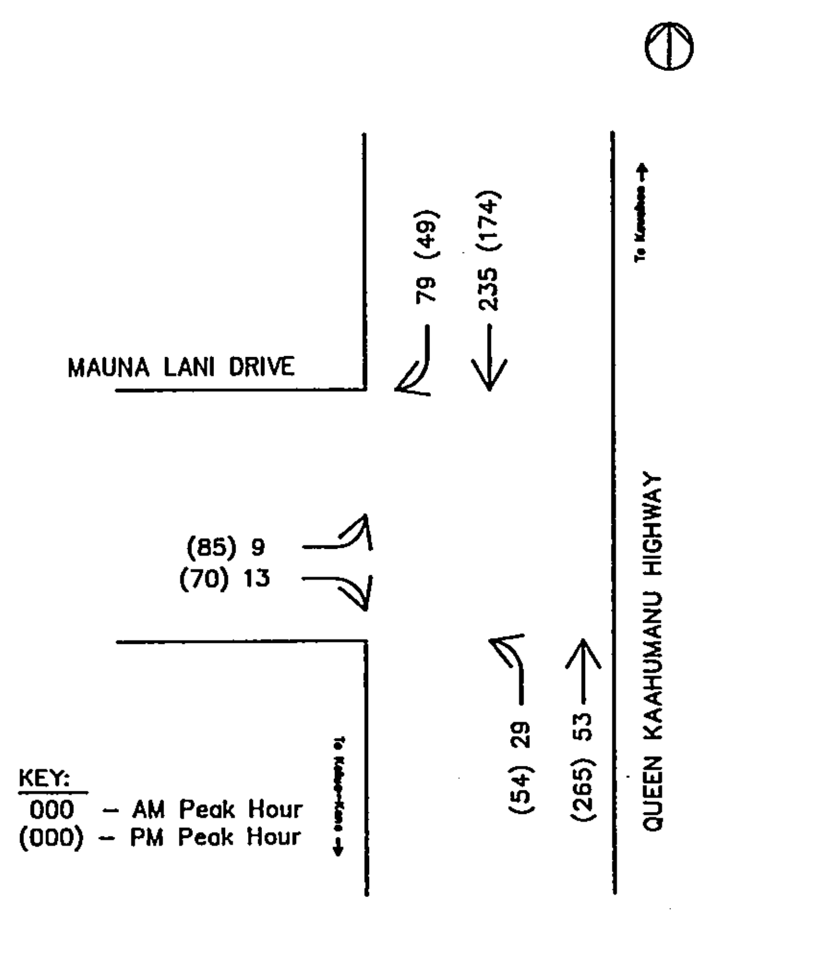


Figure 2

EXISTING TRAFFIC VOLUMES
(1988)

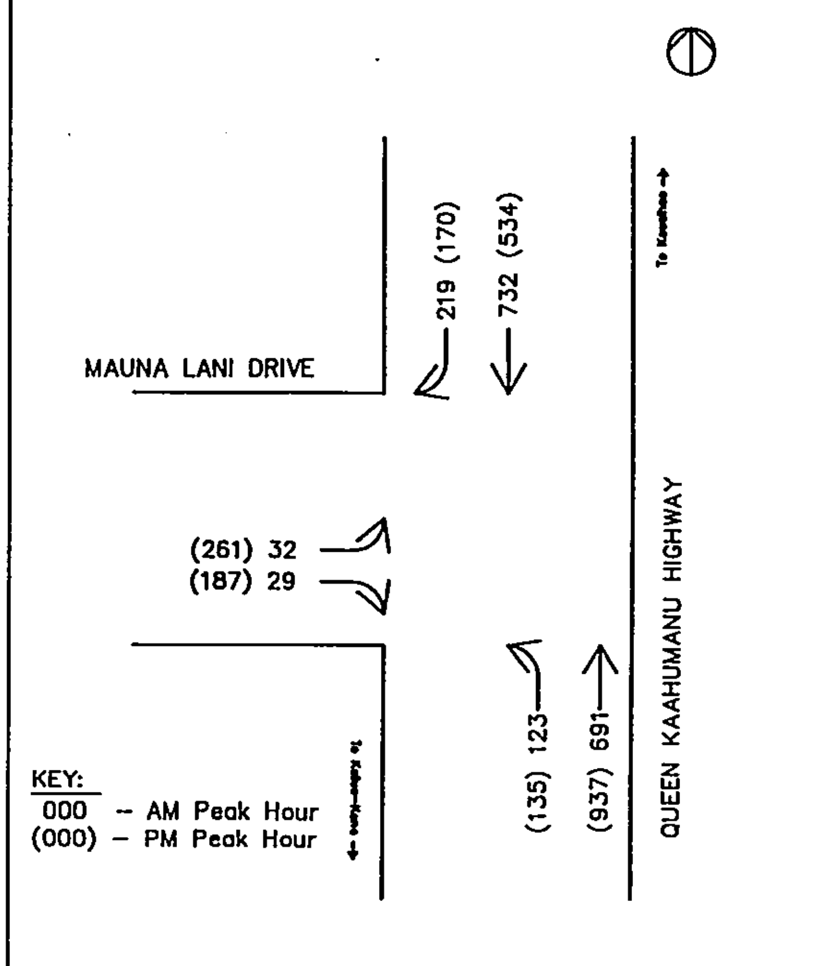


Figure 3

TRAFFIC ASSIGNMENT
FUTURE (1998) WITHOUT PROJECT

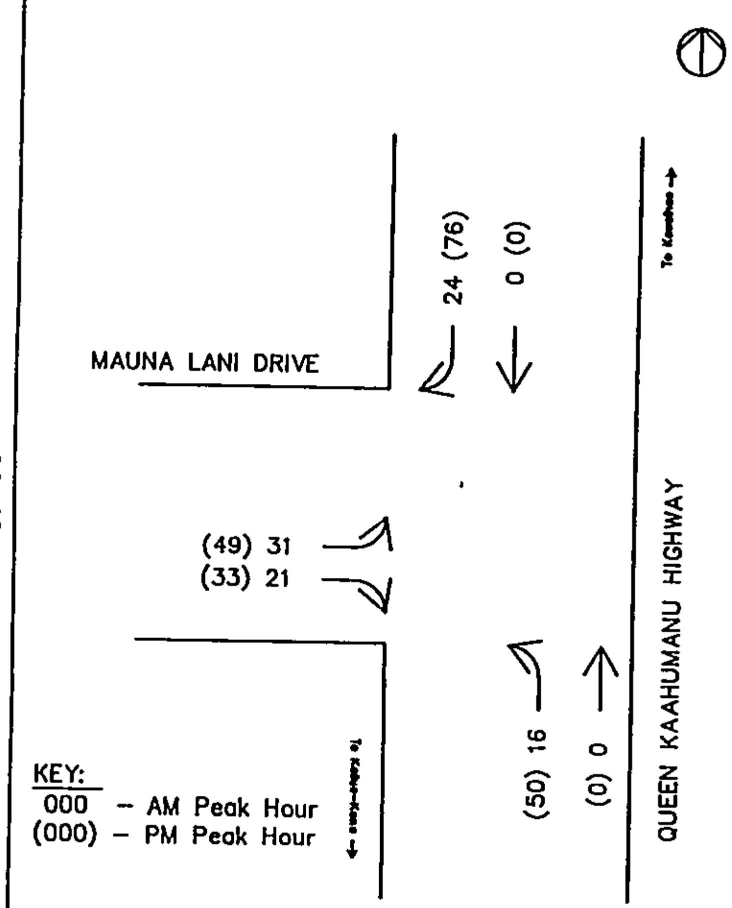


Figure 4

TRAFFIC ASSIGNMENT
COVE PROJECT TRAFFIC

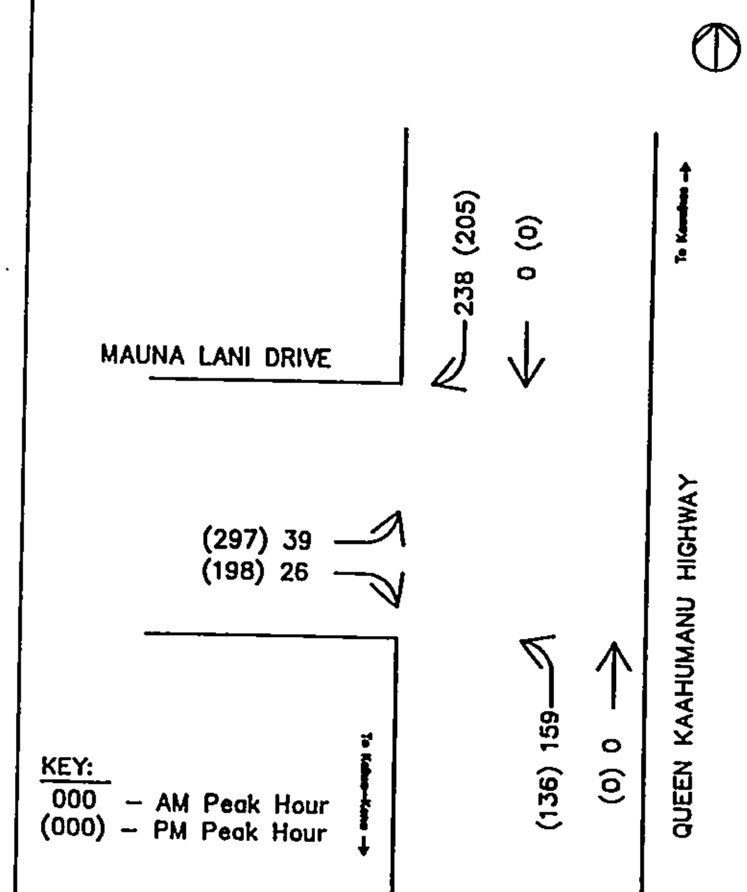


Figure 4a

TRAFFIC ASSIGNMENT
ORIGINAL PROJECT (HOTEL) TRAFFIC

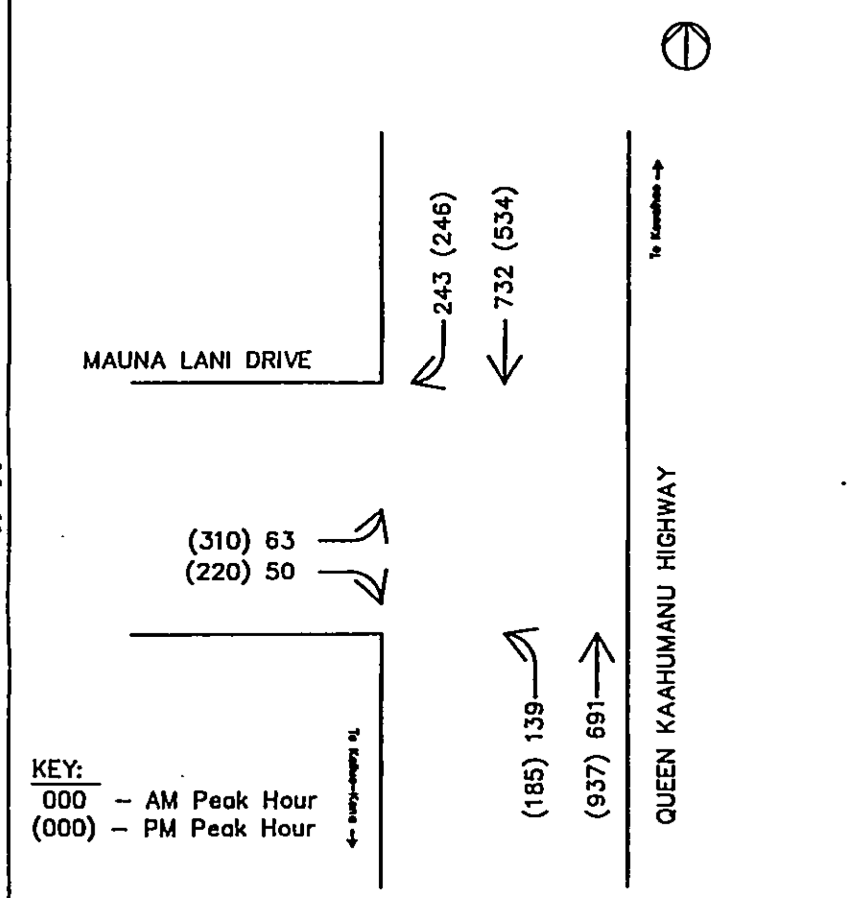


Figure 5

TRAFFIC ASSIGNMENT
FUTURE (1998) WITH COVE PROJECT

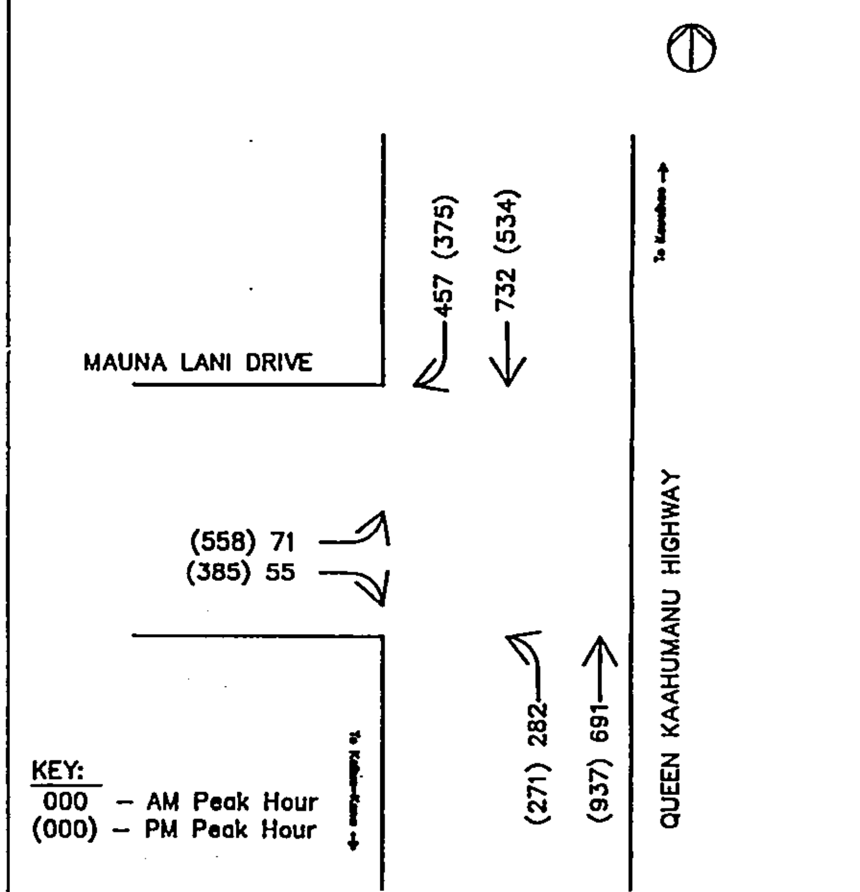


Figure 5a

TRAFFIC ASSIGNMENT
FUTURE (1998) WITH ORIGINAL (HOTEL) PROJECT

APPENDIX

The Highway Capacity Manual defines six Levels of Service; labelled A through F, from best to worst conditions. Levels of Service for signalized intersections, unsignalized intersections, and two-lane highways are not directly comparable because they are based on different operational criteria.

Unsignalized Intersections

For unsignalized intersections, the Highway Capacity Manual evaluates gaps in the major street traffic flow and calculates capacities available for left turns across oncoming traffic and for left and right turns onto the highway form the minor street.

LEVEL OF SERVICE A: Little or no delay.

LEVEL OF SERVICE B: Short traffic delays.

LEVEL OF SERVICE C: Average traffic delays.

LEVEL OF SERVICE D: Long traffic delays.

LEVEL OF SERVICE E: Very long traffic delays.

LEVEL OF SERVICE F: Demand volume exceeds capacity, resulting in extreme delays with queuing that may cause severe congestion and affect other movements at the intersection.

Signalized Intersections

Level of Service for signalized intersections is measured in terms of delay. Delay is a measure of driver discomfort, frustration, fuel consumption, and lost travel time.

LEVEL OF SERVICE A: This level describes operations with very low delay, i.e., less than 5.0 seconds per vehicle. This occurs when progression is extremely favorable, and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.

LEVEL OF SERVICE B: This level describes operations with delays in the range of 5.1 to 15.0 seconds per vehicle. This generally occurs with good progressions and/or short cycle lengths. More vehicles stop than for LOS A, causing higher average delays.

LEVEL OF SERVICE C: This level describes operations with delays in the range of 15.1 to 25.0 seconds per vehicle. These higher delays may result from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear as the number of vehicles stopping is significant; many vehicles, however, still pass through the intersection without stopping.

LEVEL OF SERVICE D: This level describes operations with delays in the range of 25.1 to 40.0 seconds per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from a combination of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

LEVEL OF SERVICE E: This level describes operations with delays in the range of 40.1 to 60.0 seconds per vehicle. This is considered to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures (queued vehicles do not clear in one cycle) are frequent occurrences.

LEVEL OF SERVICE F: This level describes operation with delay in excess of 60.0 seconds per vehicle. This is considered to be unacceptable to most drivers. This condition often occurs with oversaturation, i.e., when arrival flow rates exceed the capacity of the intersection. It may also occur at high v/c ratios below 1.00 with many individual cycle failures. Poor progression and long cycle length may also be major contributing causes to such delay levels.

Two-Lane Highways

The analysis of two-lane highways evaluates percent time delay with speed and capacity utilization serving as secondary measures.

LEVEL OF SERVICE A: Motorists are able to drive at their desired speeds. Passing demand is well below capacity and almost no platoons of three or more vehicles are observed. Drivers would be delayed no more than 30 percent of the time by slow-moving vehicles.

LEVEL OF SERVICE B: Passing demand approximately equals passing capacity. Drivers may be delayed up to 45 percent of the time, the number of platoons forming in the traffic stream begins to increase dramatically.

LEVEL OF SERVICE C: Traffic flows increase, resulting in noticeable increases of platoon formation, platoon size, and frequency of passing impediment; chaining of platoon and significant reductions of passing capacity begin to occur. Traffic flows are stable, but is susceptible to congestion caused by turning movements and slow-moving vehicles. Motorists may be delayed up to 60 percent of the time.

LEVEL OF SERVICE D: Traffic flows become unstable. The two opposing traffic streams essentially begin to operated separately as passing becomes extremely difficult. Passing demand is high, while passing capacity approaches zero. Average platoon sizes of 5 to 10 vehicles are common. Turning vehicles and/or roadside distractions cause major shock waves in the traffic stream. Delays for motorists may approach 75 percent of the time. This is the highest flow rate that can be maintained without a high probability of breakdown.

LEVEL OF SERVICE E: Traffic flows experience delays more than 75 percent of the time. Passing is virtually impossible and platooning becomes intense when slower vehicles or other interruptions are encountered. Traffic volumes may reach capacity of the highway. Operating conditions at capacity are unstable and difficult to predict or maintain; Level of Service E is a transient condition and perturbations in traffic flows would cause a rapid transition to Level of Service F.

LEVEL OF SERVICE F: Heavily congested flow with traffic demand exceeding capacity. Volumes are lower than capacity and speeds are below capacity speeds.

APPENDIX N

AIR QUALITY IMPACT ANALYSIS
MAUNA LANI COVE
SOUTH KOHALA, HAWAII

AIR QUALITY IMPACT REPORT
MAUNA LANI COVE
November 30, 1989

Prepared for

Belt, Collins & Associates

and

Mauna Lani Resort, Inc.

Prepared by

J. W. MORROW
ENVIRONMENTAL MANAGEMENT CONSULTANT
KAILUA, HAWAII

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Mauna Lani Resort, Inc. is proposing to develop a residential/resort marina project on 88 acres of land at the existing Mauna Lani Resort (Figure 1). The project site is located between the Mauna Lani Bay Hotel and the future Ritz-Carlton Mauna Lani Hotel. For planning and impact analysis purposes the maximum development would include 140 single-family homes and 250 marina slips.

The purpose of this report is to assess the impact of the proposed development on air quality on a local and regional basis. The overall project can be considered an "indirect source" of air pollution as defined in the Federal Clean Air Act [1] since its primary association with air quality is due to its inherent generation of mobile source, i.e., motor vehicle activity. Much of the focus of this analysis, therefore, is on the project's ability to generate traffic and the resultant impact on air quality. Air quality impact was evaluated for existing (1988) and future (1998) conditions.

A project such as this also has off-site impacts due to increased demand for electrical energy which must be met through the combustion of some type of fuel. This combustion process results in pollutant emissions to the air which have been addressed.

Finally, during construction of the various buildings and facilities air pollutant emissions will be generated due to vehicular movement, grading, concrete and asphalt batching, and general dust-generating construction activities. These impacts have also been addressed.

2. AIR QUALITY STANDARDS

A summary of State of Hawaii and national ambient air quality standards is presented in Table 1 [2, 3]. Note that Hawaii's standards are not divided into primary and secondary standards as are the Federal standards.

Primary standards are intended to protect public health with an adequate margin of safety while secondary standards are intended to protect public welfare through the prevention of damage to soils, water, vegetation, man-made materials, animals, wildlife, visibility, climate, and economic values [4].

Some of Hawaii's standards are clearly more stringent than their Federal counterparts but, like their Federal counterparts, may be exceeded once per year. It should also be noted that in April, 1986, the Governor signed amendments to Chapter 59 (Ambient Air Quality Standards) making the State's standards for particulate matter and sulfur dioxide the same as national standards. In the case of particulate matter, however, this uniformity did not last long. On July 1, 1987, the EPA revised the Federal particulate standard to apply only to particles 10 microns or less in diameter (PM-10) [5], leaving the State once again with standards different than the Federal ones.

In the case of the automotive pollutants [carbon monoxide (CO), oxides of nitrogen (NOx), and photochemical oxidants (Ox)], there are only primary standards. Until 1983, there was also a hydrocarbons standard which was based on the precursor role hydrocarbons play in the formation of photochemical oxidants rather than any unique toxicological effect they had at ambient levels. The hydrocarbons standard was formally eliminated in January, 1983 [6].

The U.S. Environmental Protection Agency (EPA) is mandated by Congress to periodically review and re-evaluate the Federal standards in light of new research findings [7]. The last review resulted in the relaxation of the oxidant standard from 160 to 240 micrograms/cubic meter (ug/m3) [8]. The carbon monoxide (CO), particulate matter, sulfur dioxide (SO2), and nitrogen dioxide (NO2) standards are under review, and no formal proposed changes have been made yet [9].

Finally, the State of Hawaii also has fugitive dust regulations for particulate matter (PM) emanating from construction activities [10]. There simply can be no visible emissions from fugitive dust sources.

3. EXISTING AIR QUALITY

3.1 General. The State Department of Health maintains a network of air monitoring stations around the State to gather data on the following regulated pollutants:

- total suspended particulates (TSP)
- particulate matter - 10 microns (PM-10)
- sulfur dioxide (SO2)
- carbon monoxide (CO)
- ozone (O3)
- lead (Pb)

In the case of TSP, PM-10, and SO2, measurements are made on a 24-hour basis to correspond with the averaging period specified in State and Federal standards. Samples are collected once every

six days in accordance with U.S. Environmental Protection Agency (EPA) guidelines. Carbon monoxide and ozone, however, are measured on a continuous basis due to their short-term (1-hour) standards. Lead concentrations are determined from the TSP samples which are sent to an EPA laboratory for analysis. It should also be noted that the majority of these pollutants are monitored only in Honolulu.

3.2 Department of Health Monitoring Sites. While, there is no air monitoring station in the project area, it seems safe to assume that air quality is good most of the time since there are no large stationary sources in the immediate vicinity and mobile source activity has not yet become a serious concern. In fact, since 1985 when the State Department of Health reduced its monitoring network on the Neighbor Islands, there has been no permanent air monitoring of regulated pollutants on the Island of Hawaii. However, due to public concerns about volcanic air pollution, i.e., VOG, a special monitoring study was conducted during the 1985 - 1986 period in Kailua-Kona. The results of that study are presented in Tables 2 and 3 and indicate very low levels of total suspended particulate matter (TSP) and sulfur dioxide (SO2). Both State and Federal air quality standards appear to be met.

As suggested by the above reference to VOG, the worst air pollution episodes experienced in Hawaii County are due to the infrequent and unpredictable volcanic eruptions. While volcanic emissions are somewhat variable and have not been fully characterized, it is well known that visibility is affected by the presence of fine particulates resulting directly from volcanic activity as well as secondarily from forest fires caused by lava flows. In addition there are substantial increases in the ambient concentrations of mercury and sulfur dioxide.

Measurements of sulfur dioxide taken during the January, 1983 eruptive phase, for example, indicated 24-hour concentration as high as 982 ug/m3 at the Volcano Observatory and 654 ug/m3 in Hilo. Sulfur dioxide and particulate measurements made during January and March, 1983 in Kona and Hilo are presented in Table 4. Despite the volcanic activity, concentrations were relatively low on the few days that measurements were made. The low level of sulfur dioxide may be explained by the infrequent monitoring, variable wind directions, and gas-to-particle conversion (sulfur dioxide gas to particulate sulfate) occuring in the atmosphere.

Analysis of the airborne particulate matter during the eruption revealed some rather interesting results as unusually high concentrations of selenium, arsenic, indium, gold, and sulfur were found along with strikingly high concentrations of iridium [11].

3.3 Onsite Carbon Monoxide Sampling. In conjunction with this study, air sampling was conducted along the Queen Kaahumanu Highway at Mauna Lani Drive during September, 1989.

The actual sampling site was within 10 meters of the road edge and on the west side of the highway in the morning and east side in the afternoon due to the winds prevailing at the time. A continuous carbon monoxide (CO) instrument was set up and operated during the a.m. and p.m. peak traffic hours based on the results of the traffic impact study [12]. An anemometer and vane were installed to record onsite surface winds at a 2.5 meter height. A simultaneous manual count of traffic along Queen Kaahumanu Highway was also made. The variability of each of the measured parameters during the peak hours is clearly seen in Figures 2 and 3.

During the September 6th p.m. peak hour, winds were very light and variable and the CO level averaged 2.2 milligrams per cubic meter (mg/m3). On September 7th during the a.m. peak hour, winds were generally easterly (offshore), and the CO concentration averaged 1.8 mg/m3. The CO levels were comparable to the computer-generated estimates reported in Section 6 of this report. Traffic counts were comparable to those reported in the traffic impact study.

4. CLIMATE & METEOROLOGY

4.1 Temperature & Rainfall. The project area is typical of Hawaii's climate with little seasonal or diurnal temperature variation. Monthly temperature averages vary by only about 6 degrees from the warmest months (July and August) to the coolest (January and February) [13]. Table 5 provides historical temperature data.

N-5

An 18-year rainfall record also indicates that the area is rather dry with an annual average of only 10.65 inches. Monthly means range from 2.63 inches in January to 0.14 inch in July. Table 5 includes a summary of this precipitation data. With this temperature and rainfall profile, the area has a Thornwaite precipitation/evaporation (P/E) index of 12 [14].

4.2 Surface Winds. Raw data collected at the Mauna Kea Beach Hotel in 1967 have been previously reduced to produce an annual wind rose for the project area [15]. The period of data collection ran from March through December, 1967, and totaled 3,785 hours. The annual wind rose is presented in tabular form in Table 6 and graphical form in Figure 4.

The data clearly indicate an east-west dichotomy. Closer examination of the raw data reveals the fact that the ESE-ENE winds generally occur during night, early morning and evening

hours while the WNW-W winds predominate during the daytime hours.

This suggests a strong land-seabreeze regime which apparently dominates air movement in the area. To demonstrate this more clearly, windroses were prepared for 8 a.m. and 2 p.m. These are displayed in Tables 7 and 8 and Figures 5 and 6.

5. SHORT-TERM IMPACTS

The principal source of short-term air quality impact will be construction activity. Construction vehicle activity will increase automotive pollutant concentrations along Queen Kaahumanu Highway as well as in the vicinity of the project site itself.

Because of the moderate level of existing traffic volumes, the additional construction vehicle traffic should not exceed road capacities although the presence of large trucks can reduce a roadway's capacity as well as lower average travel speeds.

The site preparation and earth moving will create particulate emissions as will building and on-site road construction. Construction vehicles movement on unpaved on-site roads will also generate particulate emissions. EPA studies on fugitive dust emissions from construction sites indicate that about 1.2 tons/acre per month of activity may be expected under conditions of medium activity, moderate soil silt content (30%), and a precipitation/evaporation (P/E) index of 50 [14,16].

Although there is little or no soil on the project site, the soil that is brought in may well have a silt content greater than the 30% cited above. This in conjunction with the relatively dry local climate (P/E Index = 12), suggests a potential for even greater fugitive dust emissions.

In addition to the onsite impacts attributable to construction activity, there will also be offsite impacts due to the operation of concrete and asphalt concrete batching plants needed for construction. Concrete requirements are estimated at 152,000 yd3 and asphalt at 31,000 tons. Estimated emissions resulting from the production of these materials and based on EPA emissions factors [16] are presented in the following table.

ESTIMATED EMISSIONS FROM
CONCRETE AND ASPHALT BATCHING

Pollutant	Emissions (tons) Concrete Batching	Asphalt Batching
Particulate matter (PM)	14.5	4.4
Sulfur dioxide (SO2)	n/a	2.4
Nitrogen Oxides (NOx)	n/a	2.6
Carbon Monoxide (CO)	n/a	1.0
Volatile Organic Compounds (VOC)	n/a	0.6

In addition to the foregoing emissions analysis, design an operating features of a typical concrete batching plant wer obtained for an ambient air impact analysis. This plant (Re Transit Mix Batch Plant, Model LO GO 5) [17], is a portable uni capable of producing up to 100 cubic yards of concrete per hour Assuming 8 hours/day operation and published EPA emission factor [15] for both direct plant emissions and fugitive dust emissions estimates of worst case ambient impact were derived using th PTPLU screening model. Ninety percent control of particulat emissions from the plant itself and 60% control of fugitive dus emissions from the process were assumed. One-hour concentratio estimates were adjusted to 8-hour averages using a EPA-recommended factor [18] and then to 24-hour averages based o a weighted averaging technique. The worst case concentration o total suspended particulates (TSP) was thus estimated to be 10 micrograms/cubic meter (ug/m3) due to the plant operation.

Assuming that the plant would be located near the project site existing data from the Kailua-Kona site were reviewed (Tables 2 3). Adding the second highest TSP concentration from the 1985-8 data (26 ug/m3) to the 105 ug/m3 yields 131 ug/m3 which is belo the State 24-hour TSP standard of 150 ug/m3. Furthermore, sinc only part of the TSP will be 10 microns or less, then complianc with the Federal PM-10 standard is also indicated.

Design and operating data for a typical asphalt concrete batc plant (Astec Industries Model PDM-636-C) were also obtained an reviewed. This plant has a production capacity of 186 T/hour an thus could provide the required 31,000 tons of asphalt withi about a month of normal operation. The two primary emissio sources associated with such a plant are the drum mix asphal plant and a 600 Kw diesel generator.

The modeling technique employed for the concrete batch plant was again employed for the asphalt plant with the results as shown in the following table.

ESTIMATED IMPACT OF AN ASPHALT CONCRETE BATCH PLANT

Pollutant	24-hour Concen. (ug/m3)	Existing Concen. (ug/m3)	Total (ug/m3)
Particulates	34.9	26	60.9
Sulfur dioxide	13.6	8	21.6
Nitrogen dioxide	203	n/a	203
Carbon monoxide	44.2	n/a	44.2
Volatile organic compounds	16.2	n/a	16.2

The existing concentrations for particulates and SO2 are 1985 Kailua-Kona data (Tables 2 & 3). The same caveats noted for the concrete batch plant also apply in this case, i.e., uncertainty about background concentration at the plant site and requirement for DOH review and permit.

6. MOBILE SOURCE IMPACT

6.1 <u>Mobile Source Activity</u>. The principal highway serving the area is the Queen Kaahumanu Highway which connects Kailua-Kona some 30 miles to the south with the Kawaihae-Waimea Highway about 10 miles to the north. These are both two-lane rural highways with capacities of about 1,500 vehicles per hour. The Queen Kaahumanu Highway is designed with a 24-foot pavement width.

Access to the project site from Queen Kaahumanu Highway is via the existing Mauna Lani Drive. Photographs of existing conditions at this intersection are presented in Figure 7.

Existing and projected traffic data for this project were provided by the traffic consultant [12] and served as the basis for this mobile source impact analysis. For comparative purposes, two future scenarios were evaluated, one with the originally proposed hotel for the site and one with the presently proposed marina.

6.2 <u>Emission Factors</u>. Automotive emission factors for carbon monoxide (CO) were generated for calendar years 1988 and 1998 using the Mobile Source Emissions Model (MOBILE-3) [19]. To localize the emission factors as much as possible, the August, 1988 age distribution for registered vehicles in the City & County of Honolulu [20] was input in lieu of national statistics.

6.3 Microscale Analysis. Analyses such as this generally involve estimation of concentrations of non-reactive pollutants. This is due to the complexity of modeling pollutants which undergo chemical reactions in the atmosphere and are subject to the effects of numerous physical and chemical factors which affect reaction rates and products. For projects involving mobile sources as the principal source, carbon monoxide is normally selected for modeling because it has a relatively long half-life in the atmosphere (ca. 1 month) [21], and it comprises the largest fraction of automotive emissions.

Due to the generally low level of urbanization in the area which would otherwise contribute to a "heat island" effect and increased turbulence, a stable atmosphere (Category "F") and neutral atmosphere (Category "D") [22], 1 meter per second (m/sec) wind speed, and an acute (30 degree) wind-road angle were assumed for morning and afternoon peak hours, respectively. Review of the traffic data, and the potential for queuing in particular, indicated that southeast and southwest wind directions were most likely to produce the maximum CO concentrations near the intersections under study; thus, these wind directions were input for the modeling.

An updated version of the EPA guideline model CALINE-4 [23, 24] was employed to estimate near-intersection carbon monoxide concentrations. An array of receptor sites at distances of 5 to 15 meters from the road edge were input to the model. Because of the growing level of urbanization in the area, a background CO concentration of 1.0 milligram per cubic meter (mg/m3) was assumed.

A summary of the results of this modeling are presented in Figures 8 and 9. The figure depicts the estimated maximum 1-hour CO concentrations in milligrams per cubic meter (mg/m3) at 12 receptor locations on the northeast or northwest side of the intersection for each of the existing or future scenarios. They show relatively small increases over the 1988 - 1998 period with or without the proposed project and indicate compliance with State and Federal 1-hour CO standards during the a.m. peak hour. During the 1998 p.m. peak, however, exceedance of the State standard is indicated at one receptor location within 10 meters of the intersection due primarily to predicted queuing of traffic trying to exit Mauna Lani Drive. This exceedance is predicted with or without the proposed development. Note also that the originally proposed hotel results in higher CO levels than the currently proposed marina.

Compliance with federal and state 8-hour standards can also be determined by applying a "persistence" factor of 0.6 to the

1-hour maximum CO values. This "persistence" factor is recommended in an EPA publication on indirect source analysis [25]. When using this approach, any CO concentration greater than 8.4 mg/m3 would indicate exceedance of the State's 8-hour standard. Similarly, any 1-hour concentration over 15.7 mg/m3 would indicate exceedance of the federal 8-hour standard. In this case, the procedure suggests exceedance of the State's 8-hour standard at the same "hotspot" identified in the 1-hour analysis.

7. OTHER LONG-TERM IMPACTS

7.1 Boat Operations. The many fuel powered vessels that will be utilizing the proposed marina will also emit the normal pollutants generated by internal combustion engines. Because many of these, particularly outboards, have underwater exhausts, there is a "scrubbing" effect on emissions. Thus, particulates and water soluble gases such as SO_2 remain in the water while the other gases and vapors are released into the air. Rough, order-of-magnitude estimates of possible emissions from such operations were computed based on EPA emission factors [17] and assumptions regarding type propulsion [26], fuel types and hours of operation. These estimated annual emissions are summarized in the following table and have been compared with the latest available Department of Health emissions inventory for Hawaii County (see also Table 9).

Estimated Annual Emissions
Due To Boat Operations

Pollutant	Emissions (T/yr)	Percent of County Emissions
Carbon monoxide	63.9	0.10 %
Total hydrocarbons	23.0	0.32
Nitrogen oxides	3.3	0.06
Sulfur oxides	0.4	0.01

7.2 Electrical Generation Impact. The estimated annual electrical load of 1.1 million kilowatt-hours (Kwhr) will contribute to the demand on the local utility necessitating additional fuel combustion. The nearest power generating station to the proposed project is the Hilo Electric Light Company's Keahole facility. It is comprised solely of diesel units. Emissions from this facility would eventually increase as a result of this and other projects' electrical demand. Estimates of the annual emissions resulting from diesel fuel combustion to meet the project's electrical demand are presented in the following table and have been compared with the county emissions inventory (see also Table 9):

Estimates of Annual Emissions Due to Electrical Generation

Pollutant	Emissions (T/yr)	Percent of 1980 County Emissions
Nitrogen oxides	19.0	0.33 %
Carbon monoxide	4.1	0.01
Total hydrocarbons	1.5	0.02
Particulate matter	1.3	0.02
Sulfur oxides	1.2	0.03

8. CONCLUSIONS AND MITIGATION

8.1 Short-Term Impacts. Since as noted in Section 5, there is some potential for fugitive dust due to the dry climate and fine soils, it will be important for adequate dust control measures to be employed during the construction period. At the latter stages of development there may be occupied units which will at times be downwind of construction activity. Fugitive dust, particularly during the drier, windier summer months, could be a source of complaints not to mention possible violations of State or Federal standards.

Dust control could be accomplished through frequent watering of unpaved roads and areas of exposed soil. The EPA estimates that twice daily watering can reduce fugitive dust emissions by as much as 50%. The earliest possible landscaping of completed areas will also help.

The production of concrete and asphalt for the project will result in off-site impacts due to emissions from those processes; however, such plants are permitted by the Department of Health and are required to be in compliance with State and Federal standards.

8.2 Mobile Source Impacts. As noted in Section 6, the project will contribute to an increase in automotive emissions in the region, but ambient carbon monoxide levels are expected to generally remain in compliance with both State and Federal ambient air quality standards. Only at "hotspots" in close proximity to the Mauna Lani Drive - Queen Kaahumanu Highway intersection during peak hours might the State's 1-hour CO standard be exceeded under the worst case conditions of traffic and meterorology. This potential impact would likely be eliminated by the construction of a second access road to the resort as recommended in the traffic impact study.

8.3 Other Long-Term Impacts.

The anticipated boat operations in the new marina will generate emissions as a result of fuel combustion. These emissions will contribute in a relatively small way (<1% increase) to West Hawaii's overall emissions inventory and are not expected to threaten state or federal air quality standards.

The proposed project will increase electrical demand which in turn will cause more fuel to be burned and more pollutants to be emitted into West Hawaii's air. The estimated emissions also represent increases over the 1980 Hawaii County Emissions Inventory of less than 1% for individual regulated pollutants. Until other nonpolluting means of generating electricity are developed or higher efficiency control technologies are applied, such increases in emissions are inevitable. Emissions can be reduced to some extent by reducing electrical demand by the user, e.g., use of solar water heating, heat pumps, waste heat recovery, etc. Ambient air quality standards, however, are predicted to be met despite the increased emissions.

REFERENCES

1. U. S. Congress. Clean Air Act Amendments of 1977 (P.L. 95-95, Section 110, Implementation Plans, August, 1977.
2. U. S. Government. Code of Federal Regulations, Title 40, Protection of Environment, Part 50, National Primary and Secondary Ambient Air Quality Standards.
3. State of Hawaii. Title 11, Administrative Rules, Chapter 59 Ambient Air Quality Standards, as amended, April, 1986.
4. Library of Congress, Congressional Research Service. A Legislative History of the Clean Air Amendments of 1970, Volume 1, p. 411, January, 1974.
5. U.S. Environmental Protection Agency. Revisions to National Ambient Air Quality Standards for Particulate Matter, Federal Register, Vol. 52, p. 2463, July 1, 1987.
6. U. S. Environmental Protection Agency. National Ambient Air Quality Standards for Hydrocarbons: Final Rulemaking, Federal Register, Volume 48, No. 3, p. 628, January, 1983.
7. U. S. Congress. Clean Air Act Amendments of 1977 (P.L. 95-95) Section 109, National Ambient Air Quality Standards, August, 1977
8. U. S. Environmental Protection Agency. National Ambient Air Quality Standards for Photochemical Oxidants: Final Rulemakin Federal Register, Volume 44, No. 28, p. 8202, February 8, 1979
9. U. S. Environmental Protection Agency. Regulatory Agenda, Federal Register, Volume 50, No. 82, p. 17784, April 29, 1985.
10. State of Hawaii. Title 11, Administrative Rules, Chapter 60, Air Pollution Control.
11. Zoller, W. H. et al. Iridium Enrichment in Airborne Particles from Kilauea Volcano: January 1983, Science 222: 1118, December, 1983
12. Belt Collins & Associates. Traffic Impact Study: Mauna Lani Cove, South Kohala, Hawaii, October, 1989.
13. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, Environmental Data Service. Hawaii and Pacific Annual Summary, 1974
14. Thornwaite, C. W. Climates of North America According to a New Classification, Geog. Rev. 21: 633-655, 1931.

REFERENCES (Continued)

15. Morrow, J. W. Air Quality Impact Analysis: Mauna Kea Beach Hotel Power Plant, February, 1979
16. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, Fourth Edition, 1985
17. Rexworks, Inc. LO GO 5 Transit Mix Batch Plant, Bulletin No. 1017-283
18. U.S. Environmental Protection Agency. Guidelines for Air Quality Maintenance Planning and Analysis, Volume 10 (Revised): Procedures for Evaluating Air Quality Impact of New Stationary Sources, EPA-450/4-77-001, October 1977.
19. U. S. Environmental Protection Agency. User's Guide to MOBILE-3 (Mobile Source Emissions Model), EPA-460/3-84-002, June, 1984.
20. City & County of Honolulu, Department of Data Systems. Age Distribution of Registered Vehicles in the City & County of Honolulu (unpublished report), August, 1988.
21. Seinfeld, John H. Air Pollution: Physical and Chemical Fundamentals, p. 69, McGraw-Hill Book Company, 1975
22. U. S. Environmental Protection Agency. Workbook of Atmospheric Dispersion Estimates, AP-26 (Sixth Edition), 1973.
23. U.S. Environmental Protection Agency. Guideline on Air Quality Models (Revised), EPA-450/2-78-027R, July, 1986.
24. California Department of Transportation. CALINE4 - A Dispersion Model for Predicting Air Pollutant Concentrations Near Roadways (Final Report), November, 1984 (Revised June, 1989).
25. U.S. Environmental Protection Agency. Guidelines for Air Quality Maintenance Planning and Analysis, Volume 9 (Revised): Indirect Sources, EPA-450/4-78-001, September, 1978.
26. State of Hawaii, Department of Business and Economic Development. State Data Book, Table 539, 1987.

TABLES

TABLE 1

SUMMARY OF STATE OF HAWAII AND FEDERAL AMBIENT AIR QUALITY STANDARDS

POLLUTANT	SAMPLING PERIOD	FEDERAL STANDARDS PRIMARY	FEDERAL STANDARDS SECONDARY	STATE STANDARDS
1. Total Suspended Particulate Matter (TSP)	Annual Geometric Mean	--	--	60
(micrograms per cubic meter)	Maximum Average in Any 24 Hours	--	--	150
2. PM-10	Annual	50	50	--
(micrograms per cubic meter	Maximum Average in Any 24 Hours	150	150	--
3. Sulfur Dioxide (SO2)	Annual Arithmetic Mean	80	--	80
(micrograms per cubic meter)	Maximum Average in Any 24 Hours	365	--	365
	Maximum Average in Any 3 Hours		1,300	1,300
4. Nitrogen Dioxide (NO2) (micrograms per cubic meter)	Annual Arithmetic Mean	100		70
5. Carbon Monoxide (CO)	Maximum Average in Any 8 Hours	10		5
(milligrams per cubic meter)	Maximum Average in Any 1 Hour	40		10
6. Ozone (micrograms per cubic meter	Maximum Average in Any 1 Hour	235		100
7. Lead (Pb) (micrograms per cubic meter)	Maximum Average in Any Calendar Quarter	1.5		1.5

TABLE 2
TSP AND SO2 MONITORING DATA
KONA, HAWAII, 1985

MONTH	TOTAL SUSPENDED PARTICULATES (TSP) 24-Hour Concentrations (ug/m3)				Sulfur Dioxide (SO2) 24-Hour Concentrations (ug/m3)			
	SAMPLES	MIN.	MAX.	MEAN	SAMPLES	MIN.	MAX.	ME
Jan 85	-	-	-	-	-	-	-	
Feb 85	-	-	-	-	-	-	-	
Mar 85	-	-	-	-	-	-	-	
Apr 85	-	-	-	-	-	-	-	
May 85	-	-	-	-	-	-	-	
Jun 85	4	9	14	12	3	<5	6	<
Jul 85	5	9	22	13	5	<5	<5	<
Aug 85	5	9	16	13	5	<5	<5	<
Sep 85	5	7	10	8	3	<5	<5	<
Oct 85	5	7	20	14	5	<5	<5	<
Nov 85	5	6	11	9	5	<5	8	<
Dec 85	5	6	18	12	5	<5	<5	<
ANNUAL	34	6	22	12	28	<5	8	<

SOURCE: Department of Health

TABLE 3
TSP AND SO2 MONITORING DATA
KONA, HAWAII, 1986

MONTH	TOTAL SUSPENDED PARTICULATES (TSP) 24-Hour Concentrations (ug/m3)				Sulfur Dioxide (SO2) 24-Hour Concentrations (ug/m3)			
	SAMPLES	MIN.	MAX.	MEAN	SAMPLES	MIN.	MAX.	MEAN
Jan 86	5	4	16	13	5	<5	<5	<5
Feb 86	5	6	26	15	5	<5	<5	<5
Mar 86	5	9	20	14	5	<5	<5	<5
Apr 86	4	10	15	13	4	<5	<5	<5
May 86	5	12	17	13	5	<5	<5	<5
Jun 86	5	12	20	15	5	<5	<5	<5
Jul 86	5	13	25	18	5	<5	12	6
Aug 86	5	18	28	22	5	<5	<5	<5
Sep 86	-	-	-	-	-	-	-	-
Oct 86	-	-	-	-	-	-	-	-
Nov 86	-	-	-	-	-	-	-	-
Dec 86	-	-	-	-	-	-	-	-
ANNUAL	39	4	28	16	38	<5	12	<5

SOURCE: Department of Health

TABLE 4

SPECIAL AIR MONITORING DATA
KONA & HILO, HAWAII
1983

	24-Hour Concentrations (ug/m3)			
	Kona		Hilo	
Date	SO2	TSP	SO2	TSP
08 Jan 83	---	---	654.7	22.6
09 Jan 83	---	---	447.7	30.6
12 Jan 83	27.0	23.4	0.6	6.9
14 Jan 83	12.0	22.2	----	----
19 Jan 83	----	----	12.2	17.6
20 Jan 83	18.9	----	----	----
04 Mar 83	4.4	39.1	32.9	53.6
05 Mar 83	0	28.4	----	30.1
07 Mar 83	----	----	0.6	37.0
08 Mar 83	0	11.9	0.6	27.5
10 Mar 83	0	12.8	21.3	38.5
11 Mar 83	----	----	0	28.2

Notes: SO2= sulfur dioxide
TSP= total suspended particulates

SOURCE: Department of Health

TABLE 5

TEMPERATURE & RAINFALL DATA
PUAKO, HAWAII

MONTH	TEMPERATURE (deg F)	RAINFALL (in)
Jan	73.10	2.63
Feb	72.90	1.50
Mar	73.80	0.67
Apr	76.70	0.83
May	77.00	0.69
Jun	78.30	0.45
Jul	78.30	0.14
Aug	79.10	0.41
Sep	77.70	0.39
Oct	77.30	0.54
Nov	75.40	0.74
Dec	73.80	1.66
Mean:	76.12	10.65

NOTES: 1. Temperature data based on a 1974 summary of the National Oceanographic and Atmospheric Administration (NOAA)(Reference 10).

2. Rainfall data based on the 1966-83 period.

TABLE 6

10-MONTH JOINT FREQUENCY DISTRIBUTION
OF WIND DATA AT THE MAUNA KEA BEACH HOTEL
MARCH - DECEMBER, 1967

DIRECTION	Wind Speed (mph) <1 - 2	3 - 7	8 - 18	19 - 24	>24	All Speeds
N	0.0005	0.0008	0.0000	0.0000	0.0000	0.0013
NNE	0.0082	0.0092	0.0008	0.0000	0.0000	0.0182
NE	0.0034	0.0209	0.0003	0.0000	0.0000	0.0246
ENE	0.0362	0.0671	0.0367	0.0085	0.0000	0.1485
E	0.0042	0.0040	0.0005	0.0000	0.0000	0.0087
ESE	0.0412	0.0948	0.1052	0.0196	0.0000	0.2608
SE	0.0048	0.0320	0.0092	0.0000	0.0000	0.0460
SSE	0.0079	0.0048	0.0040	0.0000	0.0000	0.0167
S	0.0040	0.0021	0.0000	0.0000	0.0000	0.0061
SSW	0.0008	0.0021	0.0003	0.0000	0.0000	0.0032
SW	0.0003	0.0011	0.0003	0.0000	0.0000	0.0017
WSW	0.0016	0.0050	0.0003	0.0000	0.0000	0.0069
W	0.0098	0.0235	0.0045	0.0000	0.0000	0.0378
WNW	0.0476	0.2201	0.0962	0.0000	0.0000	0.3639
NW	0.0011	0.0029	0.0000	0.0000	0.0000	0.0040
NNW	0.0135	0.0132	0.0008	0.0000	0.0000	0.0275
All Directions:	0.1851	0.5036	0.2591	0.0281	0.0000	0.9759

Calms: 0.0241

SOURCE: U.S. Army
Corps of Engineers
Pacific Ocean Division

TABLE 7

8:00 A.M. JOINT FREQUENCY DISTRIBUTION
OF WIND DATA AT THE MAUNA KEA BEACH HOTEL
MARCH - DECEMBER, 1967

DIRECTION	Wind Speed (mph) <1 - 2	3 - 7	8 - 18	19 - 24	>24	All Speeds
N	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NNE	0.0637	0.0127	0.0000	0.0000	0.0000	0.0764
NE	0.0191	0.0000	0.0000	0.0000	0.0000	0.0191
ENE	0.1465	0.0573	0.0382	0.0000	0.0000	0.2420
E	0.0064	0.0000	0.0064	0.0000	0.0000	0.0128
ESE	0.1146	0.1019	0.1338	0.0510	0.0000	0.4013
SE	0.0064	0.0000	0.0000	0.0000	0.0000	0.0064
SSE	0.0127	0.0000	0.0127	0.0000	0.0000	0.0254
S	0.0000	0.0064	0.0000	0.0000	0.0000	0.0064
SSW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WSW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WNW	0.0828	0.0064	0.0000	0.0000	0.0000	0.0892
NW	0.0064	0.0000	0.0000	0.0000	0.0000	0.0064
NNW	0.0510	0.0000	0.0000	0.0000	0.0000	0.0510
All Directions:	0.5096	0.1847	0.1911	0.0510	0.0000	0.9364

Calms: 0.0636

SOURCE: U.S. Army
Corps of Engineers
Pacific Ocean Division

TABLE 8

2:00 P.M. JOINT FREQUENCY DISTRIBUTION
OF WIND DATA AT THE MAUNA KEA BEACH HOTEL
MARCH - DECEMBER, 1967

DIRECTION	Wind Speed (mph) <1 - 2	3 - 7	8 - 18	19 - 24	>24	All Speeds
N	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NNE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ENE	0.0000	0.0000	0.0120	0.0060	0.0120	0.0300
E	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ESE	0.0000	0.0000	0.0060	0.0060	0.0000	0.0120
SE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SSE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SSW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WSW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W	0.0000	0.0060	0.0000	0.0000	0.0000	0.0060
WNW	0.0361	0.4759	0.4217	0.0000	0.0000	0.9337
NW	0.0000	0.0060	0.0000	0.0000	0.0000	0.0060
NNW	0.0060	0.0060	0.0000	0.0000	0.0000	0.0120
All Directions:	0.0421	0.4939	0.4397	0.0120	0.0120	0.9997

SOURCE: U.S. Army
Corps of Engineers
Pacific Ocean Division

TABLE 9

EMISSIONS INVENTORY
COUNTY OF HAWAII
1980

SOURCE CATEGORY	EMISSIONS (Tons/Year) TSP	SOx	NOx	CO	HC
Steam Electric Power Plants	262.9	3232.9	1308.9	65.9	21.8
Gas Utilities	0.0	0.0	11.5	0.0	0.0
Fuel Combustion in Agricultural Industry	2251.7	995.8	798.0	0.0	7.3
Refinery Industry	0.0	0.0	0.0	0.0	0.0
Petroleum Storage	0.0	0.0	0.0	0.0	391.9
Metallurgical Industries	0.0	0.0	0.0	0.0	0.0
Mineral Products Industry	1080.1	13.6	11.5	0.0	0.0
Municipal Incineration	0.0	0.0	0.0	0.0	0.0
Motor Vehicles	262.9	177.3	3048.5	42177.3	4035.4
Construction, Farm and Industrial Vehicles	40.0	31.8	453.5	1515.7	152.4
Aircraft	5.7	4.5	45.9	1449.8	174.2
Vessels	11.4	90.9	63.2	65.9	29.0
Agricultural Field Burning	1800.2	0.0	0.0	20627.3	2445.9
TOTAL IN TONS PER YEAR:	5715	4547	5741	65902	7258

SOURCE: State of Hawaii
Department of Health

F I G U R E S

FIGURE 1

PROJECT LOCATION

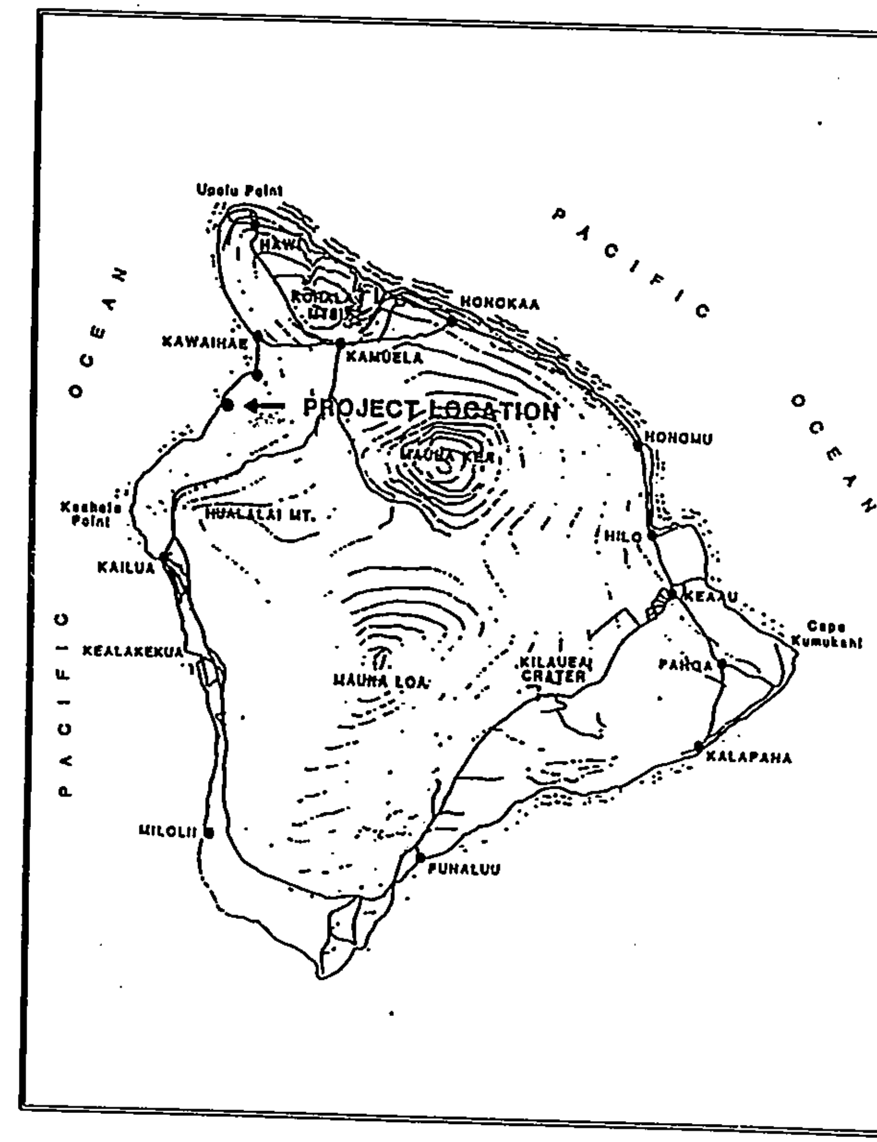


FIGURE 2

A.M. PEAK HOUR CONDITIONS
QUEEN KAAHUMANU HIGHWAY AT MAUNA LANI DRIVE
SEPTEMBER 7, 1989

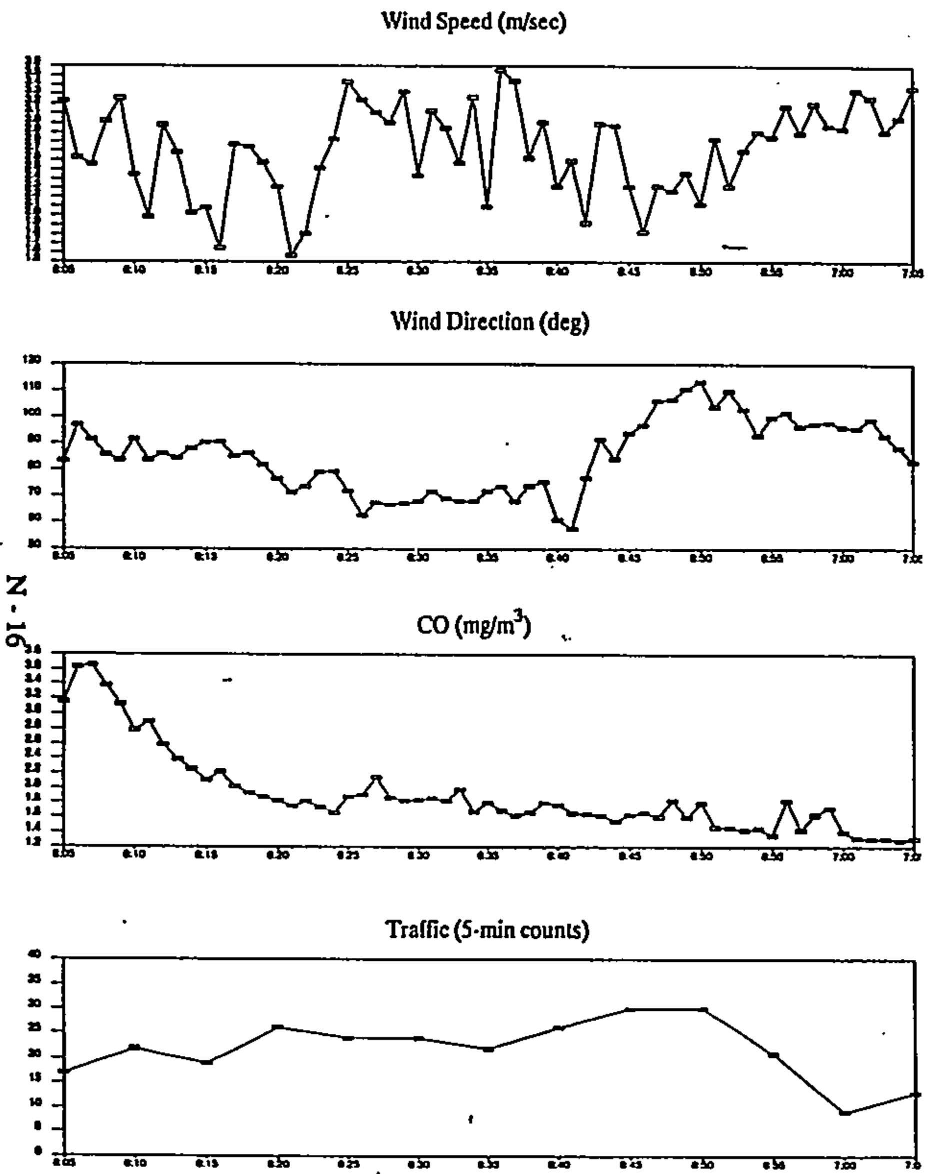


FIGURE 3

P.M. PEAK HOUR CONDITIONS
QUEEN KAAHUMANU HIGHWAY AT MAUNA LANI DRIVE
SEPTEMBER 6, 1989

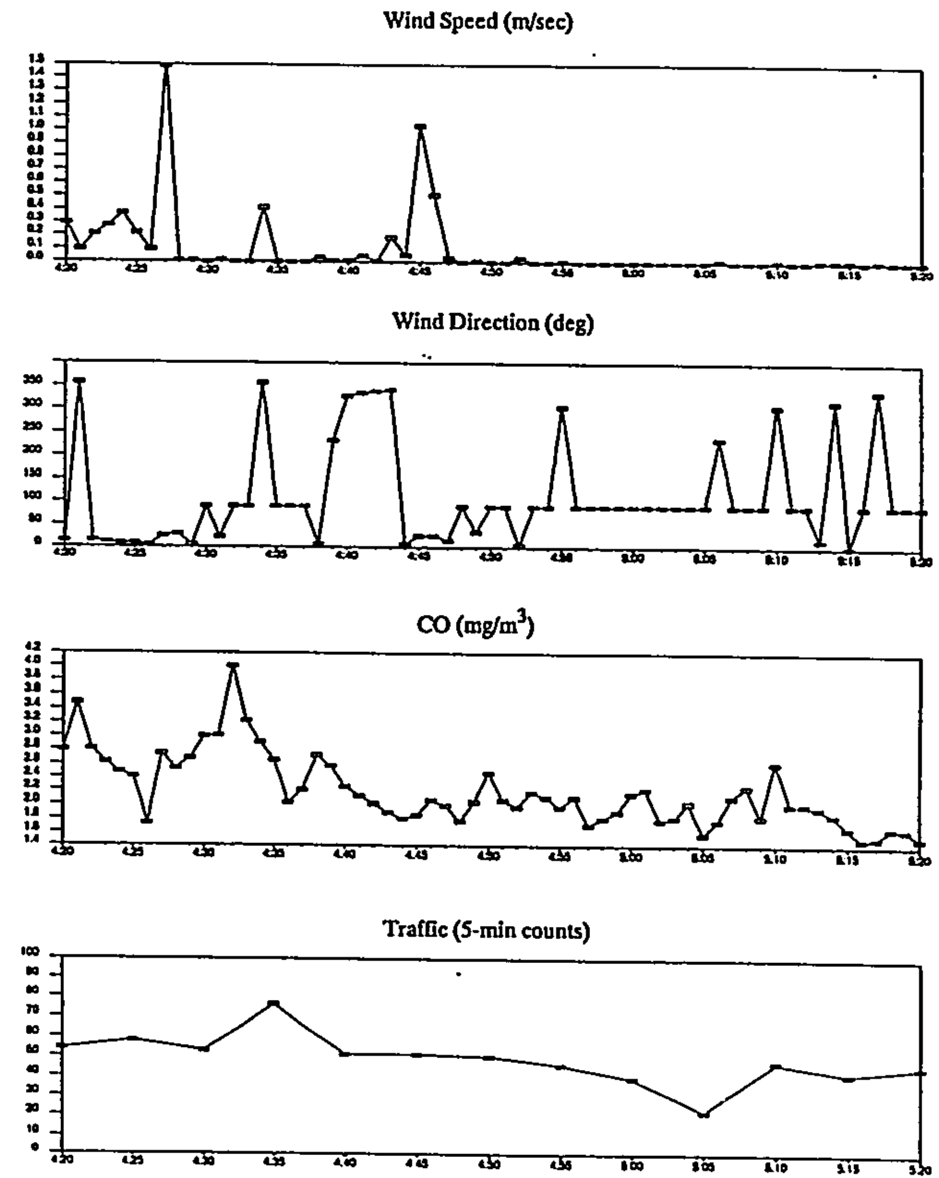
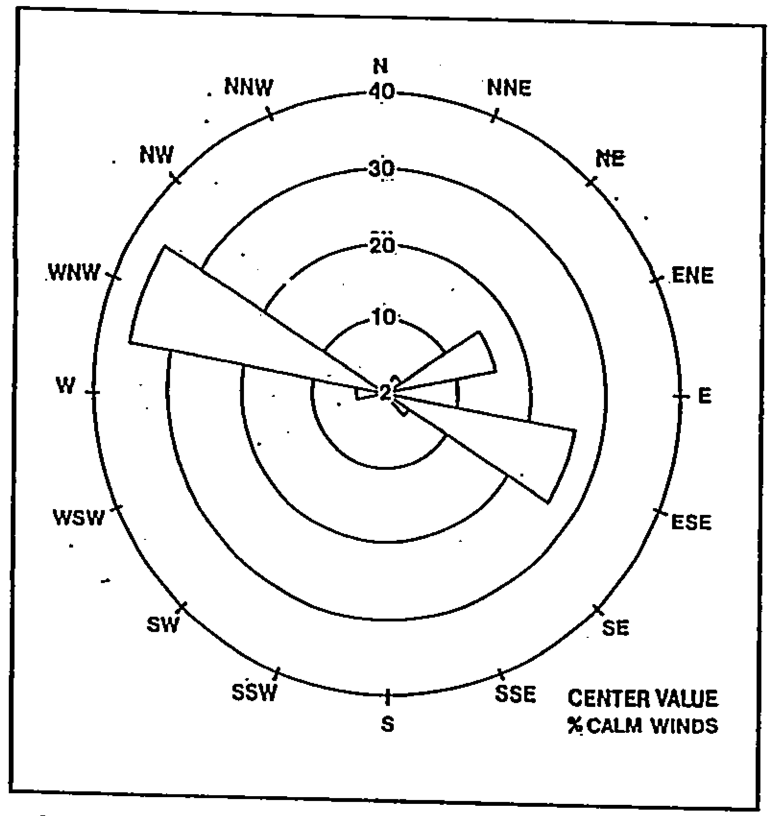


FIGURE 4

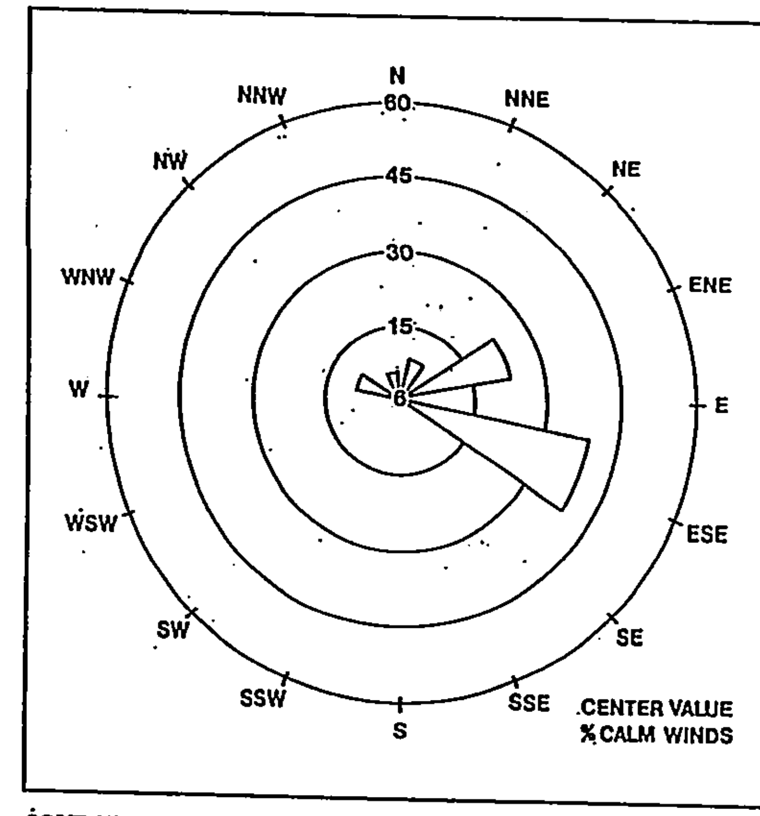
ANNUAL WINDROSE
MAUNA KEA BEACH HOTEL
ISLAND OF HAWAII



SOURCE: U.S. Army Corps of Engineers

FIGURE 5

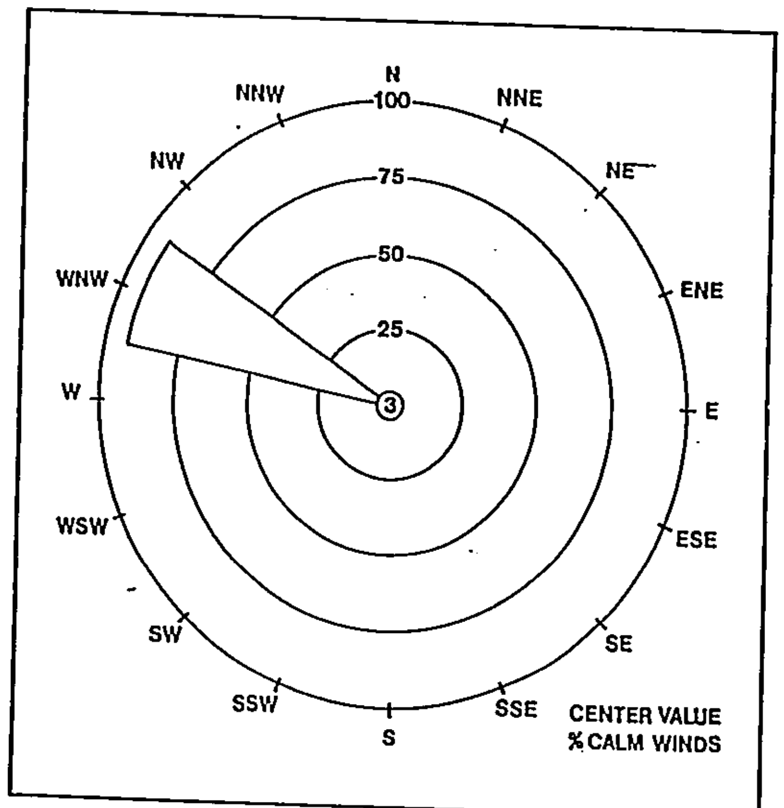
8:00 A.M. WINDROSE
MAUNA KEA BEACH HOTEL
ISLAND OF HAWAII



SOURCE: U.S. Army Corps of Engineers

FIGURE 6

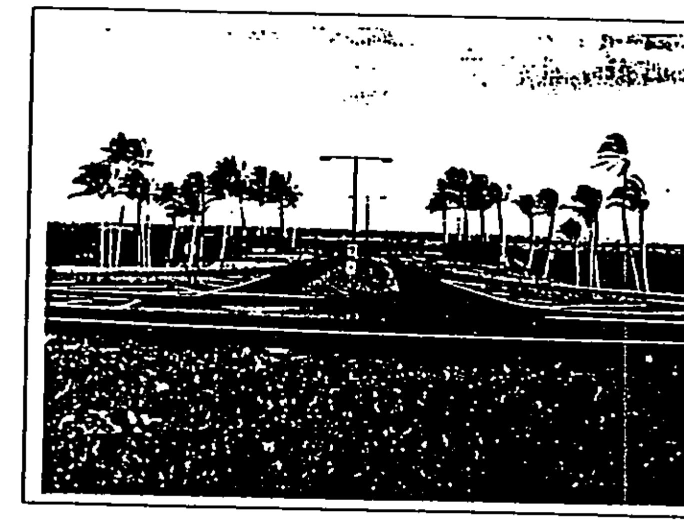
2:00 P.M. WINDROSE
MAUNA KEA BEACH HOTEL
ISLAND OF HAWAII



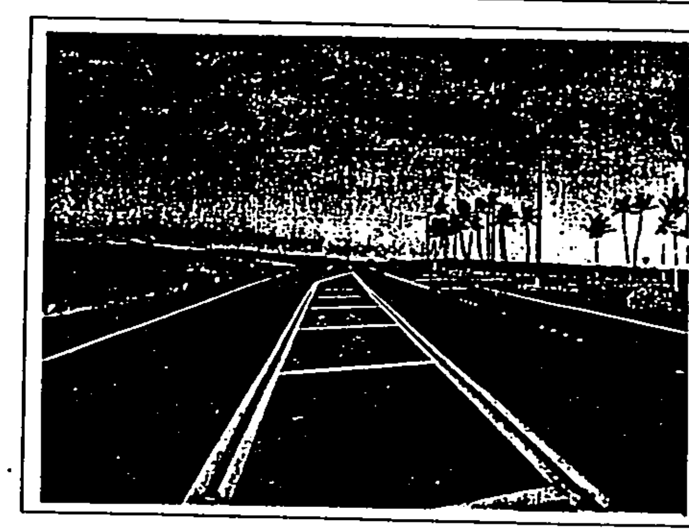
SOURCE: U.S. Army Corps of Engineers

FIGURE 7

QUEEN KAAHUMANU HIGHWAY AT MAUNA LANI DRIVE
1989



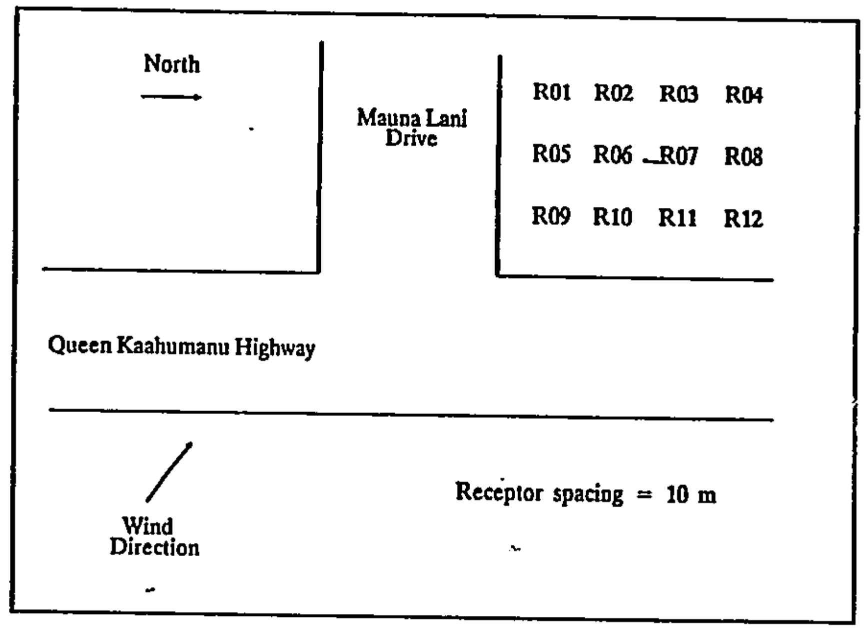
Mauna Lani Drive
(Facing West)



Queen Kaahumanu
Highway
(Facing South)

FIGURE 8

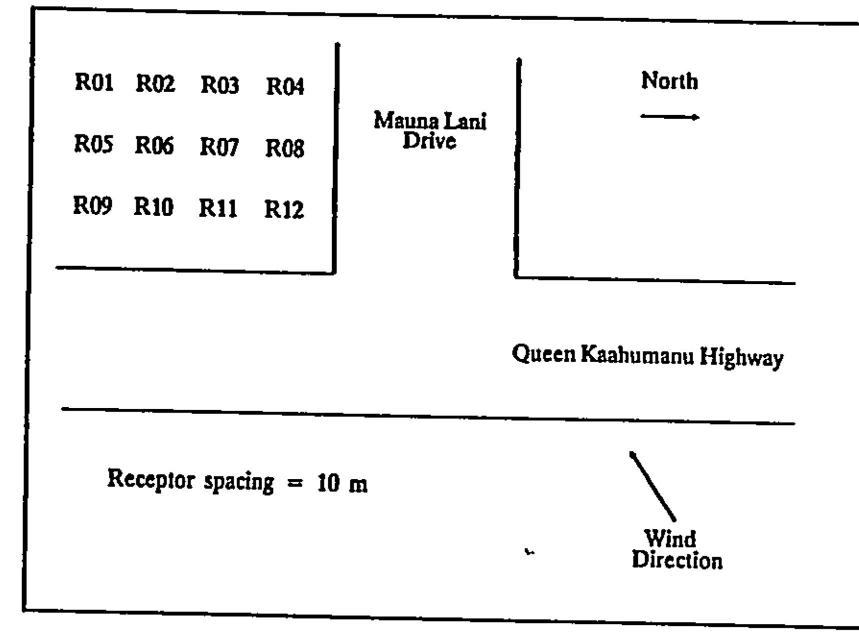
ESTIMATES OF MAXIMUM 1-HOUR CARBON MONOXIDE CONCENTRATIONS
Queen Kaahumanu Highway at Mauna Lani Drive
A.M. Peak Hour
1989 - 1998



Receptor	1988	Concentration (mg/m^3) 1998 w/o proj	1998 w/hotel	1998 w/proj
R01	2.8	2.7	3.5	3.0
R02	3.0	3.1	3.9	3.4
R03	3.0	3.4	4.3	3.9
R04	2.6	3.5	4.4	3.9
R05	3.1	2.7	3.5	3.0
R06	3.3	3.0	3.9	3.3
R07	3.5	3.5	4.7	4.0
R08	3.6	4.2	5.7	5.0
R09	3.2	3.1	4.0	3.2
R10	3.6	3.1	4.1	3.3
R11	4.0	3.4	4.4	3.6
R12	4.4	4.3	5.8	5.0

FIGURE 9

ESTIMATES OF MAXIMUM 1-HOUR CARBON MONOXIDE CONCENTRATIONS
Queen Kaahumanu Highway at Mauna Lani Drive
P.M. Peak Hour
1989 - 1998



Receptor	1988	Concentration (mg/m^3) 1998 w/o proj	1998 w/hotel	1998 w/proj
R01	3.9	3.6	4.8	3.9
R02	4.2	4.4	6.3	4.8
R03	4.3	5.1	7.4	5.6
R04	3.6	4.2	6.0	4.6
R05	4.1	3.4	4.1	3.5
R06	4.6	4.3	5.7	4.6
R07	5.5	6.2	9.1	6.7
R08	6.4	7.9	12.4	8.8
R09	4.7	3.5	3.8	3.5
R10	5.1	3.9	4.3	3.9
R11	5.4	4.9	6.4	5.1
R12	8.3	10.3	16.4	11.5

APPENDIX O

NOISE STUDY FOR MAUNA LANI COVE SOUTH KOHALA, HAWAII

NOISE STUDY FOR MAUNA LANI COVE SOUTH KOHALA, HAWAII

Prepared for:
BELT COLLINS & ASSOCIATES

Prepared by:
Y. EBISU & ASSOCIATES
1126 12th Avenue, Room 305
Honolulu, Hawaii 96816

NOVEMBER 1989

TABLE OF CONTENTS

A-WEIGHTED RECOMMENDED DESCRIPTOR LIST

TERM	SYMBOL
1. A-Weighted Sound Level	L_A
2. A-Weighted Sound Power Level	L_{WA}
3. Maximum A-Weighted Sound Level	L_{max}
4. Peak A-Weighted Sound Level	L_{Apk}
5. Level Exceeded x% of the Time	L_x
6. Equivalent Sound Level	L_{eq}
7. Equivalent Sound Level over Time (T) (1)	$L_{eq(T)}$
8. Day Sound Level	L_d
9. Night Sound Level	L_n
10. Day-Night Sound Level	L_{dn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$
12. Sound Exposure Level	L_{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine).

SOURCE: EPA ACOUSTIC TERMINOLOGY GUIDE, BNA 8-14-78, NOISE REGULATION REPORTER.

RECOMMENDED DESCRIPTOR LIST

TERM	A-WEIGHTING	ALTERNATIVE(1) A-WEIGHTING	OTHER(2) WEIGHTING	UNWEIGHTED
1. Sound (Pressure) (3) Level	L_A	L_{pA}	L_B, L_{pB}	L_p
2. Sound Power Level	L_{WA}		L_{WB}	L_W
3. Max. Sound Level	L_{max}	L_{Amax}	L_{Bmax}	L_{pmax}
4. Peak Sound (Pressure) Level	L_{Apk}		L_{Bpk}	L_{pk}
5. Level Exceeded x% of the time	L_x	L_{Ax}	L_{Bx}	L_{px}
6. Equivalent Sound Level	L_{eq}	L_{Aeq}	L_{Beq}	L_{peq}
7. Equivalent Sound Level (4) Over Time(T)	$L_{eq(T)}$	$L_{Aeq(T)}$	$L_{Beq(T)}$	$L_{peq(T)}$
8. Day Sound Level	L_d	L_{Ad}	L_d	L_{pd}
9. Night Sound Level	L_n	L_{An}	L_{Bn}	L_{pn}
10. Day-Night Sound Level	L_{dn}	L_{Adn}	L_{Bdn}	L_{pdn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$	$L_{Adn(Y)}$	$L_{Bdn(Y)}$	$L_{pdn(Y)}$
12. Sound Exposure Level	L_S	L_{SA}	L_{SB}	L_{Sp}
13. Energy Average value over (non-time domain) set of observations	$L_{eq(e)}$	$L_{Aeq(e)}$	$L_{Beq(e)}$	$L_{peq(e)}$
14. Level exceeded x% of the total set of (non-time domain) observations	$L_{x(e)}$	$L_{Ax(e)}$	$L_{Bx(e)}$	$L_{px(e)}$
15. Average L_x value	L_x	L_{Ax}	L_{Bx}	L_{px}

(1) "Alternative" symbols may be used to assure clarity or consistency.

(2) Only B-weighting shown. Applies also to C,D,E,....weighting.

(3) The term "pressure" is used only for the unweighted level.

(4) Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is Leq(1)). Time may be specified in non-quantitative terms (e.g., could be specified as Leq(WASH) to mean the washing cycle noise for a washing machine.

CHAPTER I. SUMMARY

The existing and future traffic noise levels in the vicinity of the proposed Mauna Lani Cove project in South Kohala, Hawaii were evaluated for their potential impacts on noise sensitive residents and hotel guests in the project environs. The Mauna Lani Cove project represents a change from the planned development of a hotel to the proposed development of a water oriented residential and marina project. The future traffic noise levels along the primary access roadways to the project were calculated for the Year 1998 for conditions with the proposed cove project as well as for conditions with the original hotel project.

Along Queen Ka'ahumanu Highway, traffic noise levels are expected to increase by 2 to 3 Ldn, primarily due to non-project traffic. Along Mauna Lani Drive, traffic noise levels are expected to increase by approximately 6 Ldn. Project traffic contributions to these increases are approximately 0.5 and 1.3 Ldn, respectively, which are considered to be minimal and moderate. Along the circulation roadways of the proposed Mauna Lani Cove, traffic noise levels are expected to be less than 55 Ldn at setback distances greater than 25 FT from the roadways' centerlines. Traffic noise impacts resulting from the proposed project are expected to be minimal due to adequate setback distances of existing noise sensitive properties from Queen Ka'ahumanu Highway and Mauna Lani Drive, and due to the relatively small setback distances required from the project's circulation roadways. In addition, the Mauna Lani Cove project will generate 0.5 to 3 Ldn less traffic noise along the highway and Mauna Lani Drive than would the originally planned hotel project. In this respect, the proposed marina project should be more beneficial than the original hotel project.

Adverse impacts from boating noise on existing and future noise sensitive properties are not anticipated because the proposed waterways are contained within the Mauna Lani Cove project boundaries, and because adequate setback distances exist between

the waterways and these noise sensitive properties.

Unavoidable, but temporary, noise impacts may occur during construction of the proposed project, particularly during the excavation of the waterways and particularly if blasting is necessary. Because construction activities are predicted to be audible within the project and at adjoining properties, the quality of the acoustic environment may be degraded to unacceptable levels during periods of construction. Mitigation measures to reduce construction noise to inaudible levels will not be practical in all cases. For this reason, the use of quiet equipment and construction curfew periods as required under the State Department of Health noise regulations are recommended to minimize construction noise impacts. The use of monitoring during blasting operations, proper scheduling and disclosure of detonation periods, and minimization of air blast levels to 110 dBL at noise sensitive projects are recommended mitigation measures for blasting operations.

CHAPTER II. PURPOSE

The objective of this study was to describe the existing and future noise environment in the environs of the proposed Mauna Lani Cove project in South Kohala on the island of Hawaii. Traffic noise level increases and impacts associated with the proposed development were to be determined within the project site as well as along the public roadways expected to service the project traffic. A specific objective was to determine future traffic noise level increases associated with both project and non-project traffic, and the potential noise impacts associated with these increases. Assessments of possible future impacts from boating noise in the project's marina, and from short term construction noise at the project site were also included as noise study objectives. Recommendations for minimizing identified noise impacts were also to be provided as required.

CHAPTER III. NOISE DESCRIPTORS AND THEIR RELATIONSHIP TO LAND USE COMPATIBILITY

The noise descriptor currently used by federal agencies to assess environmental noise is the Day-Night Average Sound Level (Ldn). This descriptor incorporates a 24-hour average of instantaneous A-Weighted Sound Levels as read on a standard Sound Level Meter. By definition, the minimum averaging period for the Ldn descriptor is 24 hours. Additionally, sound levels which occur during the nighttime hours of 10:00 PM to 7:00 AM are increased by 10 decibels (dB) prior to computing the 24-hour average by the Ldn descriptor. A more complete list of noise descriptors is provided in **APPENDIX B** to this report.

TABLE 1, derived from **Reference 1**, presents current federal noise standards and acceptability criteria for residential land uses. Land use compatibility guidelines for various levels of environmental noise as measured by the Ldn descriptor system are shown in **FIGURE 1**. As a general rule, noise levels of 55 Ldn or less occur in rural areas, or in areas which are removed from high volume roadways. In urbanized areas which are shielded from high volume streets, Ldn levels generally range from 55 to 65 Ldn, and are usually controlled by motor vehicle traffic noise. Residences which front major roadways are generally exposed to levels of 65 Ldn, and as high as 75 Ldn when the roadway is a high speed freeway. In the Mauna Lani Cove area, noise associated with Queen Ka'ahumanu Highway are typically less than 55 Ldn due to the large separation distances and due to noise shielding effects from intervening terrain features between the project site and the highway.

For the purposes of determining noise acceptability for funding assistance from federal agencies (FHA/HUD and VA), an exterior noise level of 65 Ldn or lower is considered acceptable. This standard is applied nationally (**Reference 2**), including Hawaii. Because of our open-living conditions, the predominant use of nat-

O-5

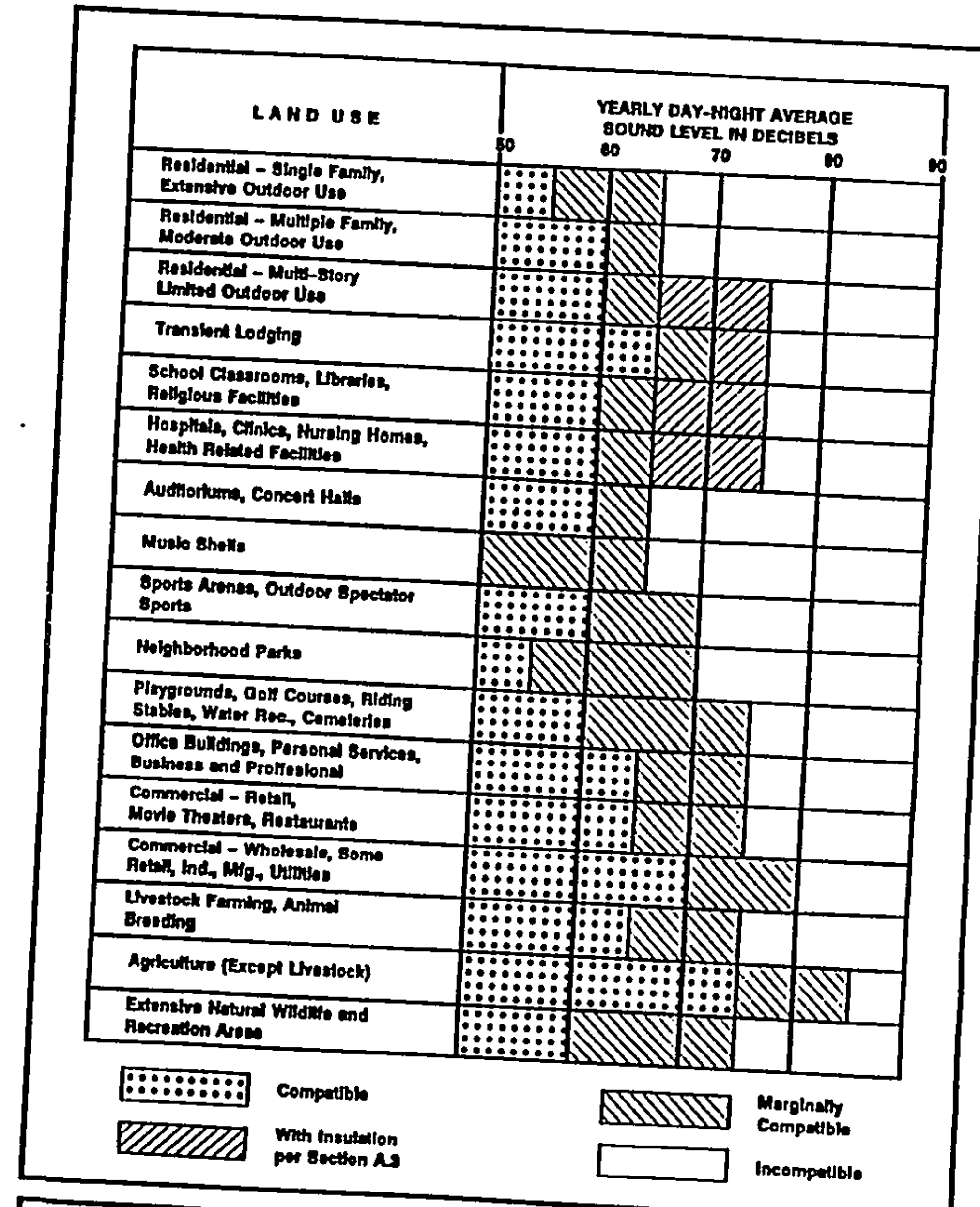
TABLE 1

EXTERIOR NOISE EXPOSURE CLASSIFICATION (RESIDENTIAL LAND USE)

NOISE EXPOSURE CLASS	DAY-NIGHT SOUND LEVEL	EQUIVALENT SOUND LEVEL	FEDERAL(1) STANDARD
Minimal Exposure	Not Exceeding 55 L_{dn}	Not Exceeding 55 L_{eq}	Unconditionally Acceptable
Moderate Exposure	Above 55 L_{dn} But Not Above 65 L_{dn}	Above 55 L_{eq} But Not Above 65 L_{eq}	Acceptable(2)
Significant Exposure	Above 65 L_{dn} But Not Above 75 L_{dn}	Above 65 L_{eq} But Not Above 75 L_{eq}	Normally Unacceptable
Severe Exposure	Above 75 L_{dn}	Above 75 L_{eq}	Unacceptable

Notes: (1) Federal Housing Administration, Veterans Administration, Department of Defense, and Department of Transportation.

(2) FHWA uses the L_{eq} instead of the L_{dn} descriptor. For planning purposes, both are equivalent if: (a) heavy trucks do not exceed 10 percent of total traffic flow in vehicles per 24 hours, and (b) traffic between 10:00 PM and 7:00 AM does not exceed 15 percent of average daily traffic flow in vehicles per 24 hours. The noise mitigation threshold used by FHWA for residences is 67 L_{eq}.



LAND USE COMPATIBILITY WITH YEARLY DAY-NIGHT AVERAGE SOUND LEVEL AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED (Source: American National Standards Institute)

FIGURE 1

urally ventilated dwellings, and the relatively low exterior-to-interior sound attenuation afforded by these naturally ventilated structures, an exterior noise level of 65 Ldn does not eliminate all risks of noise impacts. Because of these factors, and as recommended in **Reference 3**, a lower level of 55 Ldn is considered as the "Unconditionally Acceptable" (or "Near-Zero Risk") level of exterior noise. However, after considering the cost and feasibility of applying the lower level of 55 Ldn, government agencies such as FHA/HUD and VA have selected 65 Ldn as a more appropriate regulatory standard.

For commercial, industrial, and other non-noise sensitive land uses, exterior noise levels as high as 75 Ldn are generally considered acceptable. Exceptions to this occur when naturally ventilated office and other commercial establishments are exposed to exterior levels which exceed 65 Ldn.

For the purposes of this study, the level of 55 Ldn was used to define the noise impact zones in the project environs. This lower level was considered appropriate due to the resort character and relatively low ambient noise levels in the area. Also, at an exterior noise level of 55 Ldn, the noise attenuation characteristics of typical naturally ventilated dwellings produce acceptable noise levels within the dwellings (approximately 45 Ldn).

There are no construction noise or vibration standards on the island of Hawaii. On the island of Oahu, the State Department of Health (DOH) regulates noise from construction activities, through the issuance of permits for allowing excessive noise during limited time periods. State DOH noise regulations are expressed in maximum allowable property line noise limits rather than Ldn (see **Reference 4**). Although they are not directly comparable to noise criteria expressed in Ldn, State DOH noise limits for residential, commercial, and industrial lands equate to approximately 55, 60, and 76 Ldn, respectively.

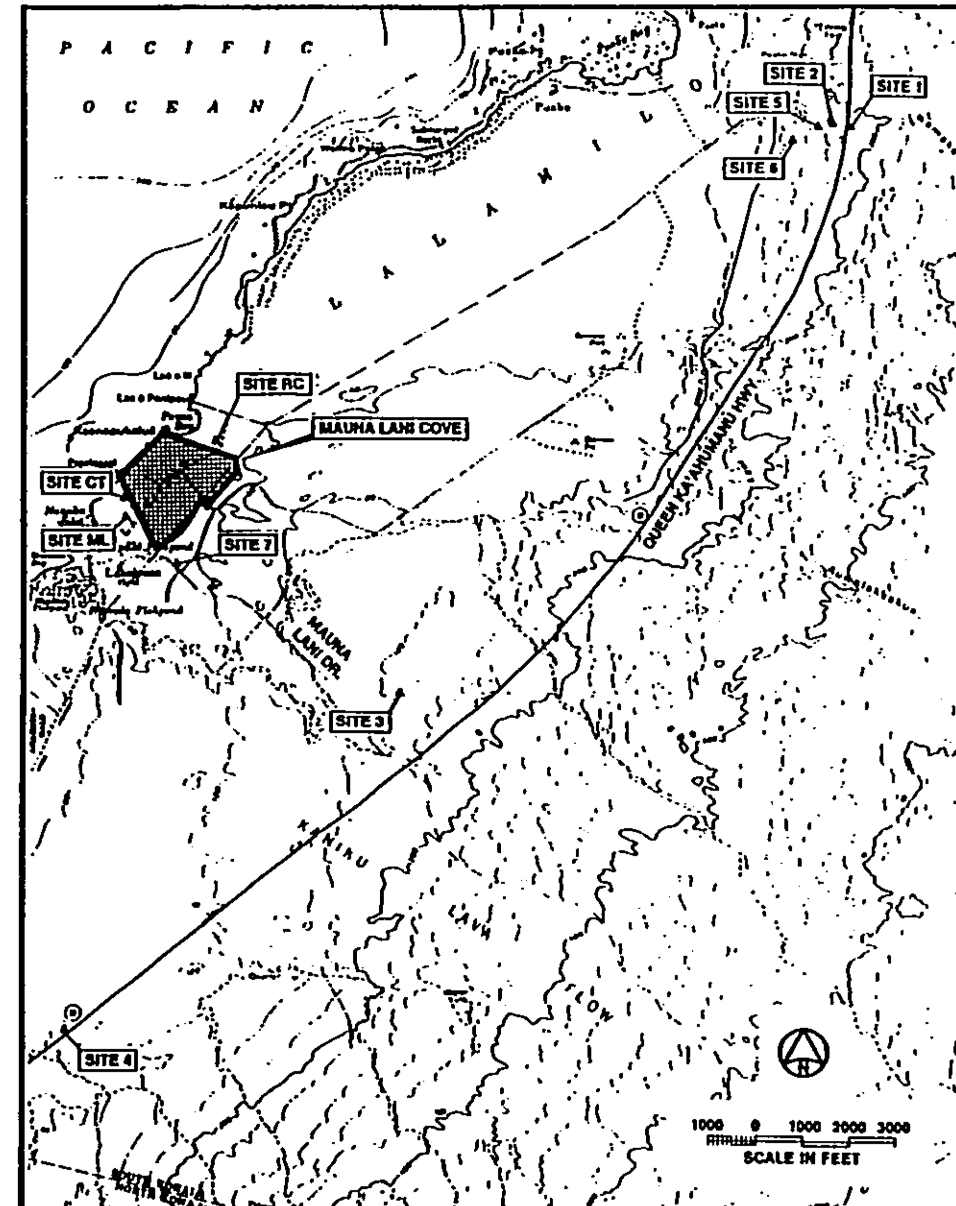
It should be noted that the noise compatibility guidelines and relationships to the Ldn noise descriptor may not be applicable to impulsive noise sources. The use of penalty factors (such as adding 10 dB to measured sound levels or the use of C-Weighting filters) have been proposed. However, the relationships between levels of impulsive noise sources and land use compatibility have not been as firmly established as have the relationships for non-impulsive sources. The State DOH limits for impulsive sounds which exceed 120 impulses in any 20 minute period are 10 dB above the limits for non-impulsive sounds. If impulsive sounds do not exceed 120 impulses in any 20 minute time period, there are no regulatory limits on their sound levels under the State DOH regulations.

CHAPTER IV. GENERAL STUDY METHODOLOGY

Existing traffic noise levels were measured at seven locations in the project environs to provide a basis for developing the project's traffic noise contributions along the roadways which will service the proposed development: Queen Ka'ahumanu Highway, Mauna Lani Drive, and the two Mauna Lani Cove entrance roadways off Mauna Lani Drive. The locations of the measurement sites are shown in **FIGURE 2**. Noise measurements were performed during the latter part of June 1989. The results of the traffic noise measurements were compared with calculations of existing traffic noise levels to validate the computer model used. The traffic noise measurement results, and their comparisons with computer model predictions of existing traffic noise levels are summarized in **TABLE 2**.

Traffic noise calculations for the existing conditions as well as noise predictions for the Year 1998 were performed using the Federal Highway Administration (FHWA) Noise Prediction Model (**Reference 5**). Traffic data entered into the noise prediction model were: hourly traffic volumes, average vehicle speeds, estimates of traffic mix, and soft ground propagation loss factor. The traffic study for the project (**Reference 6**) and Hawaii State Department of Transportation counts on Queen Ka'ahumanu Highway (**Reference 7**), were the primary sources of data inputs to the model. For existing and future traffic, it was assumed that the average noise levels, or Leq(h), during the PM peak hour were equal to the 24-hour Ldn along each roadway segment. This assumption was based on computations of both the hourly Leq and the 24-hour Ldn of traffic noise on Queen Ka'ahumanu Highway at Waikoloa Road (see **FIGURES 3 and 4**).

Traffic noise calculations for both the existing and future conditions in the project environs were developed for ground level receptors without the benefit of shielding effects. Traffic noise levels were calculated for future conditions with the previously



LOCATIONS OF NOISE MEASUREMENT SITES

FIGURE 2

TABLE 2

TRAFFIC NOISE MEASUREMENTS
(JUNE 1989)

Location	Time of Day (HRS)	Ave.Speed (MPH)	Hourly Traffic Volume Auto	Med.Truck	Heavy Truck	Measured Leq (dB)	Predicted Leq(dB)
1. 50 FT from the centerline of Queen Kaahumanu Hwy. at Puako Beach Rd (6/26/89).	1252 TO 1330	58	391	28	21	68.4	68.2
2. 300 FT from the centerline of Queen Kaahumanu Hwy. at Puako Beach Rd (6/26/89).	1129 TO 1217	58	332	24	15	51.8	52.0
3. 50 FT from centerline of Mauna Lani Dr. entrance road. (6/26/89).	1610 TO 1710	35	226	7	8	57.0	57.3
4. 50 FT from the centerline of Queen Kaahumanu Hwy. north of Waikaloa Beach Rd (6/26/89).	0945 TO 1046	52	427	25	21	66.7	66.7
5. At north end of Mauna Lani Resort Service Road, 600 FT from centerline of Q. Kaahumanu Hwy (6/26/89).	1429 TO 1440	58	391	28	21	39.5	48.0
6. At north end of Mauna Lani Resort Service Road, 1100 FT from centerline of Q. Kaahumanu Hwy. (6/26/89).	1449 TO 1455	58	391	28	21	34.8	44.0

TABLE 2 (CONTINUED)

TRAFFIC NOISE MEASUREMENTS
(JUNE 1989)

Location	Time of Day (HRS)	Ave.Speed (MPH)	Hourly Traffic Volume Auto	Med.Truck	Heavy Truck	Measured Leq (dB)	Predicted Leq(dB)
7. 50 FT from centerline of Mauna Lani Drive entrance road at golf cart path (6/27/89).	1624 TO 1639	29	190	0	8	53.6	53.7
RC Near Ritz Carlton Hotel gate (6/25/89).	1532 TO 1535	N/A	N/A	N/A	N/A	46.2	N/A
CT Near new cottages at golf course (6/25/89).	1545 TO 1551	N/A	N/A	N/A	N/A	47.0	N/A
ML Near Mauna Lani Hotel entrance (6/25/89).	1556 TO 1612	N/A	N/A	N/A	N/A	52.8	N/A

*Note: Traffic noise predictions at Locations 5 & 6 based upon 1252 to 1330 HRS spot counts.

FIGURE 3

HOURLY VARIATIONS OF TRAFFIC NOISE AT 100 FT SETBACK DISTANCE FROM THE CENTERLINE OF QUEEN KA'AHUMANU HWY. AT WAIKOLOA RD.

(STA. 8+ NORTH 5/2-3/88)

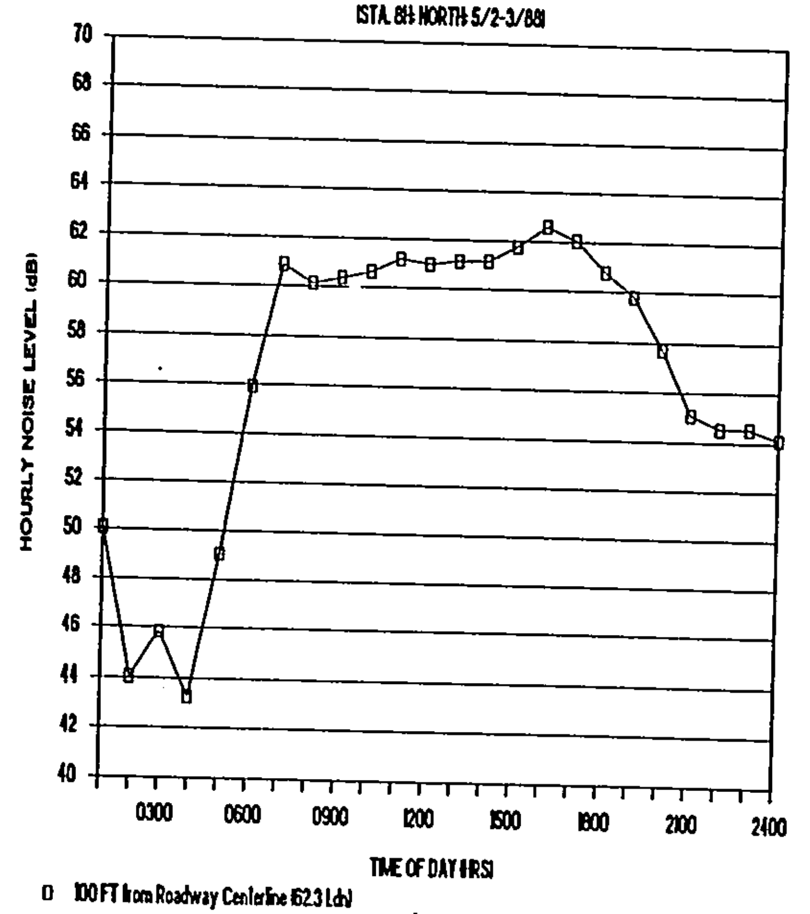
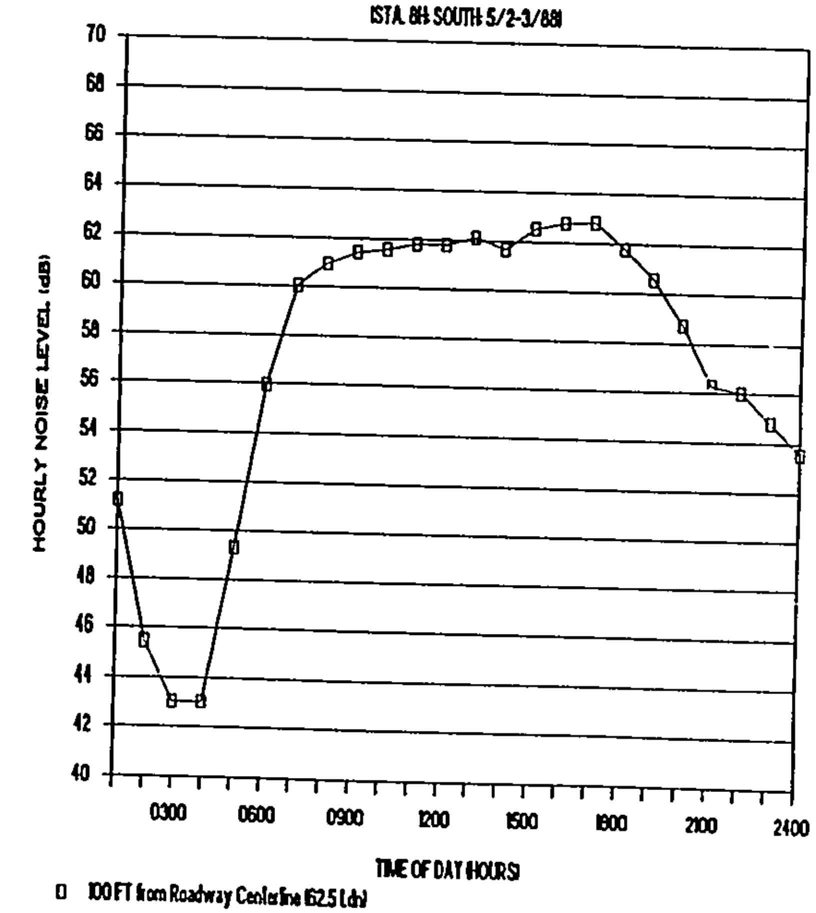


FIGURE 4

HOURLY VARIATIONS OF TRAFFIC NOISE AT 100 FT SETBACK DISTANCE FROM THE CENTERLINE OF QUEEN KA'AHUMANU HWY. AT WAIKOLOA RD.

(STA. 8+ SOUTH 5/2-3/88)



proposed hotel project completed as well as for future conditions with the proposed Mauna Lani Cove project completed in place of the hotel project. The forecasted changes in traffic noise levels over existing levels were calculated for both scenarios, and noise impact risks evaluated. The relative contributions of non-project and project related traffic to the total noise levels were also calculated, and an evaluation of possible traffic noise impacts was made.

Measurements of powerboat noise levels were performed at the Ala Wai Small Boat Harbor channel entrance at Magic Island, Oahu to determine typical noise levels to be expected of powerboats or motoring sailboats which may operate in Mauna Lani Cove. These measurements were used to predict noise levels at future noise sensitive properties at Mauna Lani Cove, and to assess potential noise impacts.

Calculations of average exterior and interior noise levels from construction activities were performed for typical naturally ventilated and air conditioned dwellings. Predicted noise levels were compared with existing background ambient noise levels, and the potential for noise impacts were assessed. Potential noise and vibration impacts from possible blasting operations were also discussed, and mitigation measures recommended.

CHAPTER V. EXISTING NOISE ENVIRONMENT

The existing traffic noise levels in the project environs are in the "Minimal Exposure, Unconditionally Acceptable" category in the project environs, as well as on the grounds of the neighboring Mauna Lani Bay Hotel and Ritz Carlton Hotel. Background ambient noise levels in the inland portions of the project environs are controlled by the natural sounds of wind and foliage or birds, and are less than 50 Ldn. Minimum instantaneous noise levels are in the order of 35 to 40 dB. In areas which are barren and without foliage, minimum background ambient noise levels are in the order of 25 to 30 dB. Near the shoreline, and ocean and surf control the level of background ambient noise, which is normally greater than 50 Ldn.

The results of the June 1989 traffic and background ambient noise measurements are summarized in **TABLE 2**. Sites 1 and 2 were on flat terrain in the vicinity of the Puako Beach Road intersection and the existing pumping station on Queen Ka'ahumanu Highway. Site 3 was along the eastern portion of Mauna Lani Drive, and Site 4 was near the Waikoloa Road intersection along Queen Ka'ahumanu Highway. Sites 5 and 6 were inside the north gate of the existing dirt service road, with obstructed field-of-views to the highway. Site 7 was alongside the west section of Mauna Lani Drive near the golf cart crossing. Sites RC, CT, and ML were adjacent to the project site at the neighboring hotel properties.

Results of calculations of existing (CY 1988) traffic noise levels during the PM peak hour period are shown in **TABLE 3**. The results of the calculations apply at 50 FT distances from the centerlines of Queen Ka'ahumanu Highway north and south of the Mauna Lani Drive intersection, and from the centerlines of the east and west sections of Mauna Lani Drive. Calculated setback distances from these roadways to the existing 55, 60, and 65 Ldn contours are shown in **TABLE 4**. **FIGURES 5** and **6** depict the existing Ldn vs. distance curves for Queen Ka'ahumanu Highway and Mauna Lani Drive.

TABLE 3

COMPARISONS OF EXISTING AND FUTURE TRAFFIC NOISE LEVELS ALONG ACCESS ROADS TO PROJECT SITE (50 FT FROM ROADWAY CENTERLINES)

LOCATION	SPEED (MPH)	VPH	***** HOURLY LEQ IN dB **** AUTO	MT	HT	ALL VEH
CY 1988 PM PEAK HR. TRAFFIC:						
Queen Ka'ahumanu Hwy. (North)	58	573	65.1	64.0	63.8	69.1
Queen Ka'ahumanu Hwy. (South)	52	563	63.2	62.3	62.5	67.5
Mauna Lani Drive (East)	35	258	53.4	50.7	53.7	57.6
Mauna Lani Drive (West)	29	206	49.4	47.0	50.7	54.0
Cove's East Entrance Road	N/A					
Cove's West Entrance Road	N/A					
CY 1998 PM PEAK HR. TRAFFIC:						
Queen Ka'ahumanu Hwy. (North)	45	2,027	66.4	65.7	66.6	71.0
Queen Ka'ahumanu Hwy. (South)	45	1,876	66.0	65.4	66.2	70.7
Mauna Lani Drive (East)	35	961	59.1	56.5	59.4	63.3
Mauna Lani Drive (West)	29	785	55.2	52.8	56.5	59.9
Cove's East Entrance Road	25	193	46.8	42.1	44.1	49.5
Cove's West Entrance Road	25	15	35.6	30.9	32.8	38.3

Notes:
(1) Assumed traffic mix of 90.0% autos, 6.0% medium trucks, and 4.0% heavy vehicles on Queen Ka'ahumanu Highway.

(2) Assumed traffic mix of 93.5% autos, 3.5% medium trucks, and 3.0% heavy vehicles on Mauna Lani Drive.

(3) Assumed traffic mix of 97.0% autos, 2.0% medium trucks, and 1.0% heavy vehicles on Marina Entrance Roads.

(4) 93%/7% split assumed for Mauna Lani Cove's East/West Entrance Roads, respectively.

TABLE 4

EXISTING AND FUTURE DISTANCES TO 55, 60, AND 65 Ldn CONTOURS

STREET SECTION	55 Ldn SETBACK (FT) EXISTING	FUTURE	60 Ldn SETBACK (FT) EXISTING	FUTURE	65 Ldn SETBACK(FT) EXISTING	FUTURE
Queen Ka'ahumanu Hwy. (North)	220	584	120	271	73	126
Queen Ka'ahumanu Hwy. (South)	200	554	115	257	70	119
Mauna Lani Drive (East)	64	178	40	83	< 30	38
Mauna Lani Drive (West)	45	105	< 30	49	< 30	< 30
Cove's East Entrance Road	N/A	< 30	N/A	< 15	N/A	< 15
Cove's West Entrance Road	N/A	< 15	N/A	< 15	N/A	< 15

Notes:
(1) All setback distances are from the roadways' centerlines.
(2) See TABLE 3 for traffic volume, speed, and mix assumptions.
(3) Ldn assumed to be equal to Peak Hour Leq along all roadways.
(4) Setback distances are for unobstructed line-of-sight conditions.
(5) "<" signifies "less than."

FIGURE 5a

EXISTING AND FUTURE TRAFFIC NOISE
VS. DISTANCE FROM CENTERLINE OF
QUEEN KA'AHUMANU HIGHWAY (NORTH)

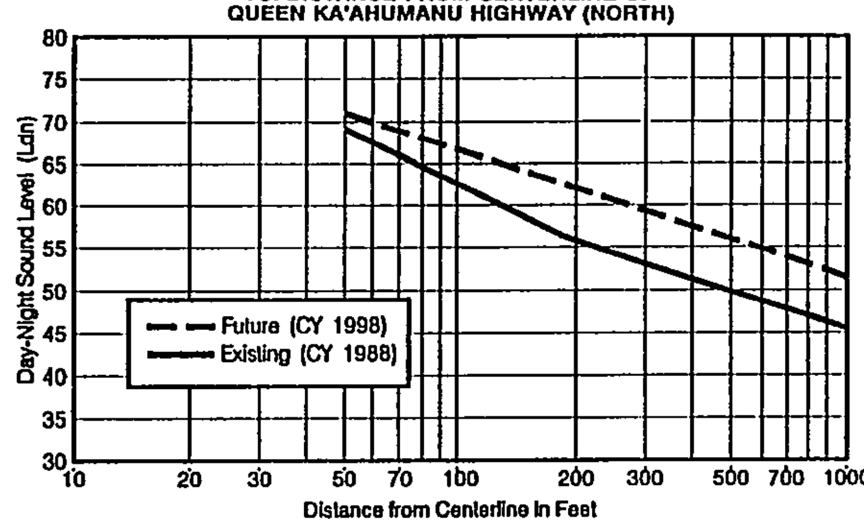


FIGURE 5b

EXISTING AND FUTURE TRAFFIC NOISE
VS. DISTANCE FROM CENTERLINE OF
QUEEN KA'AHUMANU HIGHWAY (SOUTH)

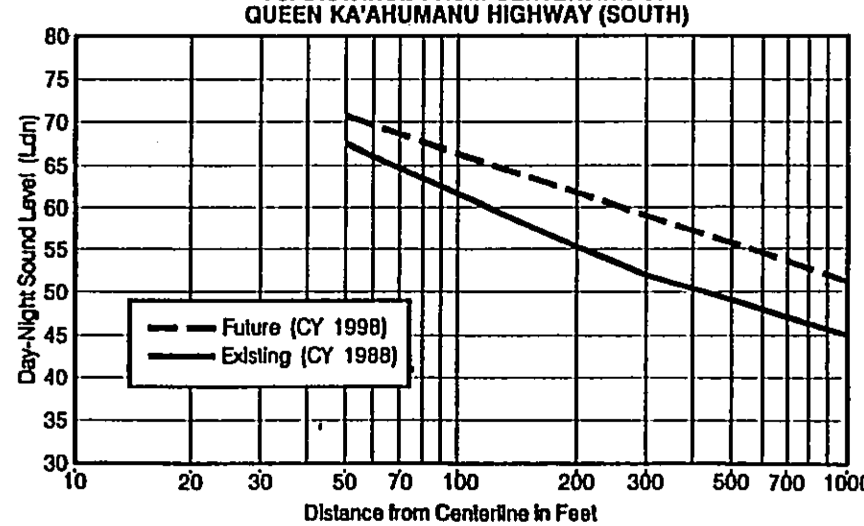


FIGURE 6a

EXISTING AND FUTURE TRAFFIC NOISE
VS. DISTANCE FROM CENTERLINE OF
MAUNA LANI DRIVE (EAST)

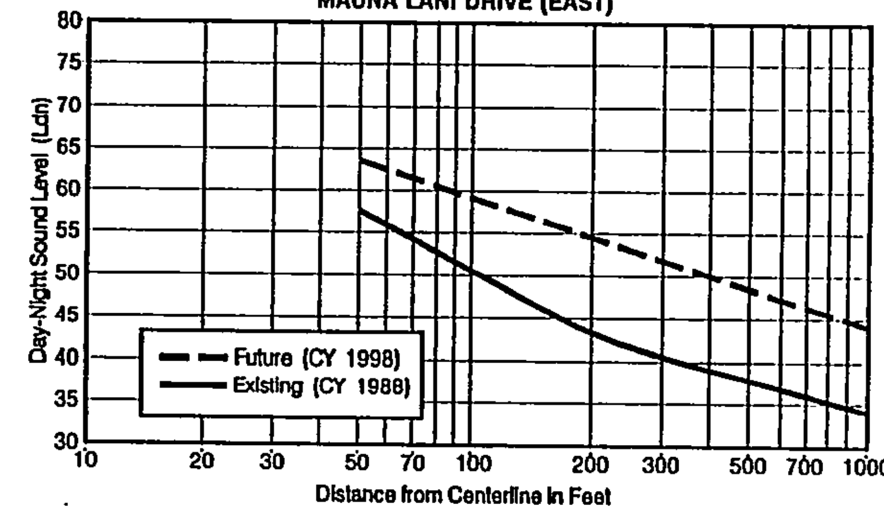
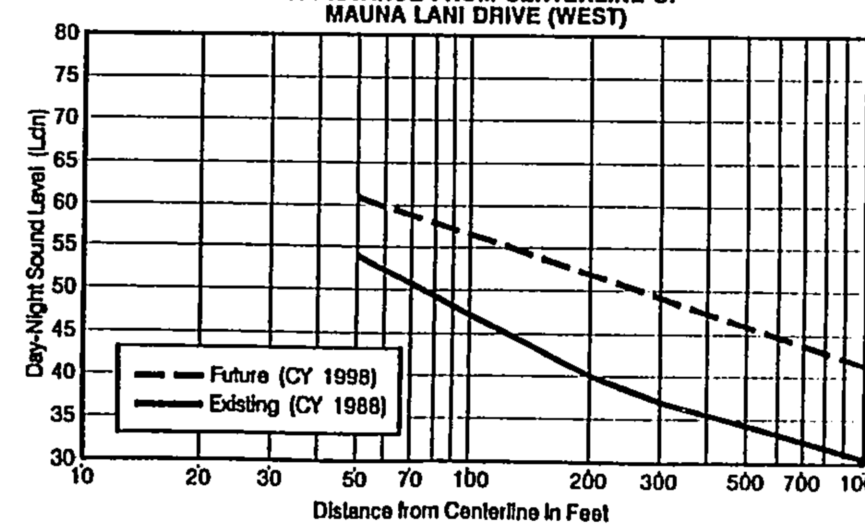


FIGURE 6b

EXISTING AND FUTURE TRAFFIC NOISE
VS. DISTANCE FROM CENTERLINE OF
MAUNA LANI DRIVE (WEST)



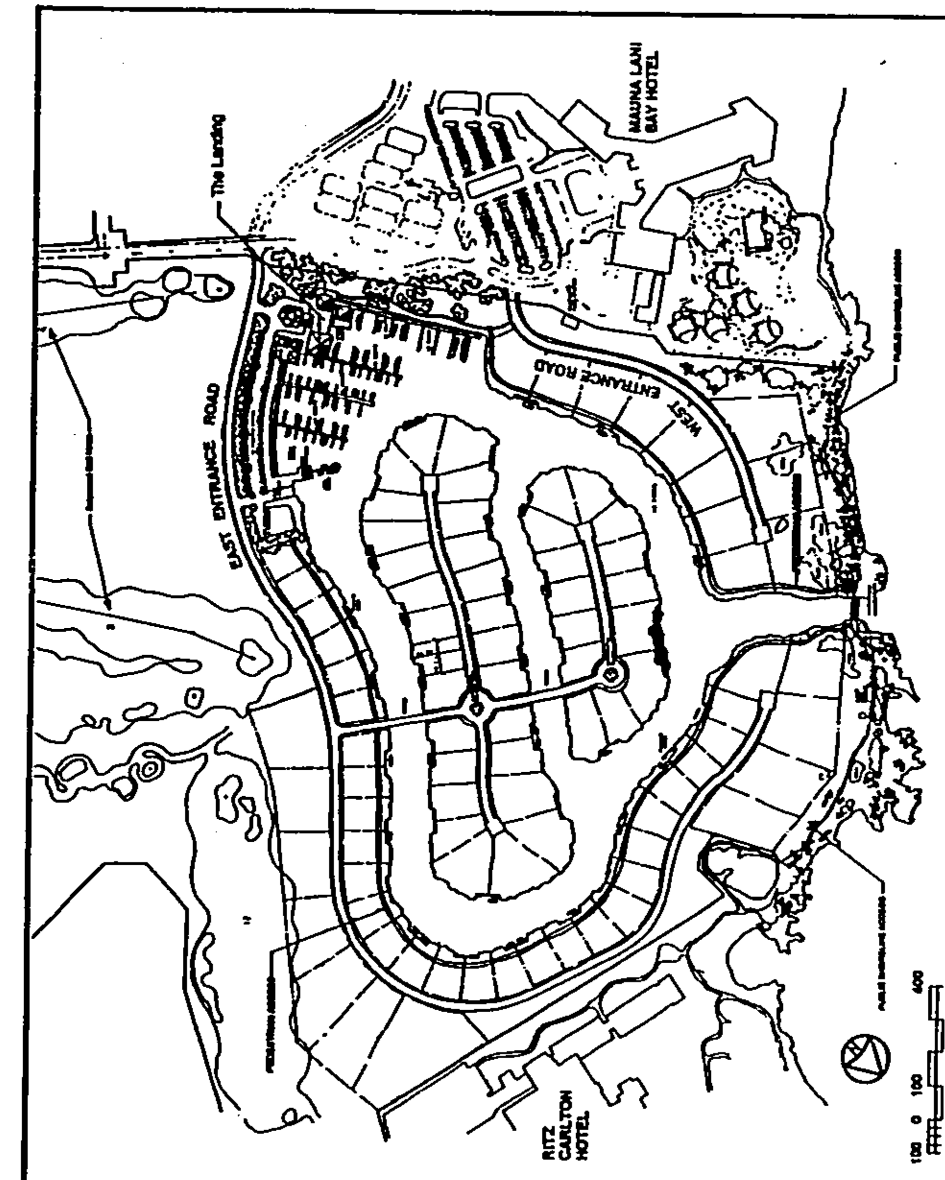
The traffic noise levels shown in the tables and figures only apply when unobstructed line-of-sight conditions exist to the roadways. These conditions would generally occur at short (50 to 100 FT) distances to a roadway, within any flat, open space along the roadway, and at distant, but elevated locations above the roadway. The existing traffic noise levels shown in the tables and figures should be reduced by 3 to 5 dB (or Ldn) if partial shielding (line-of-sight obstruction) exists between the roadway and the receptor location. If the receptor is located behind an obstruction (berm or hill), the noise levels in the tables and figures should be reduced by 5 to 10 dB.

CHAPTER VI. FUTURE TRAFFIC NOISE ENVIRONMENT

Predictions of future traffic noise levels were made using the traffic volume assignments of **Reference 6** for CY 1998 with and without the proposed Mauna Lani Cove project. The future condition without the proposed project is expected to result in higher volumes of traffic because the original plan involved a more intensive hotel development rather than a water-oriented residential development. The future projections of project plus non-project traffic on the roadways which would service the project are shown in **TABLE 3** for the PM peak hour of traffic. As indicated in **TABLE 3**, by CY 1998, traffic conditions on Queen Ka'ahumanu Highway will worsen, with average vehicle speeds reduced by 7 to 13 MPH from existing conditions. Traffic noise levels along Queen Ka'ahumanu Highway are expected to increase by approximately 2 to 3 Ldn by CY 1998, primarily as a result of non-project traffic. Similarly, as a result of non-project traffic, noise levels along Mauna Lani Drive are expected to increase by approximately 6 Ldn units.

The contribution of project traffic noise to the total noise levels along the Queen Ka'ahumanu Highway is less than 0.5 Ldn units, which is insignificant. Along Mauna Lani Drive, project traffic contributes approximately 1.3 Ldn to total future noise levels, which is a moderate increase. Of greater significance is that, without the Mauna Lani Cove project, future traffic noise along Queen Ka'ahumanu Highway are predicted to be at least 0.5 to 0.7 Ldn higher than the future noise levels indicated in **TABLE 3**. Without the Mauna Lani Cove project, future traffic noise along Mauna Lani Drive are predicted to be at least 2 to 3 Ldn higher than the future noise levels indicated in **TABLE 3**. Future traffic noise along these two roadways are expected to be lower with the Mauna Lani Cove project because the originally planned hotel project would have generated higher volumes of traffic on these two roadways.

TABLE 4 summarizes the predicted setback distances to the 55, 60, and 65 Ldn traffic noise contour lines along the roadways servicing the project and attributable to both project plus non-project traffic by CY 1998. The setback distances in TABLE 4 do not include the beneficial effects of noise shielding from terrain features and highway cuts, or the detrimental effects of additive contributions of noise from intersecting streets. As indicated in TABLE 4, relatively large setback distances to the 55 Ldn contour of 500 to 600 FT from the centerline of the existing Queen Ka'ahumanu Highway are predicted in CY 1998. It should be noted, however, that at these large setback distances, the likelihood of intervening terrain features or line-of-sight obstructions is very high, and traffic noise levels would probably be at least 5 to 10 Ldn units less than 55 Ldn. Along the two circulation roadways of Mauna Lani Cove (see FIGURE 7), traffic noise levels are expected to be very low and in the "Minimal Exposure, Unconditionally Acceptable" noise exposure category. In addition, these circulation roadways are located in excess of 100 FT from the neighboring hotels and cottages, and adverse traffic noise impacts from the project are not expected.



MAUNA LANI COVE CONCEPT PLAN

FIGURE 7

CHAPTER VII. DISCUSSION OF PROJECT RELATED NOISE IMPACTS AND POSSIBLE NOISE MITIGATION MEASURES

Traffic Noise. By CY 1998, traffic conditions along Queen Ka'ahumanu Highway are expected to worsen as non-project traffic is added to the highway. As a result of this, average vehicle speeds along the existing highway are expected to decrease by 5 to 13 MPH. Traffic noise levels along the highway are expected to increase by 2 to 3 Ldn, primarily due to non-project traffic. Along Mauna Lani Drive, and primarily due to non-project traffic, noise levels are expected to increase by approximately 6 Ldn units.

The Mauna Lani Cove project is expected to generate less traffic on both Queen Ka'ahumanu Highway and Mauna Lani Drive than would the originally planned hotel project. Because of this, the Mauna Lani Cove project will lessen the increases in traffic volumes and traffic noise which were originally associated with non-project traffic in CY 1998. The amount of reduction in originally forecasted traffic noise was calculated as approximately 0.5 to 3 Ldn units along Queen Ka'ahumanu Highway and Mauna Lani Drive. For this reason, the proposed project is viewed as being beneficial rather than detrimental in respect to traffic noise impacts.

Along the project's circulation roadways, traffic noise levels are expected to be less than 50 Ldn at 50 FT setback distance from the centerlines of the roadways. Minimum setback distances to the 55 Ldn contour along the Mauna Lani Cove's east and west entrance roads are estimated to be 25 and 10 FT, respectively, from the roadways' centerlines. Because the project's plan provides for these setback distances to the proposed residences, adverse noise impacts on future residents from project traffic are not expected. Additionally, the project's circulation roadways are at least 100 FT from the nearest noise sensitive structure toward the south on the grounds of the Mauna Lani Bay Hotel, and at least 150 FT from the nearest noise sensitive structure toward

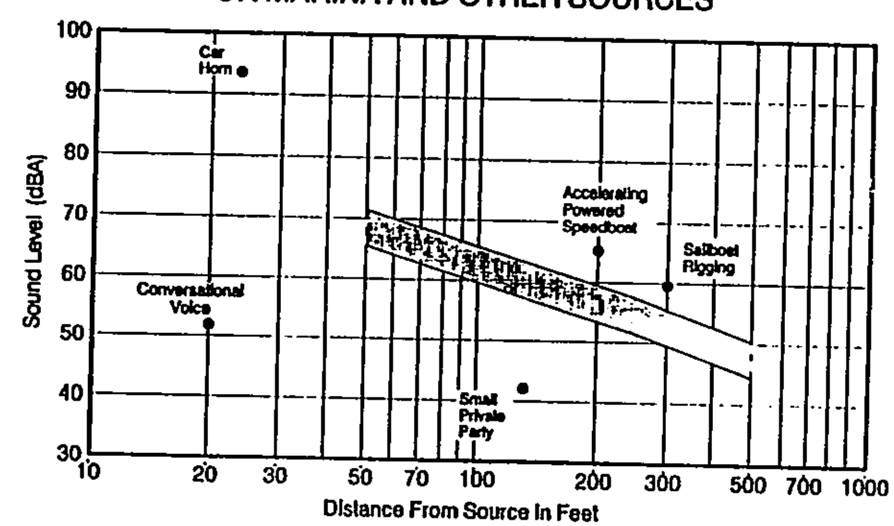
the north on the grounds of the Ritz Carlton Hotel. Because of these large setback distances, project traffic noise at neighboring noise sensitive properties should be less than 50 Ldn, and adverse noise impacts are not expected at these neighboring properties.

Boating Noise. Although future marina residents are expected to demonstrate some tolerance toward boating noise, an assessment was performed of expected noise impacts from powerboats and motoring sailboats within the proposed marina. A maximum of 175 boats are expected to be berthed in the marina. Separation distances between the boats and marina residences are expected to be in the order of 50 to 150 FT. Predicted maximum sound levels vs. distance to powerboats and motoring sailboats within the marina are shown in FIGURE 8. From the figure, noise levels from powered boats in the marina are expected to range from 55 to 72 dB, and will be audible at residences along the marina's waterways. In respect to noise exposure as expressed by the Ldn descriptor, worst case noise levels are expected to occur at the marina's entrance channel. At this location, and on a hypothetical worst case day when all 175 boats leave and return to the marina, boating noise levels could range from 50 to 55 Ldn at approximately 100 FT from the centerline of the entrance channel. At more inland locations or during days of less boat trips, boating noise levels should be less by 3 Ldn units for every 50 percent reduction in the total number of daily passby events of motoring boats. Based on these results, boating noise is not expected to generate adverse noise impacts within the marina.

General Construction Noise. Audible construction noise will probably be unavoidable during the entire project construction period. The total time period for construction is unknown, but it is anticipated that the actual work will be moving from one location on the project site to another during that period. Actual length of exposure to construction noise at any receptor location will probably be less than the total construction period for the

FIGURE 8

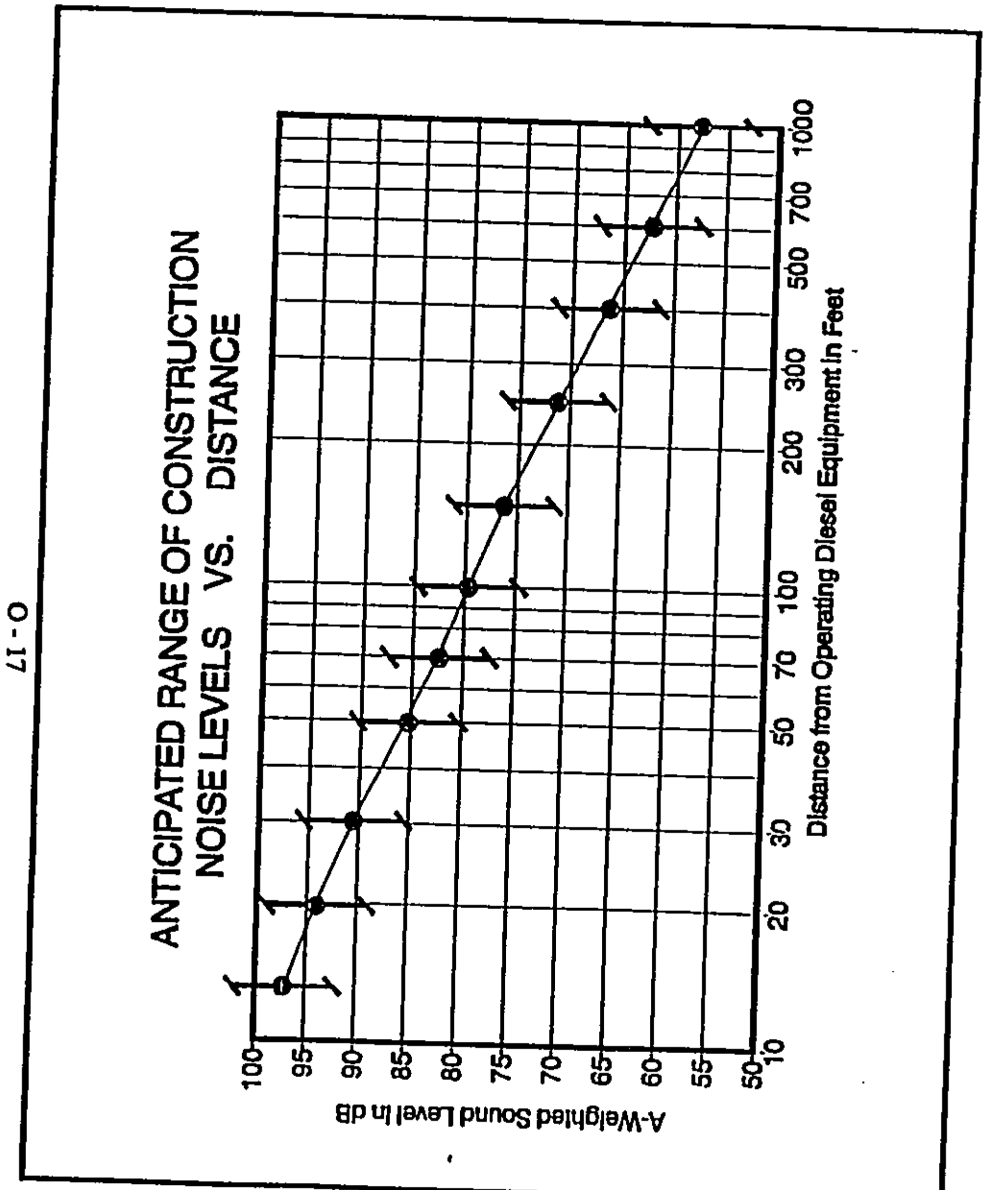
SOUND LEVELS VS. DISTANCE FROM POWERED BOATS WITHIN HARBOR OR MARINA AND OTHER SOURCES



KEY: Typical range of noise levels from Powered Boats within harbor or marina

entire project. Typical levels of exterior noise from construction activity (excluding pile driving activity) are shown in FIGURE 9. The impulsive noise levels of impact pile drivers are approximately 15 dB higher than the levels shown in FIGURE 9, while the intermittent noise levels of vibratory pile drivers are at the upper end of the noise level ranges depicted in the figure. Typical levels of construction noise inside naturally ventilated and air conditioned structures are approximately 10 and 20 dB less, respectively, than the levels shown in FIGURE 9. The noise sensitive properties which are predicted to experience the highest noise levels during construction activities on the project site are the existing cottages on the grounds of the Mauna Lani Bay Hotel, the guest suites at the Ritz Carlton and Mauna Lani Bay Hotels, and residences within the Mauna Lani Cove development. Adverse impacts from construction noise are not expected to be in the "public health and welfare" category due to the temporary nature of the work and due to the administrative controls available for its regulation. Instead, these impacts will probably be limited to the temporary degradation of the quality of the acoustic environment in the immediate vicinity of the project site.

Mitigation of construction noise to inaudible levels will not be practical in all cases due to the intensity of construction noise sources (80 to 90+ dB at 50 FT distance), and due to the exterior nature of the work (pile driving, grading and earth moving, trenching, concrete pouring, hammering, etc.). The use of properly muffled construction equipment should be required on the job site. In addition, if soil conditions allow, the use of vibratory pile driving equipment is also recommended for minimizing construction noise impacts. The incorporation of State Department of Health construction noise limits and curfew times, which are applicable on the island of Oahu (Reference 4), is another noise mitigation measure which can be applied to this project. TABLE 5 depicts the allowed hours of construction for normal construction noise (levels which do not exceed 95 dB at the project's property



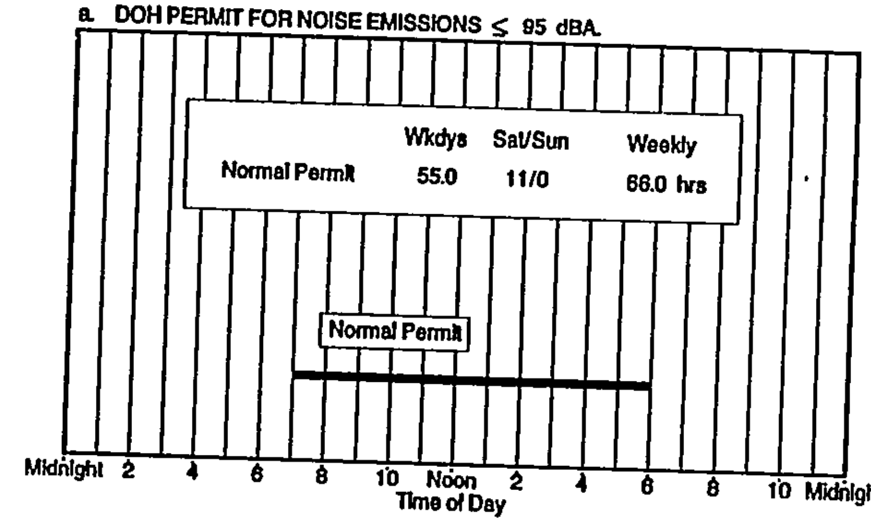
CONSTRUCTION NOISE LEVELS VS. DISTANCE

FIGURE 9

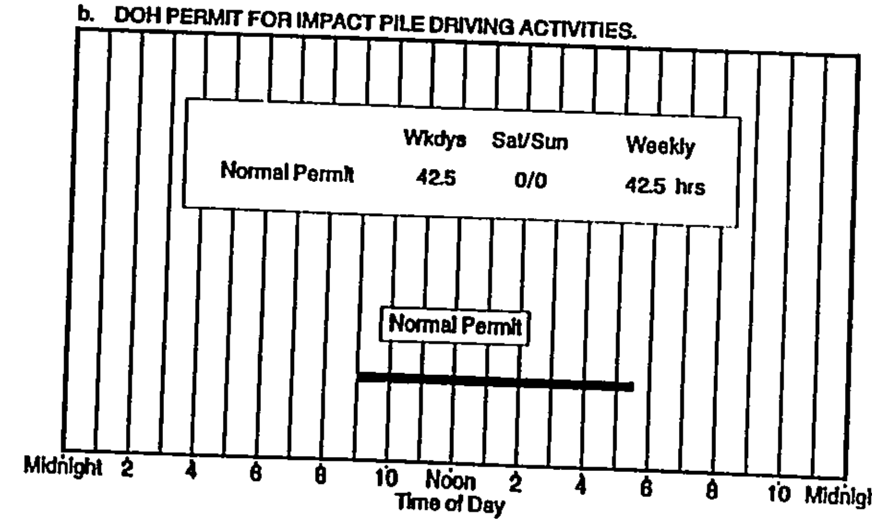
TABLE 5

AVAILABLE WORK HOURS UNDER DOH PERMIT PROCEDURES FOR CONSTRUCTION NOISE

a. DOH PERMIT FOR NOISE EMISSIONS ≤ 95 dBA.



b. DOH PERMIT FOR IMPACT PILE DRIVING ACTIVITIES.



line) and for construction noise which exceeds 95 dB at the project's property line. Noisy construction activities are not allowed on holidays under the DOH permit procedures.

<u>Noise and Vibration from Blasting.</u> Blasting may be used to fragment rock, coral, or lava during the excavation phase of the construction project in order to reduce the total time required to complete the project. Blast induced ground and air vibrations have the potential to startle or annoy surrounding residents and guests, and to also cause damage to structures.

The air blasts associated with blasting are concussion type, low frequency vibrations, which are of relatively short duration (or impulsive) and generally described in terms of peak overpressure in psi, or in dBL. The dominant sources of the air blast are the Air Pressure Pulse, which is caused by the large displacement of the ground surface near the charge, and the Stemming Release Pulse, which is caused by gas pressure ejecting the stemming (fill) material from the hole bored for the explosive charge. When exposed to high peak overpressure levels exceeding 141 dBL, large plate glass windows may break. At peak overpressure levels of 171 dBL, most windows can be expected to break. For these reasons, air blast levels during blasting are generally limited to levels below the 141 dBL level in order to minimize risks of damage to structures.

The low frequency characteristic (usually referred to as bass sounds) of air blast noise tends to induce vibrations in structures (and subsequent complaint reactions) due to the low resonant frequency (10 to 25 Hz) of buildings. High frequency sounds of equal amplitude to blast noise generally do not induce vibrations and cause physical damage to structures. Although the human ear has an opposite characteristic (i.e., the ear is less sensitive to low frequency sounds), structures which vibrate can produce secondary audible effects such as rattling sounds (of fixtures, doors, etc.), and effects which are sensitive to touch (or feelable). Sound levels at which these secondary effects occur

vary with the weight (and probably stiffness) of the structure. In general, the inception point of sound induced vibration is difficult to establish, but may occur at levels as low as 80 dBL. These levels are significantly below the peak levels of 120 to 136 dBL which have been associated with low risk of damage to structures.

Ground vibrations, or seismic waves, are also generated during blasting operations, and are generally described in terms of peak particle velocity in inches/second. Most of the seismic energy remains trapped in the ground, but some energy is released as an overpressure pulse into the air (or Rock Pressure Pulse). In general, the ground vibrations as well as the airborne Rock Pressure Pulse are expected to be less intrusive than the Air Pressure and Stemming Release Pulses. As an example, tunneling work along Dole Street on Oahu for a sewer project generated some initial air blast complaints from nearby residents during blasting of the surface entrance to the tunnel. However, once the entrance to the tunnel was formed and blasting was confined to tunneling underground, complaints stopped. Maximum ground vibration levels during the tunneling work was limited to 2 inches/second, but blasting was conducted during all hours of the day and night (approximately 5 blasts per day). A total of 6 delays were typically used, with fixed delays of approximately 200 milliseconds, and with a maximum charge weight per delay of approximately 8.6 pounds.

Predictions of peak overpressure or ground vibration levels vs. scaled distance from the blast are not precise, with initial uncertainties for a given location in the order of 20 to 30 dBL. For this reason, it is standard practice to employ seismograph monitoring of air and ground vibrations during blasting operations with a 3-axis geophone (for ground vibrations) and a microphone (for air vibrations). The construction specifications for blasting operations generally require seismograph monitoring at the structure(s) closest to the bore holes. Based on the monitoring data, explosive charge sizes (or weights) are adjusted in order to limit peak overpressures of the air blasts to levels below the threshold of possible damage to structures. Based on standard practices, it is expected that, without special mitigation measures, maximum vibration levels at structures closest to the bore holes will be approximately 136 dBL for the air blasts and 2 inches/second for the seismic vibrations.

Since complaints resulting from air blast noise levels may occur at levels considerably below those necessary to cause damage to structures (120 to 136 dBL), additional mitigation measures will probably be required to minimize risks of antagonizing nearby residents and hotel guests. These recommended mitigation measures are described as follows:

- o Monitor air blast and ground vibration levels simultaneously at the closest noise sensitive residence(s) or structure(s).

- o For initial blasts, prior to establishment of a data base of air blast levels vs. scaled distance, use a maximum charge weight (in equivalent pounds of TNT) per delay of less than (D/70)**2 pounds (or distance divided by 70, and quantity squared), where D is the distance in feet between the charge and the nearest noise sensitive residence or structure.

- o If practical, reduce maximum air blast levels to less than 110 dBL at the nearest noise sensitive residences in response to air blast complaints. Possible methods of accomplishing this are: reducing charge sizes; increasing delay intervals; increasing hole depth; orienting bore holes to direct the Stemming Release Pulse away from noise sensitive properties; trucking in high quality stemming material to minimize stemming blowouts; and filling (sandbagging) over the area to be blasted and the detpnating chord.

- o Schedule actual blasting during the warm periods of the day to minimize the possibility of thermal ducting and focusing of air blast noise at large distances from the blast. If possible, schedule blasting during fixed time periods which are publicized and made known to area residents and hotel guests.

- o Restrict blasting operations which exceed 95 dBL at residences or guest suites to the hours of 9:00 AM to 5:30 PM of the same day, and to weekdays (excluding holidays). For other noise sources associated with excavation operations, follow State Department of Health permit procedures and requirements for construction activities on Oahu.

APPENDIX A. REFERENCES

(1) "Guidelines for Considering Noise in Land Use Planning and Control"; Federal Interagency Committee on Urban Noise; June 1980.

(2) "Environmental Criteria and Standards, Noise Abatement and Control, 24 CFR, Part 51, Subpart B"; U.S. Department of Housing and Urban Development; July 12, 1979.

(3) "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety"; Environmental Protection Agency (EPA 550/9-74-004); March 1974.

(4) "Title 11, Administrative Rules, Chapter 43, Community Noise Control for Oahu"; Hawaii State Department of Health; November 6, 1981.

(5) Barry, T. and J. Reagan, "FHWA Highway Traffic Noise Prediction Model"; FHWA-RD-77-108, Federal Highway Administration; Washington, D.C.; December 1978.

(6) Traffic Impact Study - Mauna Lani Cove; Belt Collins & Associates; October 1989.

(7) May 2-3, 1988 24-Hour Traffic Counts; Station 8-H, Queen Ka'ahumanu Highway at Waikoloa Road; Hawaii State Department of Transportation.

APPENDIX B

EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE

Descriptor Symbol Usage

The recommended symbols for the commonly used acoustic descriptors based on A-weighting are contained in Table I. As most acoustic criteria and standards used by EPA are derived from the A-weighted sound level, almost all descriptor symbol usage guidance is contained in Table I.

Since acoustic nomenclature includes weighting networks other than "A" and measurements other than pressure, an expansion of Table I was developed (Table II). The group adopted the ANSI descriptor-symbol scheme which is structured into three stages. The first stage indicates that the descriptor is a level (i.e., based upon the logarithm of a ratio), the second stage indicates the type of quantity (power, pressure, or sound exposure), and the third stage indicates the weighting network (A, B, C, D, E.....). If no weighting network is specified, "A" weighting is understood. Exceptions are the A-weighted sound level and the A-weighted peak sound level which require that the "A" be specified. For convenience in those situations in which an A-weighted descriptor is being compared to that of another weighting, the alternative column in Table II permits the inclusion of the "A". For example, a report on blast noise might wish to contrast the LCdn with the LAdn.

Although not included in the tables, it is also recommended that "Lpn" and "LepN" be used as symbols for perceived noise levels and effective perceived noise levels, respectively.

It is recommended that in their initial use within a report, such terms be written in full, rather than abbreviated. An example of preferred usage is as follows:

The A-weighted sound level (LA) was measured before and after the installation of acoustical treatment. The measured LA values were 85 and 75 dB respectively.

Descriptor Nomenclature

With regard to energy averaging over time, the term "average" should be discouraged in favor of the term "equivalent". Hence, Leq, is designated the "equivalent sound level". For Ld, Ln, and Ldn, "equivalent" need not be stated since the concept of day, night, or day-night averaging is by definition understood. Therefore, the designations are "day sound level", "night sound level", and "day-night sound level", respectively.

The peak sound level is the logarithmic ratio of peak sound pressure to a reference pressure and not the maximum root mean square pressure. While the latter is the maximum sound pressure level, it is often incorrectly labelled peak. In that sound level meters have "peak" settings, this distinction is most important.

"Background ambient" should be used in lieu of "background", "ambient", "residual", or "indigenous" to describe the level characteristics of the general background noise due to the contribution of many unidentifiable noise sources near and far.

With regard to units, it is recommended that the unit decibel (abbreviated dB) be used without modification. Hence, DBA, PNdB, and EPNdB are not to be used. Examples of this preferred usage are: the Perceived Noise Level (Lpn was found to be 75 dB. Lpn = 75 dB). This decision was based upon the recommendation of the National Bureau of Standards, and the policies of ANSI and the Acoustical Society of America, all of which disallow any modification of bel except for prefixes indicating its multiples or submultiples (e.g., deci).

Noise Impact

In discussing noise impact, it is recommended that "Level Weighted Population" (LWP) replace "Equivalent Noise Impact" (ENI). The term "Relative Change of Impact" (RCI) shall be used for comparing the relative differences in LWP between two alternatives.

Further, when appropriate, "Noise Impact Index" (NII) and "Population Weighed Loss of Hearing" (PHL) shall be used consistent with CHABA Working Group 69 Report <u>Guidelines for Preparing Environmental Impact Statements (1977)</u>.

APPENDIX B (CONTINUED)

TABLE I

A-WEIGHTED RECOMMENDED DESCRIPTOR LIST

TERM	SYMBOL
1. A-Weighted Sound Level	L_A
2. A-Weighted Sound Power Level	L_{WA}
3. Maximum A-Weighted Sound Level	L_{max}
4. Peak A-Weighted Sound Level	L_{Apk}
5. Level Exceeded x% of the Time	L_x
6. Equivalent Sound Level	L_{eq}
7. Equivalent Sound Level over Time (T) (1)	$L_{eq(T)}$
8. Day Sound Level	L_d
9. Night Sound Level	L_n
10. Day-Night Sound Level	L_{dn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$
12. Sound Exposure Level	L_{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine).

SOURCE: EPA ACOUSTIC TERMINOLOGY GUIDE, BNA 8-14-78, NOISE REGULATION REPORTER.

APPENDIX B (CONTINUED)

TABLE II

RECOMMENDED DESCRIPTOR LIST

TERM	A-WEIGHTING	ALTERNATIVE(1) A-WEIGHTING	OTHER(2) WEIGHTING	UNWEIGHTED
1. Sound (Pressure) (3) Level	L_A	L_{pA}	L_B, L_{pB}	L_p
2. Sound Power Level	L_{WA}		L_{WB}	L_W
3. Max. Sound Level	L_{max}	L_{Amax}	L_{Bmax}	L_{pmax}
4. Peak Sound (Pressure) Level	L_{Apk}		L_{Bpk}	L_{pk}
5. Level Exceeded x% of the time	L_x	L_{Ax}	L_{Bx}	L_{px}
6. Equivalent Sound Level	L_{eq}	L_{Aeq}	L_{Beq}	L_{peq}
7. Equivalent Sound Level (4) Over Time(T)	$L_{eq(T)}$	$L_{Aeq(T)}$	$L_{Beq(T)}$	$L_{peq(T)}$
8. Day Sound Level	L_d	L_{Ad}	L_d	L_{pd}
9. Night Sound Level	L_n	L_{An}	L_{Bn}	L_{pn}
10. Day-Night Sound Level	L_{dn}	L_{Adn}	L_{Bdn}	L_{pdn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$	$L_{Adn(Y)}$	$L_{Bdn(Y)}$	$L_{pdn(Y)}$
12. Sound Exposure Level	L_S	L_{SA}	L_{SB}	L_{Sp}
13. Energy Average value over (non-time domain) set of observations	$L_{eq(e)}$	$L_{Aeq(e)}$	$L_{Beq(e)}$	$L_{peq(e)}$
14. Level exceeded x% of the total set of (non-time domain) observations	$L_{x(e)}$	$L_{Ax(e)}$	$L_{Bx(e)}$	$L_{px(e)}$
15. Average L_x value	L_x	L_{Ax}	L_{Bx}	L_{px}

(1) "Alternative" symbols may be used to assure clarity or consistency.

(2) Only B-weighting shown. Applies also to C,D,E,....weighting.

(3) The term "pressure" is used only for the unweighted level.

(4) Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is Leq(1). Time may be specified in non-quantitative terms (e.g., could be specified as Leq(WASH) to mean the washing cycle noise for a washing machine.

APPENDIX P

MAUNA LANI COVE OCEAN MONITORING PROGRAM (DRAFT)

DRAFT

MAUNA LANI COVE

OCEAN MONITORING PROGRAM

Preconstruction
Construction
Post Construction

October 1990

1. INTRODUCTION AND CONTENT

The nearshore environment and associated lava rock and coral reefs are among the most valuable aesthetic, ecologic and economic resources in the State of Hawaii in general and specifically on the west coast of the island of Hawaii. Recognizing these factors, Mauna Lani Resort, Inc. has striven to protect and preserve the offshore and onshore natural resources of the resort area. The resort has successfully engaged in a comprehensive environmental protection program that includes protection and enhancement of the offshore resources, restoration of coastal and anchialine ponds and preservation and protection of historical/archaeological resources within the resort boundaries. These natural and man-made resources have been and will continue to be used in interpretive educational programs for the general public and Hawaiian cultural groups. Coastal developments, such as the proposed Mauna Lani Cove, could have negative impacts on the nearshore environment if not constructed and operated with appropriate environmental protection controls and monitoring.

The purpose of this document is to serve as a general guide defining the water quality, marine biological and ciguatera monitoring that will be conducted prior to, during and following construction of Mauna Lani Cove, Mauna Lani Resort, South Kohala, Hawaii. A proposed schedule of observations, a site map indicating the monitoring stations, intended field plan, sampling depths, sampling methods and brief comments on analyses methodologies are presented. In developing this general guide, the proposed construction sequence, construction scheduling and anticipated seasonal coastal conditions were considered. The monitoring program measurements would be coordinated with the construction activity, with appropriate monitoring methodology employed to aid in minimizing environmental impacts on the existing coastal resources. The final monitoring program will be developed in consultation among Mauna Lani Resort, Inc., The US Department of the Army, Corps of Engineers, National Marine Fisheries Service, US Fish and Wildlife Service, State Departments of Health and Land and Natural Resources and the Hawaii County Planning Department.

2. CRITERIA

The criteria for the monitoring program measurements included consideration of the following conditions and concerns:

P-2

a. Blasting, dredging and other in-the-water construction activities required for the access channel could impact the biota of the construction and adjacent area; affect state water quality standards; and potentially result in increased incidences of ciguatera.

b. The establishment of a physical, chemical and biological starting baseline based upon historical data is required to have a measure against which construction and post construction conditions can be compared and evaluated.

c. The existing biota and water quality characteristics of the access channel construction area are typical of naturally stressed South Kohala coast conditions. Threatened green turtles transit through or near the access channel construction area and endangered humpback whales offshore the resort area in deeper waters.

d. Mauna Lani Resort, Inc. would contract with an experienced, qualified firm or individuals to perform the monitoring program defined herein.

e. Preconstruction monitoring would begin at least two months preceding in-the-water access channel construction. The field monitoring program would conclude one-month following completion of access channel construction, including that related to removal of the beach berm, and the ciguatera monitoring program would be extended for a 12-month period following access channel construction unless a ciguatera incidence occurs as a result of access channel construction, in which case the ciguatera monitoring would be extended for a 24-month period following completion of access channel construction.

f. The preconstruction monitoring would be initiated upon issuance of the Corps of Engineers Permit, the Conservation District Use Permit and any County of Hawaii permits that may be required.

g. The state water quality standards (Department of Health, Administrative Rules, Chapter 54, "Wet Criteria") for construction will be maintained, as applicable.

h. Monitoring will include the existing and future potential release of infiltrating nutrient and biocide loading to coastal waters.

i. Nearshore water quality and biological conditions will be monitored during opening of the Cove to the ocean.

j. Spoils drainage will be observed to assure that it is isolated from direct discharge into the ocean.

k. That applicable environmental protection measures as noted in the Mauna Lani Cove Final Supplemental Environmental Impact Statement will be observed prior to, during and following construction of the Cove.

3. MONITORING PROGRAM

3.1 BASELINE STUDIES

Historical data, past project field data and new field data, as required, would be assembled to establish the physical/chemical/biological and ciguatera (dinoflagellate population and fish toxicity) baseline conditions of the access channel construction area. The baseline area to be considered would be limited to the area in which the marine survey included in the Final Supplemental Environmental Impact Statement (Final Supp EIS) was conducted. Baseline turtle surveys would be made in those areas also surveyed for the Final Supp EIS (see Figure 1 attached hereto).

3.2 PHYSICAL/CHEMICAL FIELD WORK

The physical/chemical field work would be performed at the six (6) stations shown on Figure 1. Field water quality samples would be taken at the surface and near the bottom at each station a minimum of two times prior to construction, two times per month during construction and at least twice following construction of the entrance channel and at least twice after the access channel has been opened to the interior of the Cove. The two sample periods prior to construction along with those previously taken for the Final Supp EIS, would be considered representative of and establish the baseline conditions. All applicable state water quality parameters would be monitored as would potential biocides that might enter coastal waters following application to Mauna Lani golf course or landscaped areas. As a minimum, water quality monitoring would include temperature, salinity, dissolved oxygen and nutrients (dissolved nitrate-nitrite, total nitrogen, dissolved phosphate and total phosphorus). Suspended solids would be taken as turbidity observations. Other supporting data collected during each monitoring period, and reported as ranges, would include wave observations, tides and surface expressions, if any, of circulation and current patterns. Ambient weather data, wind speed and direction, temperature and general climatic conditions, would also be recorded during each monitoring period. During the field monitoring program, sampling times would be varied such that physical/chemical sampling would be conducted at different times of the day and at different tidal cycles. Water quality monitoring would be accomplished such that samples are taken during both ebb and flood tides. A report summarizing the baseline results would be prepared following completion of the field work. The baseline report, in conjunction with applicable state water quality standards, would be used to measure water quality conditions in the project area during and after construction.

3.3 BIOLOGICAL FIELD WORK

The biological field work would be performed in conjunction with the physical/chemical field work. Surveys would be conducted using the same transects as those used in the marine survey for the Final Supp EIS. The biological surveys would examine the benthic biological conditions of the access channel area at the same level of detail as in previous surveys. The intertidal area fronting the Cove would be surveyed for occurrence and abundance of macroalgae, indicator invertebrate species and vertebrate species commonly inhabiting or frequenting the survey area. Biological surveys would be made two times prior to construction, two times per month during construction and at least twice following construction of the entrance channel and at least twice after the access channel has been opened to the interior of the Cove. The two sample periods prior to construction along with those previously taken for the Supp EIS, would be considered representative of and establish the baseline conditions. A report summarizing the baseline results would be prepared following completion of the field work. The baseline report, in conjunction with previous survey results would be used to measure biological conditions in the project area during and after construction.

3.4 ENDANGERED/THREATENED SPECIES FIELD WORK

Two preconstruction surveys of the known green turtle resting/feeding areas in the vicinity of Mauna Lani Resort would be made. These surveys would be taken at dawn and during high tides, but not on consecutive days. The surveys would be conducted from the

surface by personnel in boats, as well as by scuba divers or personnel towed behind the survey boat through the known green turtle resting/feeding areas. During construction, the contractor would be required to monitor for the presence of green turtles near the construction area during all ocean work, regardless of whether blasting is or is not used. Turtles found in the construction area would be carefully herded away from the construction area. Offshore construction activities would only be conducted from the May through October period. The access channel would not be opened to the ocean during the winter months.

3.5 CIGUATERA FIELD WORK

The ciguatera monitoring program would include sampling of the dinoflagellate (*Gambierdiscus toxicus*) populations and toxicity of fish. For the dinoflagellate monitoring, 20 samples per field day would be taken from macroalgae collected in and adjacent to the area of active open coastal or access channel dredging. Field sampling would be conducted at least one month in advance of access channel construction activities and at least once per month during construction and at least once per month for a 12-month period following access channel construction, unless an incidence of ciguatera poisoning occurs during or immediately following construction, in which case the ciguatera monitoring program would be extended to 24 months following access channel construction. Sampling would be conducted throughout the construction area, dependent upon the presence of suitable macroalgae for collection purposes. In addition to macroalgae, monthly samples of at least 30 fishes would be collected during each of the sampling periods noted above and the fish tested for toxicity by an experienced, qualified person or organization, using the Stick Immunoenzyme Assay technology. Monthly reports would list the identity and weight of each fish and whether it tested positive or negative for toxicity. The percentage of fish that were tested positive would also be reported and the results would be analyzed in conjunction with the dinoflagellate results to provide and early indication of public health concerns. Should either the macroalgae and/or fish species test positive for ciguatera poisoning, Mauna Lani Resort, Inc. would post "NO FISHING" signs along the shoreline fronting the resort and publish notice of such findings in the local newspapers. Fishing would be curtailed until such time as the ciguatera toxin is no longer detected.

APPENDIX Q

MAUNA LANI COVE MANAGEMENT AND OPERATIONS RULES AND REGULATIONS (DRAFT)

lease agreement in order that the owner may continue use of the Cove.

9. A provision that the use permit or lease agreement with its attendant privileges is revocable and cancelable in accordance with the Cove Rules and Regulations; and the owner's covenant to pay, upon his failure to promptly remove his vessel from The Cove upon revocation, cancellation or termination of the use permit or lease agreement, a reasonable sum to be made part of the agreement as liquidated damages.

10. The owner's authorization of the management of the Cove to remove his vessel pursuant to the applicable provisions of the Rules and Regulations.

11. The owner's covenant to pay all costs and attorney's fees and charges in the event the management of the Cove is forced to institute a suit against the owner of his violation of any and all provisions of the Rules and Regulations.

12. A provision stating that neither the agreement, use permit or lease agreement or the privileges attendant thereto is assignable nor in any way transferable in any part or in its entirety.

13. An open provision to enable the management of the Cove and the owner to negotiate additional terms, covenants and conditions as may be proper under particular circumstances, including but not limited to provisions requiring sufficient comprehensive liability insurance coverage and performance and/or compliance bonds in such amounts as may be warranted under the circumstances.

14. A provision that in the event the fees and charges which shall have accrued in favor of the management of the Cove shall not be paid as provided in the Rules and Regulations, the management of the Cove, after reasonable notice, take possession of the vessel, its tackle, apparel, fixtures, equipment and furnishings and may retain such possession until charges then owing and any charges which shall thereafter accrue are fully paid and the remedy thus provided in addition to and not in lieu of any other remedies which the management of the Cove may have by virtue of statute or otherwise.

Q-10

e.	Vehicle/Boat Trailer Parking Area	$5.00 to $10.00/24-hour day.
f.	Dry Storage (Boats)	$45.00 to $60.00/month.

g. Other services will be charged in accordance with applicable rates at the time the services are provided. The Harbor Master will maintain an up-to-date schedule of these fees.

EXHIBIT A

CONTENTS DESCRIPTION OF THE AGREEMENT BETWEEN BOATOWNER AND MAUNA LANI RESORT, INC. PURSUANT TO USE OF MAUNA LANI COVE

An agreement between Mauna Lani Resort, Inc. and the boatowner, effectuating the provisions of the Mauna Lani Cove Management and Operations Rules and Regulations, shall contain the following terms, covenants and conditions:

1. The owner's certification of all information contained in the application and submitted by him/her as being true.

2. The owner's covenant to abide by any and all provisions of the Cove Management and Operations Rules and Regulations, and the incorporation by reference of such rules and regulations into the agreement.

3. The owner's authorization of the management of The Cove to assign and reassign berths and spaces for his vessel as deemed appropriate by the management of the Cove.

4. A provision stating that all persons signing the agreement shall be jointly and severally liable for the full performance of all terms, covenants and conditions thereof.

5. The owner's authorization of the management of the Cove to board his vessel to effect reasonable inspection in the manner and pursuant to the procedures specified in the Cove Management and Operations Rules and Regulations.

6. The owner's covenant to pay all applicable fees and charges, and his authorization of the management of the Cove to assess collection and service charges for the delinquent payment thereof.

7. The owner's covenant to indemnify Mauna Lani Resort, Inc., the management of the Cove and their officers and employees for damages and injuries arising out of the owner's exercise of privileges granted by the use permit or lease agreement.

8. A provision that the term of the agreement and use permit or lease agreement shall terminate upon expiration of the period stated therein pursuant to the applicable provisions of the Cove Management and Operations Rules and Regulations thereby requiring a renewal of the agreement and use permit or

Q-8

B. USE FEES

B.1 Payment, Delinquency and Liens

A permittee, upon issuance of a use permit and/or lease, shall in addition to paying fees and charges as they become due, deposit with Mauna Lani Resort, the Cove management or as they may be directed by the Harbor Master, a security deposit equal to two (2) months' fees and charges at the rate prescribed in these rules in effect on the date of issuance of the permit as security for the faithful performance on the permittee's part of all the terms and conditions, specified therein. The deposit will be returned, without interest, to the permittee upon termination of the permit only if the terms and conditions have been faithfully performed to the satisfaction of the Harbor Master.

As a prerequisite to the issuance of a temporary mooring permit for a boat that will be in the Cove for more than fourteen (14) days, the permittee shall make a security deposit of one month's fees and charges, in addition to any other fees and charges, to Mauna Lani Resort, the Cove management or as directed by the Harbor Master. Transient boats, i.e., those staying less than fourteen (14) days, shall pay the fees shown below in Section B.2

Launch ramp fees, including any parking or assistance fees, if a one time occurrence, shall be paid prior to the vessel being allowed to be launched.

All fees and charges are due and payable on the first of each month. If the effective date of the use permit is other than the first day of the month, charges for that month will be prorated for the number of days remaining in the month. In the event that any check or other method of payment of the fees and charges is dishonored, an additional fee of $50.00 will be charged and all costs incurred in the collection of unpaid or

past due fees and charges, including reasonable attorneys fees, shall be borne by the person or persons owing such fees.

B.2 Fee Structure and Amounts

The following mooring rate ranges are presently under consideration. The final rates shall be in effect upon adoption of these rules and/or as modified by Mauna Lani Resort, Inc., the Cove management or the Harbor Master from time to time:

a. Mooring Rates at The Landing: Recreational Vessels	$10.00 to $30.00 per foot of vessel.
Commercial Vessels	Per terms of lease agreement.
b. Temporary Mooring Rate at The Landing (Vessels staying thirty (30) days or less)	$10.00 to 15.00 per 24-hour day per foot of vessel (special kamaaina rates will apply to Hawaii residents.
c. Transient Fee (vessels staying less than fourteen (14) days	$5.00 to 10.00 per hour (special kaamaina rates will apply to Hawaii residents).
d. Launch Ramp: Annual Pass	$200.00 to $400.00 per year (special kamaaina rates will apply to Hawaii residents).
Non-Annual Pass	$10.00 to 20.00 per launch/retrieval (special kamaaina rates will apply to Hawaii residents).

trailers alone, shall only be parked within the designated boat trailer parking area. Other vehicles shall only be parked in posted parking areas. At no time shall any parked vehicle be allowed to park for a period of time exceeding the posted time limits for a parking area.

G. ENVIRONMENTAL PROTECTION

G.1 General Statement

Mauna Lani Resort, Inc. and the Cove management are fully committed to the protection, preservation and maintenance of the many significant cultural and natural resources found within and adjacent to and offshore of the resort and Cove. It is the intention of the Cove management to assure that those using the Cove and the facilities located therein, observe all federal, state and county environmental protection and fish and game rules and regulations, especially those pertaining to endangered and threatened species. The management of the Cove will provide each permittee an informational packet containing applicable federal, state and county rules and regulations as well as information relative to penalties for violation of those rules and regulations. Further, it is the intent of the Cove management and Harbor Master to immediately revoke the permit and/or permission to use the Cove and/or facilities therein of any person found to be violating any of the applicable environmental rules and regulations.

G.2 Endangered and Threatened Species

The waters off the Cove and Mauna Lani Resort are known to be the feeding and resting grounds for green turtles and, during the winter months (November through April), humpback whales transit the offshore waters. All boaters and users of the Cove and general public areas adjacent thereto, shall comply with all federal, state and county rules and regulations pertaining to the protection and preservation of endangered and threatened species.

Violation of these rules and regulations will result in the immediate revocation of all use of the Cove and facilities located therein. Further, violation of these rules and regulations will result in the immediate reporting of any violation to the proper federal, state or county authorities.

G.3 Anchialine Ponds and Cultural Resources

The inshore areas around the Cove and Mauna Lani Resort include several anchialine and coastal ponds and archaeological/historical/cultural resources. Many of these resources have been restored and are maintained for the use and enjoyment of all persons. At no time shall any person tamper with, degrade in any way or cause any of the natural or cultural resources within the Cove and/or Mauna Lani Resort to be tampered with or degraded. Violation of this rule will result in the immediate expulsion of that person or persons from the Cove and/or Mauna Lani Resort and the immediate reporting of that person to the appropriate federal, state or county enforcement agency.

III. FEES AND CHARGES

A. GENERAL STATEMENT

The fees and charges relative to use of the Cove and facilities therein will be calculated to produce an amount at least sufficient to pay the expenses of operating, maintaining and managing the facilities and services and the cost, including interest and debt service of amortizing the capital costs of the Cove and facilities, including but not limited to berths, slips, launch ramp, parking areas, general public areas and general navigation channels and aids.

E.2 <u>Restricted Areas</u>

Only authorized persons may enter or remain upon restricted areas of the Cove. Restricted areas will be marked with appropriate signage and include but are not limited to private residential lots, mooring docks and moored boats.

E.3 <u>Restricted Activities</u>

No person shall consume and/or use liquor of any type within the public areas, except within the restaurant or other designated areas, at any time. No person shall use or consume drugs of any type anywhere within the Cove complex. There shall be no use of fireworks or other pyrotechnics at any time within or on the public areas of the Cove and/or Mauna Lani Resort without the express written permission of the Resort. The use of bicycles, skateboards, or other recreational equipment or games shall be controlled such that other persons are not bothered, injured or affected in any manner that might be considered to be a nuisance. Any person or persons found violating these restrictions will be prosecuted to the full extent of the law and shall be fully responsible for any damages caused by their actions.

Q-6

F. VEHICLE PARKING AND OPERATION

F.1 <u>General Statement</u>

The County of Hawaii traffic code and any other applicable county ordinance relating to vehicular operation and safety, as well as all other Mauna Lani Resort, Inc. traffic rules shall apply to the operation of motor vehicles on the parking areas and roadways serving the Cove and facilities therein.

F.2 <u>Licensing and Safety Inspection</u>

No vehicle shall be operated on or parked at Mauna Lani Resort, the Cove or any facilities therein unless such vehicle is currently licensed by the appropriate governmental agency and has the required evidence of safety inspection.

F.3 <u>Operation of Motor Vehicles</u>

No motor vehicle shall be operated within Mauna Lani Resort or the Cove in a careless or negligent manner or in disregard of the rights and safety of others, or without due caution or circumspection, or at a speed or in a manner which endangers or is likely to endanger a person or property or while the operator is under the influence of intoxicating liquor, or narcotic or habit forming drugs, or if the vehicle is so constructed, equipped, loaded or in a condition which could endanger other persons or other person's property.

F.4 <u>Traffic Controls</u>

All vehicular traffic within Mauna Lani Resort and/or the Cove, shall comply with any lawful order, notice, signal or direction of any regular or special police or security officer. When such traffic is controlled by signs and pavement markings, the signs and markings shall be obeyed unless a regular or special police or security officer directs otherwise. All posted speed controls within Mauna Lani Resort and/or the Cove or facilities therein, shall be strictly obeyed.

F.5 <u>Parking</u>

Except as otherwise authorized by Mauna Lani Resort, Inc. and/or the Cove management, no person shall stop, park or permit to remain halted, a motor vehicle in front of a driveway or on the land side of the launch ramp or at any place other than in an authorized parking area. Vehicles with boat trailers and/or boat entering the Cove, the Harbor Master or his delegated representative shall place a dye tablet in each toilet on the vessel and that tablet shall be kept in that toilet as long as the vessel is within the Cove. Removal, flushing or otherwise removing the dye tablet from the vessel toilet(s) shall, at the discretion of the Harbor Master, be sufficient cause to immediately revoke the mooring permit for that vessel and/or remove the vessel from the Cove at the vessel owner's expense.

D.8 Fire Safety

All vessels moored in or using the Cove and all facilities within the Cove shall be used and maintained in such a manner as to not constitute a potential fire hazard. All vessels moored in or using the Cove shall be equipped with US Coast Guard approved fire extinguishers as prescribed in the State of Hawaii Boating Rules. The failure to conform to any federal, state or county statute, rule, standard or ordinance or these rules affecting fire safety, may be construed by the Harbor Master as being in violation of these rules and shall be cause for immediate revocation of all privileges relating to the use of the Cove and facilities and services located therein.

Q-5

D.9 Fueling

The fueling of vessels in the Cove shall only take place at the fuel dock and shall only be accomplished in compliance with the following:

a. Prior to fueling a vessel, the operator shall:
   (1) securely moor the vessel;
   (2) stop all engines, motors, fans and devices liable to produce sparks;
   (3) extinguish all fires; and
   (4) close all ports, windows, doors and hatches.
b. Persons fueling a vessel shall:
   (1) refrain from smoking, striking matches or lighters or throwing switches; and

   (2) keep nozzle of hose, or can, in continuous contact with fuel opening to guard against static sparks.
c. After fueling is complete, the following actions shall be taken:
   (1) close all fill openings;
   (2) wipe up spilled fuel;
   (3) open all ports, windows, doors and hatches;
   (4) permit vessel to ventilate for at least five (5) minutes; and
   (5) check that there are no fuel fumes in the bilges or below deck spaces before starting machinery or lighting fires.

D.9 Lifesaving Equipment Required

Any vessel utilizing the Cove and/or the facilities therein, shall be equipped with approved lifesaving equipment as prescribed by applicable federal and State of Hawaii boating rules. The lifesaving equipment shall at all times be kept in good and serviceable condition for immediate and effective use and shall be so placed as to be readily accessible.

E. CONDUCT OF THE PUBLIC

E.1 General Statement

Mauna Lani Resort, Inc. and the Cove management have made several areas in and around the Cove accessible to the general public for the use and enjoyment of the general public as well as those moored or using the Cove or facilities located therein. Mauna Lani Resort, Inc. and the Cove management expect that the general public will be aware of and respect the rights of others and conduct themselves accordingly while using the general public areas of the Cove. The general public will be subject to these rules as well as all applicable federal, state and county penal laws and any other rules of conduct established by Mauna Lani Resort, Inc.

be kept in a condition of reasonable cleanliness and sanitation so as not to constitute a common nuisance or potential danger to public health. Nothing in this subchapter of these rules shall be construed to limit the power and authority of any county, state or federal agency relative to their authority, duties and responsibilities regarding vessels and the operation thereof.

D.2 <u>Garbage and Other Refuse or Offensive Matter</u>

No one shall have or keep on that person's vessel any refuse, garbage, decaying matter, or any other matter which gives off an offensive odor except when same is being disposed of as garbage and is kept in a receptacle which shall be kept closed by a tight fitting cover at all times except when being filled or emptied. The Cove management will provide common refuse bins, which will be emptied and cleaned at regular intervals, in which all vessel refuse and garbage shall be emptied. Vessel owners shall be responsible for assuring that all refuse or garbage is placed in the common refuse bins and cleaning up any litter that may inadvertently fall out of the common bins when refuse and garbage are being emptied into the bins.

D.3 <u>Flies and Rodents</u>

No one shall have or keep on that person's vessel or allow to be kept on that person's vessel, any article, substance or thing in which flies may breed, unless same be kept securely protected from flies. No rubbish or waste of any kind shall be placed, left dumped or permitted to accumulate or remain on any vessel or in the vicinity of the same, in such a way as to constitute a breeding place for rodents.

D.4 <u>Littering Land Areas Prohibited</u>

No person shall throw, place, leave, deposit or abandon or cause or permit to be thrown, placed, left or abandoned any litter within or adjacent to the seaward or landward sides of the

Q-4

Cove. All litter shall be disposed of in common rubbish bins provided by the Cove management and such disposal shall be per paragraph D.2 above. No person shall use the common refuse or other refuse containers within the Cove for disposal of litter brought into the Cove except when the litter is generated during and results from a vessel's voyage. The Harbor Master will issue citations to any person or persons found littering any area adjacent to the seaward or landward sides of the Cove. All costs associated with the removal of litter shall be assessed to the person or persons responsible for littering.

D.5 <u>Littering or Polluting Water</u>

No person shall place, throw, deposit or discharge or cause to be thrown, placed, deposited or discharged into the waters of the Cove or offshore waters, any litter, fish or other marine organism parts, sewage or other gaseous, liquid or solid materials which render the water unsightly, noxious, or otherwise unwholesome so as to be detrimental to the public health and welfare or to the enjoyment of the water for recreational or habitat purposes.

D.6 <u>Clean-Up of Waterways</u>

The Harbor Master or his delegated representative, will, on a daily basis, monitor and remove any litter that might collect or accumulate within the Cove channels. The Harbor Master will issue citations to any person or persons found littering the Cove and all costs associated with the removal of litter shall be assessed to the person or persons responsible for littering.

D.7 <u>Marine Toilets</u>

No toilet on a vessel shall be operated so as to discharge any untreated or treated sewage directly or indirectly into the Cove waters. All vessels shall make use of the wastewater pumpout facilities provided by the management of the Cove. Upon desist from violating or permitting violation of these rules or any other applicable rules and regulations pertaining to safe boating and/or environmental protection. In addition, a permit and/or lease may be revoked for a deliberate misstatement of or willful failure to disclose any material fact in an application for a permit or lease. Further, at the Harbor Master's discretion, a permit and/or lease may be revoked if, in the judgement of the Harbor Master, the continuation of a permit and/or lease is not in the best interests of Mauna Lani Resort, Inc., and/or the Cove.

B.4 Inspections

All vessels located in or upon the Cove waters shall be subject to inspection by the Harbor Master at any time when necessary and proper for the purpose of enforcing these rules.

Q-3

B.5 Cancellation of Permit and/or Lease

A use permit and/or lease may be canceled by a boat owner upon thirty (30) days written notice to the Harbor Master.

B.6 Removal of a Vessel

Upon notice to the owner and after a reasonable time has elapsed for the owner to remove a vessel from the Cove if so directed for any reason by the Harbor Master, the Harbor Master may remove and dispose of any vessel moored or otherwise left at the Cove, including any property or personal articles located thereon, its tackle, apparel, fixtures, equipment and furnishings, when the presence of the vessel is contrary to law or any provisions of these rules or when the Harbor Master deems such actions to be necessary to protect the health and welfare or vessels of others using the Cove or any facilities located at the Cove or The Landing. Any action taken by the Harbor Master to remove the vessel, including any property or personal articles

located thereon, shall be at the sole cost and risk of the vessel owner.

C. BOAT OPERATION

C.1 General Statement

The provisions of this subchapter shall govern the operation of vessels in the Cove and shall be considered to be in addition to existing and/or amended county, state and federal rules and regulations affecting boat operations.

C.2 Navigating or Mooring Vessels in The Cove

Whenever a vessel enters the Cove, its operator shall immediately come under the jurisdiction of these rules. Such vessels shall be operated, navigated, moored or stored in accordance with reasonable directions of the Harbor Master. Each vessel is to be navigated within the Cove at a speed slow enough that its wake will not disturb any other vessel or property. All posted speed limits within the Cove shall be strictly followed and enforced. No vessel shall anchor in the Cove or moor at any other location than the one assigned by the Harbor Master. Vessels shall abide by all small boat "rules of the road" and shall obey all navigational aids entering and leaving the Cove. At no time shall any boat be operated within the Cove in an unsafe or unseamanlike manner. Violation of any navigational or safe boating rules shall, at the discretion of the Harbor Master, result in the immediate revocation of any use permit and reporting to appropriate state and federal boating agencies.

D. SANITATION AND FIRE SAFETY

D.1 General Statement

All vessels moored at or using the Cove or Cove facilities and any facility or property used at the Cove, at all times shall

Q-2

Mauna Lani Resort, Inc. reserves the right for commercial use of the mooring facilities on a restrictive lease only basis. Dormant vessels will not be permitted at any time unless the owner presents valid evidence to the Harbor Master that the vessel is dormant because of circumstances beyond his control. The Harbor Master reserves the right to restrict the use of the Cove facilities to those who observe all rules and regulations and make full and timely payment of their fees and charges. Violation of any of these rules may result in the immediate revocation of any use permit and/or entry permission. The costs associated with the violation of any of these rules shall be borne entirely by the vessel owner or operator and Mauna Lani Resort, Inc. and/or the Cove management may take any necessary legal steps to collect such costs from the boat owner or operator.

B.2 Agreement for Use of The Cove and Facilities

Before any property or facility at the Cove is utilized by any vessel, its owner shall execute an agreement (Exhibit A hereto) with Mauna Lani Cove stating that the boat owner shall comply with all Cove, County of Hawaii, State of Hawaii and Federal small boat rules and regulations, safety factors and environmental protection measures, including those applicable to endangered and threatened species. Upon receipt of such an agreement and approval of same by the Cove Executive Manager and others as may be required by the Cove management, the Harbor Master may issue a permit for use of the Cove facilities.

Permits will be issued for the following:

a. Mooring Permit - a use permit authorizing the docking or mooring of a vessel within the Cove or Landing mooring areas. No vessel shall be anchored within the Cove nor shall any vessel moor or dock, for an extended period of time, at any location other than the one assigned by the Harbor Master. Mooring and docking shall only be by boat owners who have been issued a Mooring Permit. Mooring

permits will be issued annually and must be renewed annually. Temporary mooring permits may be issued for transient boats that will be moored in The Cove for thirty (30) days or less. At no time shall mooring permittees or any one else be allowed to live on board their vessel for more than fourteen (14) days without the express written permission of the Harbor Master and Cove Executive Manager.

b. Launch Permit - a use permit allowing the permittee to launch his/her boat from the Cove small boat launch ramp. A launch permit will also allow the permittee to temporarily moor at the fuel dock and make use of other services as required. Launch Permits will be issued annually and for one time events and must be displayed on the vessel. Boats without a launch permit will not be allowed to use the small boat launch ramp. Launching will be performed by the boat owner with assistance from Cove personnel. Vehicles and boat trailers will be parked in the designated boat trailer parking area. No boats, trailers or vehicles will be allowed to park on or adjacent to the launch ramp for any purpose other than boat launching/retrieving. Boat owners will notify the Harbor Master when they will be returning to the launch ramp such that the Cove personnel can assist with retrieval of the boat trailer.

c. Commercial Lease - a lease which allows the owner of a commercial vessel (sport fishing charter or sight seeing charter) to moor and use the Cove facilities for the commercial activities specified in the business lease. No activities outside the permit will be authorized. No commercial leases will be issued for thrill craft or other similar type activities. Commercial vessels will shall not be anchored within the Cove nor shall any commercial vessel moor or dock, for an extended period of time, at any location other than the one assigned by the Harbor Master. Commercial permits will be issued annually and must be renewed annually.

B.3 Revocation of Use Permit

Mauna Lani Resort, Inc. and the Cove management reserve the right to revoke any Cove use permit and/or lease if, after notice and warning, the permittee or lessee fails to remedy any breech of duties, covenants or conditions of the permit or lease or to

Q-1

DRAFT
October 1990

MAUNA LANI COVE

MANAGEMENT AND OPERATIONS

RULES AND REGULATIONS

I. INTRODUCTION

As a private residential small boat marina on the Island of Hawaii, Mauna Lani Cove provides Mauna Lani Resort an opportunity to develop a healthy balance in public and private usage of small boat facilities in Hawaii and institute a sound operations plan. The rules and regulations included herein are based on the following principals:

- Protection and preservation of environmental and cultural resources
- Efficiency of operation and management
- Order and cleanliness of the marina
- Character and attitude of personnel
- Quality and scope of services offered
- Rates charged for services and sales

Mauna Lani Cove will be among a select group of new marinas in the world designed for a high level of service while providing a valuable and needed resource for local resident use. Dockside facilities and operational procedures will be selected and designed for the level of services to be offered while maintaining or enhancing the environmental quality, safety and maintenance of the facilities. The Cove will serve as a safe haven for transient interisland, intercontinental and international yachts and local boaters and sailors during inclement weather; provide fuel and sewage pumpout services for

all boaters; and serve as a potential venue for international and local yacht racing, canoeing and other ocean recreation events. In keeping with the above, the following management and operations rules and regulations will apply equally and consistently to all users of the facilities.

II. COVE MANAGEMENT

A. MANAGEMENT STRUCTURE

Mauna Lani Cove will have two management components: one for the residential common areas and one for The Landing, channels, berths and other boating areas. The residential component will be managed by a homeowners association, of which Mauna Lani Resort, Inc. will be a member and the marina component will be managed exclusively by Mauna Lani Resort, Inc. via an executive manager and trained, experienced harbor master. The executive manager will oversee general operations, including management of the public areas and commercial/retail space at the Landing, and act as a liaison with the homeowners association. The Harbor Master will be responsible for pedestrian bridge operation, waterways and berths, fuel dock and waste pumpout station, fee collection, berth assignment, environmental protection, security and general safety.

B. USE OF THE COVE

B.1 General Statement and Restrictions on Use of The Cove

Use of the Cove and all Cove facilities will be with the permission of the Harbor Master. It is the policy of Mauna Lani Cove that the moorings in the marina be used only for the purpose of accommodating vessels used for recreational boating activities involving transportation on water or for the landing of fish and not for commercial boat charters. Fish cleaning and/or the cleaning or dressing of any other marine organisms within the Cove shall be strictly prohibited.

APPENDIX R

GROUNDWATER IMPACT ASSESSMENT, MAUNA LANI MARINA

BELT COLLINS & ASSOCIATES
GROUNDWATER IMPACT ASSESSMENT
MAUNA LANI MARINA
MARCH 1990

INTRODUCTION

This investigation has been undertaken as part of hydrogeological studies relating to the proposed marina development at Lahuipuaa in the South Kohala District on the island of Hawaii. A detailed assessment of the impact of the marina on the local groundwater system and at existing/future irrigation wells has been completed.

The study, commissioned by Belt Collins & Associates, has utilised a computer based numerical model of the aquifer system which provides a basis for analysis on both a regional scale and a local marina scale. The contained report presents relevant data, model results and appropriate tables summarising expected piezometric head conditions at critical locations and water balance data.

NUMERICAL MODELLING OF THE AQUIFER

It is extremely difficult to assess the relative contribution of the various components in the hydrogeologic system using classical analytical methods which generally assume regional homogeneity in the form of 1 dimensional equations. With a computer based numerical model however, it is possible to more accurately simulate expected conditions and to explore the impact of land use changes and groundwater abstraction changes by introducing spatial and temporal variability.

A distributed parameter finite element type scheme has been adopted (AQUIFEM, Wilson et.al. 1979) for the purpose. Using this approach, the study region has been discretised into a number of triangular elements each capable of simulating vertical fluxes (rainfall infiltration, pumping etc), aquifer transmission properties, and the lowering of groundwater levels. These are assembled into a regional grid comprising 984 triangular elements described by 536 nodes at their respective vertices, illustrated in Figure 1. The finite element mesh is graded from coarse elements representing regional conditions to a finer mesh in the vicinity of the marina, to permit more accurate representation of the impact of the marina development.

The northwestern boundary of the modelled area has been located along the coastline and nodes have been assigned constant piezometric head (0.02 foot). Tidal water level variations within the aquifer near the coastline have been not been considered.

R - 1

To the northeast and southwest, boundary nodes are aligned with regional flow lines (streamlines) where groundwater flow may occur along (parallel to) the boundary but not across it. The inland boundary is located approximately 2.5 miles from the coast and at 400 feet above sea level. This boundary has been assigned a uniform flux (groundwater recharge or inflow) of 3 MGD/mile (Scenario I) or 6 MGD/mile (Scenario II). These inflow conditions have been applied to provide a likely range of expected piezometric heads and fluxes into the marina.

Local rainfall is of the order of 10 inches per year. Rainfall or irrigation recharge to the aquifer has not been considered, resulting in conservative estimates of the impact of additional abstraction and/or marina development.

An effective aquifer thickness is calculated by the model as a function of the piezometric head assuming a Ghyben-Herzberg type salt water/fresh water interface is present over all of the modelled region. This assumes a reasonably sharp interface between fresh and salt water which is a valid approximation for highly transmissive aquifers. The water table fluctuates in response to atmospheric pressure, with groundwater influx to maintain the hydraulic gradients measured in the area supplied from the inland extension of the aquifer system and/or runoff, recharge to the aquifer.

Aquifer properties have been calibrated for both upstream flux conditions to simulate prevailing field measured conditions, based upon a constant permeability across the entire aquifer. Current draft from the existing irrigation and water supply wells (as per Table 1) is included as a flux from the appropriate node in the model. Table 2 summarises the inflow and corresponding calibrated permeability. Predicted water levels for each permeability condition are presented in Figures 2 and 5, for Scenario I and Scenario II, respectively.

	Existing Draft (MGD)	Future Draft (MGD)
Mauna Lani Wells		
Pauko Shaft	1.1	1.1
Nursery Well	0.1	0.1
Future Irrigation Well	-	0.6
Future Irrigation Well	-	0.6
Waikoloa Wells		
Nursery Well	1.1	1.1
STP Well	0.35	0.35
Well No. 1	0.5	0.5
Well No. 2	0.85	0.85
Well No. 3 (future)	-	0.85
TOTAL	4.00	6.05

Table 1: Existing and Future Groundwater Abstraction

	Boundary Inflow (MGD/mile)	Permeability (feet/day)
Scenario I	3.0	9000
Scenario II	6.0	18000

Table 2: Boundary Inflow and Permeability

Given that the simulation results approximate the regional groundwater contours and the response to abstraction it may be assumed that the numerical model reliably simulates the water balance and response to groundwater fluxes.

GROUNDWATER IMPACT ASSESSMENT

Predicted water levels for existing the groundwater abstraction pattern (Figures 2 and 5) demonstrate the impact of coastal embayments, which focus groundwater outflow to the ocean. A gradual steepening of the water level gradient is observed from the inland margin to the coast, reflecting the effective thinning of the aquifer as the thickness of the freshwater lens decreases.

Minimal difference between predicted levels for high and low permeability distributions is noted (generally less than 0.25 foot). However, the local impact of groundwater abstraction is clearly more evident with lower permeabilty (particularly at the Waikoloa Wells).

A summary of groundwater levels for each scenario for existing conditions and future abstraction without and with the proposed marina is presented in Table 3. It is apparent from these predicted levels that for both scenarios the impact of the marina is significantly less than that attributed to future additional pumping.

	Mauna Lani Wells		Waikoloa Wells	
	Puako Shaft	Southern Future Well	Nursery Well	Future Well
Scenario I				
Existing Draft	1.36	1.61	0.95	1.57
Future Draft	1.25	1.42	0.86	1.38
With Marina	1.22	1.38	0.85	1.35
Scenario II				
Existing Draft	1.48	1.66	1.17	1.68
Future Draft	1.43	1.57	1.13	1.59
With Marina	1.41	1.53	1.12	1.57

Water levels in feet above sea level.

Table 3: Predicted Water Levels at Existing and Future Wells

MACKIE MARTIN & ASSOCIATES PTY LTD

Computed groundwater fluxes across the coast, presented in Table 4, indicate the magnitude of flux into the marina and the corresponding flux across an equivalent length of coastline without the marina. A more than twofold increase in groundwater outflow into the marina reflects the deviation of streamlines to the marina.

	Total Draft (MGD)	Coastal Flux at Marina (MGD)	Flux into Marina (MGD)
Scenario I			
Existing Draft	4.00	1.14	-
Future Draft	6.05	0.98	-
With Marina	6.05	0.04	2.53
Scenario II			
Existing Draft	4.00	2.44	-
Future Draft	6.05	2.29	-
With Marina	6.05	0.09	5.90

Table 4: Summary of Groundwater Fluxes

CONCLUDING REMARKS

The current study has been undertaken to assess the implications of the proposed marina development upon the regional water table and to quantify the water balance relating thereto.

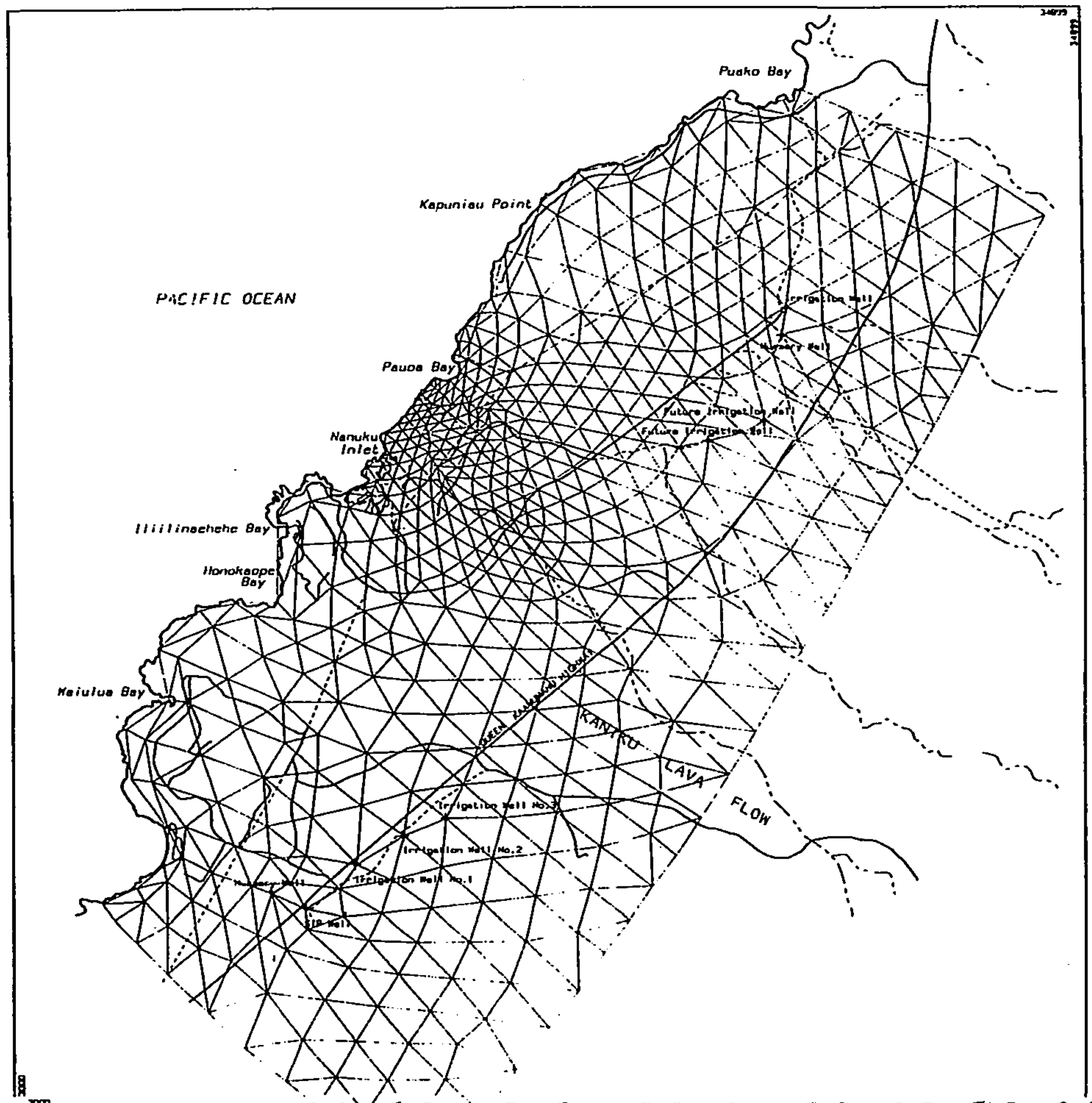
In determining the expected water table response, two likely groundwater flux and permeability relationships have been considered and the relative impact on groundwater systems assessed using a computer based numerical model. The following points are noted:

- Local rainfall is of the order of 10 inches per annum, which is conservatively assumed to provide no additional recharge across the study area.
- Similarly, return from irrigation water has not been included in water budget calculations.
- Regional impact of additional groundwater abstraction is predicted to be less than 0.1 foot away from the new wells.
- Regional impact of the marina is less than 0.05 foot at the irrigation wells.
- The marina acts as a local sink, focussing groundwater flow. Groundwater fluxes into the marina are expected to range between 2.5 and 5.9 MGD.

Mackie Martin & Associates Pty. Ltd.
March 1990

REFERENCES

Wilson, J.L., Townley, L.R. and Sa da Costa, A., 1979. Mathematical development and verification of a finite element aquifer flow model AQUIFEM-1, Technical Report No.248, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology.



MAUNA LANI MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

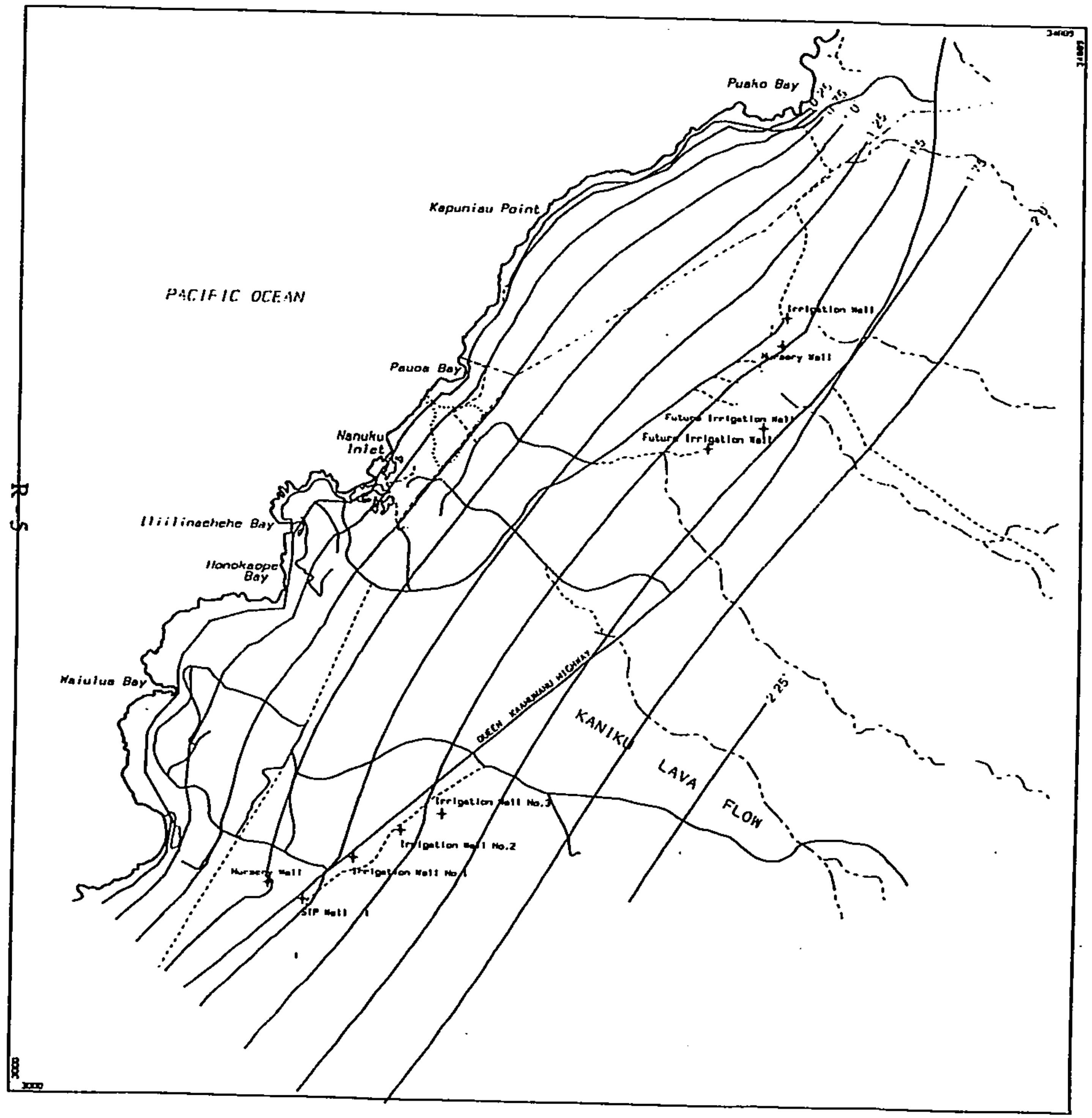
LEGEND:
- Coastline
- Fish Ponds
- Major Roads
- Minor Roads (tracks)
- Surface water channels (gulches)
- Proposed Marina

0 2000 4000 6000 8000
DRAWN SCALE 1:118147
(1 Inch to 3000 Feet)

FINITE ELEMENT GRID

FIGURE 1

Mackie Martin & Associates



MAUNA LANI MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Fish Ponds
- Major Roads
- Minor Roads (Tracks)
- Surface water channels (gulches)
- Proposed Marina
- Water table contour (feet)

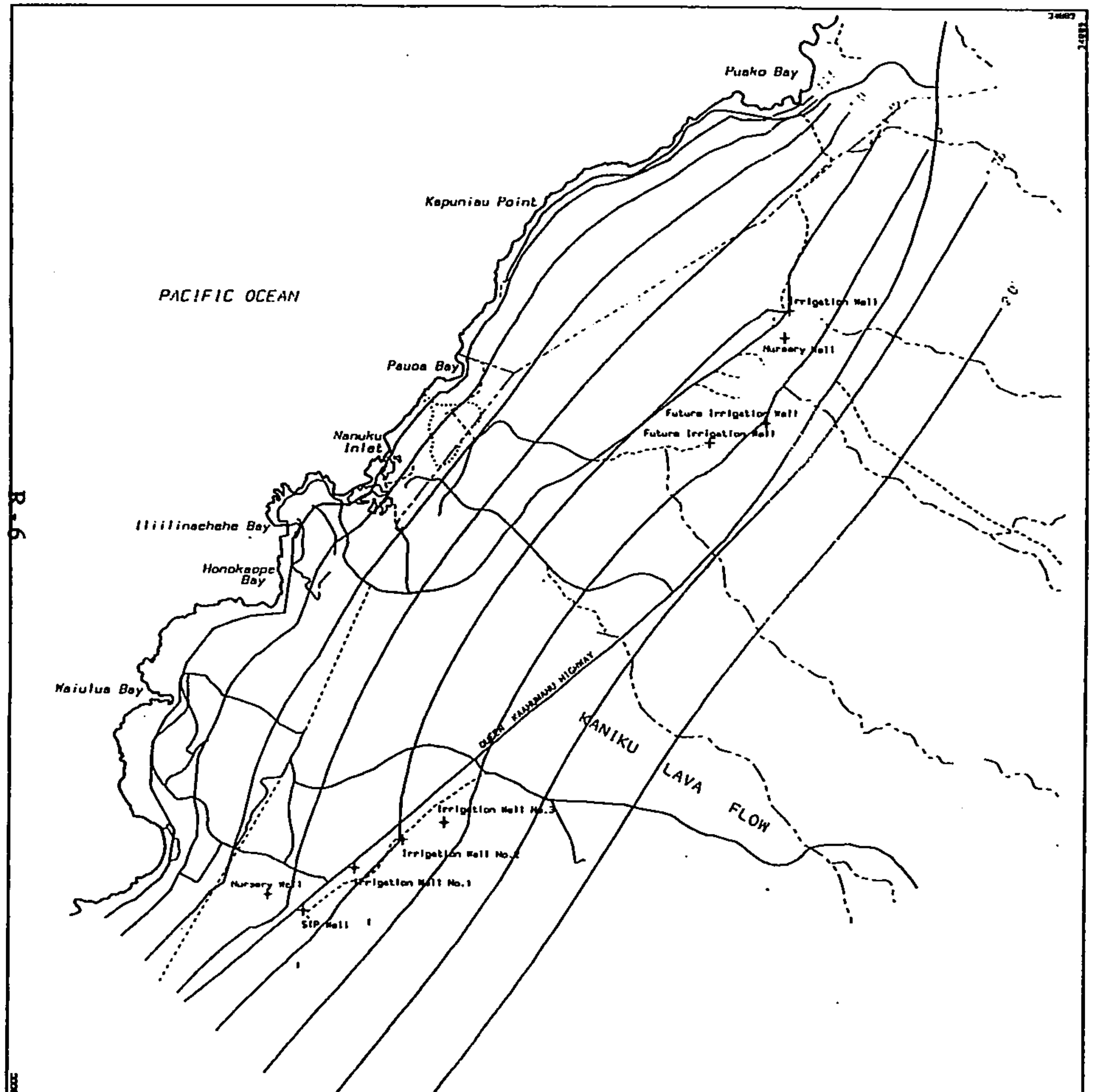
Note: Inflow along inland boundary is 3 MGD/mile
Aquifer permeability is 5000 ft/day
Effective aquifer thickness is 41 x head

0 2000 4000 6000 8000
DRAWN SCALE 1:118110
(1 inch to 3000 feet)

SCENARIO I
EXISTING CONDITIONS

FIGURE 2

Mackie Martin & Associates
GROUNDWATER ENGINEERING



MAUNA LANI MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Fish Ponds
- Major Roads
- Minor Roads (tracks)
- Surface water channels (gulches)
- Proposed Marina
- Water table contour (feet)

Note: Inflow along inland boundary is 3 MGD/mile
Aquifer permeability is 5000 ft/day
Effective aquifer thickness is 41 x head

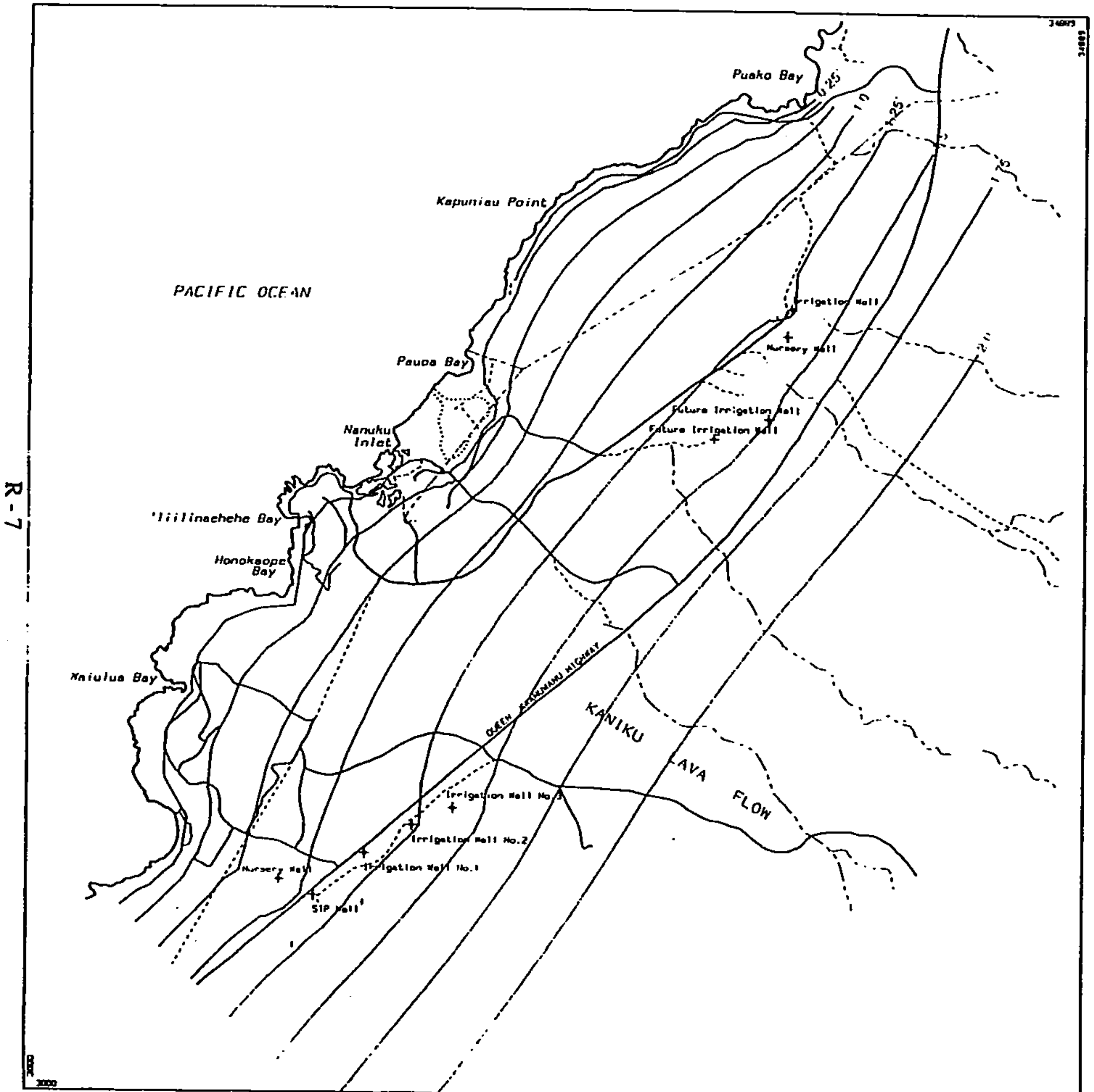
0 2000 4000 6000 8000

DRAWN SCALE 1:118110
(1 inch to 3000 feet)

SCENARIO I
FUTURE ABSTRACTION

FIGURE 3

Mackie Martin & Associates



MAUNA LANI MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Fish Ponds
- Major Roads
- Minor Roads (tracks)
- Surface water channels (gulches)
- Proposed Marina
- Water table contour (feet)

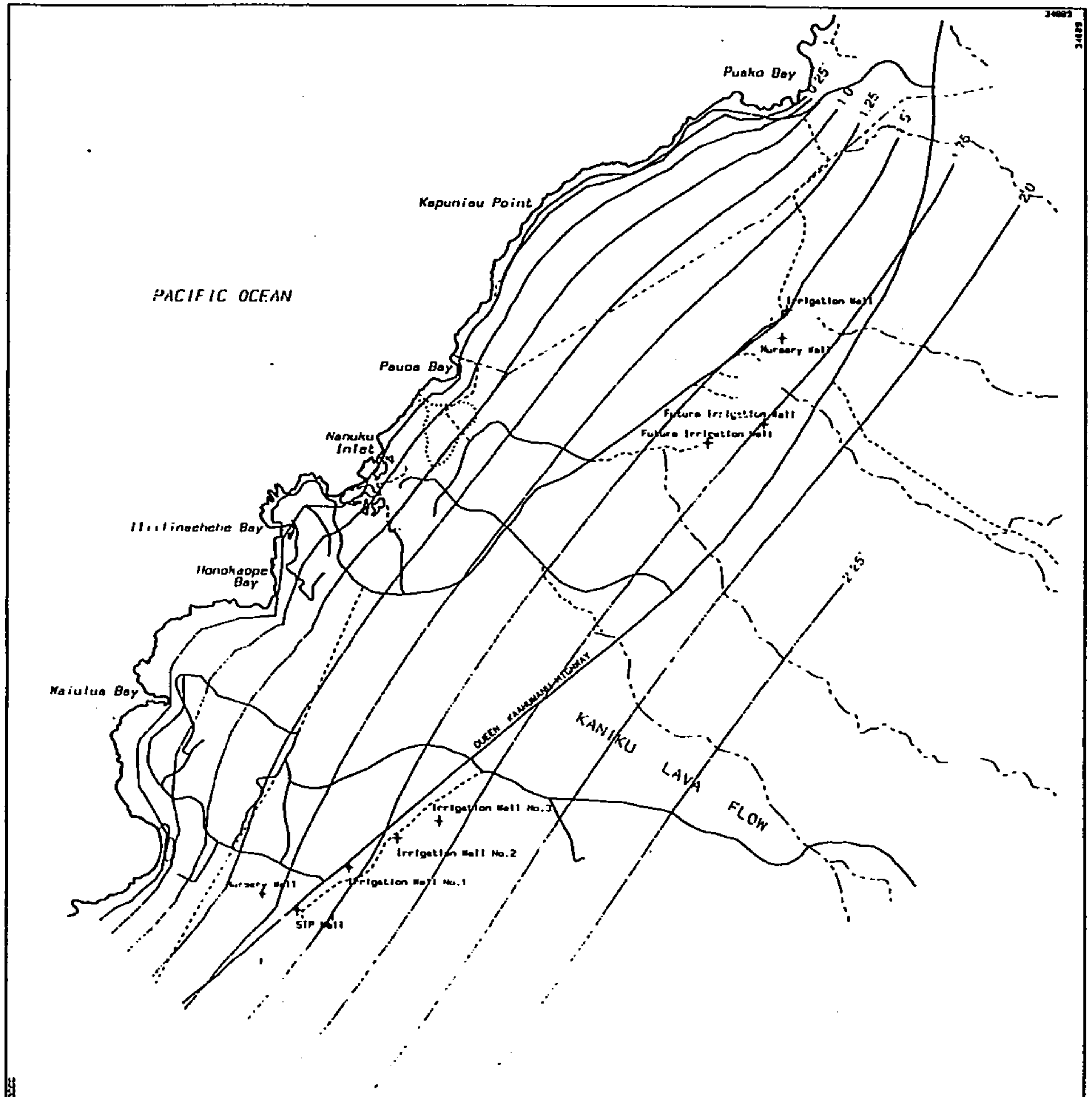
Note: Inflow along inland boundary is 3 MGD/mile
Aquifer permeability is 9000 ft/day
Effective aquifer thickness is 41 x head

0 2000 4000 6000 8000
DRAWN SCALE 1:118110
(1 inch to 3000 feet)

SCENARIO I
FUTURE ABSTRACTION
WITH PROPOSED MARINA

FIGURE 4

Mink Martin & Associates



MAUNA LANI MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:

- Coastline
- Fish Ponds
- Major Roads
- Minor Roads (tracks)
- Surface water channels (gulches)
- Proposed Marina
- Water table contour (feet)

Note: Inflow along inland boundary is 6 MGD/mile
Aquifer permeability is 18000 ft/day
Effective aquifer thickness is 41 x head

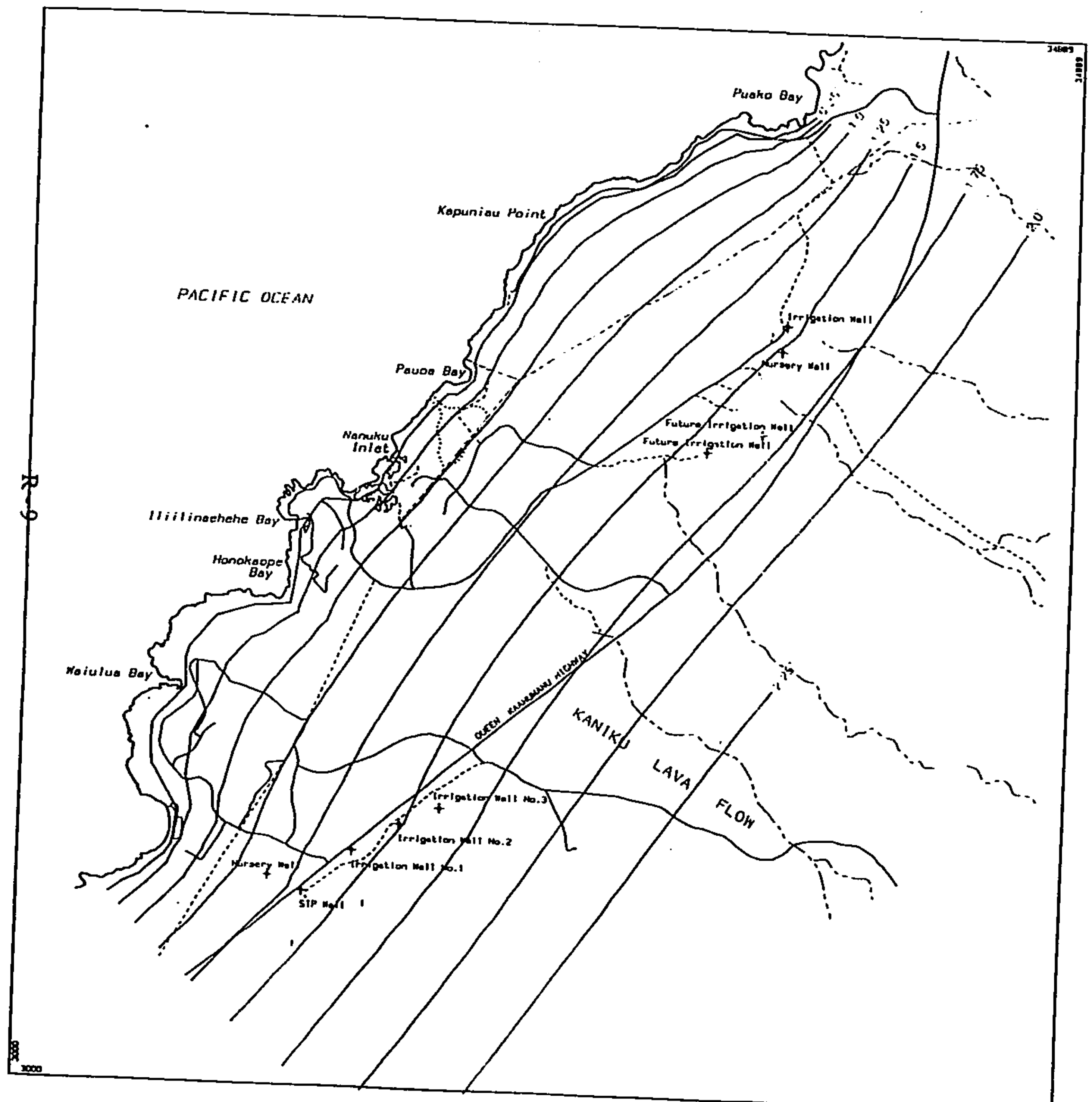
0 2000 4000 6000 8000

DRAWN SCALE 1:118110
(1 inch to 3000 feet)

SCENARIO II
EXISTING CONDITIONS

FIGURE 5

Mackie Martin & Associates



MAUNA LANI MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Fish Ponds
- Major Roads
- Minor Roads (tracks)
- Surface water channels (gulches)
- Proposed Marina
- Water table contour (feet)

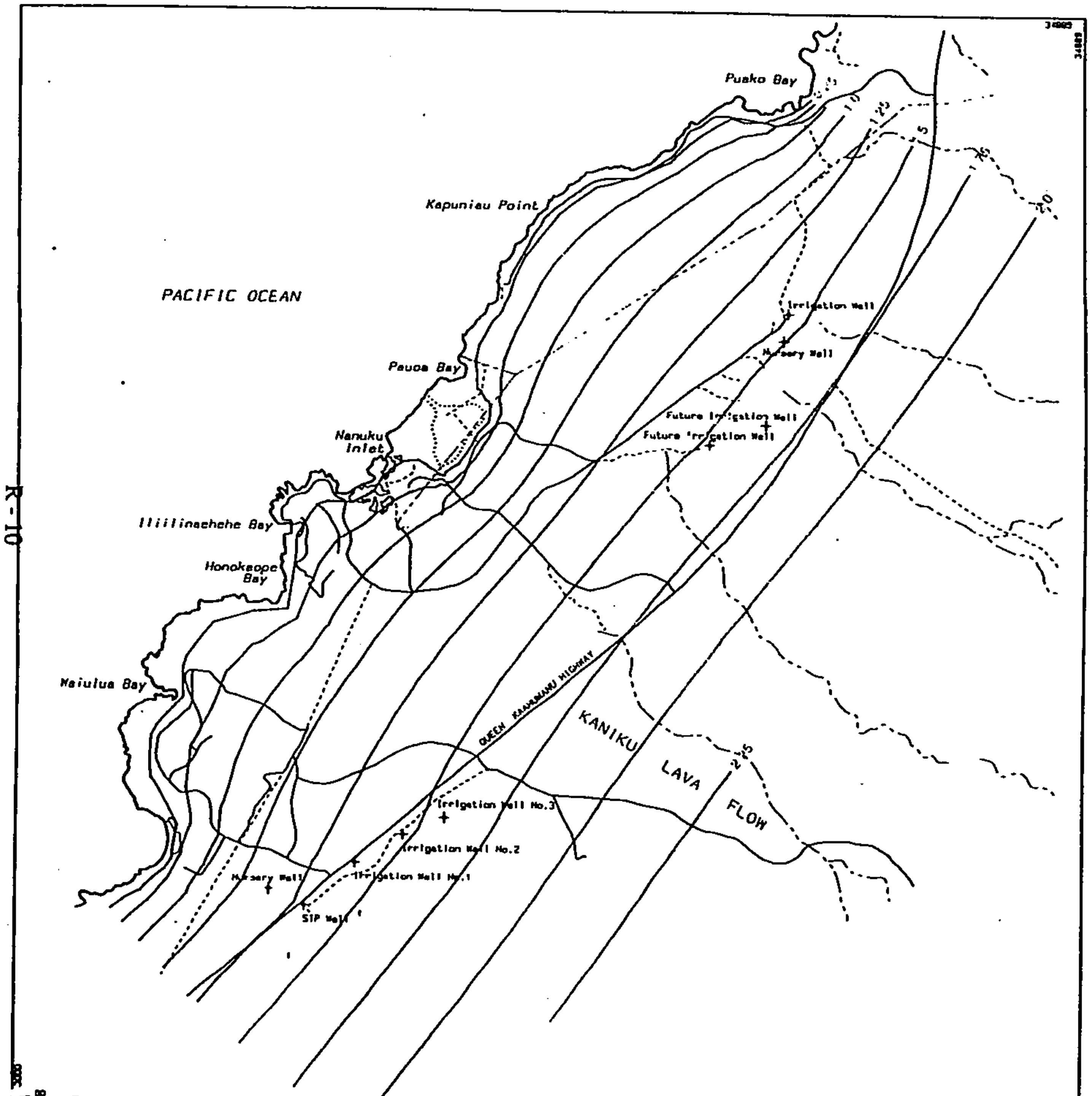
Note: Inflow along inland boundary is 6 MGD/mile
Aquifer permeability is 18000 ft/day
Effective aquifer thickness is 41 x head

0 2000 4000 6000 8000
DRAWN SCALE 1:118110
(1 inch to 3000 feet)

SCENARIO II
FUTURE ABSTRACTION

FIGURE 6

Mackie Martin & Associates



MAUNA LANI MARINA
GROUNDWATER IMPACT
ASSESSMENT
On Behalf of
BELT COLLINS & ASSOCIATES

LEGEND:
- Coastline
- Fish Ponds
- Major Roads
- Minor Roads (tracks)
- Surface water channels (gulches)
- Proposed Marina
- Water table contour (feet)

Note: Inflow along inland boundary is 6 MGD/mile
Aquifer permeability is 18000 ft/day
Effective aquifer thickness is 41 x head

0 2000 4000 6000 8000

DRAWN SCALE 1:118110
(1 inch to 3000 feet)

SCENARIO II
FUTURE ABSTRACTION
WITH PROPOSED MARINA

FIGURE 7

Waikie Martin & Associates

Groundwater Assessment Summary

It is estimated that from two to six million gallons of brackish groundwater would discharge daily into the proposed marina. The influence of this discharge on water quality and circulation in the marina is discussed in Chapter IV, Section 3.3. There will also be an effect on the brackish groundwater aquifer which exists around and inland of the marina. Groundwater levels (or heads) will be lowered slightly and, in close proximity to the marina, some increase in its salinity is expectable. Because this groundwater resource is used for golf course irrigation by both the Mauna Lani and Waikoloa Beach Resorts, an assessment of the marina's impact on it is appropriate.

A quantitative evaluation of the marina's effects was made using a computer-based numerical model. Construction of the model was a joint effort. Existing groundwater conditions, including the probable range of flow through the aquifer, head levels, draft rates by irrigation wells, boundary conditions, and permeability of the basalt lava, were initially set out by Belt Collins & Associates. Mackie Martin & Associates then developed the computer model using a distributed parameter finite element program known as AQUIFEM. A more detailed description of the model can be found in the report by Mackie Martin & Associates in this appendix. After the model was initially constructed, a number of runs were made to calibrate it. Key parameter values and assumptions for this work are discussed below.

Areal Extent. Figure 1, taken from the Mackie Martin & Associates report, illustrates the geographic extent of the computer-driven numerical model. It uses 536 nodes and 984 triangular elements to cover an area that spans approximately six miles of the coastline and extends two to two and one-half miles inland. The density of the nodes is greatest in and around the marina.

Lateral Boundaries of the Model. The two lateral boundaries of the model run directly toward the shoreline along assumed flowlines. The north end is a flowline which terminates at Puako Bay, about 2.6 miles from the proposed marina. The south end is a flowline to Anaehoomalu Bay, 3.3 miles southwest of the marina. Assuming these flowline boundaries establishes, in effect, that the marina's possible influence will not extend beyond it. The southwest boundary is a little further away from the marina than the northern one in order to include all the Waikoloa Beach Resort wells.

Inland and Shoreline Boundaries. The inland boundary is an arbitrary line which runs parallel to the general trend of the shoreline and is perpendicular to lines of flow from inland sources of groundwater recharge. The coastal boundary is modeled as a line of unimpeded discharge into coastal waters which generally approximates the configuration of the shoreline.

Natural Flow Through The Aquifer to Shoreline Discharge. Two rates of flux through the aquifer were modeled to encompass the probable range of actual values. These rates are three and six million gallons per day (MGD) per coastal mile, equivalent to a total flow through the model of 18 to 36 MGD. All of this flow is equally distributed along the model's inland boundary. The actually occurring flowrate can only be estimated. The most comprehensive estimate was made using the computer-assisted water budget approach described in "Groundwater Recharge and Coastal Discharge for the Northwest Coast of the Island of Hawaii: A Computerized Water Budget Approach", Water Resources Research Center Technical Report No. 110 by Brian Kanehiro and Frank Peterson in 1977. It placed the most probable flux value at 6.4 MGD per coastal mile. Based on observed occurrences in the aquifer, including heads, gradients, and salinity responses to pumping at wells, and on permeability coefficients which are necessary to reproduce these heads and gradients in the numerical model, the 6.4 MGD per mile rate is likely to be at the upper end of the range of the most probable flux.

Recharge Within the Area of the Model Itself. Average rainfall within the modeled area is 10 inches per year. Although much of this area is bare, porous lava through which some recharge by rainfall does occur, this amount has not been included. Similarly, recharge by irrigation return from golf courses, hotels, condominiums, and plant nurseries has not been included. The total amount of local recharge may be in the range of two to four MGD. Since it has not been included, the analysis is conservative.

Draft Rates From Wells. Two scenarios of pumping from wells have been analyzed. One is the present draft rate by existing wells; the other is a near future draft rate reflecting completion of Mauna Lani's second golf course and outfitting a new irrigation well at Waikoloa Beach Resort. Individual wells and their respective draft rates, which total four and six MGD for these two development stages, are tabulated below. It is likely that third and fourth golf courses will ultimately be constructed at both of the resorts, bringing the eventual total number of courses within the modeled area to eight. This could require up to four MGD more irrigation supply than the 6.05 MGD near future draft rate. However, sewage treatment plant effluent is used to augment the supply from brackish wells at both resorts. Its increasing amounts resulting from new hotels and condominiums should meet the future increase in golf course irrigation.

Present and Future Use of Brackish Ground Water

	Present Draft Rate (MGD)	Near-Future Draft Rate (MGD)
Brackish Wells at Mauna Lani Resort		
Puako Shaft	1.10	1.10
Nursery Well	0.10	0.10
New Irrigation Wells (2)	- -	1.20
Subtotal for Mauna Lani	1.20	2.40
Brackish Wells at Waikoloa Beach Resort		
Nursery Well	1.10	1.10
STP (51-Foot) Well	0.35	0.35
Well No. 1	0.50	0.50
Well No. 2	0.85	0.85
Well No. 3	- -	0.85
Subtotal for Waikoloa	2.80	3.65
Total Groundwater Draft Rate	4.00	6.05

Flow Section of the Basal Lens. The numerical model is based on the assumption that groundwater occurs as a basal lens in hydraulic continuity with saline water at depth. The Ghyben-Herzberg relationship has been employed such that the thickness of the lens is 41 times the height of the water table above sea level. Sea level is taken as a constant 0.0-foot elevation with no tidal effects. Discharge along the shoreline has been assumed to occur at a head of 0.02 feet.

Permeability Coefficients. Using all of the foregoing assumptions and parameters, values of permeability were tried in the computer model to replicate existing heads in the basal aquifer. For the three and six MGD per coastal mile groundwater flowrates, permeability coefficients of 9,000 and 18,000 feet per day, respectively, reasonably reproduce existing heads and gradients in the aquifer. From the perspective of these heads and gradients, model results are quite similar for the two flowrates. The only significant differences occur in the near vicinity of the irrigation wells. The response at wells is greater for lower flowrate and permeability coefficient values.

After satisfactorily reproducing known conditions within the aquifer, the model was used to examine the effect that excavating the marina could have. All of these results are depicted graphically on diagrams in this appendix. They are summarized here as changes in head in the aquifer at points of interest and by alterations of shoreline discharge into and adjacent to the marina. Head declines as a result of the marina are 0.01 to 0.04 feet at the locations of existing and future wells (refer to the tabulation below). This is a relatively insignificant impact. It is also less than the 0.05- to 0.19-foot head drops which are predicted to occur as a result of near-future pumping increases at wells.

Changes in Head Predicted for Future Irrigation and the Marina Excavation

Groundwater Flowrate and Development Scenario	Mauna Lani Resort Heads: At the Puako Shaft (feet)	Mauna Lani Resort Heads: At the New Well Next to the STP (feet)	Waikoloa Beach Resort Heads in Feet: At the Nursery Well (feet)	Waikoloa Beach Resort Heads in Feet: At Well No. 3 (feet)
Flux of 3 MGD per Coastal Mile				
• Existing Draft Rates	1.36	1.61	0.95	1.57
• Future Draft without Marina	1.25	1.42	0.86	1.38
• Future Draft with Marina	1.22	1.38	0.85	1.35
Flux of 6 MGD per Coastal Mile				
• Existing Draft Rates	1.48	1.66	1.17	1.68
• Future Draft without Marina	1.43	1.57	1.13	1.59
• Future Draft with Marina	1.41	1.53	1.12	1.57

The marina is likely to be an effective focal point for groundwater discharge. At the future draft rate from irrigation wells, discharge along the shoreline encompassed by the maximum width of the marina is in the range of 1.0 to 2.3 MGD. After the marina is excavated, however, approximately 2.6 times this rate or from 2.5 to 5.9 MGD would discharge into the marina itself and then flow out its entrance channel into coastal waters (refer to the tabulation below). This phenomenon would occur because groundwater flow from beyond the width of the marina would be diverted from its present path toward the shoreline into the marina itself. There would not be a change in the total amount of shoreline discharge, simply a redirecting of where it occurs. The focusing of discharge into the marina means that there would be correspondingly less discharge along the shoreline to either side.

Anticipated Changes in Localized Shoreline Discharge of Groundwater as a Result of the Marina

Groundwater Flowrate and Development Scenario	Discharge Along the Shoreline Encompassed by the Marina (MGD)	Discharge into the Marina Itself (MGD)
Flux of 3 MGD per Coastal Mile		
• Future Draft Rate without the Marina	0.98	—
• Future Draft Rate with the Marina	0.04	2.53
Flux of 6 MGD per Coastal Mile		
• Future Draft Rate without the Marina	2.29	—
• Future Draft Rate with the Marina	0.09	5.90

APPENDIX S

WATER QUALITY AND EXCHANGE CHARACTERISTICS OF MAUNA LANI COVE

WATER QUALITY AND
EXCHANGE CHARACTERISTICS
OF
MAUNA LANI COVE

PREPARED FOR:

Peratrovich, Nottingham and Drage, Inc.
100 Eastlake Avenue East, Suite 310
Seattle, Washington 98109

PREPARED BY:

OCEES International, Inc.
3786 Pukalani Place
Honolulu, Hawaii 96816

December 1989

CONTENTS

PREFACE

This study is being conducted as a result of discussions among Jeff Gilman of Peratrovich, Nottingham and Drage, Inc. (PND), Marcia Stevens of Mauna Lani Resort, and Hans Krock of OCEES, International, Inc..

The work here builds on the excellent work done by Hydro Research Science, Inc. as reported in Hydraulic Model Study of the Mauna Lani Cove, September 1989, and uses data gathered by PND and Sea Engineering, Inc. regarding groundwater flow and coastal currents.

The objective of this study is to incorporate stratified flow and phytoplankton growth rate as factors affecting the water quality in the proposed Mauna Lani Cove. Since these factors cannot be simulated in a physical model and depend on local conditions it is necessary to use a semi-empirical approach involving a "box" model and observations of phytoplankton growth rates elsewhere in Hawaii.

BACKGROUND AND SETTING

The proposed Mauna Lani Cove is located on the leeward side of the Big Island of Hawaii. This area is characterized by the absence of surface streams and the general absence of trade winds. Drainage of up-country rainfall is via infiltration and groundwater flow to the coastline. Detail knowledge of lava tubes or even areas of high or low permeability is lacking. However, it is possible to estimate average groundwater flows. The wind regime is influenced by day-night temperature changes which cause on-shore breezes during the afternoon and off-shore movement at night.

The tide is typical for mid-oceanic island conditions having both semidiurnal and diurnal components. As an overall annual average there is a 2.48 feet tidal variation per 24 hours.

The fresh water flow will enter along the landward edge of the marina and result in density stratifications similar to that observed in other harbors along this coast. The groundwater inflow will result in a gradient in the surface layer toward the marina mouth and will cause inmixing of bottom layer water. This in turn will result in landward flow of the bottom layer. In general, the wind will add mixing energy. Some wind induced net transport will occur in those channels aligned with the wind direction. In this regard some minor realignment of the entrance channel might be considered to enhance wind induced transport. However, it is recognized that navigational considerations also must be considered.

Ocean water in the vicinity of Hawaii is typically low in nutrients and hence in phytoplankton density. Along the Kona Coast the near-shore waters are higher in nitrogen due to groundwater discharge. However, since phosphorus does not readily move through the ground and since there is very little surface water discharge, these near-shore waters are typically low in phosphorus. This means that phosphorus becomes the limiting nutrient and control of phosphorus constitutes control of water quality in terms of plankton density and associated turbidity.

PROBLEM STATEMENT

The primary problem that is being addressed in this study is the maintenance of acceptable water quality in the proposed Mauna Lani Cove and Marina. Since no point source discharges are planned, acceptable water quality is related to aesthetic considerations rather than health questions.

The aesthetic question is primarily one of water clarity (as measured by turbidity). In the case of Mauna Lani Cove the main factor influencing water clarity is plankton density. Plankton density will increase exponentially when the limiting nutrient is added and a long enough residence time is provided. This means that good water quality can be maintained by restricting the addition of the limiting nutrient (phosphorus) and/or by reducing the residence time (i.e. exposure time to the higher nutrient concentration).

The problem is to quantitatively compare alternative Mauna Lani Cove configurations, with and without pumping new water from different sources and recommend an effective way to maintain acceptable water quality.

BOX MODEL

A relatively simple but effective way to analyze the exchange characteristics of an embayment or estuary is to use a box model. The primary analytical technique used in a box model is the mass balance. This simply means that in any control volume (i.e. box) the inflow is equal to the outflow plus or minus any storage or withdrawal from storage, plus or minus sources or sinks.

The selection of the box boundaries is primarily dependent on hydraulic control sections which constrain flow and thereby allow circulation to develop within each box. Hydraulic control sections might be shallow areas, narrow areas or sharp turns.

Transport of water through the various boxes can be driven by several factors such as the tide, fresh water flow, and wind induced forces. Each of these factors is added to the box model and the resulting net rates of water exchange among the boxes are calculated.

For stratified conditions the box model has separate boxes for the upper layer and the lower layer. Selecting the thickness of each layer can be done by direct measurement for existing water bodies or by comparison to similar areas for proposed projects such as the Mauna Lani Marina.

In most cases the net flow direction among the boxes is obvious from the location of the source and the geometry of the water body. In those cases where two or more outlets exist the flow is proportioned to the ratio of cross-sectional areas.

Once all of the flows among the boxes have been calculated the average residence time within each individual box is determined as well as the cumulative residence time of the water in each box with respect to the ocean. The key relationship here is the volume divided by the flowrate in. The cumulative residence time simply takes into account the ages of each incoming stream and

adds them in proportion to their volumetric flow rate.

With cumulative residence time identified an estimate can be made of the effect of such time dependent reactions as the growth of phytoplankton. At this point some simplifying assumptions are made to allow easy calculations. These assumptions are that the water within each box is completely mixed and that the net phytoplankton growth rate is similar to that measured elsewhere under similar conditions. The accuracy of these assumptions depend on the choices made for the box boundaries and the judgement of the researcher regarding net growth rates under various conditions.

Of these two assumptions the one dealing with the growth rate is the more important. In the case of the Mauna Lani box model considered here the growth rates were based on measurements made in Hawaii Kai Marina and in Kanehoe Bay with and without wastewater addition.

With the cumulative residence time known and a net growth rate selected the expected phytoplankton concentration is known. The starting concentration may be different for each water source adding to the system. For Mauna Lani the major source is the adjacent ocean with a chlorophyll-a concentration of 0.15 mg/m^3.

Excessive phytoplankton concentration results in unaesthetic turbid conditions and may lead to oxygen depletion at night.

S - 5

TIDAL EXCHANGE

Applying the box model technique to the proposed Mauna Lani Cove starts by defining the geometry of the water area. A general outline of the proposed cove is shown in Figure 1. The water area is then divided into several sectors (i.e. boxes) by locating hydraulic control sections. These sectors are shown in Figure 2 along with their surface areas, volumes and average depths.

Also shown is the transition zone between the mouth of the proposed cove and the ocean. This transition zone can reach the mouth of the cove during flood tide.

The first condition that is evaluated using the box model is that of tidal influence alone with no fresh water input and hence no significant stratification. The individual box characteristics, the flow between boxes and the residence times are presented in Table 1. The longest residence time with respect to the ocean, about 19 days, is found in the marina proper. This result is in line with the results of the physical model which also considered the tide as the principal exchange mechanism and did not consider any stratification. The residence times and flows are also shown in Figure 3 which is a schematic of the Marina Cove in the form of boxes.

If the same tide-only condition is applied to the two layer box model the results are the same. The conditions and results of these calculations are given in Tables 2A and 2B and in Figure 4.

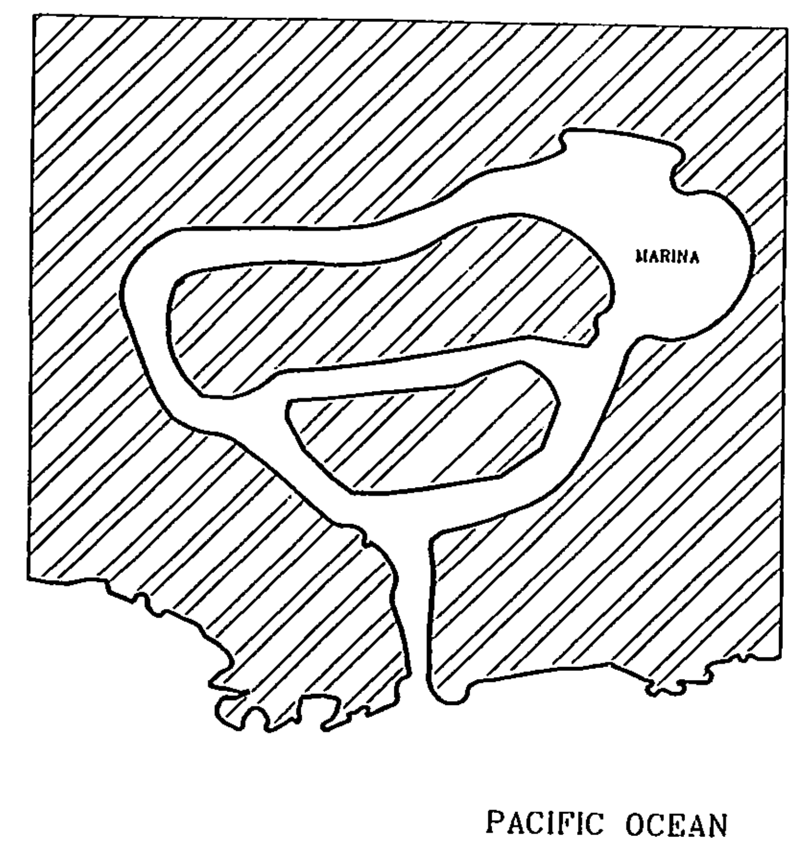


Figure 1.

MAUNA LANI COVE WATERQUALITY STUDY CONFIGURATION OF MARINA DECEMBER 5, 1989 MZ FILE: 16D020	OCEES International, Inc. OCEAN ENGINEERING & ENERGY SYSTEMS 3706 PUKALANI ST. HONOLULU, HAWAII 96816 TEL. (808) 734-7414

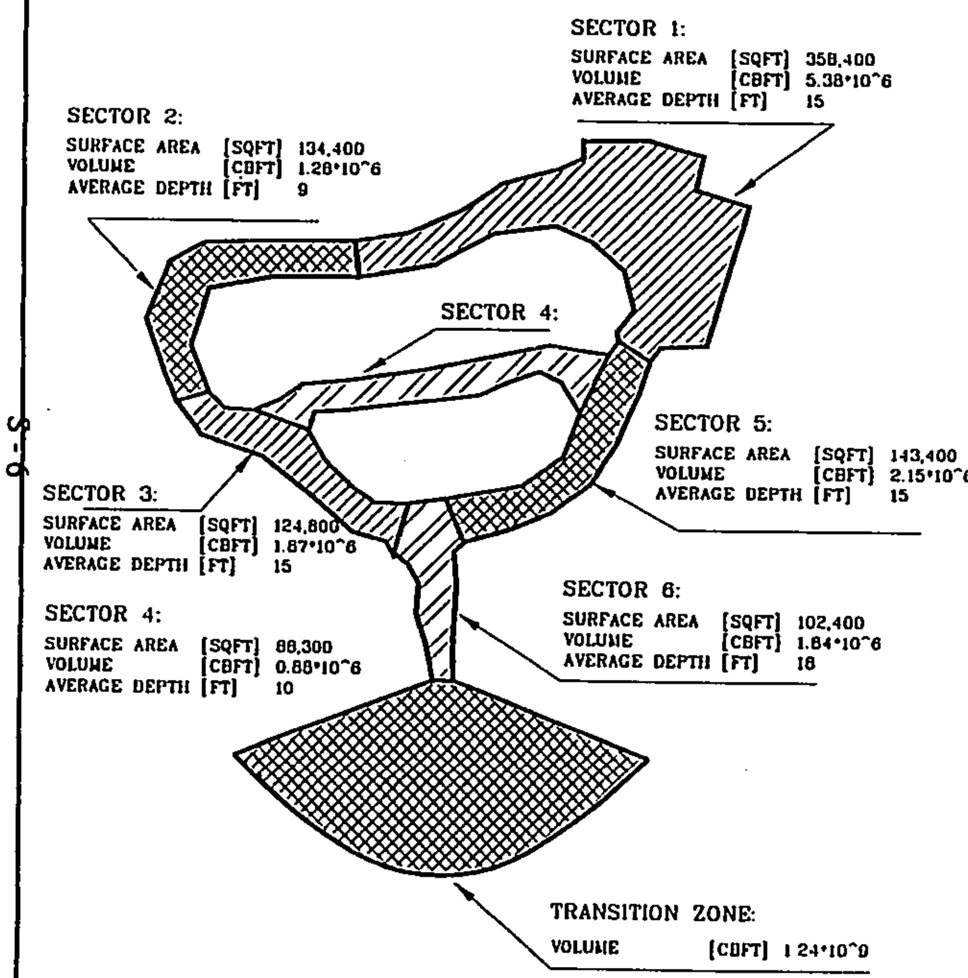


Figure 2.

MAUNA LANI COVE WATER QUALITY STUDY DEFINITION OF MODEL SECTORS DECEMBER 5, 1989 FILE: 16D030	OCEES International, Inc. OCEAN ENGINEERING & ENERGY SYSTEMS 3700 PUKALANI PL. HONOLULU, HAWAII 96816 TEL (808) 734-7414

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16U010

Calculation of residence times of BOXMODEL 1 - UNSTRATIFIED Watercolumns
Only tidal influences are considered

INPUT:

AREAS:	[SQFT]	AVERAGE DEPTH	[ft]	VOLUMES:	[CBFT]
A1 =	358400.00	D1 =	15.00	V1 =	5.376E+06
A2 =	134400.00	D2 =	9.50	V2 =	1.277E+06
A3 =	124800.00	D3 =	15.00	V3 =	1.872E+06
A4 =	88320.00	D4 =	10.00	V4 =	8.832E+05
A5 =	143360.00	D5 =	15.00	V5 =	2.150E+06
A6 =	102400.00	D6 =	18.00	V6 =	1.843E+06
				VT =	1.240E+09

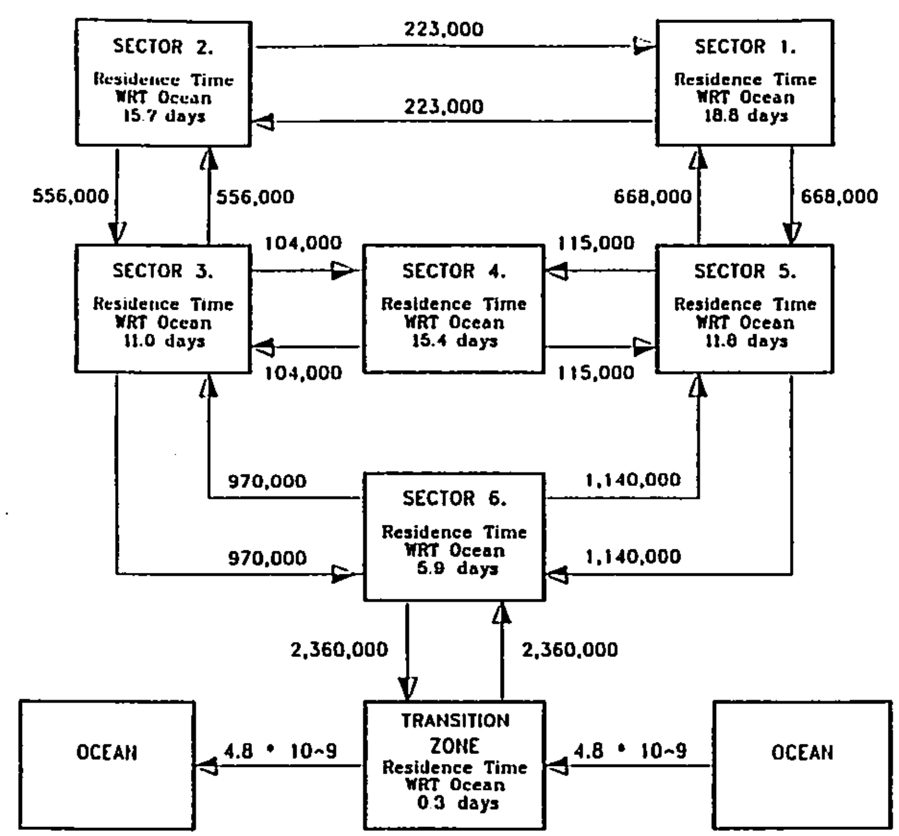
TIDAL PRISM: 2.48 [ft/day]

CALCULATION OF FLOWS:

F15 =	6.68E+05	[cbft/day]	F51 =	6.68E+05	[cbft/day]
F12 =	2.23E+05	[cbft/day]	F21 =	2.23E+05	[cbft/day]
F23 =	5.56E+05	[cbft/day]	F32 =	5.56E+05	[cbft/day]
F45 =	1.15E+05	[cbft/day]	F54 =	1.15E+05	[cbft/day]
F43 =	1.04E+05	[cbft/day]	F34 =	1.04E+05	[cbft/day]
F36 =	9.70E+05	[cbft/day]	F63 =	9.70E+05	[cbft/day]
F56 =	1.14E+06	[cbft/day]	F65 =	1.14E+06	[cbft/day]
F67 =	2.36E+06	[cbft/day]	F76 =	2.36E+06	[cbft/day]
TI =	4.80E+09	[cbft/day]	TO =	4.80E+09	[cbft/day]

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
R1 =	6.0	[days]	R10 =	18.8	[days]
R2 =	4.7	[days]	R20 =	15.7	[days]
R3 =	5.1	[days]	R30 =	11.0	[days]
R4 =	4.0	[days]	R40 =	15.4	[days]
R5 =	5.8	[days]	R50 =	11.8	[days]
R6 =	5.7	[days]	R60 =	5.9	[days]
RT =	0.3	[days]	RT0 =	0.3	[days]

Table 1.



NOTE:

Flowrates are given in [cbft/day]

Figure 3.

OCEES International, Inc.

MAUNA LANI COVE WATER QUALITY STUDY FLOW IN UNSTRATIFIED MODEL - TIDE ONLY DECEMBER 5, 1989 FILE: 16D010	OCEAN ENGINEERING & ENERGY SYSTEMS 3780 PUKALANI PL., HONOLULU, HAWAII 96816 TEL.: (808) 734-7414

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16U020 PAGE 1

Calculation of characteristics of BOXMODEL 2 - STRATIFIED Watercolumns

CALCULATION OF CROSS SECTIONAL AREAS:

STRATIFICATION 5.00 [ft]

CROSS SECTIONS:	DEPTH [ft]	WIDTH [ft]	TOTAL AREA [sqft]	AREA TOP [sqft]	AREA BOTTOM [sqft]	AREA TOP [%]	AREA BOTTOM [%]
S12	6.00	100.00	600.00	500.00	100.00	0.83	0.17
S15	15.00	120.00	1800.00	600.00	1200.00	0.33	0.67
S23	12.00	90.00	1080.00	450.00	630.00	0.42	0.58
S34	10.00	90.00	900.00	450.00	450.00	0.50	0.50
S45	10.00	100.00	1000.00	500.00	500.00	0.50	0.50
S36	15.00	120.00	1800.00	600.00	1200.00	0.33	0.67
S56	15.00	120.00	1800.00	600.00	1200.00	0.33	0.67
S57	18.00	120.00	2160.00	600.00	1560.00	0.28	0.72

CALCULATION OF SECTOR VOLUMINA:

STRATIFICATION 5.00 [ft]

SECTOR:	AVERAGE DEPTH [ft]	SURFACE AREA [sqft]	TOTAL VOLUME [cbft]	VOLUME TOP [cbft]	VOLUME BOTTOM [cbft]
1.00	15.00	3.23E+05	4.85E+06	1.62E+06	3.23E+06
2.00	9.50	1.73E+05	1.64E+06	8.64E+05	7.78E+05
3.00	15.00	1.25E+05	1.87E+06	6.24E+05	1.25E+06
4.00	10.00	8.83E+04	8.83E+05	4.42E+05	4.42E+05
5.00	15.00	1.43E+05	2.15E+06	7.17E+05	1.43E+06
6.00	18.00	1.02E+05	1.84E+06	5.12E+05	1.33E+06

Table 2A.

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16U020 PAGE 2

Calculation of flow rates of BOXMODEL 2 - STRATIFIED Watercolumns
Only tidal influences are considered

CALCULATION OF SECTORIAL INFLOW:

STRATIFIED SECTOR INFLOW:		FLOW (cbft/day)	FED FROM UNSTRATIFIED SECTOR INFLOW:	FLOW (cbft/day)
F112T		185442	F12	222530.18
F182B		37088	F12	222530.18
	SUM	2.23E+05		
F115T		222530	F15	667590.55
F185B		445060	F15	667590.55
	SUM	6.68E+05		
F213T		231802	F23	556325.46
F283B		324523	F23	556325.46
	SUM	5.56E+05		
F413T		51952	F43	103903.19
F483B		51952	F43	103903.19
	SUM	1.04E+05		
F415T		57724	F45	115447.99
F485B		57724	F45	115447.99
	SUM	1.15E+05		
F316T		323394	F36	970181.41
F386B		646788	F36	970181.41
	SUM	9.70E+05		
F516T		379696	F56	1139086.84
F586B		759391	F56	1139086.84
	SUM	1.14E+06		
F617		656389	F67	2363000.00
F687		1706611	F67	2363000.00
	SUM	2.36E+06		

Table 2B.

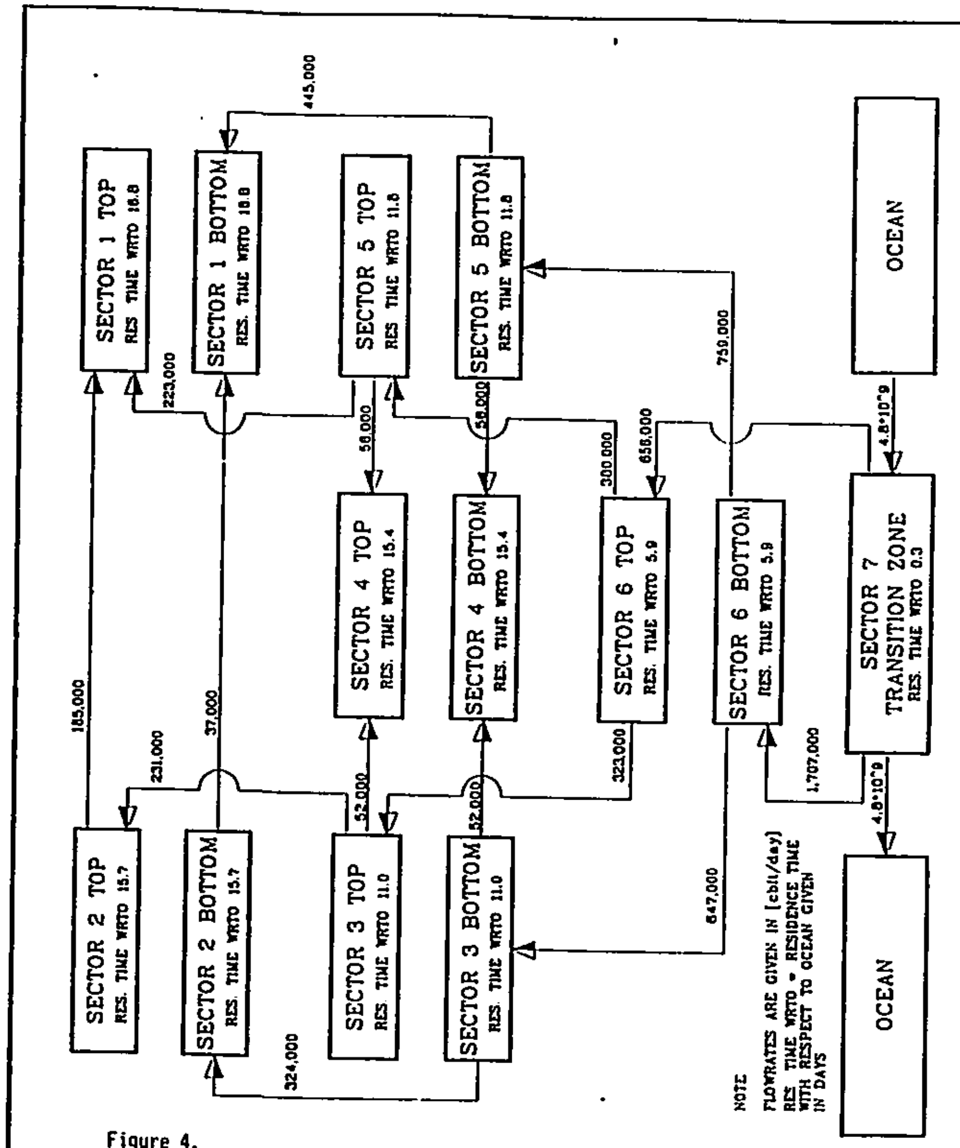


Figure 4.

MAUNA LANI COVE WATER QUALITY STUDY
FLOW IN STRATIFIED MODEL - TIDE ONLY
DECEMBER 7, 1989
FILE: 16D050

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3706 PUKALANI PL. HONOLULU, HAWAII 96816
TEL. (808) 734-7414

(the channel between the two islands). The residence time in sector 1 has in fact slighly decreased (by about 4%). However, the residence time in sector 4 has increased from 15.4 days for tide only conditions to 23.8 days (about 55%) for tide plus fresh water inflow. The residence time in the bottom layer has decreased for all sectors.

S-9

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16W030

Calculation of flow rates of BOXMODEL 2 - STRATIFIED Watercolumns
Only FRESHWATER INTRUSION is considered

INPUT:

SALINITY OF FRESHWATER INTRUSION:

SECTOR 1	0.00	[ppm]
SECTOR 2	0.00	[ppm]

SALINITY OF TOPLAYERS:		SALINITY OF BOTTOM LAYERS:	
SECTOR	SALINITY	SECTOR	SALINITY
1	30.00 [ppm]	1	35.00 [ppm]
2	30.00 [ppm]	2	35.00 [ppm]
3	31.70 [ppm]	3	35.00 [ppm]
4	31.70 [ppm]	4	35.00 [ppm]
5	31.70 [ppm]	5	35.00 [ppm]
6	33.40 [ppm]	6	35.00 [ppm]

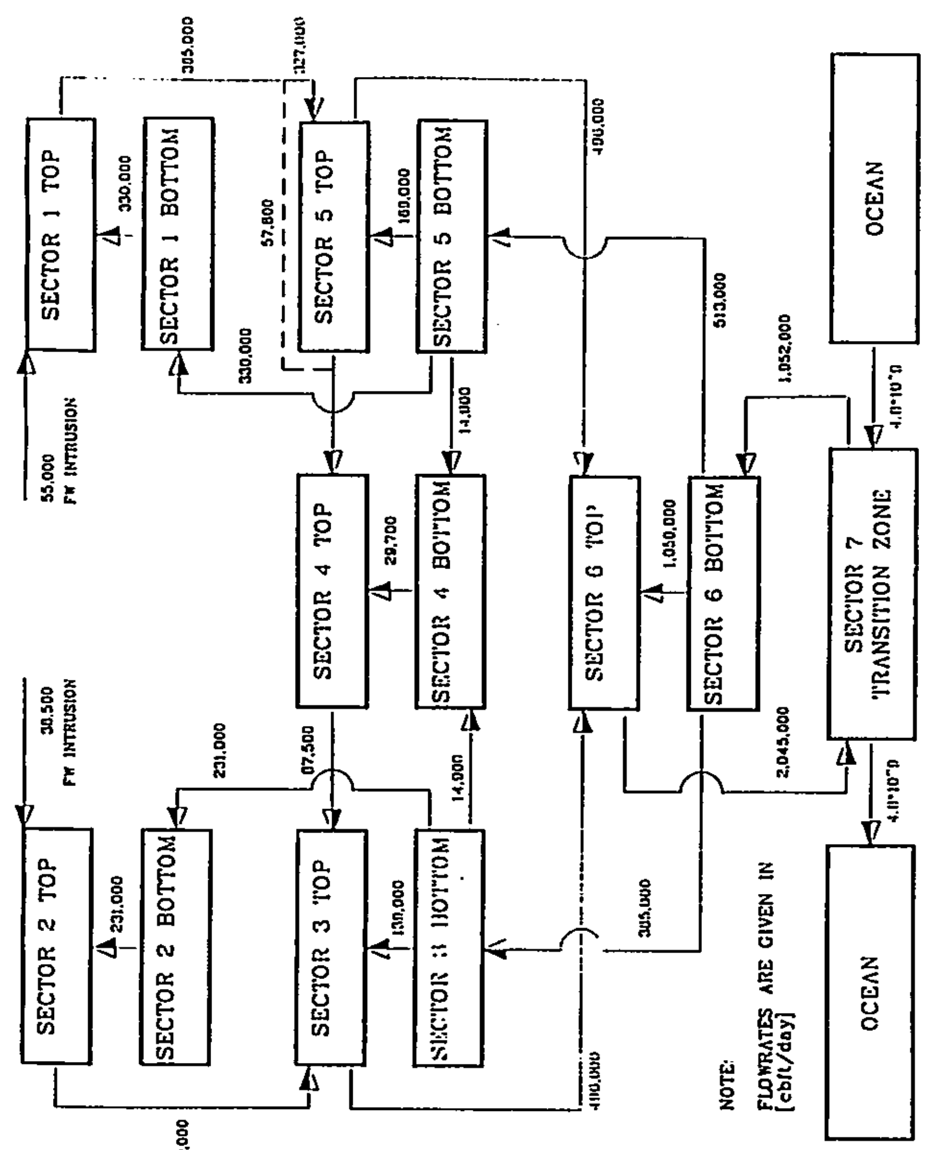
SALINITY OF TRANSITION ZONE 35.00 [ppm]
SALINITY OF OCEAN 35.00 [ppm]

FRESH WATER INTRUSION:
SCETOR 1 5.50E+04 [cbft/day]
SCETOR 2 3.85E+04 [cbft/day]

CALCULATION OF FLOWS:

F12T2B	2.31E+05	[cbft/day]	
OUTFL.TOP2	2.70E+05	[cbft/day]	OUTFLOW FROM TOP OF SECTOR 2
F12B3B	2.31E+05	[cbft/day]	
F11T1B	3.30E+05	[cbft/day]	
OUTFL.TOP1	3.85E+05	[cbft/day]	OUTFLOW FROM TOP OF SECTOR 1
F11B5B	3.30E+05	[cbft/day]	
F14T5T	5.78E+04	[cbft/day]	
F15T1T	3.27E+05	[cbft/day]	NOTE:
F13T2T	2.70E+05	[cbft/day]	Flowdefinition:
F14T4B	2.97E+04	[cbft/day]	Example:
F13T4T	8.75E+04	[cbft/day]	F13T3B means flow due to Freshwater Injection
F13T3B	1.39E+05	[cbft/day]	from sector 3 Top to sector 3 Bottom
F16T3T	4.96E+05	[cbft/day]	
F14B3B	1.49E+04	[cbft/day]	
F14B5B	1.49E+04	[cbft/day]	
F15T5B	1.69E+05	[cbft/day]	
F16T5T	4.96E+05	[cbft/day]	
F15B6B	5.13E+05	[cbft/day]	
F13B6B	3.85E+05	[cbft/day]	
F16T6B	1.05E+06	[cbft/day]	
F16BT	1.95E+06	[cbft/day]	
F1T6T	2.05E+06	[cbft/day]	
TRANSITION IN	4.80E+09	[cbft/day]	
TRANSITION OUT	4.80E+09	[cbft/day]	

TABLE 3.



S-10

Figure 5.

OCEES International, Inc.

MAUNA LANI COVE WATER QUALITY STUDY
FLOW IN STRATIFIED MODEL - FRESHWATER INTRUSION ONLY
DECEMBER 8, 1989
FILE: 16D060

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL (808) 734-7414

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16U050

Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Only tidal influences are considered
Tide is flowing only in bottom layers

STRATIFICATION 5.00 [ft]

INPUT:

AREAS:	[SQFT]	AVERAGE DEPTH	[ft]	VOLUMES:	[CBFT]
A1 =	358400.00	D1 =	10.00	V1 =	3.58E+06
A2 =	134400.00	D2 =	4.50	V2 =	6.05E+05
A3 =	124800.00	D3 =	10.00	V3 =	1.25E+06
A4 =	88320.00	D4 =	5.00	V4 =	4.42E+05
A5 =	143360.00	D5 =	10.00	V5 =	1.43E+06
A6 =	102400.00	D6 =	13.00	V6 =	1.33E+06
				V7 =	1.24E+09

TIDAL PRISM: 2.48 [ft/day]

CALCULATION OF FLOWS:

F15 =	8.22E+05	[cbft/day]	F51 =	8.22E+05	[cbft/day]
F12 =	6.85E+04	[cbft/day]	F21 =	6.85E+04	[cbft/day]
F23 =	4.02E+05	[cbft/day]	F32 =	4.02E+05	[cbft/day]
F45 =	1.15E+05	[cbft/day]	F54 =	1.15E+05	[cbft/day]
F43 =	1.04E+05	[cbft/day]	F34 =	1.04E+05	[cbft/day]
F36 =	8.16E+05	[cbft/day]	F63 =	8.16E+05	[cbft/day]
F56 =	1.29E+06	[cbft/day]	F65 =	1.29E+06	[cbft/day]
F67 =	2.36E+06	[cbft/day]	F76 =	2.36E+06	[cbft/day]
TI =	4.80E+09	[cbft/day]	TO =	4.80E+09	[cbft/day]

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Immediate downstream sector

R1 =	4.0	[days]
R2 =	2.2	[days]
R3 =	2.9	[days]
R4 =	2.0	[days]
R5 =	3.8	[days]
R6 =	3.7	[days]
RT =	0.3	[days]

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Ocean

R10 =	11.9	[days]
R20 =	9.0	[days]
R30 =	6.8	[days]
R40 =	9.3	[days]
R50 =	7.8	[days]
R60 =	3.9	[days]
RT0 =	0.3	[days]

Table 4.

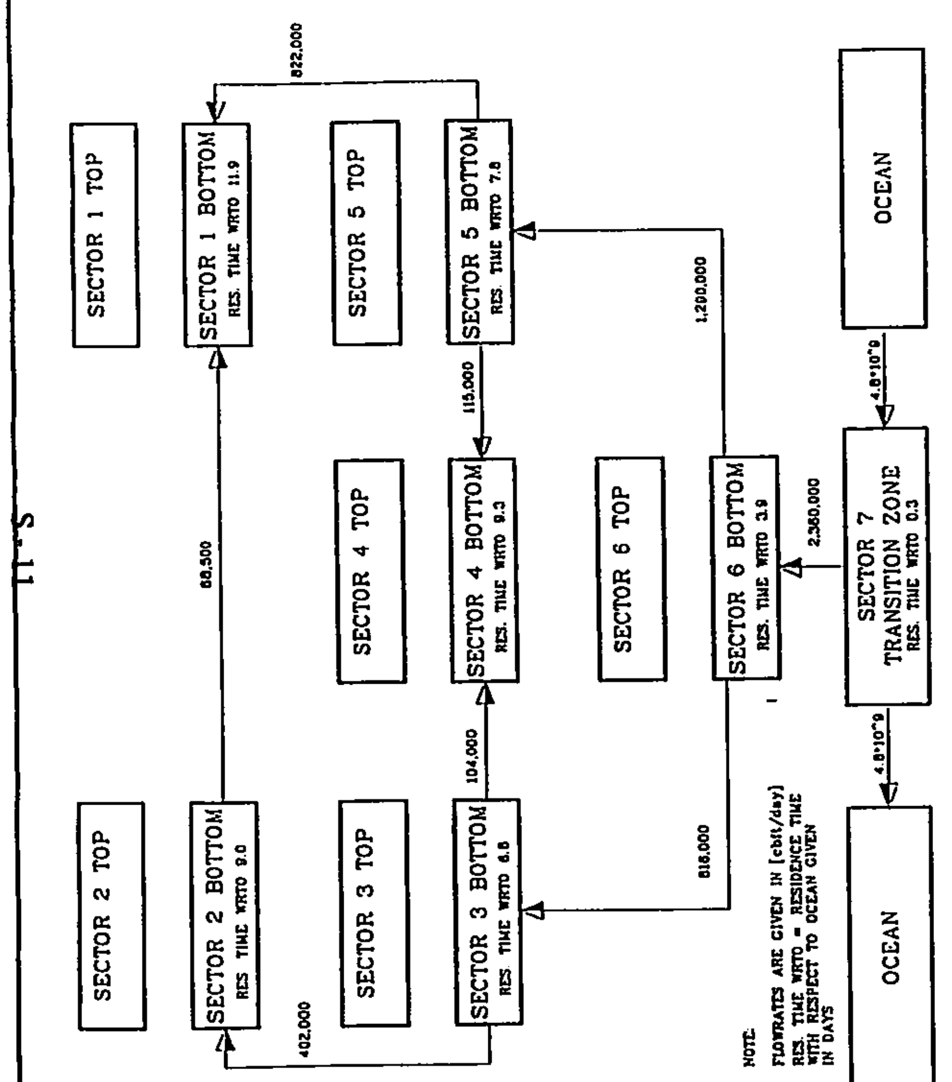


Figure 6.

MAUNA LANI COVE WATER QUALITY STUDY
FLOW IN STRATIFIED MODEL - TIDE ONLY
TIDAL FLOW ONLY IN BOTTOM LAYERS
DECEMBER 8, 1989
FILE 16D070

OCEES International, Inc.

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

22

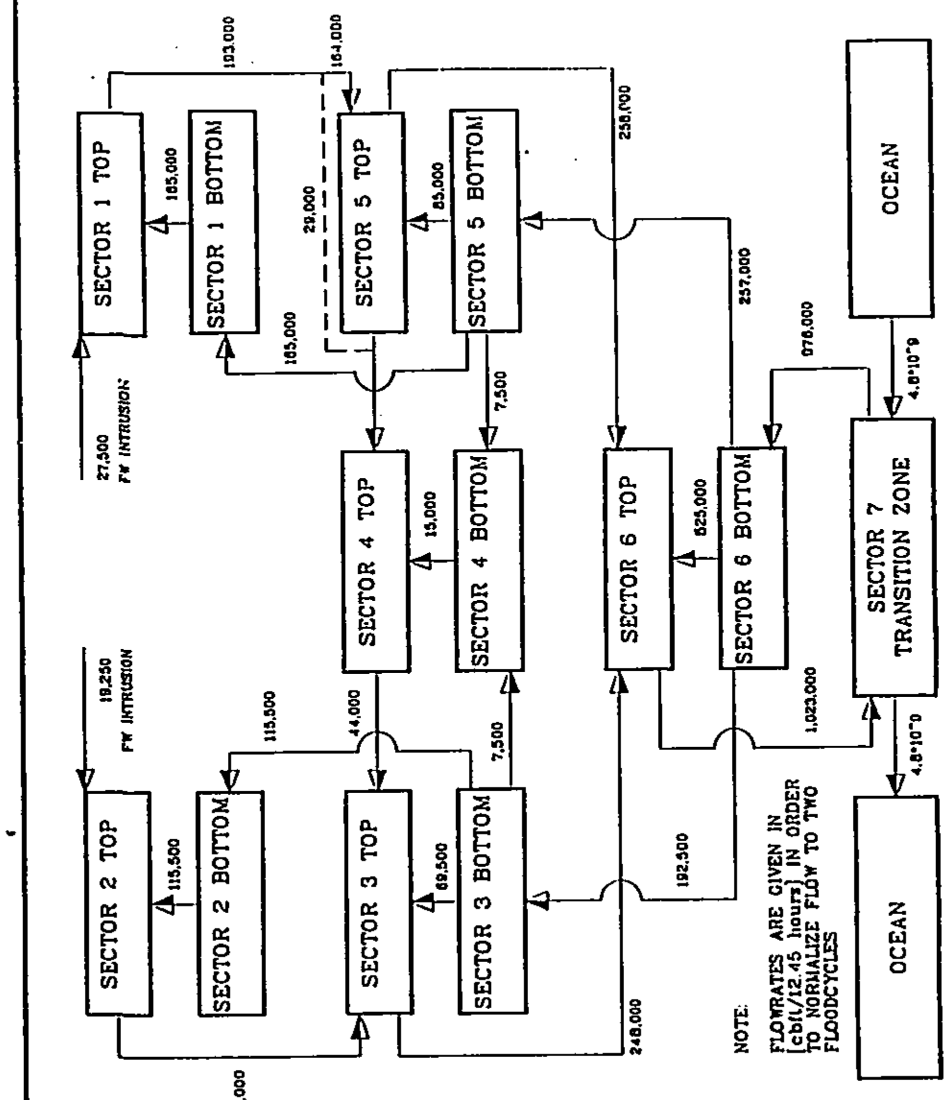


Figure 7.

MAUNA LANI COVE WATER QUALITY STUDY
STRATIFIED MODEL - FRESHWATER INTRUS
ONLY - NORMALIZED TO TWO FLOODCYCLES
DECEMBER 8, 1989
FILE 16D080

OCEES International, Inc.

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

23

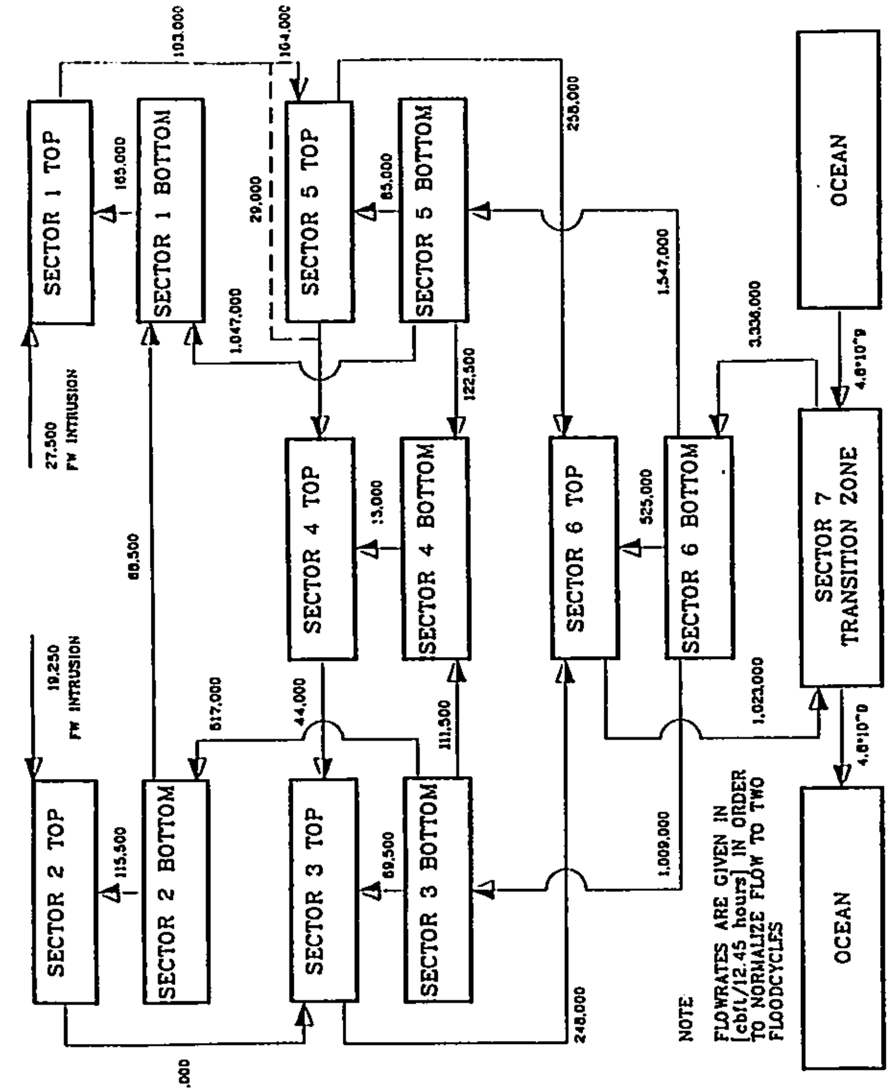


Figure 8.

OCEES International, Inc.

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF-SUPERPOSITION FW.INTRUS AND TIDE
FLOWCONDITIONS DURING FLOOD TIDE
DECEMBER 11, 1989
FILE 16D090

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

24

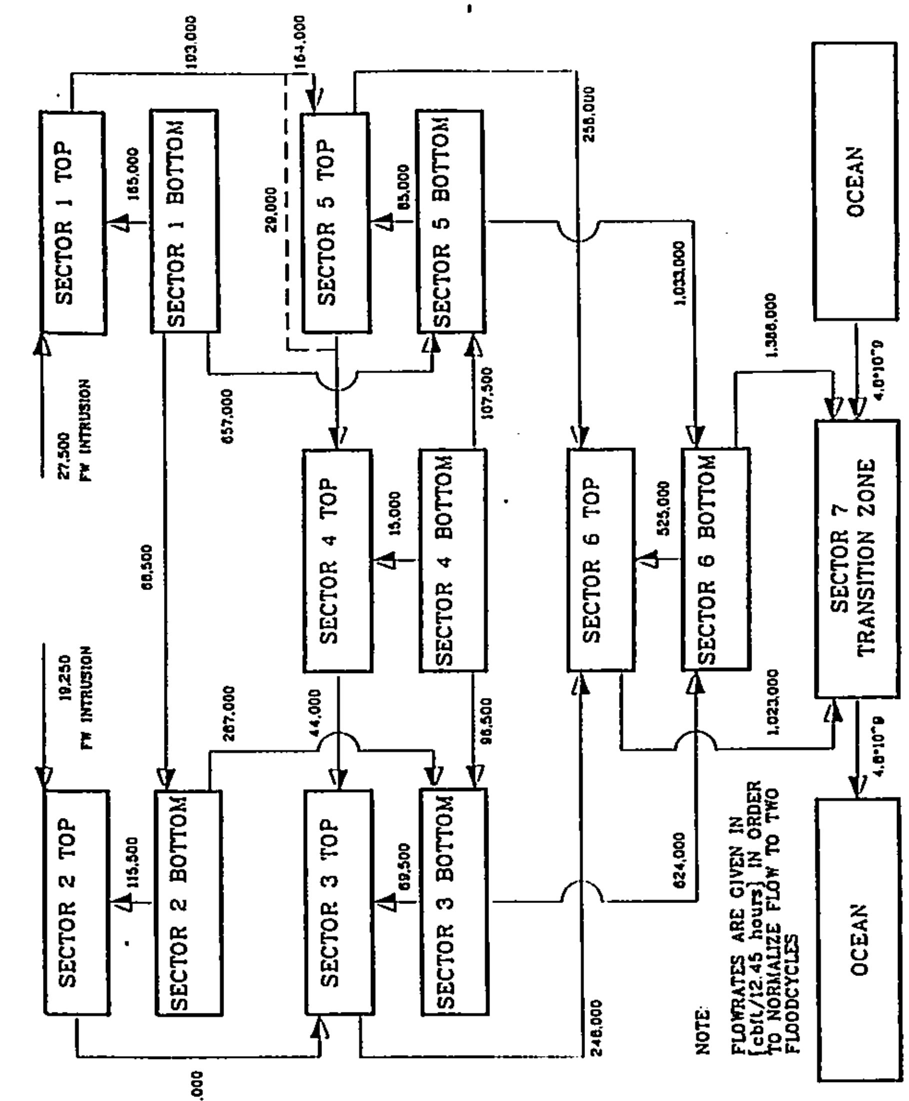


Figure 9.

OCEES International, Inc.

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF-SUPERPOSITION FW.INTRUS AND TIDE
FLOWCONDITIONS DURING EBB TIDE
DECEMBER 11, 1989
FILE 16D100

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

25

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16U060 PAGE 1

Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Superposition of FRESHWATER INTRUSION and TIDE
Tide is flowing only in bottom layers

STRATIFICATION 5.00 [ft] TIDAL PRISM: 2.48 [ft/day]

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	[CBFT]	TOPLAYER	[CBFT]
V1B =	3.58E+06	V1T =	1.79E+06
V2B =	6.05E+05	V2T =	6.72E+05
V3B =	1.25E+06	V3T =	6.24E+05
V4B =	4.42E+05	V4T =	4.42E+05
V5B =	1.43E+06	V5T =	7.17E+05
V6B =	1.33E+06	V6T =	5.12E+05
VT =	1.24E+09		

CALCULATION OF FLOWS: [cbft/two floodperiods]

FW. INTRUSION IN SECTOR 1 = 19250.00
FW. INTRUSION IN SECTOR 2 = 27500.00

ST11B5B =	1.05E+06	ST12T2B =	1.16E+05
ST11B2B =	6.85E+04	ST11T1B =	1.65E+05
ST12B3B =	5.17E+05	ST14T5T =	2.89E+04
ST14B5B =	1.23E+05	ST15T1T =	1.64E+05
ST14B3B =	1.12E+05	ST13T2T =	1.35E+05
ST13B6B =	1.01E+06	ST14T4B =	1.49E+04
ST15B6B =	1.55E+06	ST13T4T =	4.38E+04
ST16B7B =	3.34E+06	ST13T3B =	6.95E+04
TRANS.IN =	4.80E+09	ST16T3T =	2.48E+05
		ST15T5B =	8.45E+04
		ST16T5T =	2.48E+05
		ST16T6B =	5.25E+05
		ST1T6T =	1.03E+06

NOTE:
Flowdefinition-Example:
ST13T2T means flow due to Superposition Tide and freshwater Intrusion from sector 3 Top to sector 2 Bottom

Table 5A.

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16U060 PAGE 2

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Immediate downstream sector

RT1B =	3.2	[days]
RT2B =	1.6	[days]
RT3B =	2.3	[days]
RT4B =	1.9	[days]
RT5B =	3.3	[days]
RT6B =	2.6	[days]
RT1T =	9.7	[days]
RT2T =	4.7	[days]
RT3T =	2.5	[days]
RT4T =	10.1	[days]
RT5T =	2.9	[days]
RT6T =	0.5	[days]
RTTR =	0.3	[days]

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Ocean

RT1BO =	9.4	[days]
RT2BO =	6.7	[days]
RT3BO =	5.1	[days]
RT4BO =	7.5	[days]
RT5BO =	6.1	[days]
RT6BO =	2.9	[days]
RT1TO =	18.1	[days]
RT2TO =	10.1	[days]
RT3TO =	13.6	[days]
RT4TO =	23.8	[days]
RT5TO =	16.9	[days]
RT6TO =	9.4	[days]
RTTRO =	0.3	[days]

Table 5B.

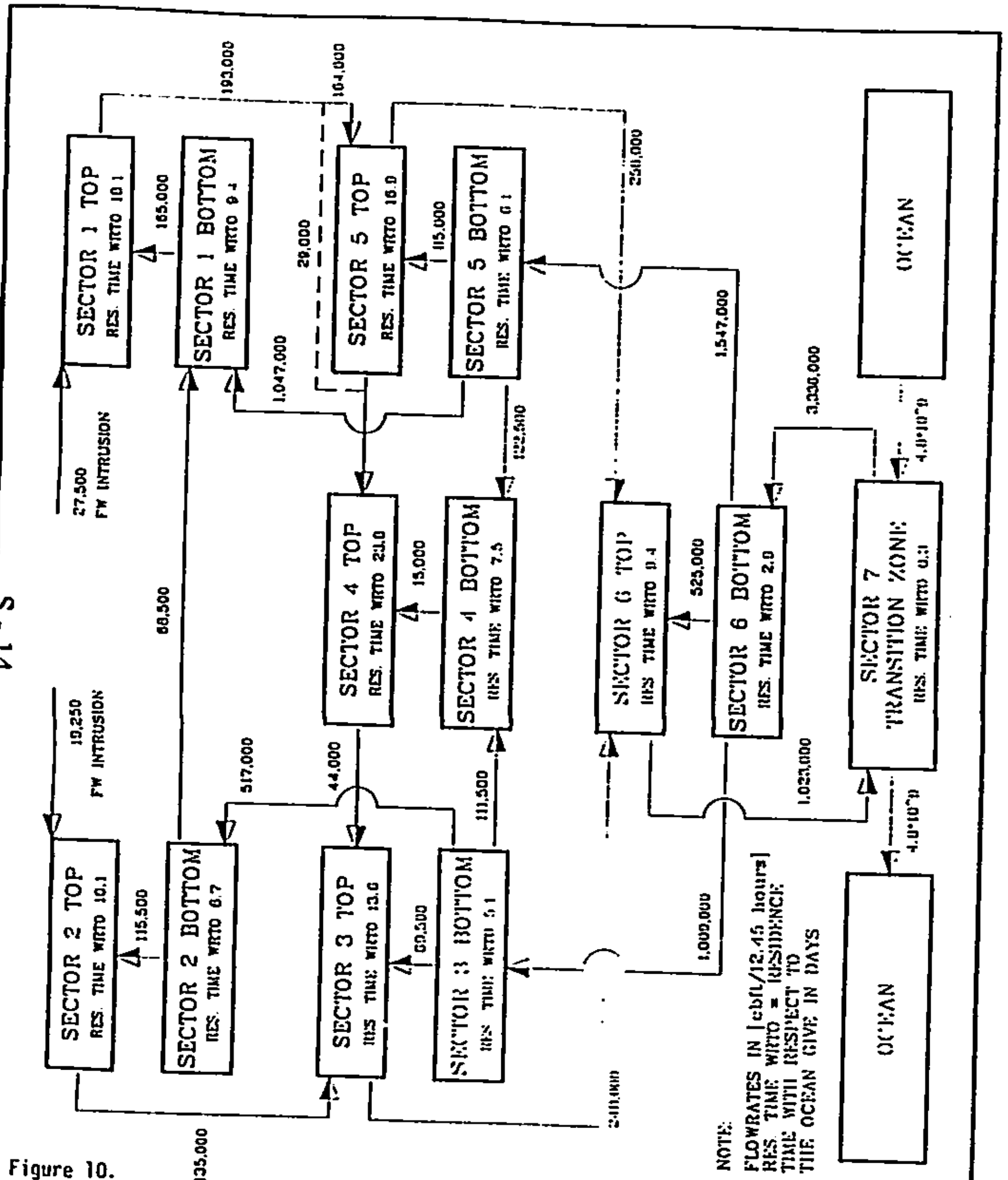


Figure 10.

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF - SUPERPOSITION FW.INTRUS AND TIDE
RESIDENCE TIMES WITH RESPECT TO OCEAN
DECEMBER 11, 1989
FILE: 16DH10

OCEES International, Inc

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

PUMPING ALTERNATIVES

The possibility of reducing the residence time in the various sectors of the proposed Mauna Lani Cove by pumping new water into the landward portion can be evaluated using the two layer box model. The effect of such a scheme depends not only on the volume of the flow but also on several water quality characteristics. These include the salinity and temperature (i.e. density), the nutrient content, and the chlorophyll-a concentration.

Considering the relatively long residence times already found for the top layer, the sensitivity to nutrients (especially phosphorus), and the potentially high chlorophyll-a content, the best water would be fresh water which is very low in nutrients and chlorophyll-a. Since large quantities (or even small quantities) of such water are not readily available the best choice is the adjacent seawater which, although not fresh, is low in nutrients and chlorophyll-a.

Addition of saltwater to the marina would directly affect flow in the bottom layer. The influence on the top layer would be indirect in that the upwardly mixing water is younger. The pumping flow rate per day being considered here is that being considered by PND for pumping from an inland pond. In that case pumping would occur once every four days. Here that pumping rate was calculated on a per day basis and applied only during ebb tide. (Pumping during flood tide would only substitute pumped water for tidal flow with little benefit.)

The results of the evaluation of pumped flow alone are given in Table 11. The major point illustrated here is that the pumped flow is very much smaller than the tidal flow and the change in residence time is not large.

The combination of tidal flow, fresh water flow, and seawater pumping directly from the ocean is given in Tables 7A and 7B and

Figure 12. Again it should be noted that although this rate of pumping decreases almost all of the residence times, those decreases are small.

The case of pumping from a seawater reservoir is shown in Tables 8A and 8B and Figure 13. Here the residence time of the water in the reservoir is taken to be four days. It is evident that there is a slight increase in the residence times when pumping from a reservoir as compared to pumping directly from the ocean. Of more concern is the probable higher nutrient content of the reservoir water due to surface drainage to the reservoir from the surrounding golf course or other landscaped and fertilized areas.

FILE: 16W070

Calculation of flowrates of BOXMODEL 2 - STRATIFIED Watercolumns
Only SEAWATER flushing considered.
Flow due to flushing is restricted to bottom layers.

STRATIFICATION 5.00 (ft)

INPUT:
CROSS SECTIONS: (SQFT)

S12	=	100.00
S15	=	1200.00
S23	=	630.00
S34	=	450.00
S45	=	500.00
S36	=	1200.00
S67	=	1560.00

SEAWATER FLUSHING 1.33E+05 (cbft/day)

CALCULATION OF FLOWS:

FF2B1B =	1.02E+04	(cbft/day)
OUTFLOW FROM 2	1.23E+05	(cbft/day)
FF5B1B =	9.09E+04	(cbft/day)
FF3B2B =	1.02E+04	(cbft/day)
FF4B5B =	3.18E+04	(cbft/day)
FF3B4B =	3.18E+04	(cbft/day)
FF6B3B =	4.21E+04	(cbft/day)
FF6B5B =	9.09E+04	(cbft/day)
FFT6B =	1.33E+05	(cbft/day)
TI =	4.80E+09	(cbft/day)

Table 6.

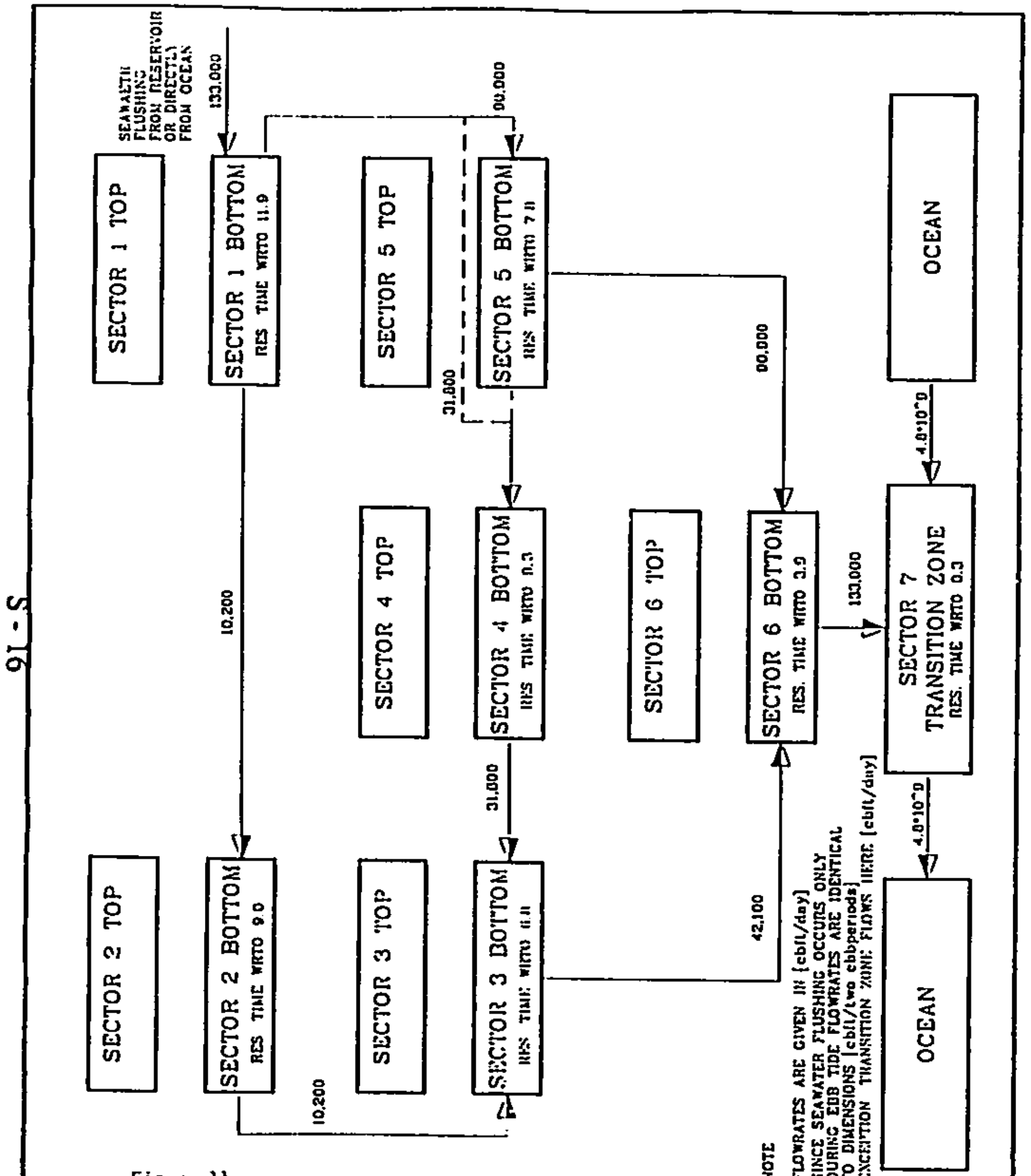


Figure 11.

MAUNA LANI COVE WATER QUALITY STUDY
STRATIFIED MODEL - SEAWATER FLUSHING
FLOW ONLY IN BOTTOM LAYERS
DECEMBER 14, 1989
FILE: 16D130

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16W080 PAGE 1

Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Superposition of FRESHWATER INTRUSION, TIDE and SEAWATER FLUSHING
Tide and seawater flushing is flowing only in bottom layers
Flowcontributions:
Flood components: Freshwater intrusion and tide
Ebb components: Seawater flushing DIRECTLY FROM OCEAN

STRATIFICATION 5.00 [ft] TIDAL PRISM: 2.48 [ft/day]

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	[CBFT]	TOPLAYER	[CBFT]
V1B =	3.58E+06	V1T =	1.79E+06
V2B =	6.05E+05	V2T =	6.72E+05
V3B =	1.25E+06	V3T =	6.24E+05
V4B =	4.42E+05	V4T =	4.42E+05
V5B =	1.43E+06	V5T =	7.17E+05
V6B =	1.33E+06	V6T =	5.12E+05
VT =	1.24E+09		

CALCULATION OF FLOWS:

FLOOD FLOW COMPONENTS:
[cbft/two floodperiods]
FW. INTRUS.IN SECTOR 1=19250.00
FW. INTRUS.IN SECTOR 2=27500.00

EBB FLOW COMPONENTS:
[cbft/two ebbperiods]
SW. FLUSHING 1.33E+05

ST11B5B =	1.05E+06	FF2B1B = 1.02E+04	[cbft/day]
ST11B2B =	6.85E+04	FF5B1B = 9.09E+04	[cbft/day]
ST12B3B =	5.17E+05	FF3B2B = 1.02E+04	[cbft/day]
ST14B5B =	1.23E+05	FF4B5B = 3.18E+04	[cbft/day]
ST14B3B =	1.12E+05	FF3B4B = 3.18E+04	[cbft/day]
ST13B6B =	1.01E+06	FF6B3B = 4.21E+04	[cbft/day]
ST15B6B =	1.55E+06	FF6B5B = 9.09E+04	[cbft/day]
ST16B7B =	3.34E+06	FF16B = 1.33E+05	[cbft/day]
TRANS.IN =	4.80E+09	TI = 4.80E+09	[cbft/day]
ST12T2B =	1.16E+05		
ST11T1B =	1.65E+05		
ST14T5T =	2.89E+04		
ST15T1T =	1.64E+05		
ST13T2T =	1.35E+05		
ST14T4B =	1.49E+04		
ST13T4T =	4.38E+04		
ST13T3B =	6.95E+04		
ST16T3T =	2.48E+05		
ST15T5B =	8.45E+04		
ST16T5T =	2.48E+05		
ST16T6B =	5.25E+05		
ST1T6T =	1.03E+06		

Table 7A

S - 17

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16G080 PAGE 2

ASSUMPTION: RESIDENCE TIME WRTO OF SEAWATER FLUSHING INTAKE 0.00 DAYS

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
RT1B =	2.9	[days]	RT1BO =	8.6	[days]
RT2B =	1.6	[days]	RT2BO =	7.0	[days]
RT3B =	2.2	[days]	RT3BO =	5.3	[days]
RT4B =	1.7	[days]	RT4BO =	7.6	[days]
RT5B =	3.1	[days]	RT5BO =	6.4	[days]
RT6B =	2.5	[days]	RT6BO =	3.0	[days]
RT1T =	9.7	[days]	RT1TO =	17.4	[days]
RT2T =	4.7	[days]	RT2TO =	10.3	[days]
RT3T =	2.5	[days]	RT3TO =	13.8	[days]
RT4T =	10.1	[days]	RT4TO =	23.6	[days]
RT5T =	2.9	[days]	RT5TO =	16.5	[days]
RT6T =	0.5	[days]	RT6TO =	9.4	[days]
RTTR =	0.3	[days]	RTTRO =	0.3	[days]

Table 7B.

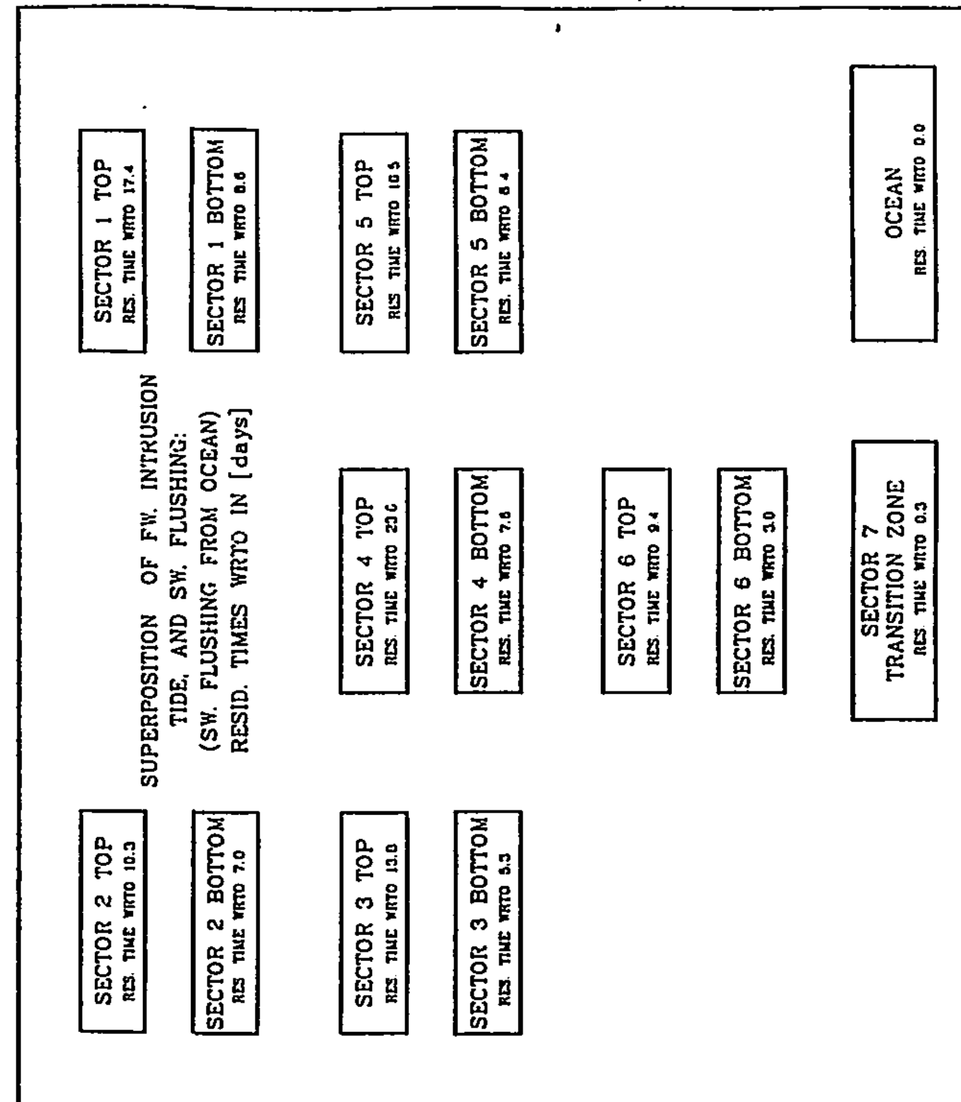


Figure 12.

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF -SUPERPOS FW INTRUS + TIDE: SW.FLUSH.
RESIDENCE TIMES WITH RESPECT TO OCEAN
DECEMBER 11, 1989
FILE: 16D140

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3706 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16W080 PAGE 1

Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Superposition of FRESHWATER INTRUSION, TIDE and SEAWATER FLUSHING
Tide and seawater flushing is flowing only in bottom layers
Flowcontributions:
Flood components: Freshwater intrusion and tide
Ebb components: Seawater flushing FROM SEAWATER RESERVOIR

STRATIFICATION 5.00 (ft) TIDAL PRISM: 2.48 (ft/day)

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	(CBFT)	TOPLAYER	(CBFT)
V1B =	3.58E+06	V1T =	1.79E+06
V2B =	6.05E+05	V2T =	6.72E+05
V3B =	1.25E+06	V3T =	6.24E+05
V4B =	4.42E+05	V4T =	4.42E+05
V5B =	1.43E+06	V5T =	7.17E+05
V6B =	1.33E+06	V6T =	5.12E+05
VT =	1.24E+09		

CALCULATION OF FLOWS:

FLOOD FLOW COMPONENTS: (cbft/two floodperiods)		EBB FLOW COMPONENTS: (cbft/two ebbperiods)		
FW. INTRUS.IN SECTOR 1=19250.00		SW. FLUSHING	1.33E+05	
FW. INTRUS.IN SECTOR 2=27500.00				
ST1185B =	1.05E+06	FF281B =	1.02E+04	(cbft/day)
ST1182B =	6.85E+04	FF581B =	9.09E+04	(cbft/day)
ST1283B =	5.17E+05	FF382B =	1.02E+04	(cbft/day)
ST1485B =	1.23E+05	FF485B =	3.18E+04	(cbft/day)
ST1483B =	1.12E+05	FF384B =	3.18E+04	(cbft/day)
ST1386B =	1.01E+06	FF683B =	4.21E+04	(cbft/day)
ST1586B =	1.55E+06	FF685B =	9.09E+04	(cbft/day)
ST1687B =	3.34E+06	FFT6B =	1.33E+05	(cbft/day)
TRANS.IN =	4.80E+09	TI =	4.80E+09	(cbft/day)
ST1212B =	1.16E+05			
ST1111B =	1.65E+05			
ST1415T =	2.89E+04			
ST1511T =	1.64E+05			
ST1312T =	1.35E+05			
ST1414B =	1.49E+04			
ST1314T =	4.38E+04			
ST1313B =	6.95E+04			
ST1613T =	2.48E+05			
ST1515B =	8.45E+04			
ST1615T =	2.48E+05			
ST1616B =	5.25E+05			
ST116T =	1.03E+06			

Table 8A.

36

MAUNA LANI COVE WATERQUALITY STUDY OCEES, Intern., INC DECEMBER 1989

FILE: 16W080 PAGE 2

ASSUMPTION: RESIDENCE TIME WRTO OF SEAWATER FLUSHING INTAKE 4.00 DAYS

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
RT1B =	2.9	(days)	RT1BO =	9.0	(days)
RT2B =	1.6	(days)	RT2BO =	7.0	(days)
RT3B =	2.2	(days)	RT3BO =	5.3	(days)
RT4B =	1.7	(days)	RT4BO =	7.6	(days)
RT5B =	3.1	(days)	RT5BO =	6.4	(days)
RT6B =	2.5	(days)	RT6BO =	3.0	(days)
RT1T =	9.7	(days)	RT1TO =	17.8	(days)
RT2T =	4.7	(days)	RT2TO =	10.3	(days)
RT3T =	2.5	(days)	RT3TO =	13.8	(days)
RT4T =	10.1	(days)	RT4TO =	23.8	(days)
RT5T =	2.9	(days)	RT5TO =	16.8	(days)
RT6T =	0.5	(days)	RT6TO =	9.5	(days)
RTTR =	0.3	(days)	RTTRO =	0.3	(days)

Table 8B.

37

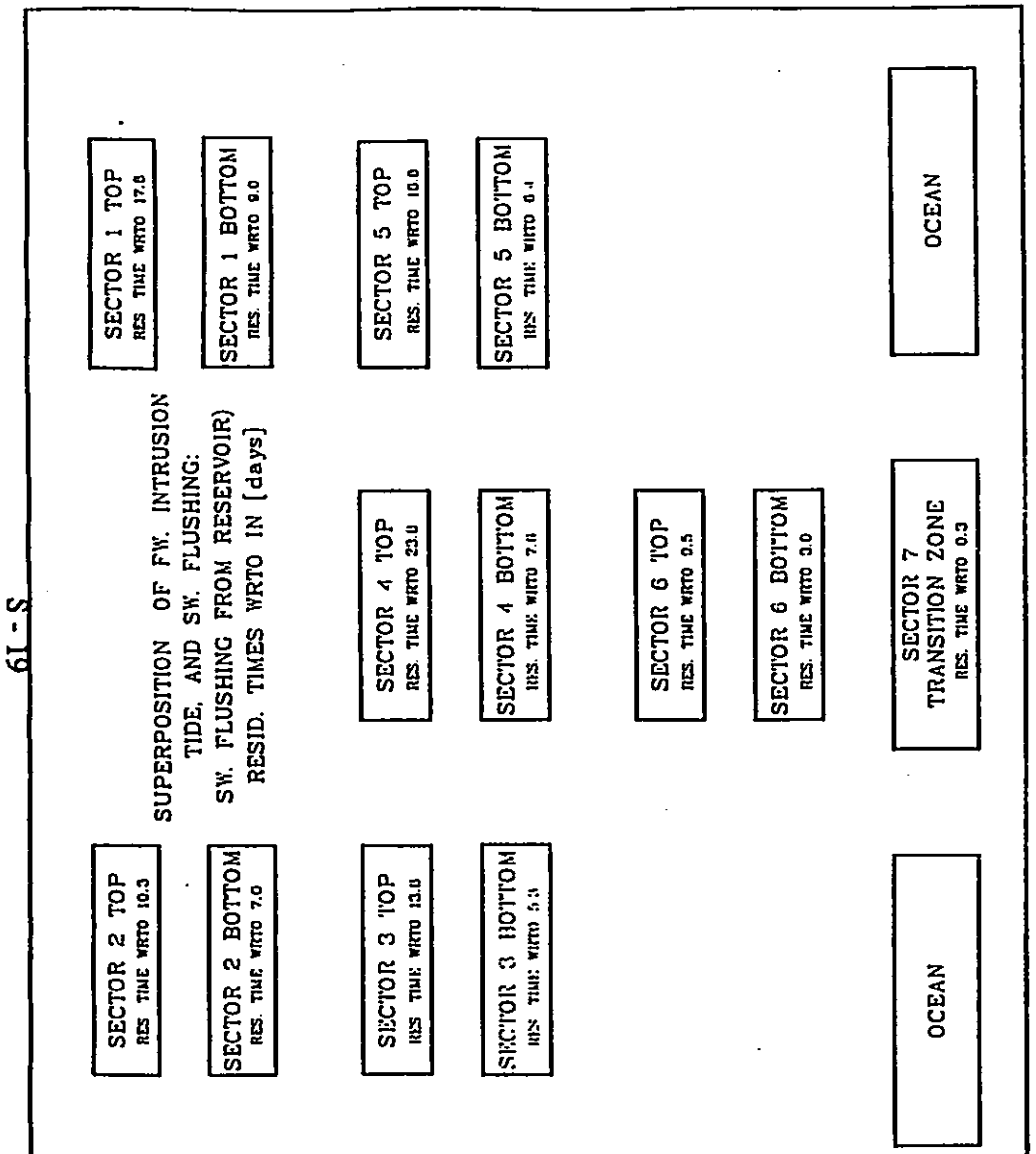


Figure 13.

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF.-SUPERPOS FW INTRUS -TIDE-SW FLUSH
RESIDENCE TIMES WITH RESPECT TO OCEAN
DECEMBER 12, 1989
FILE 16D150

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL. HONOLULU, HAWAII 96816
TEL (808) 734-7414

PHYTOPLANKTON GROWTH

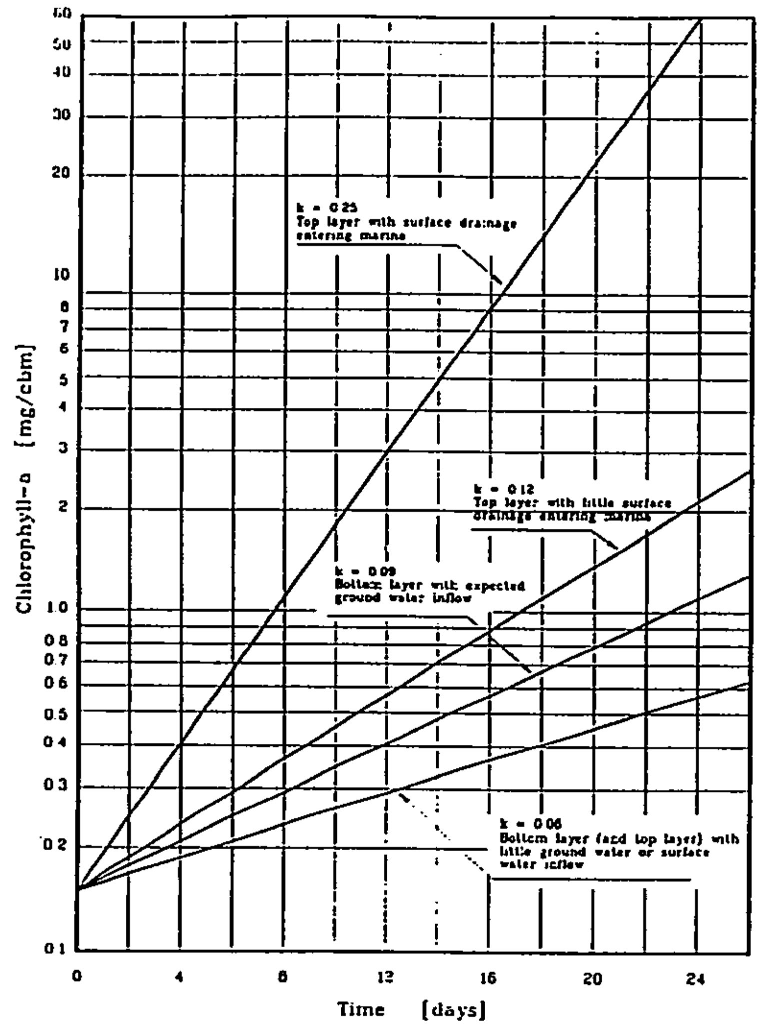
Knowing the residence times in the various sectors under several flow conditions does not directly give the water quality conditions. A dominant factor for establishing the water quality is the net growth rate of phytoplankton.

In the open ocean under steady state conditions the net growth rate is zero since the gross growth rate is balanced by the sum of the predation rate and the settling rate. If there is an addition of the limiting nutrient then the gross growth rate outstrips the removal rate and there is a net increase in plankton concentration.

Experience in other areas in Hawaii has resulted in the identification of representative net growth rates for several conditions found in embayment or estuarine waters. Hawaii Kai Marina is characterized by good vertical mixing and the input of nutrient rich surface flow. Hawaii Kai Marina also does not have much benthic predation of phytoplankton because of the soft bottom conditions. The result is a net growth rate of 0.25 per day.

In Kaneohe the net growth rate with sewage addition was found to be 0.12 per day while that with no sewage addition was 0.09 per day. Since Kaneohe Bay does have a moderate inflow of surface drainage it does not present the possible conditions along the Kona coast where very little surface runoff enters coastal waters. For those conditions it is estimated that the net growth rate is about 0.06 per day.

The results of exponential growth at various rates with a common starting point of 0.15 mg/m^3 are illustrated in Figure 14. By combining the residence times calculated earlier with the information in Figure 14 reasonably reliable predictions can be made of the chlorophyll-a concentration and hence the water clarity. Chlorophyll-a concentrations less than about 1 mg/m^3



Chlorophyll-A concentration vs. estimated Sector residence time

Figure 14.

OCEES International, Inc.

MAUNA LANI COVE WATER QUALITY STUDY
CHLOROPHYLL CONCENTRATION VERSUS
ESTIMATED SECTOR RESIDENCE TIME
DECEMBER 12, 1989
FILE 16D120

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL. HONOLULU, HAWAII 96816
TEL (808) 734-7414

CONCLUSIONS

1. The water quality in the proposed Mauna Lani Marina is dependent on the geometry of the marina, the tidal prism, the rate of ground water inflow, the rate of surface drainage inflow, the rate of pumped inflow, and the water quality of all these factors.

2. If there is little ground water inflow and surface drainage is diverted away from the marina, then the water will not be stratified and the phytoplankton growth rate will be small and tidal exchange will be sufficient to maintain good water quality.

3. If ground water inflow is as expected, then the water column will be stratified and the water quality will depend on the rate of growth of phytoplankton and on the residence time of the water in the various sectors.

4. Adequate water quality can be achieved by limiting the input of phosphorus by severely limiting surface drainage input and thereby limiting the phytoplankton growth rate.

5. If severe limitation of surface drainage is impractical then a combination of moderate surface drainage limitation (i.e. allowing drainage only from the two islands but not from the other areas) and seawater pumping would result in adequate water quality. The source of pumped water should be directly from the ocean rather than from the wells. Well water is likely to be higher in nutrients, low in oxygen, and possibly contain dissolved iron.

6. If excessive nutrients are allowed to enter the marina waters then the plankton growth rate would be high and even the pumping alternative would be inadequate to maintain acceptable water quality.

RECOMMENDATIONS

1. Restriction of the inflow of phosphorus to the water of the proposed Mauna Lani Cove is the principal recommendation of this study. Since phosphorus is primarily added through surface drainage, (especially with sediment and/or fertilizer) the best control is to divert surface drainage away from the marina.

2. Although some slight improvements would result from the rate of pumping being contemplated, that improvement is probably too small to justify the expenditure. In any case, if phosphorus is strictly limited the water quality in the marina should be quite acceptable without pumping.

REFERENCES

1. Investigation of Hawaii Kai Marina:
   Sunn, Low, Tom and Hara, Inc. Honolulu, Hawaii, May 1974

2. Kaneohe Bay Data Evaluation Study:
   Pacific, Inc., Honolulu, Hawaii, 1978.

3. Hydraulic Model Study of the Mauna Lani Cove:
   Hydro Research Science, Inc., Santa Clara, September 1989.

4. State of Hawaii Water Quality Standards:
   Revised 1989

**WATER QUALITY AND
EXCHANGE CHARACTERISTICS
OF
HAUNA LANI COVE
ADDENDUM**

PREPARED FOR:

Peratrovich, Nottingham and Drage, Inc.
1100 Eastlake Avenue East, Suite 310
Seattle, Washington 98109

PREPARED BY:

OCEES International, Inc.
3786 Pukalani Place
Honolulu, Hawaii 96816

January 1990

CONTENTS

DEFINITION OF BOX MODEL VARIATIONS

The four case studies investigated are defined as follows:

CASE 1: This box model configuration is the original as presented in the report.

CASE 2: For this box model variation:

1) The depth of the all sectors is uniformly reduced by 2 ft relative to the depth used for the report.
2) The fresh water intrusion rate is 2 MGD/mile; as used in the report.

CASE 3: For this box model variation:

1) The depth of the all sectors is the same as in the report.
2) The fresh water intrusion rate is increased to 4 MGD/mile.

CASE 4: For this box model variation:

1) The depth of the all sectors is uniformly reduced by 2 ft relative to the depth used for the report.
2) The fresh water intrusion rate is increased to 4 MGD/mile.

RESULTS OF CASE STUDIES

The calculations of the three new cases were conducted in the same manner as in the original report.

The first new condition considered in this ADDENDUM is making the entire Mauna Lani Cove 2 feet shallower . Such a change will, of course, result in a shortening of the residence times because of smaller volumes and higher relative tidal flow rate. These conditions are shown in TABLES A-1 through A-3. The effect of fresh water inflow at a rate of 2 MGD/mile is shown in TABLE A4 and FIGURES A4 and A5.

The effect of an increase in fresh water inflow is indicated in FIGURES A6 and A7.

The condition originally considered in the report (case 1 in this ADDENDUM) is shown again here in TABLES A-5A and A-5B for comparison.

The results of case 2, which decreases the depth but keeps the lower fresh water flow rate, is given in TABLES A-6A and A-6B and FIGURE A-9. It is evident that there is a general reduction in the residence times of all sectors of about 1 to 2 days.

Case 3 considers the condition of a larger fresh water flow with the original depth. The results are given in TABLES A-7A and A-7B and FIGURE A-10. Again there is a general decrease in residence times with the most reduction in the surface layers. The effect is greater than that noted for case 2.

The effect of both reducing the depth and considering a higher rate of fresh water flow constitutes case 4 which is shown in TABLES A-8A and A-8B and FIGURE A-11. The greatest reduction in residence time is evident here.

A comparison among the four cases is given in TABLES A-9A and A-9B and in FIGURES A-12 through A-16 as bar graphs.

CONCLUSIONS AND RECOMMENDATIONS

The effect of residence time reduction on water quality is more dramatic because the relationship to the plankton concentration is exponential rather than linear. By going to FIGURE 14 of the report (phytoplankton net growth rates) it is evident that case 4 would significantly improve water quality above that found in case 1.

Since case 1 was likely to be only marginally in compliance with State of Hawaii Water Quality Standards with respect to chlorophyll-a and turbidity any reduction in residence times will give a factor of safety. The sector of the longest residence time, the top layer of the channel between the islands, has reduced its residence time from about 24 days to about 13 days. Case 4 would still require control of surface drainage to maintain the phosphorus limited growth rate and good water quality but there is less urgency in the completeness of that control.

This evaluation also shows that the pumping alternative is not necessary to maintain good water quality if, indeed, the 4 MGD/mile fresh water groundwater inflow occurs into the proposed Mauna Lani Cove.

If acceptable from the standpoint of navigation it is recommended that the originally planned depth be uniformly reduced by 2 feet.

TABLES AND FIGURES

Tables and figures pertaining to this report are presented in the following pages.

Water Quality and Exchange Characteristics of Mauna Lani Cove
ADDENDUM
by OCEES International, Inc., Honolulu, Hawaii, January 1990

FILE: 16UA2010

Calculation of residence times of BOXMODEL 1 - UNSTRATIFIED Watercolumn
Only tidal influences are considered
Modification of box model calculated in file 16U010:
* Depths of sectors reduced by 2 feet

INPUT:

AREAS:	[SQFT]	MODIFIED AVERAGE DEPTH	[ft]	MODIFIED VOLUMES:	[CBFT]
A1 =	358400.00	D1 =	13.00	V1 =	4.659E+06
A2 =	134400.00	D2 =	7.50	V2 =	1.008E+06
A3 =	124800.00	D3 =	13.00	V3 =	1.622E+06
A4 =	88320.00	D4 =	8.00	V4 =	7.066E+05
A5 =	143360.00	D5 =	13.00	V5 =	1.864E+06
A6 =	102400.00	D6 =	16.00	V6 =	1.638E+06
				VT =	1.240E+09

TIDAL PRISM: 2.48 [ft/day]

CALCULATION OF FLOWS:

F15 =	7.08E+05	[cbft/day]	F51 =	7.08E+05	[cbft/day]
F12 =	1.82E+05	[cbft/day]	F21 =	1.82E+05	[cbft/day]
F23 =	5.15E+05	[cbft/day]	F32 =	5.15E+05	[cbft/day]
F45 =	1.15E+05	[cbft/day]	F54 =	1.15E+05	[cbft/day]
F43 =	1.04E+05	[cbft/day]	F34 =	1.04E+05	[cbft/day]
F36 =	9.29E+05	[cbft/day]	F63 =	9.29E+05	[cbft/day]
F56 =	1.18E+06	[cbft/day]	F65 =	1.18E+06	[cbft/day]
F67 =	2.36E+06	[cbft/day]	F76 =	2.36E+06	[cbft/day]
TI =	4.80E+09	[cbft/day]	TO =	4.80E+09	[cbft/day]

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
R1 =	5.2	[days]	R10 =	16.0	[days]
R2 =	3.8	[days]	R20 =	13.2	[days]
R3 =	4.2	[days]	R30 =	9.4	[days]
R4 =	3.2	[days]	R40 =	13.0	[days]
R5 =	5.0	[days]	R50 =	10.2	[days]
R6 =	4.9	[days]	R60 =	5.2	[days]
RT =	0.3	[days]	R10 =	0.3	[days]

TABLE A-1A

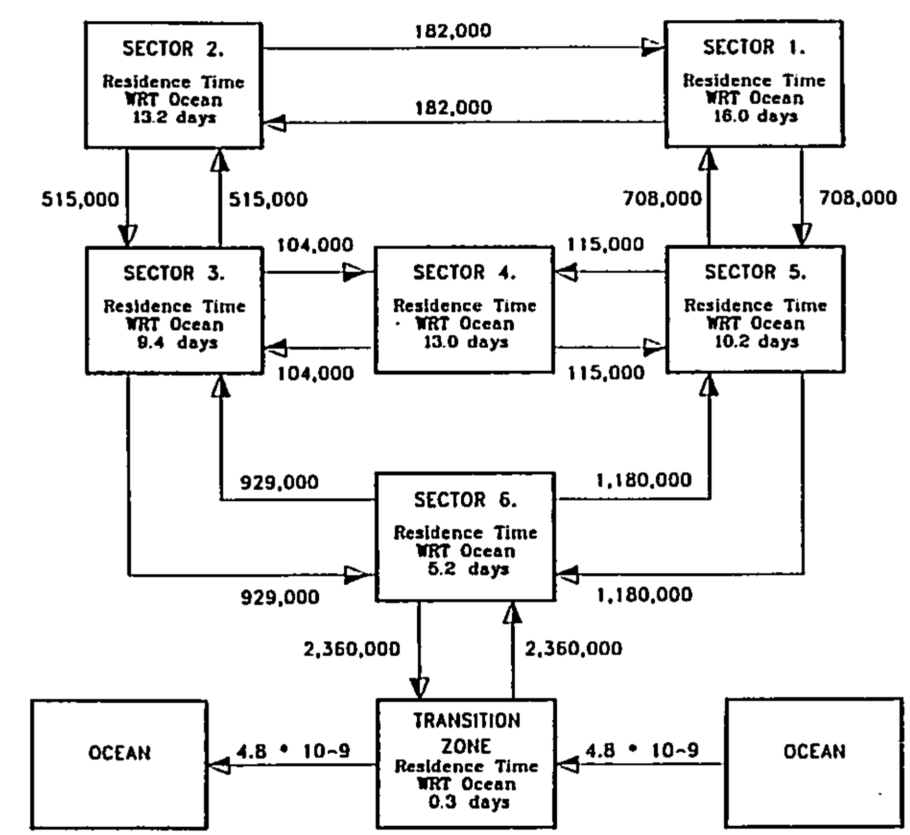
MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16MA2010 PAGE 2

MODIFIED CROSS SECTIONS: [SQFT]		MODIFIED DEPTH OF CROSS SECTIONS: [FT]		WIDTH OF CROSS SECTIONS: [FT]	
S12 =	400.00	S12 =	4.00	S12 =	100.00
S15 =	1560.00	S15 =	13.00	S15 =	120.00
S23 =	900.00	S23 =	10.00	S23 =	90.00
S34 =	720.00	S34 =	8.00	S34 =	90.00
S45 =	800.00	S45 =	8.00	S45 =	100.00
S36 =	1560.00	S36 =	13.00	S36 =	120.00
S67 =	1920.00	S67 =	16.00	S67 =	120.00

ORIGINAL SECTOR AVERAGE DEPTH [FT]		ORIGINAL DEPTH OF CROSS SECTIONS: [FT]	
D1 =	15.00	S12 =	6.00
D2 =	9.50	S15 =	15.00
D3 =	15.00	S23 =	12.00
D4 =	10.00	S34 =	10.00
D5 =	15.00	S45 =	10.00
D6 =	18.00	S36 =	15.00
		S67 =	18.00

TABLE A-1B



NOTE:

Flowrates are given in [cbft/day]
Original depth of sectors are reduced by 2 ft

FIGURE A-1

MAUNA LANI COVE WATER QUALITY STUDY FLOW IN UNSTRATIFIED MODEL – TIDE ONLY ADDENDUM – SECTOR DEPTH REDUCTION JANUARY 15, 1990 FILE: 16A2D010	OCEES International, Inc. OCEAN ENGINEERING & ENERGY SYSTEMS 3786 PUKALANI PL., HONOLULU, HAWAII 96816 TEL.: (808) 734-7414

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16A2020 PAGE 1

Calculation of characteristics of BOXMODEL 2 - STRATIFIED Watercolumns
Modification of box model calculated in file 16U020

CALCULATION OF CROSS SECTIONAL AREAS:

STRATIFICATION 5.00 [ft]

CROSS SECTIONS:	DEPTH [ft]	WIDTH [ft]	TOTAL AREA [sqft]	AREA TOP [sqft]	AREA BOTTOM [sqft]	AREA TOP [ratio]	AREA BOTTOM [ratio]
S12	4.00	100.00	400.00	400.00	0.00	1.00	0.00
S15	13.00	120.00	1560.00	600.00	960.00	0.38	0.62
S23	10.00	90.00	900.00	450.00	450.00	0.50	0.50
S34	8.00	90.00	720.00	450.00	270.00	0.63	0.38
S45	8.00	100.00	800.00	500.00	300.00	0.63	0.38
S36	13.00	120.00	1560.00	600.00	960.00	0.38	0.62
S56	13.00	120.00	1560.00	600.00	960.00	0.38	0.62
S67	16.00	120.00	1920.00	600.00	1320.00	0.31	0.69

CALCULATION OF SECTOR VOLUMINA:

STRATIFICATION 5.00 [ft]

SECTOR:	AVERAGE DEPTH [ft]	SURFACE AREA [sqft]	TOTAL VOLUME [cbft]	VOLUME TOP [cbft]	VOLUME BOTTOM [cbft]
1.00	15.00	3.23E+05	4.85E+06	1.62E+06	3.23E+06
2.00	9.50	1.34E+05	1.28E+06	6.72E+05	6.05E+05
3.00	15.00	1.25E+05	1.87E+06	6.24E+05	1.25E+06
4.00	10.00	8.83E+04	8.83E+05	4.42E+05	4.42E+05
5.00	15.00	1.43E+05	2.15E+06	7.17E+05	1.43E+06
6.00	18.00	1.02E+05	1.84E+06	5.12E+05	1.33E+06

TABLE A-2A

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16A2020 PAGE 2

Calculation of flow rates of BOXMODEL 2 - STRATIFIED Watercolumns
Only tidal influences are considered
Modification of box model calculated in file 16U020

CALCULATION OF SECTORIAL INFLOW:

STRATIFIED SECTOR INFLOW:		FLOW [cbft/day]	FED FROM UNSTRATIFIED SECTOR INFLOW:	FLOW [cbft/day]
F1T2T		1.82E+05	F12	181657
F1B2B		0.00E+00	F12	181657
	SUM	1.82E+05		
F1T5T		2.72E+05	F15	708463
F1B5B		4.36E+05	F15	708463
	SUM	7.08E+05		
F2T3T		2.58E+05	F23	515453
F2B3B		2.58E+05	F23	515453
	SUM	5.15E+05		
F4T3T		6.49E+04	F43	103903
F4B3B		3.90E+04	F43	103903
	SUM	1.04E+05		
F4T5T		7.22E+04	F45	115448
F4B5B		4.33E+04	F45	115448
	SUM	1.15E+05		
F3T6T		3.57E+05	F36	929309
F3B6B		5.72E+05	F36	929309
	SUM	9.29E+05		
F5T6T		4.54E+05	F56	1179960
F5B6B		7.26E+05	F56	1179960
	SUM	1.18E+06		
F6T7		7.38E+05	F67	2363000
F6B7		1.62E+06	F67	2363000
	SUM	2.36E+06		

TABLE A-2B

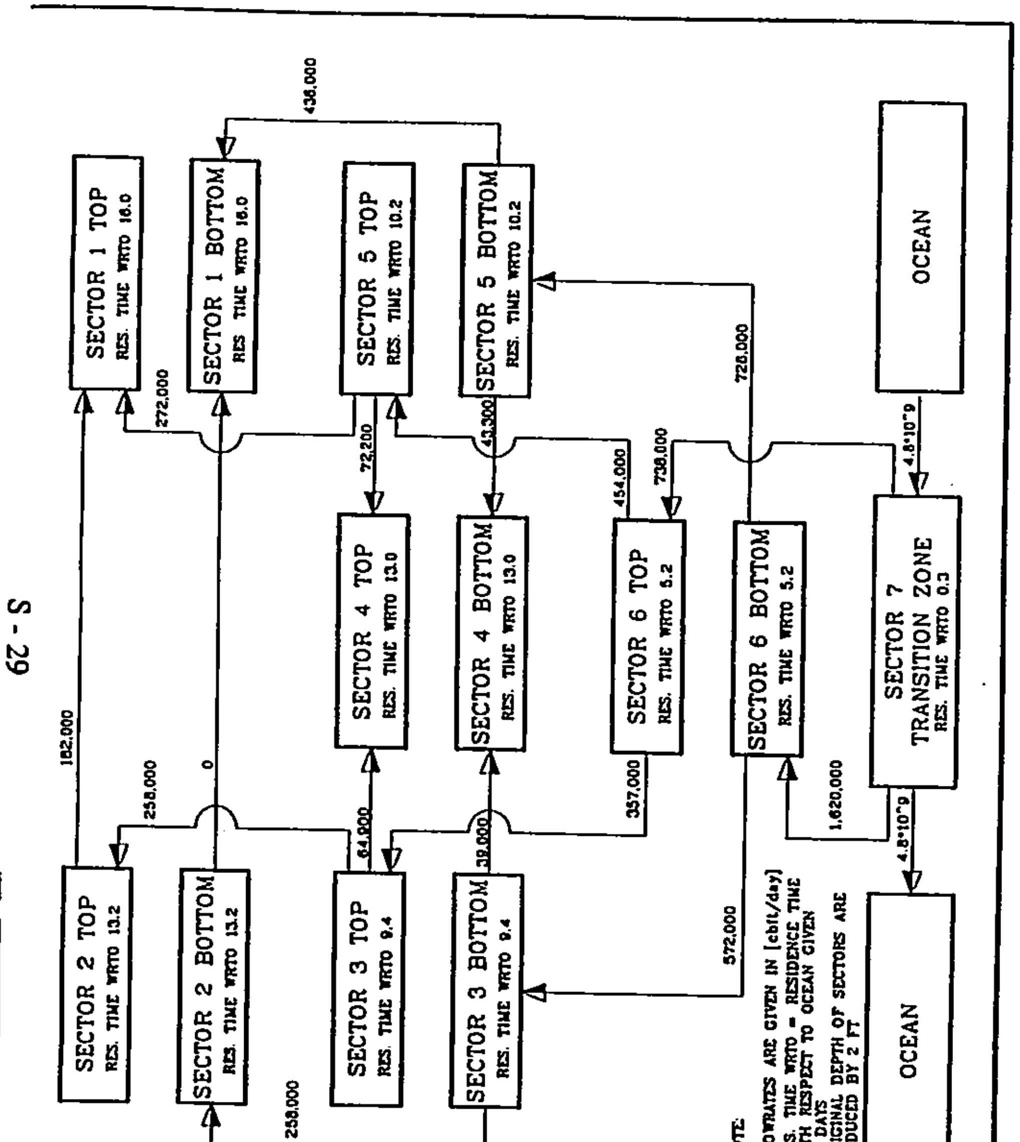


FIGURE A-2

MAUNA LANI COVE WATER QUALITY STUDY FLOW IN STRATIFIED MODEL – TIDE ONLY ADDENDUM – SECTOR DEPTH REDUCTION JANUARY 15, 1990 FILE: 16DA2050	OCEES International, Inc. OCEAN ENGINEERING & ENERGY SYSTEMS 3786 PUKALANI PL. HONOLULU, HAWAII 96816 TEL: (808) 734-7414

13

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES., Intern., INC JANUARY 1990

FILE: 16UA2050

Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Only tidal influences are considered
Tide is flowing only in bottom layers
Modification of file 16U050
Sector depths reduced by 2 ft

STRATIFICATION 5.00 [ft]

INPUT:

AREAS:	[SQFT]	MODIFIED AVERAGE DEPTH OF BOTTOM LAYER [ft]		MODIFIED VOLUMES OF BOTTOM LAYER [cbft]	
A1 =	358400.00	D1 =	8.00	V1 =	2.87E+06
A2 =	134400.00	D2 =	2.50	V2 =	3.36E+05
A3 =	124800.00	D3 =	8.00	V3 =	9.98E+05
A4 =	88320.00	D4 =	3.00	V4 =	2.65E+05
A5 =	143360.00	D5 =	8.00	V5 =	1.15E+06
A6 =	102400.00	D6 =	11.00	V6 =	1.13E+06
				V7 =	1.24E+09

TIDAL PRISM: 2.48 [ft/day]

CALCULATION OF FLOWS:

F15 =	8.90E+05 [cbft/day]		F51 =	8.90E+05 [cbft/day]	
F12 =	0.00E+00 [cbft/day]		F21 =	0.00E+00 [cbft/day]	
F23 =	3.34E+05 [cbft/day]		F32 =	3.34E+05 [cbft/day]	
F45 =	1.15E+05 [cbft/day]		F54 =	1.15E+05 [cbft/day]	
F43 =	1.04E+05 [cbft/day]		F34 =	1.04E+05 [cbft/day]	
F36 =	7.48E+05 [cbft/day]		F63 =	7.48E+05 [cbft/day]	
F56 =	1.36E+06 [cbft/day]		F65 =	1.36E+06 [cbft/day]	
F67 =	2.36E+06 [cbft/day]		F76 =	2.36E+06 [cbft/day]	
TI =	4.80E+09 [cbft/day]		TO =	4.80E+09 [cbft/day]	

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector		CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean	
R1 =	3.2 [days]	R10 =	9.4 [days]
R2 =	1.0 [days]	R20 =	6.1 [days]
R3 =	2.0 [days]	R30 =	5.1 [days]
R4 =	1.2 [days]	R40 =	6.9 [days]
R5 =	3.1 [days]	R50 =	6.2 [days]
R6 =	2.9 [days]	R60 =	3.2 [days]
R7 =	0.3 [days]	R70 =	0.3 [days]

TABLE A-3

14

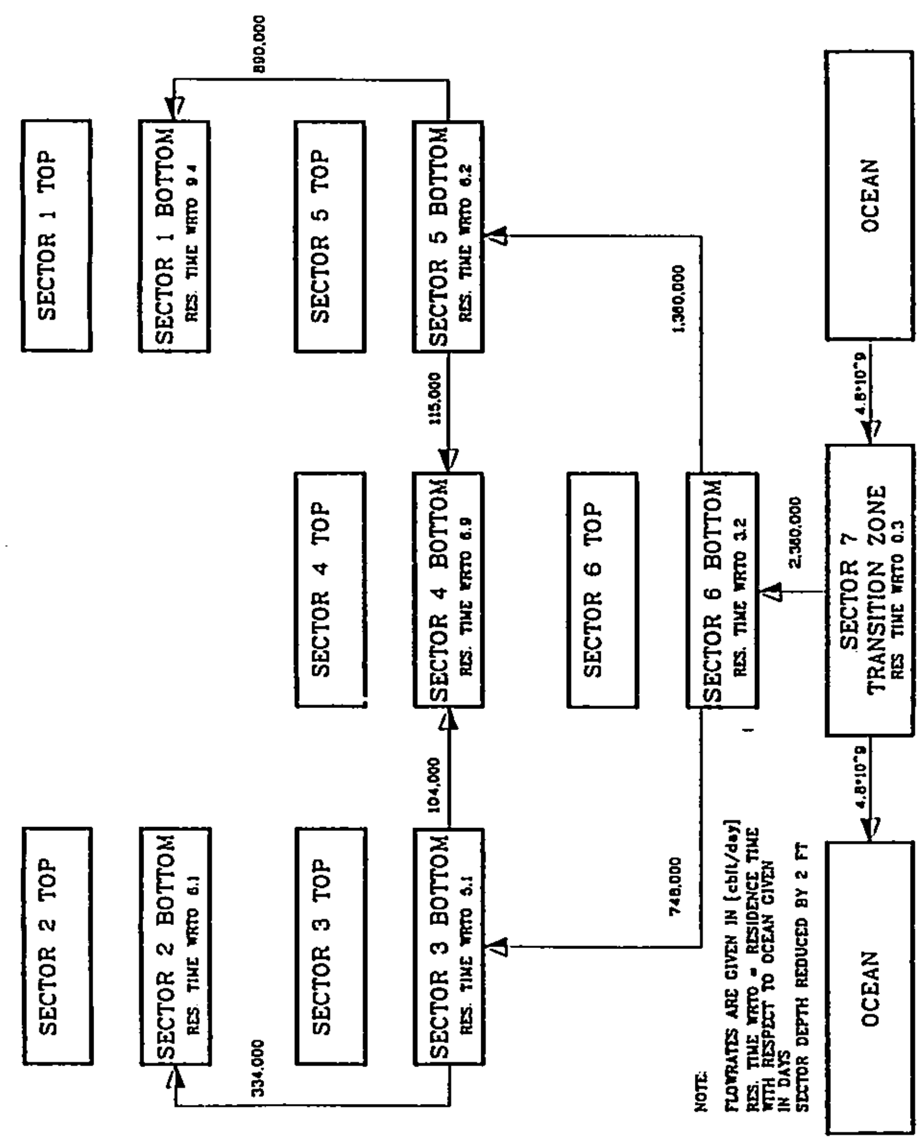


FIGURE A-3

MAUNA LANI COVE WATER QUALITY STUDY
FLOW IN STRATIFIED MODEL - TIDE ONLY
TIDAL FLOW ONLY IN BOTTOM LAYERS
ADDENDUM - SECTOR DEPTH REDUCTION
JANUARY 17, 1990
FILE 16DA2070

OCEES International, Inc.

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL: (808) 734-7414

FILE: 16UA3030

Calculation of flow rates of BOXMODEL 2 - STRATIFIED Watercolumns
Only FRESHWATER INTRUSION is considered
Modification of STRATIFIED box model calculated in file 16U030

INPUT:
SALINITY OF FRESHWATER INTRUSION:

SECTOR 1	0.00	[ppm]
SECTOR 2	0.00	[ppm]

SALINITY OF TOPLAYERS:		SALINITY OF BOTTOM LAYERS:	
SECTOR	SALINITY	SECTOR	SALINITY
1	30.00 [ppm]	1	35.00 [ppm]
2	30.00 [ppm]	2	35.00 [ppm]
3	31.70 [ppm]	3	35.00 [ppm]
4	31.70 [ppm]	4	35.00 [ppm]
5	31.70 [ppm]	5	35.00 [ppm]
6	33.40 [ppm]	6	35.00 [ppm]

SALINITY OF TRANSITION ZONE 35.00 [ppm]
SALINITY OF OCEAN 35.00 [ppm]

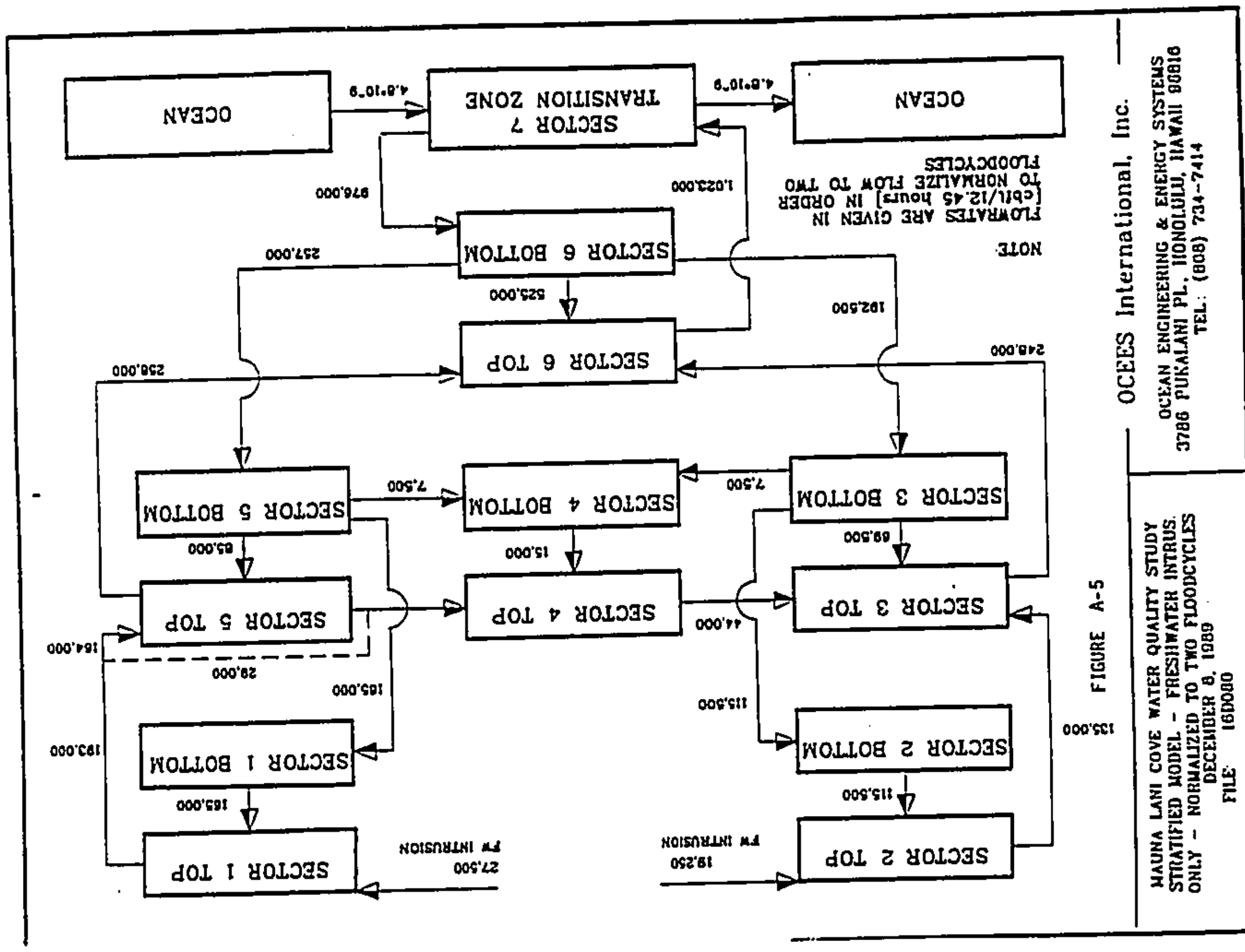
FRESH WATER INTRUSION: in [cbft/day]			FRESH WATER INTRUSION: in [cbft/day]		
MODIFICATION: based on 4 MGAL/day/mile			ORIGINAL: based on 2 MGAL/day/mile		
SECTOR 1	110000	[cbft/day]	SECTOR 1	55000	[cbft/day]
SECTOR 2	77000	[cbft/day]	SECTOR 2	38500	[cbft/day]

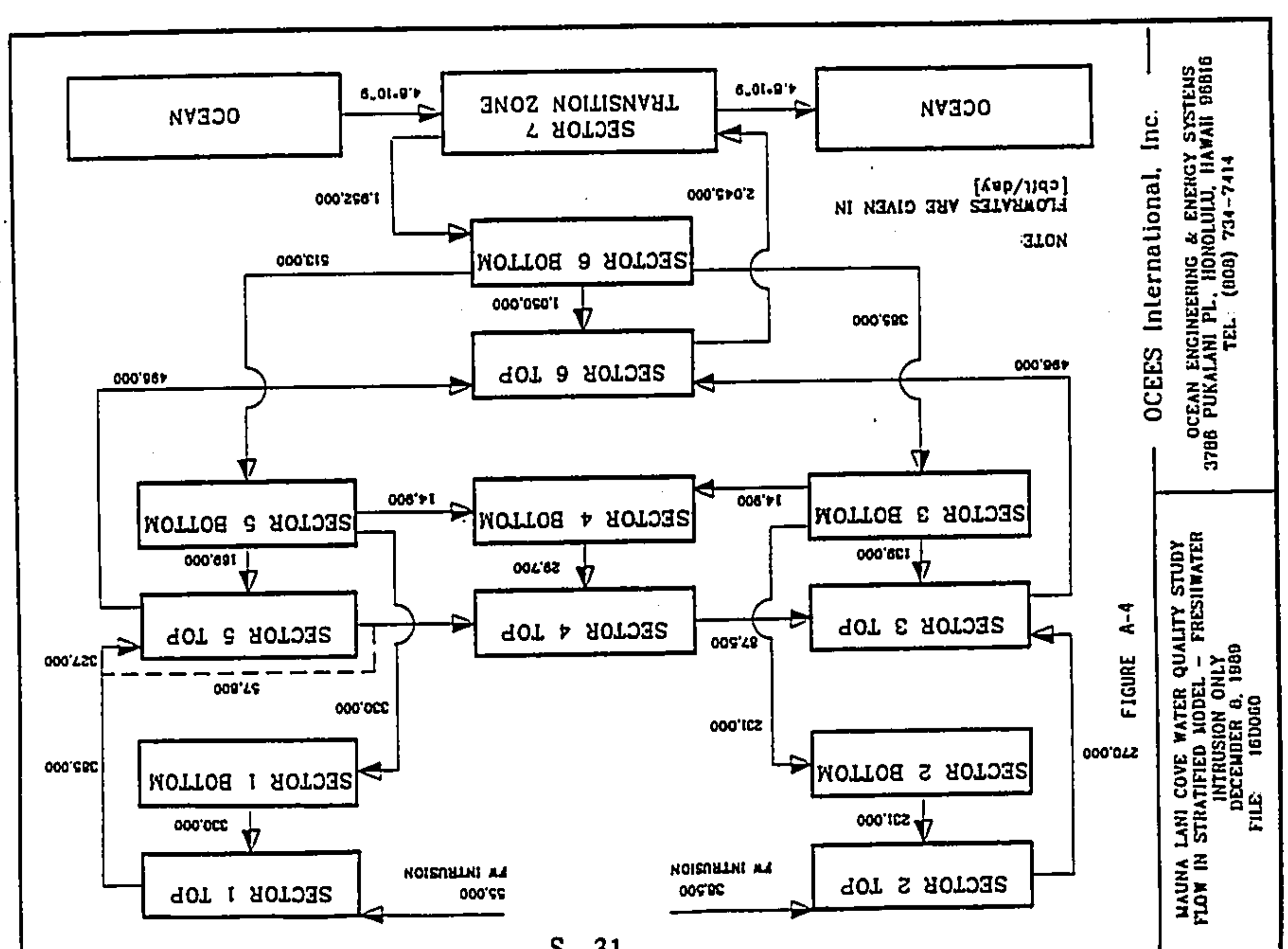
CALCULATION OF FLOWS: (based on 4 MGAL/day/mile)

F12T2B	4.62E+05	[cbft/day]	
OUTFL.TOP2	5.39E+05	[cbft/day]	OUTFLOW FROM TOP OF SECTOR 2
F12B3B	4.62E+05	[cbft/day]	
F11T1B	6.60E+05	[cbft/day]	
OUTFL.TOP1	7.70E+05	[cbft/day]	OUTFLOW FROM TOP OF SECTOR 1
F11B5B	6.60E+05	[cbft/day]	
F14T5T	1.16E+05	[cbft/day]	
F15T1T	6.55E+05	[cbft/day]	
F13T2T	5.39E+05	[cbft/day]	
F14T4B	5.95E+04	[cbft/day]	
F13T4T	1.75E+05	[cbft/day]	
F13T3B	2.78E+05	[cbft/day]	
F16T3T	9.92E+05	[cbft/day]	
F14B3B	2.97E+04	[cbft/day]	
F14B5B	2.97E+04	[cbft/day]	
F15T5B	3.37E+05	[cbft/day]	
F16T5T	9.92E+05	[cbft/day]	
F15B6B	1.03E+06	[cbft/day]	
F13B6B	7.69E+05	[cbft/day]	
F16T6B	2.11E+06	[cbft/day]	
F16BT	3.90E+06	[cbft/day]	
F1T6T	4.09E+06	[cbft/day]	
TRANSITION IN	4.80E+09	[cbft/day]	
TRANSITION OUT	4.80E+09	[cbft/day]	

NOTE:
Flowdefinition:
Example:
F13T3B means flow due to Freshwater injection to sector 3 Top from sector 3 Bottom

TABLE A-4


OCEAN
SECTOR 7 TRANSITION ZONE
OCEAN
SECTOR 6 BOTTOM
SECTOR 6 TOP
SECTOR 5 BOTTOM
SECTOR 4 BOTTOM
SECTOR 3 BOTTOM
SECTOR 5 TOP
SECTOR 4 TOP
SECTOR 3 TOP
SECTOR 1 BOTTOM
SECTOR 2 BOTTOM
SECTOR 1 TOP
SECTOR 2 TOP
FW INTRUSION
NOTE:
FLOWRATES ARE GIVEN IN [cbft/12.45 hours] IN ORDER TO NORMALIZE FLOW TO TWO FLOODCYCLES
FIGURE A-5
OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL: (808) 734-7414
MAUNA LANI COVE WATER QUALITY STUDY
STRATIFIED MODEL - FRESHWATER INTRUS
ONLY - NORMALIZED TO TWO FLOODCYCLES
DECEMBER 8, 1989
FILE 16D080
18


OCEAN
SECTOR 7 TRANSITION ZONE
OCEAN
SECTOR 6 BOTTOM
SECTOR 6 TOP
SECTOR 5 BOTTOM
SECTOR 4 BOTTOM
SECTOR 3 BOTTOM
SECTOR 5 TOP
SECTOR 4 TOP
SECTOR 3 TOP
SECTOR 1 BOTTOM
SECTOR 2 BOTTOM
SECTOR 1 TOP
SECTOR 2 TOP
FW INTRUSION
NOTE:
FLOWRATES ARE GIVEN IN [cbft/day]
FIGURE A-4
OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL: (808) 734-7414
MAUNA LANI COVE WATER QUALITY STUDY
FLOW IN STRATIFIED MODEL - FRESHWATER
INTRUSION ONLY
DECEMBER 8, 1989
FILE 16D060
17

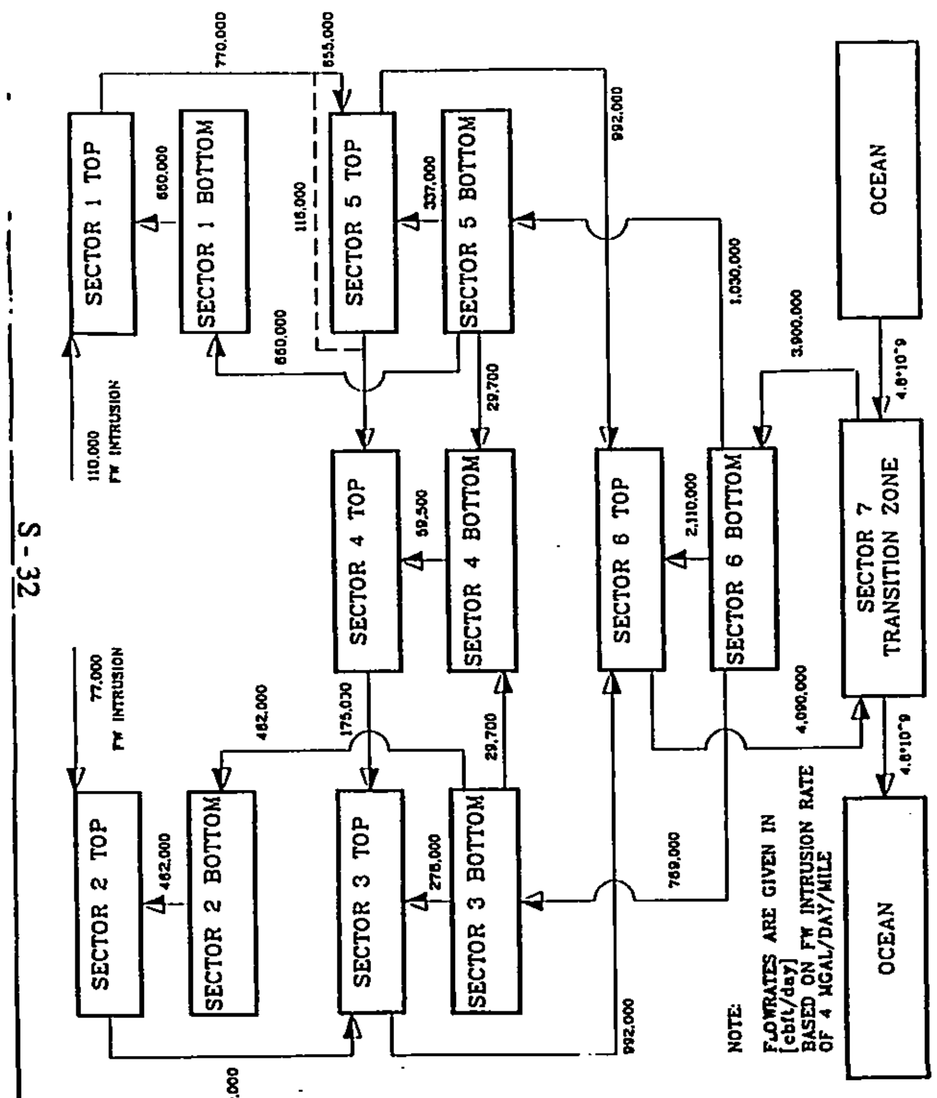


FIGURE A-6

OCEES International, Inc.

MAUNA LANI COVE WATER QUALITY STUDY
FLOW IN STRATIF. MODEL - FW INTRUSION ONLY
ADDENDUM - FW INTRUSION INCREASED
JANUARY 16, 1990 MZ
FILE: 16DA3060

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL.: (808) 734-7414

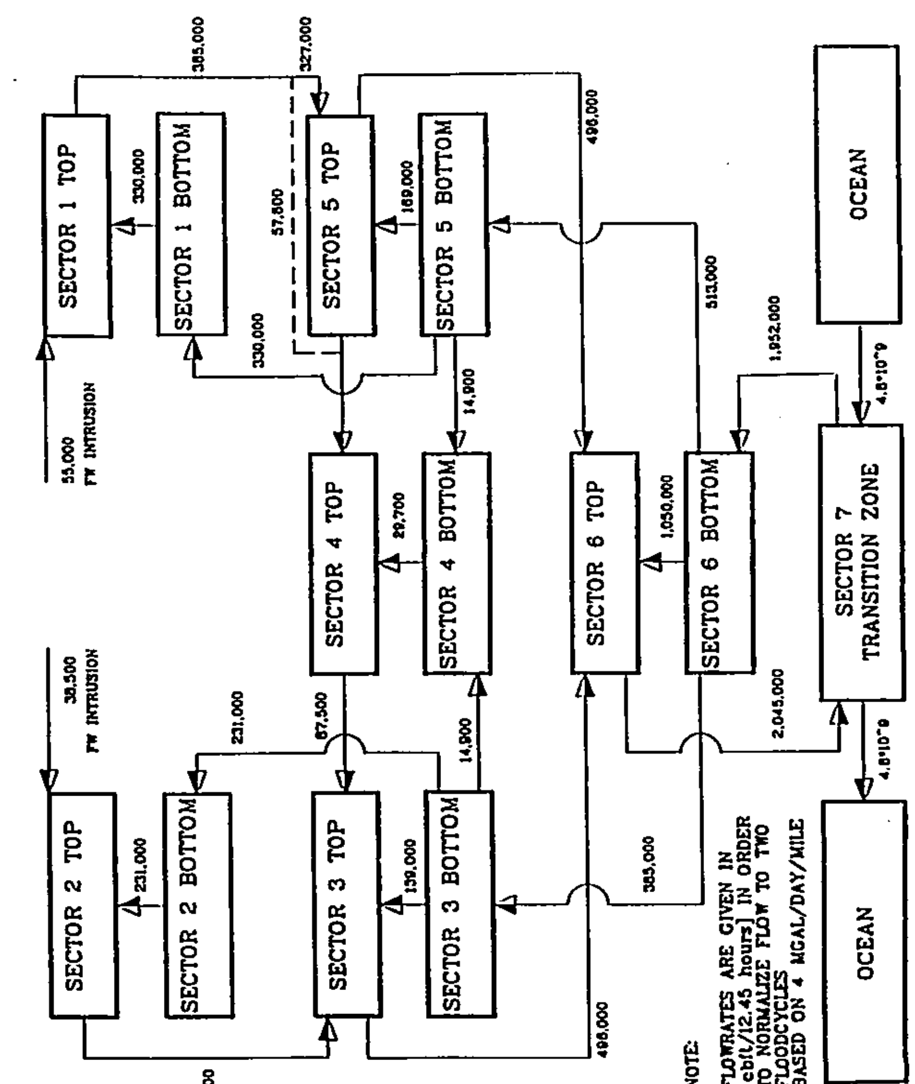


FIGURE A-7

OCEES International, Inc.

MAUNA LANI COVE WATER QUALITY STUDY
FLOW IN STRATIF. MODEL - FW INTRUSION ONLY
FW INTRUSION NORMALIZED TO TWO FLOODCYCLE
ADDENDUM - FW INTRUSION INCREASED
JANUARY 16, 1990 MZ
FILE: 16DA3060

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL.: (808) 734-7414

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16UA1060 PAGE 1

Modification of file 16U060
Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Superposition of FRESHWATER INTRUSION and TIDE
Tide is flowing only in bottom layers
ADDENDUM: CASE 1:
ORIGINAL CONDITION AS IN REPORT

STRATIFICATION 5.00 [ft] TIDAL PRISM: 2.48 [ft/day]

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	[CBFT]	TOPLAYER	[CBFT]
V1B =	3.58E+06	V1T =	1.79E+06
V2B =	6.05E+05	V2T =	6.72E+05
V3B =	1.25E+06	V3T =	6.24E+05
V4B =	4.42E+05	V4T =	4.42E+05
V5B =	1.43E+06	V5T =	7.17E+05
V6B =	1.33E+06	V6T =	5.12E+05
VT =	1.24E+09		

CALCULATION OF FLOWS: [cbft/two floodperiods]

FW. INTRUSION IN SECTOR 1 = 19250.00
FW. INTRUSION IN SECTOR 2 = 27500.00

ST11B5B =	1.05E+06	ST12T2B =	1.16E+05
ST11B2B =	6.85E+04	ST11T1B =	1.65E+05
ST12B3B =	5.17E+05	ST14T5T =	2.89E+04
ST14B5B =	1.23E+05	ST15T1T =	1.64E+05
ST14B3B =	1.12E+05	ST13T2T =	1.35E+05
ST13B6B =	1.01E+06	ST14T4B =	1.49E+04
ST15B6B =	1.55E+06	ST13T4T =	4.38E+04
ST16B7B =	3.34E+06	ST13T3B =	6.95E+04
TRANS.IN =	4.80E+09	ST16T3T =	2.48E+05
		ST15T5B =	8.45E+04
		ST16T5T =	2.48E+05
		ST16T6B =	5.25E+05
		ST1T6T =	1.03E+06

NOTE:
Flowdefinition-Example:
ST13T2B means flow due to Superposition Tide and freshwater Intrusion to sector 3 Top from sector 2 Bottom

TABLE A-5A

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16UA1060 PAGE 2

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Immediate downstream sector

RT1B =	3.2	[days]
RT2B =	1.6	[days]
RT3B =	2.3	[days]
RT4B =	1.9	[days]
RT5B =	3.3	[days]
RT6B =	2.6	[days]
RT1T =	9.7	[days]
RT2T =	4.7	[days]
RT3T =	2.5	[days]
RT4T =	10.1	[days]
RT5T =	2.9	[days]
RT6T =	0.5	[days]
RTTR =	0.3	[days]

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Ocean

RT1BO =	9.4	[days]
RT2BO =	6.7	[days]
RT3BO =	5.1	[days]
RT4BO =	7.5	[days]
RT5BO =	6.1	[days]
RT6BO =	2.9	[days]
RT1TO =	18.1	[days]
RT2TO =	10.1	[days]
RT3TO =	13.6	[days]
RT4TO =	23.8	[days]
RT5TO =	16.9	[days]
RT6TO =	9.4	[days]
RTTRO =	0.3	[days]

TABLE A-5B

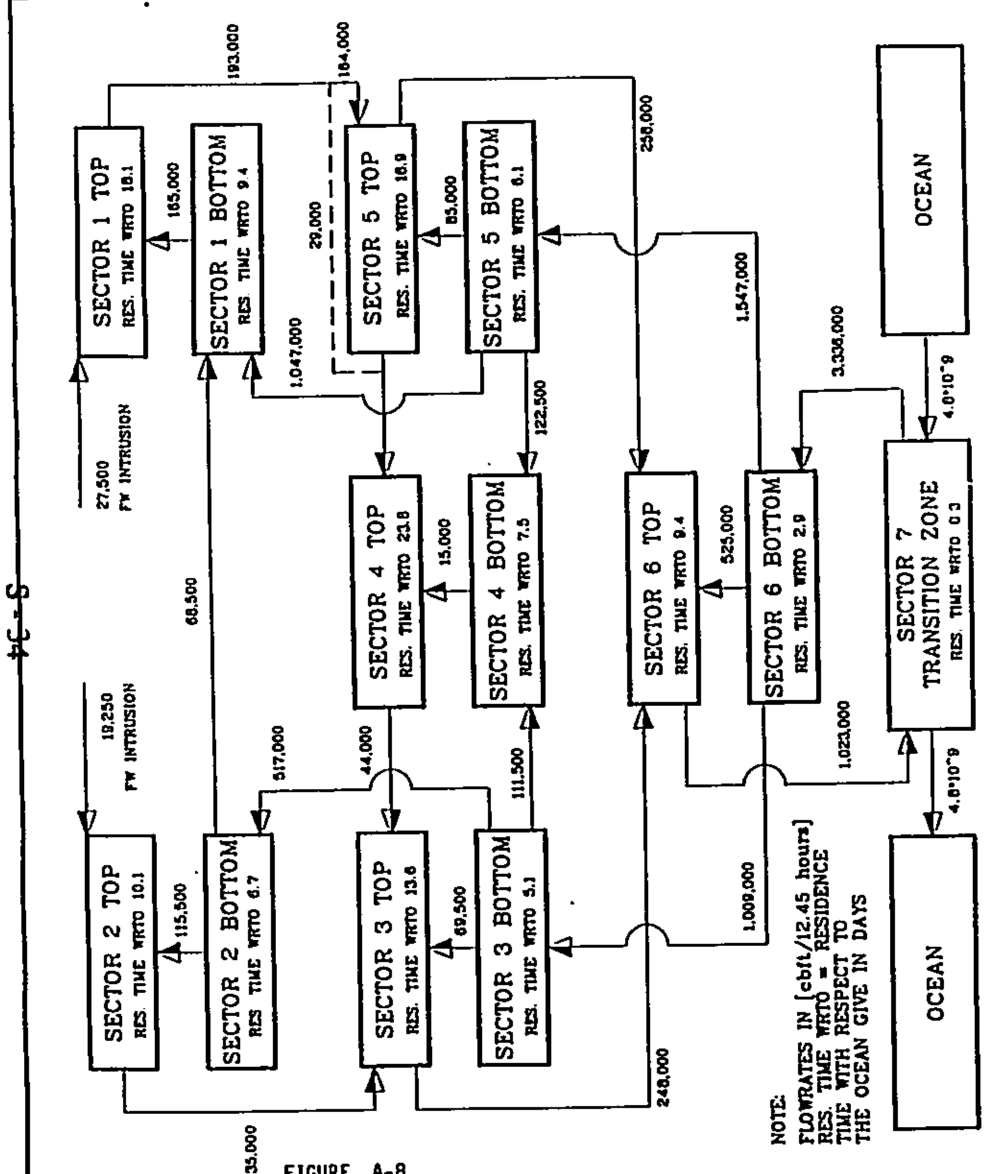


FIGURE A-8

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF.-SUPERPOSITION FW.INTRUS. AND TIDE
RESIDENCE TIMES WITH RESPECT TO OCEAN
ADDENDUM: CASE 1
JANUARY 18, 1990
FILE: 16DA1110

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

NA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16UA2060 PAGE 1

Modification of file 16U060
Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Superposition of FRESHWATER INTRUSION and TIDE
Tide is flowing only in bottom layers
ADDENDUM: CASE 2:
FW INTRUSION IS 2 (Mgal/day/mile) (as in report)
SECTORS OF BOXMODEL 2 FT SHALLOWER

STRATIFICATION 5.00 [ft] TIDAL PRISM: 2.48 [ft/day]

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	[CBFT]	TOPLAYER	[CBFT]
V1B =	2.87E+06	V1T =	1.79E+06
V2B =	3.36E+05	V2T =	6.72E+05
V3B =	9.98E+05	V3T =	6.24E+05
V4B =	2.65E+05	V4T =	4.42E+05
V5B =	1.15E+06	V5T =	7.17E+05
V6B =	1.13E+06	V6T =	5.12E+05
VT =	1.24E+09		

CALCULATION OF FLOWS: [cbft/two floodperiods]

FW. INTRUSION IN SECTOR 1 = 19250.00
FW. INTRUSION IN SECTOR 2 = 27500.00

ST1185B =	1.06E+06	ST1212B =	1.16E+05
ST1182B =	0.00E+00	ST1111B =	1.65E+05
ST1283B =	4.50E+05	ST1415T =	2.89E+04
ST1485B =	1.22E+05	ST1511T =	1.64E+05
ST1483B =	1.11E+05	ST1312T =	1.35E+05
ST1386B =	9.41E+05	ST1414B =	1.49E+04
ST1586B =	1.62E+06	ST1314T =	4.38E+04
ST1687B =	3.34E+06	ST1313B =	6.95E+04
TRANS.IN =	4.80E+09	ST1613T =	2.48E+05
		ST1515B =	8.45E+04
		ST1615T =	2.48E+05
		ST1616B =	5.25E+05
		ST116T =	1.03E+06

NOTE:
Flowdefinition-Example:
ST1312B means flow due to Superposition Tide and freshwater intrusion to sector 3 Top from sector 2 Bottom

TABLE A-6A

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16UA2060 PAGE 2

CALCULATION OF RESIDENCE TIMES:			CALCULATION OF RESIDENCE TIMES:		
With respect to (WRT) Immediate downstream sector			With respect to (WRT) Ocean		
RT1B =	2.7	(days)	RT1BO =	7.6	(days)
RT2B =	0.7	(days)	RT2BO =	4.6	(days)
RT3B =	1.6	(days)	RT3BO =	3.8	(days)
RT4B =	1.1	(days)	RT4BO =	5.5	(days)
RT5B =	2.6	(days)	RT5BO =	4.8	(days)
RT6B =	2.0	(days)	RT6BO =	2.3	(days)
RT1T =	9.7	(days)	RT1TO =	16.5	(days)
RT2T =	4.7	(days)	RT2TO =	8.4	(days)
RT3T =	2.5	(days)	RT3TO =	12.1	(days)
RT4T =	10.1	(days)	RT4TO =	22.1	(days)
RT5T =	2.9	(days)	RT5TO =	15.4	(days)
RT6T =	0.5	(days)	RT6TO =	8.3	(days)
RT7R =	0.3	(days)	RT7RO =	0.3	(days)

TABLE A-6B

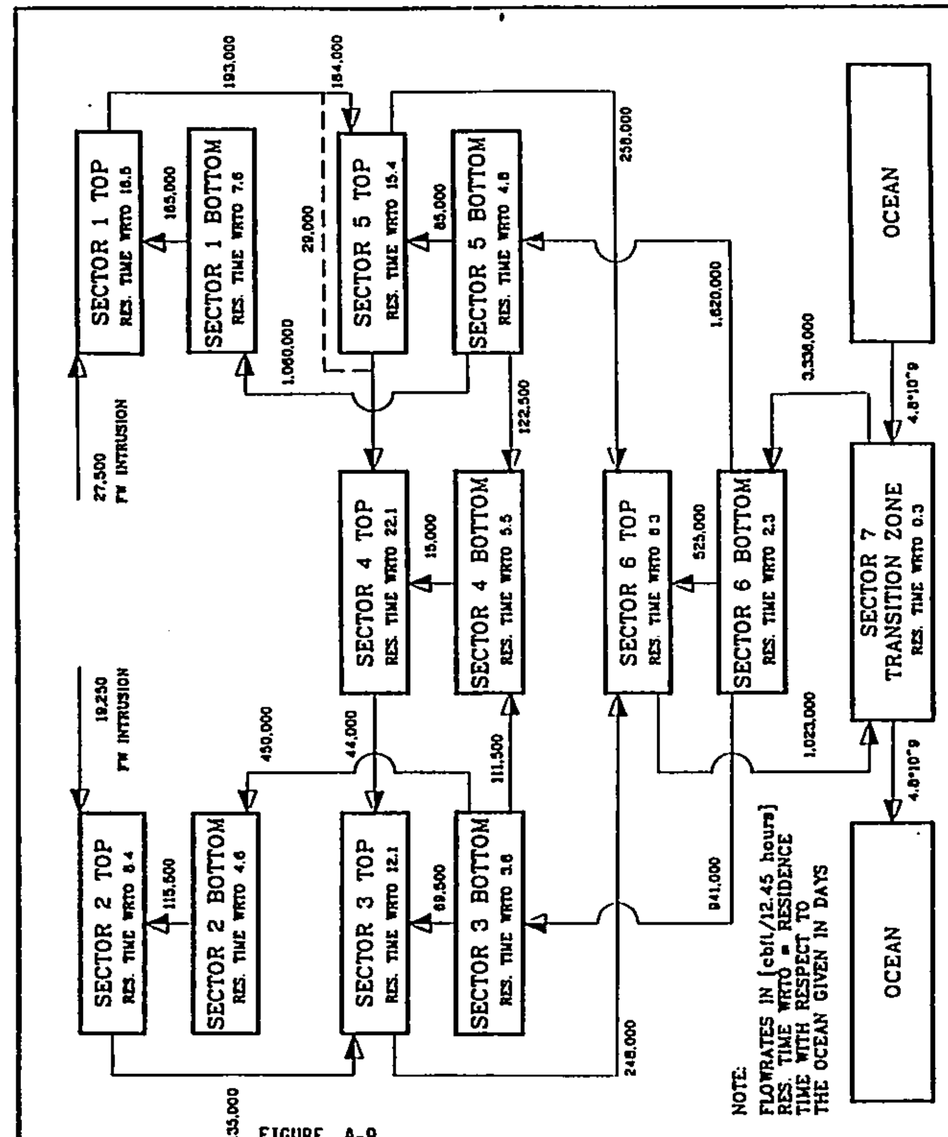


FIGURE A-9

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF.-SUPERPOSITION FW.INTRUS. AND TIDE
RESIDENCE TIMES WITH RESPECT TO OCEAN
ADDENDUM CASE 2
JANUARY 18, 1990
FILE: 16DA2110

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3706 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

FILE: 16WA3060 PAGE 1

Modification of file 16W060
Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Superposition of FRESHWATER INTRUSION and TIDE
Tide is flowing only in bottom layers
ADDENDUM: CASE 3:
FW INTRUSION IS 4 [Mgal/day/mile]
SECTORS OF BOXMODEL HAVE ORIGINAL DEPTH (as in report)

STRATIFICATION 5.00 [ft] TIDAL PRISM: 2.48 [ft/day]

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	[CBFT]	TOPLAYER	[CBFT]
V1B =	3.58E+06	V1T =	1.79E+06
V2B =	6.05E+05	V2T =	6.72E+05
V3B =	1.25E+06	V3T =	6.24E+05
V4B =	4.42E+05	V4T =	4.42E+05
V5B =	1.43E+06	V5T =	7.17E+05
V6B =	1.33E+06	V6T =	5.12E+05
VT =	1.24E+09		

CALCULATION OF FLOWS: [cbft/two floodperiods]

FW. INTRUSION IN SECTOR 1 = 38500.00
FW. INTRUSION IN SECTOR 2 = 55000.00

ST11B5B =	1.22E+06	ST1212B =	2.31E+05
ST11B2B =	6.85E+04	ST111T1B =	3.30E+05
ST12B3B =	6.33E+05	ST1415T =	5.80E+04
ST14B5B =	1.30E+05	ST1511T =	3.28E+05
ST14B3B =	1.19E+05	ST1312T =	2.70E+05
ST13B6B =	1.20E+06	ST1414B =	2.98E+04
ST15B6B =	1.81E+06	ST1314T =	8.75E+04
ST16B7B =	4.31E+06	ST1313B =	1.39E+05
TRANS.IN =	4.80E+09	ST1613T =	4.96E+05
		ST1515B =	1.69E+05
		ST1615T =	4.96E+05
		ST1616B =	1.06E+06
		ST116T =	2.05E+06

NOTE:
Flowdefinition-Example:
ST13T2B means flow due to Superposition Tide and freshwater Intrusion to sector 3 Top from sector 2 Bottom

TABLE A-7A

FILE: 16WA3060 PAGE 2

CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Immediate downstream sector			CALCULATION OF RESIDENCE TIMES: With respect to (WRT) Ocean		
RT1B =	2.8	[days]	RT1BO =	7.9	[days]
RT2B =	1.3	[days]	RT2BO =	5.4	[days]
RT3B =	1.9	[days]	RT3BO =	4.1	[days]
RT4B =	1.8	[days]	RT4BO =	6.4	[days]
RT5B =	2.8	[days]	RT5BO =	5.1	[days]
RT6B =	2.0	[days]	RT6BO =	2.3	[days]
RT1T =	5.1	[days]	RT1TO =	12.5	[days]
RT2T =	2.6	[days]	RT2TO =	7.4	[days]
RT3T =	1.3	[days]	RT3TO =	9.1	[days]
RT4T =	5.0	[days]	RT4TO =	14.8	[days]
RT5T =	1.4	[days]	RT5TO =	11.5	[days]
RT6T =	0.3	[days]	RT6TO =	6.4	[days]
RTTR =	0.3	[days]	RTTRO =	0.3	[days]

TABLE A-7B

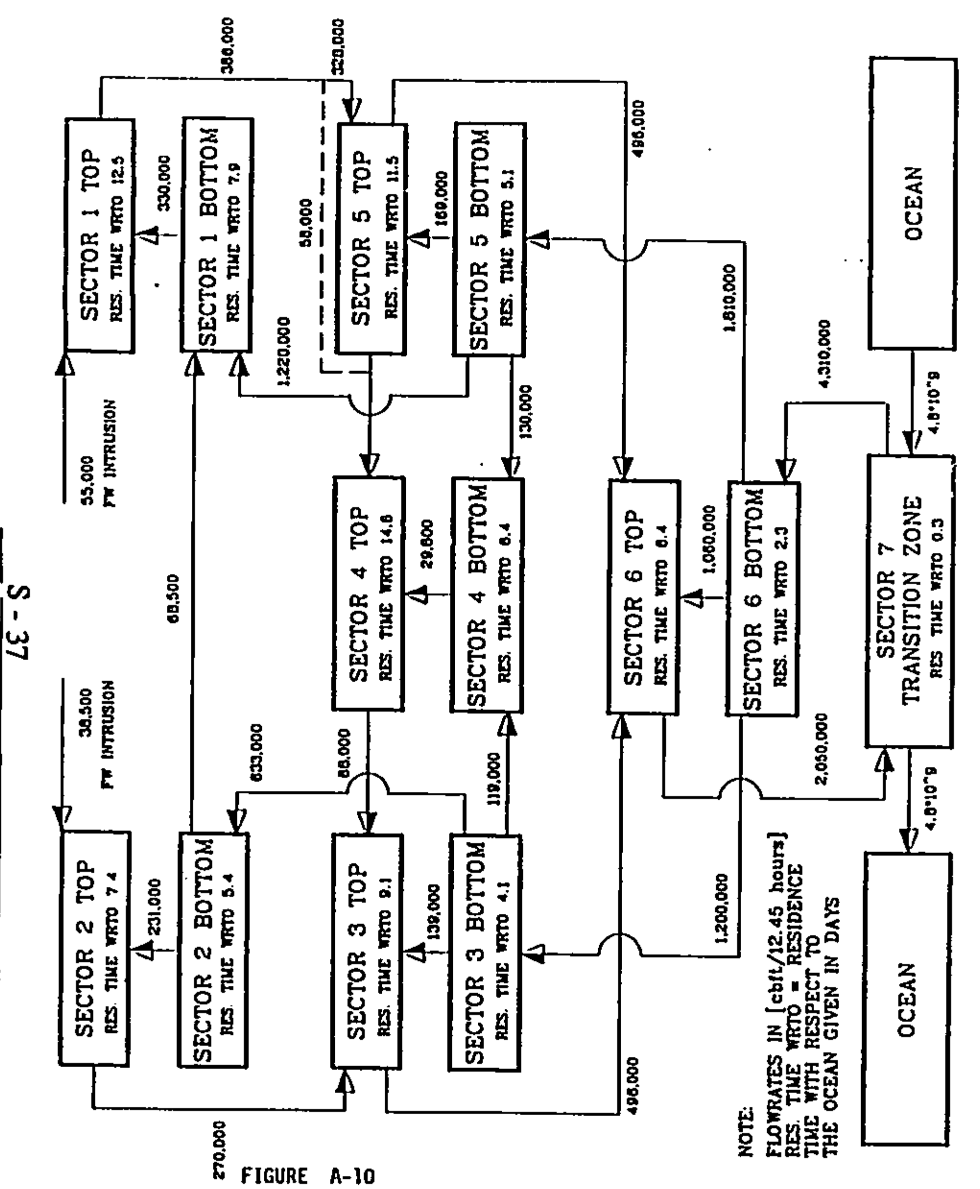


FIGURE A-10

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF.-SUPERPOSITION FW.INTRUS. AND TIDE
RESIDENCE TIMES WITH RESPECT TO OCEAN
ADDENDUM: CASE 3
JANUARY 18, 1990
FILE: 16DA3110

OCEES International, Inc.

OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

S - 37

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16WA6060 PAGE 1

Modification of file 16W060
Calculation of residence times of BOXMODEL 2 - STRATIFIED Watercolumns
Superposition of FRESHWATER INTRUSION and TIDE
Tide is flowing only in bottom layers
ADDENDUM: CASE 4:
FW INTRUSION IS 4 [Mgal/day/mile]
SECTORS OF BOXMODEL 2 FT SHALLOWER

STRATIFICATION 5.00 [ft] TIDAL PRISM: 2.48 [ft/day]

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	[CBFT]	TOPLAYER	[CBFT]
V1B =	2.87E+06	V1T =	1.79E+06
V2B =	3.36E+05	V2T =	6.72E+05
V3B =	9.98E+05	V3T =	6.24E+05
V4B =	2.65E+05	V4T =	4.42E+05
V5B =	1.15E+06	V5T =	7.17E+05
V6B =	1.13E+06	V6T =	5.12E+05
VT =	1.24E+09		

CALCULATION OF FLOWS: [cbft/two floodperiods]

FW. INTRUSION IN SECTOR 1 = 38500.00
FW. INTRUSION IN SECTOR 2 = 55000.00

ST11B5B =	1.22E+06	ST12T2B =	2.31E+05
ST11B2B =	0.00E+00	ST11T1B =	3.30E+05
ST12B3B =	5.65E+05	ST14T5T =	5.80E+04
ST14B5B =	1.30E+05	ST15T1T =	3.28E+05
ST14B3B =	1.19E+05	ST13T2T =	2.70E+05
ST13B6B =	1.13E+06	ST14T4B =	2.98E+04
ST15B6B =	1.87E+06	ST13T4T =	8.75E+04
ST16B7B =	4.31E+06	ST13T3B =	1.39E+05
TRANS.IN =	4.80E+09	ST16T3T =	4.96E+05
		ST15T5B =	1.69E+05
		ST16T5T =	4.96E+05
		ST16T6B =	1.06E+06
		ST1T6T =	2.05E+06

NOTE:
Flowdefinition-Example:
ST13T2B means flow due to Superposition Tide and freshwater Intrusion to sector 3 Top from sector 2 Bottom

TABLE A-8A

MAUNA LANI COVE WATERQUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16MA4060 PAGE 2

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Immediate downstream sector

RT1B =	2.4	(days)
RT2B =	0.6	(days)
RT3B =	1.3	(days)
RT4B =	1.1	(days)
RT5B =	2.2	(days)
RT6B =	1.6	(days)
RT1T =	4.9	(days)
RT2T =	2.3	(days)
RT3T =	1.3	(days)
RT4T =	5.0	(days)
RT5T =	1.4	(days)
RT6T =	0.3	(days)
RT7R =	0.3	(days)

CALCULATION OF RESIDENCE TIMES:

With respect to (WRT)
Ocean

RT1BO =	6.4	(days)
RT2BO =	3.7	(days)
RT3BO =	3.1	(days)
RT4BO =	4.7	(days)
RT5BO =	4.0	(days)
RT6BO =	1.8	(days)
RT1TO =	10.6	(days)
RT2TO =	5.3	(days)
RT3TO =	7.3	(days)
RT4TO =	13.1	(days)
RT5TO =	9.8	(days)
RT6TO =	5.3	(days)
RT7RO =	0.3	(days)

TABLE A-8B

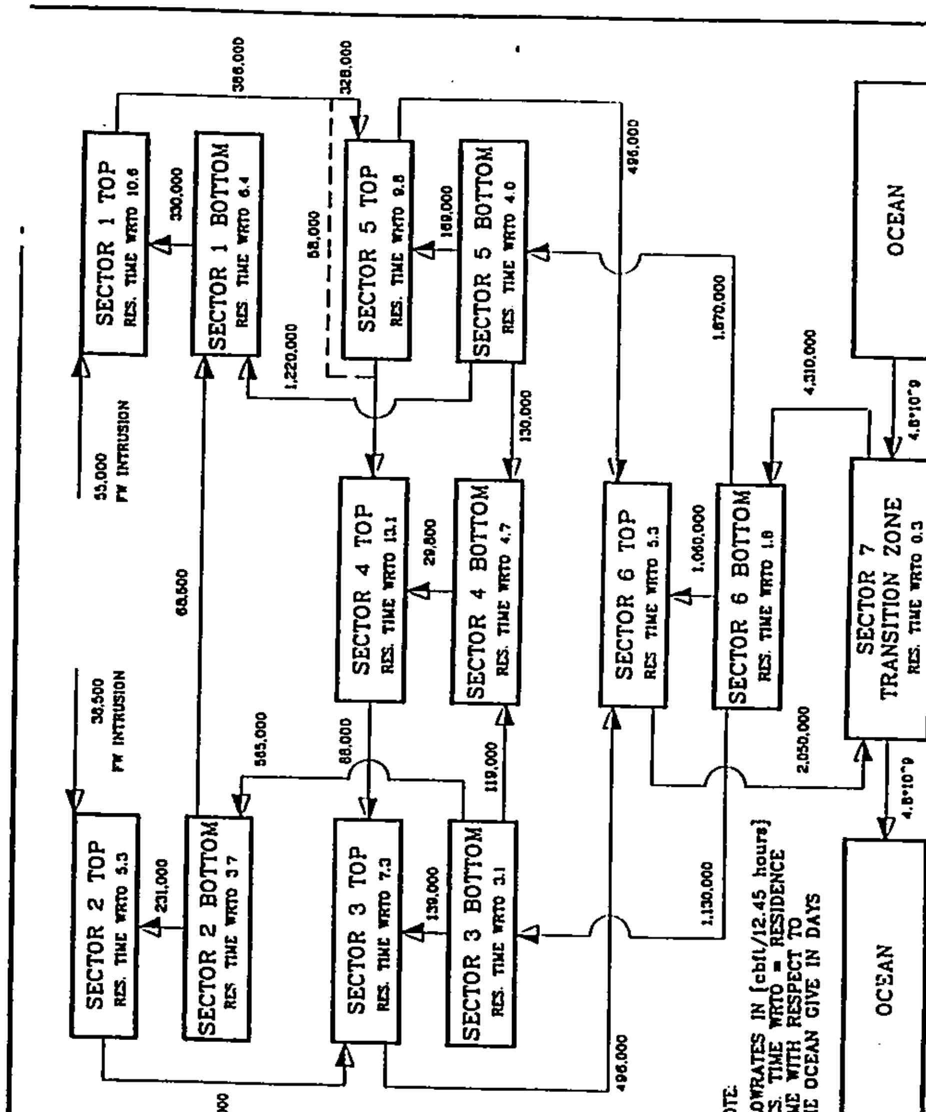


FIGURE A-11

MAUNA LANI COVE WATER QUALITY STUDY
STRATIF.-SUPERPOSITION FW.INTRUS. AND TIDE
RESIDENCE TIMES WITH RESPECT TO OCEAN
ADDENDUM: CASE 4
JANUARY 18, 1990
FILE: 16DA4110

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

MAUNA LANI COVE WATER QUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16A090 PAGE 1

ADDENDUM:
Summary of results for residence times

RESIDENCE TIMES:

With respect to (URT) OCEAN in [days] :

		CASE 1	CASE 2	CASE 3	CASE 4
SECTOR 1	BOTTOM LAYER	9.40	7.60	7.90	6.40
SECTOR 2	BOTTOM LAYER	6.70	4.60	5.40	3.70
SECTOR 3	BOTTOM LAYER	5.10	3.80	4.10	3.10
SECTOR 4	BOTTOM LAYER	7.50	5.50	6.40	4.70
SECTOR 5	BOTTOM LAYER	6.10	4.80	5.10	4.00
SECTOR 6	BOTTOM LAYER	2.90	2.30	2.30	1.80
SECTOR 1	TOP LAYER	18.10	16.50	12.50	10.60
SECTOR 2	TOP LAYER	10.10	8.40	7.40	5.30
SECTOR 3	TOP LAYER	13.60	12.10	9.10	7.30
SECTOR 4	TOP LAYER	23.80	22.10	14.80	13.10
SECTOR 5	TOP LAYER	16.90	15.40	11.50	9.80
SECTOR 6	TOP LAYER	9.40	8.30	6.40	5.30
TRANSITION ZONE		0.30	0.30	0.30	0.30

TABLE A-9A

MAUNA LANI COVE WATER QUALITY STUDY-ADDENDUM OCEES, Intern., INC JANUARY 1990

FILE: 16A090 PAGE 2

ADDENDUM:
Summary of results for residence times

RESIDENCE TIMES:

With respect to (URT) OCEAN in [days] :

	CASE 1	CASE 2	CASE 3	CASE 4
SECTOR 1 BOTTOM LAYER	9.40	7.60	7.90	6.40
SECTOR 1 TOP LAYER	18.10	16.50	12.50	10.60
SECTOR 2 BOTTOM LAYER	6.70	4.60	5.40	3.70
SECTOR 2 TOP LAYER	10.10	8.40	7.40	5.30
SECTOR 3 BOTTOM LAYER	5.10	3.80	4.10	3.10
SECTOR 3 TOP LAYER	13.60	12.10	9.10	7.30
SECTOR 4 BOTTOM LAYER	7.50	5.50	6.40	4.70
SECTOR 4 TOP LAYER	23.80	22.10	14.80	13.10
SECTOR 5 BOTTOM LAYER	6.10	4.80	5.10	4.00
SECTOR 5 TOP LAYER	16.90	15.40	11.50	9.80
SECTOR 6 BOTTOM LAYER	2.90	2.30	2.30	1.80
SECTOR 6 TOP LAYER	9.40	8.30	6.40	5.30
TRANSITION ZONE	0.30	0.30	0.30	0.30

TABLE A-9B

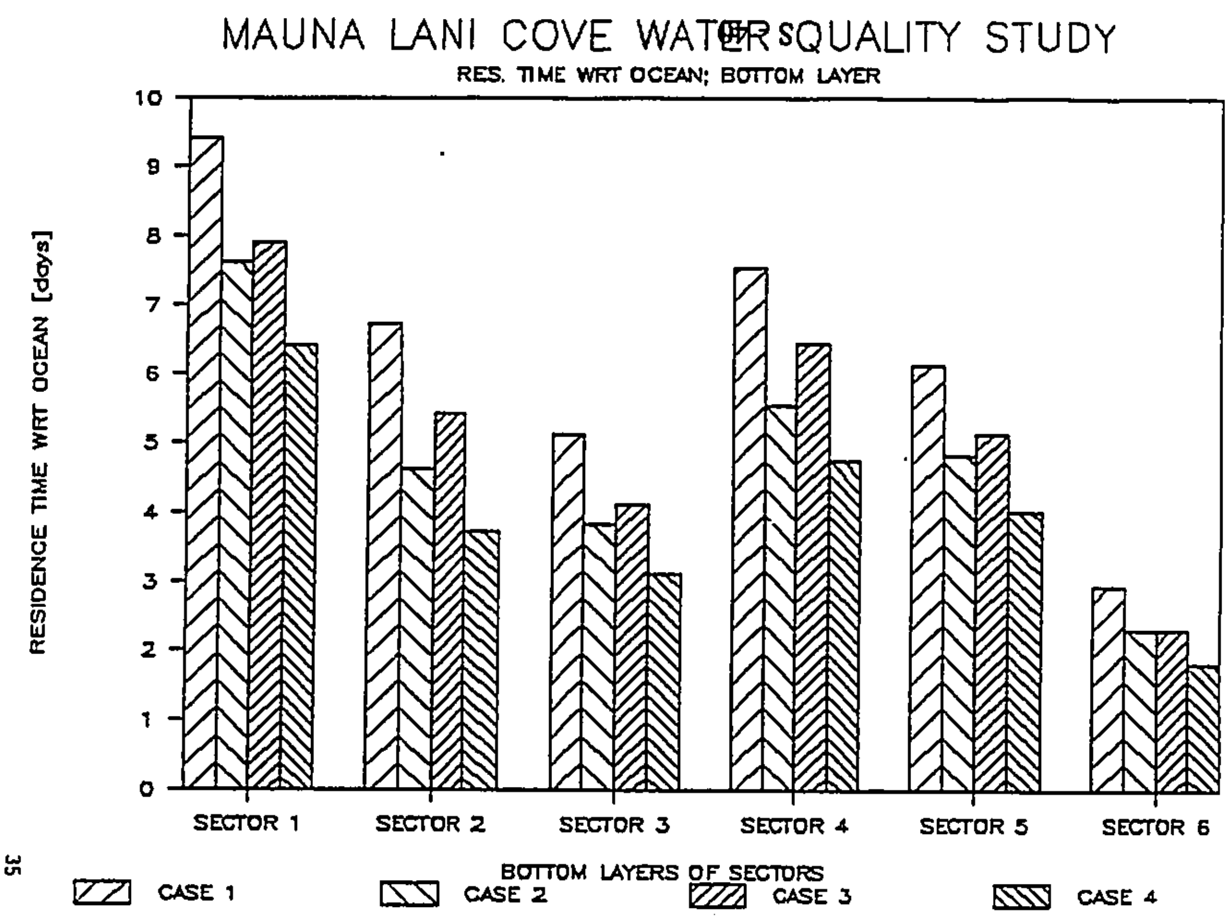


FIGURE A-12

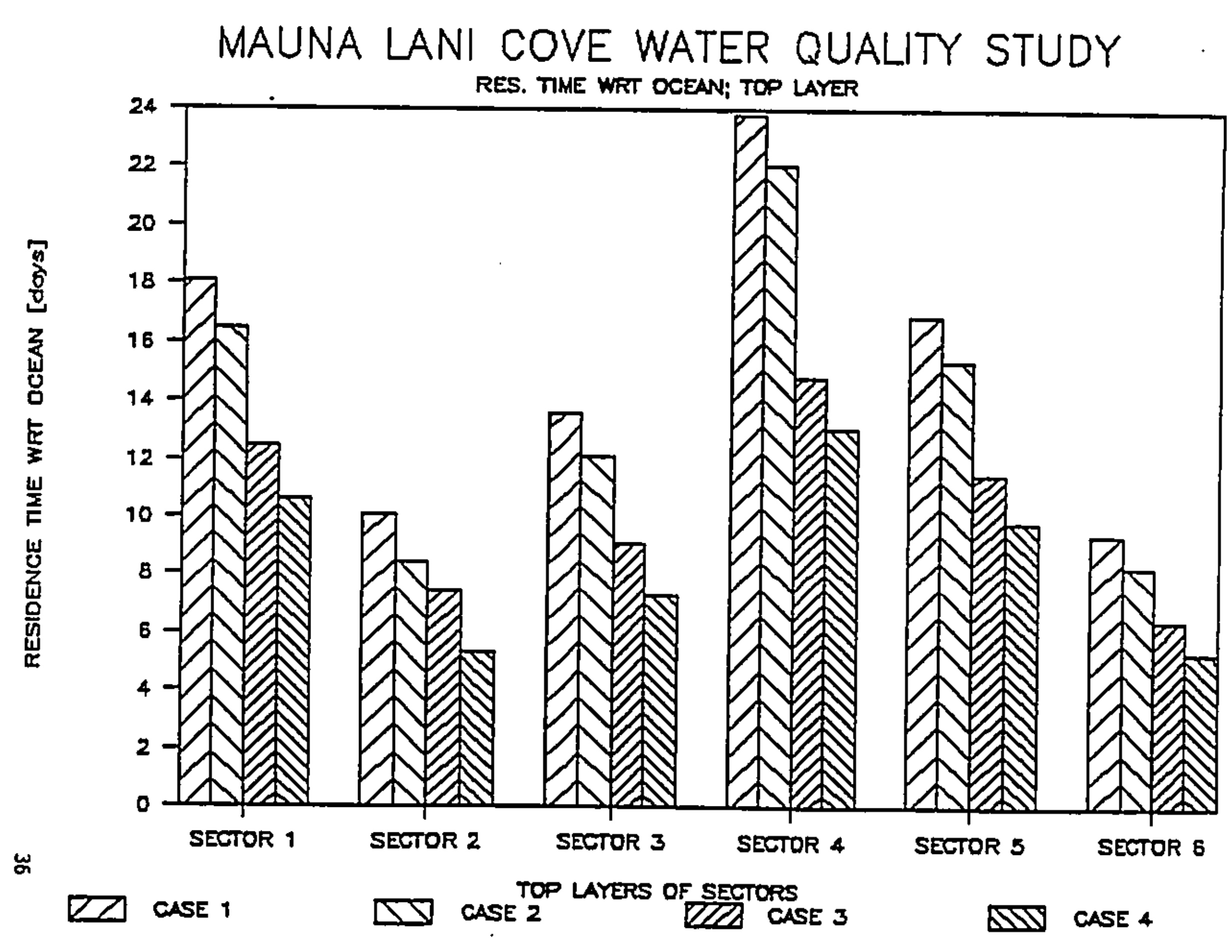


FIGURE A-13

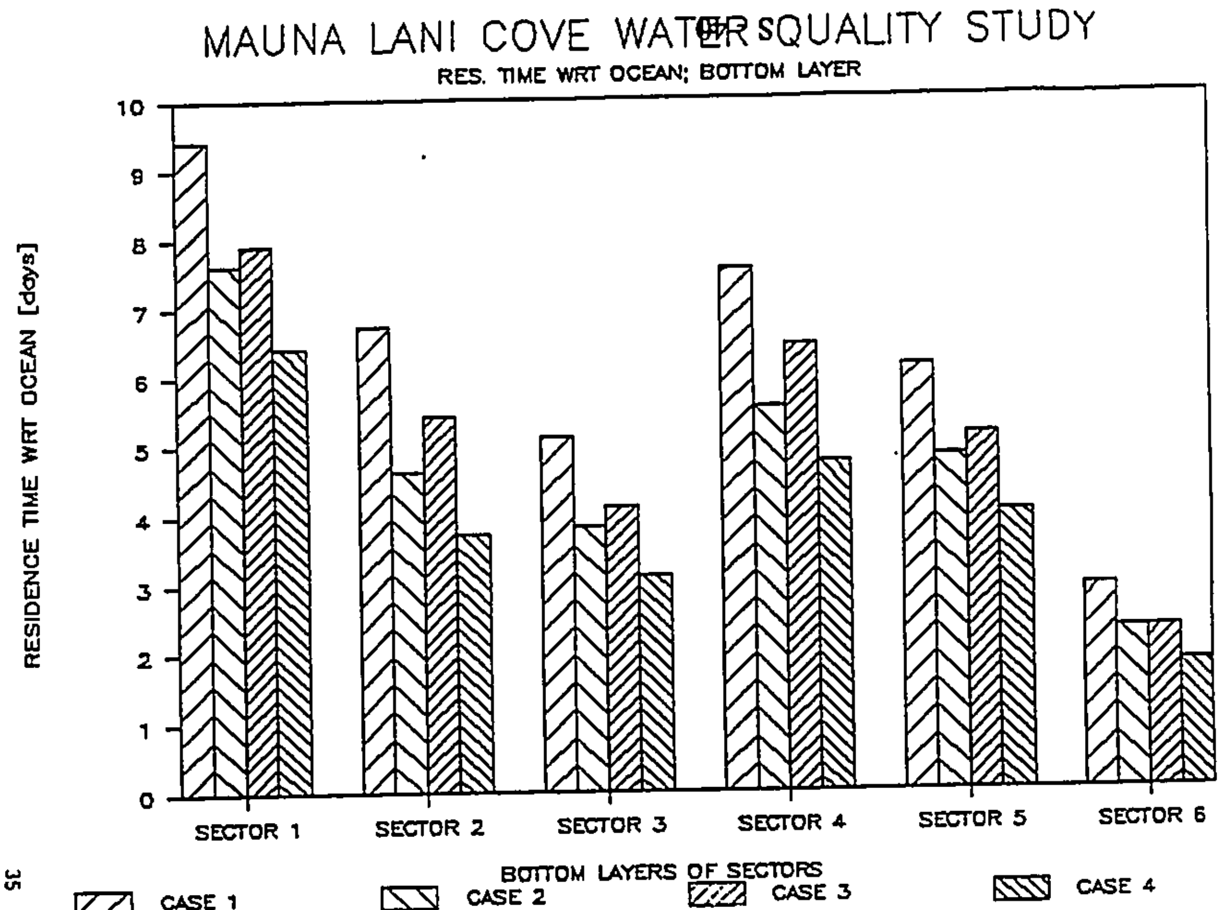


FIGURE A-12

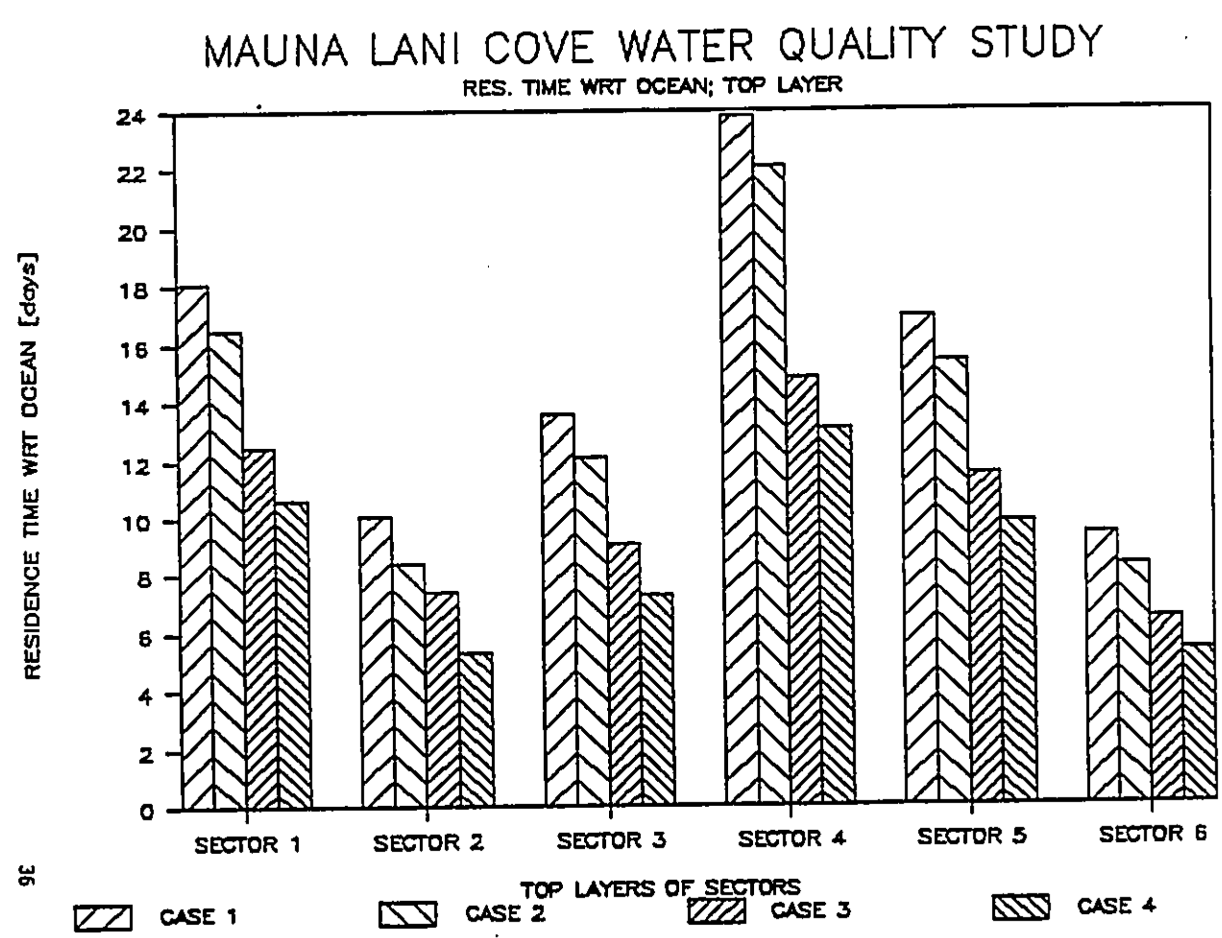


FIGURE A-13

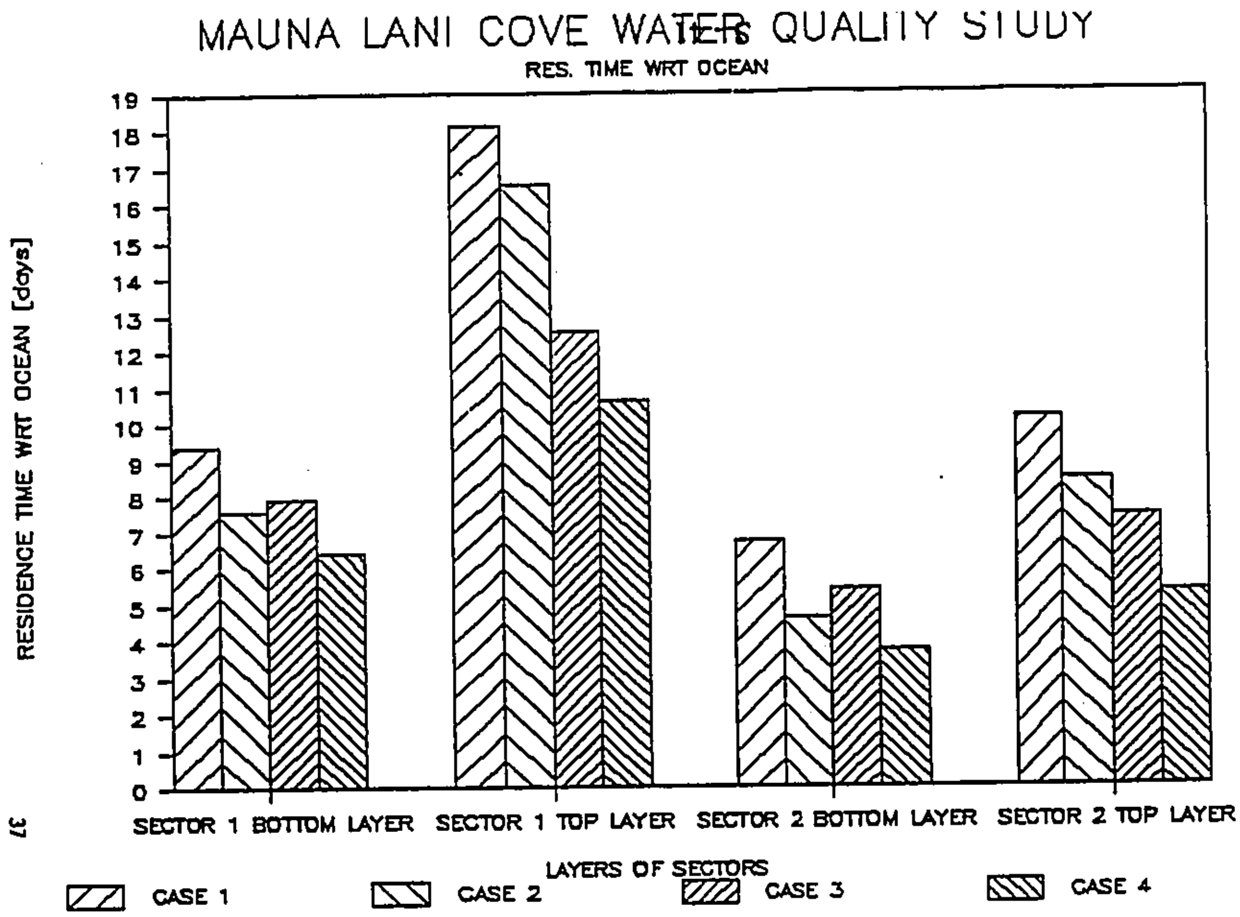


FIGURE A-14

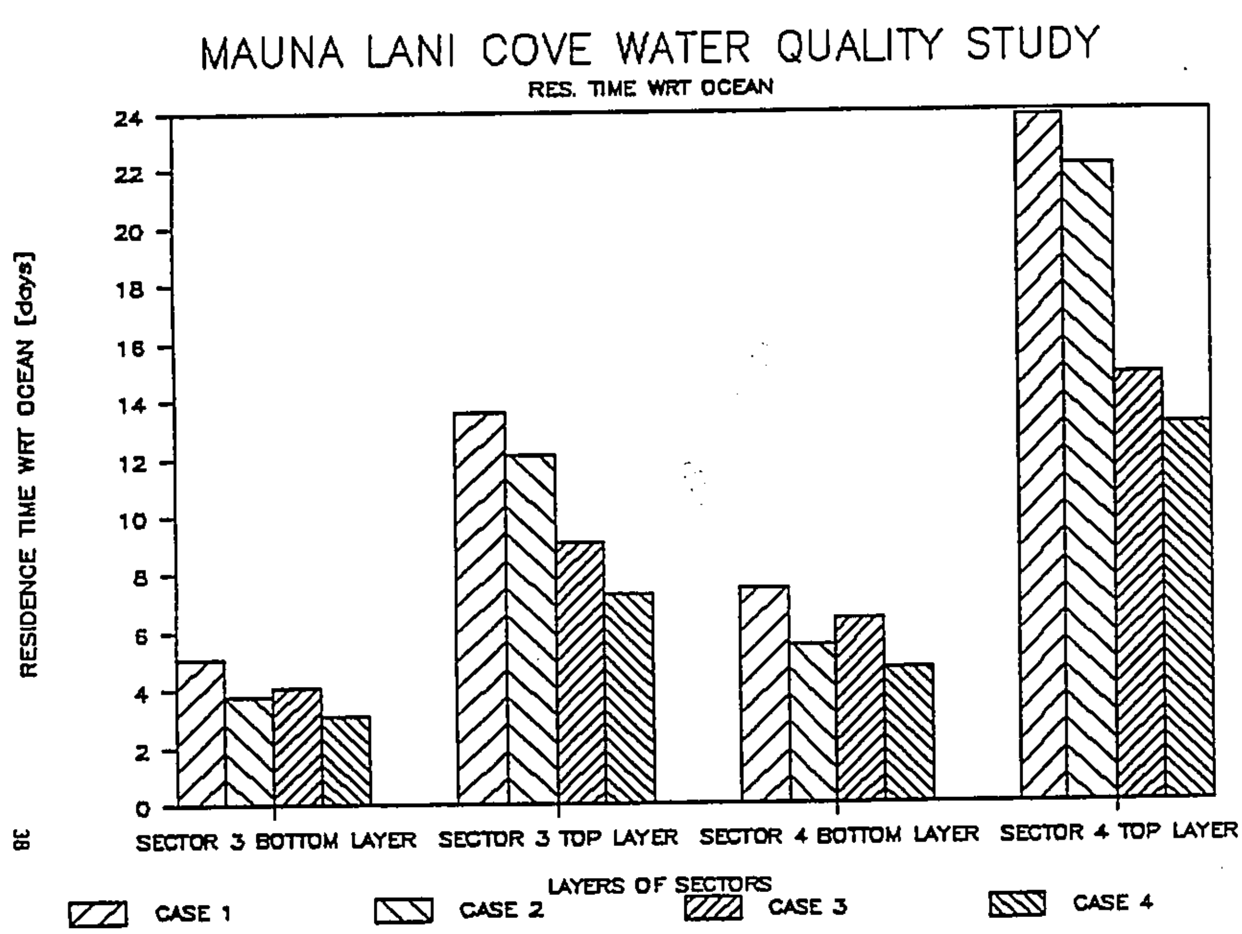


FIGURE A-16

MAUNA LANI COVE WATER QUALITY STUDY

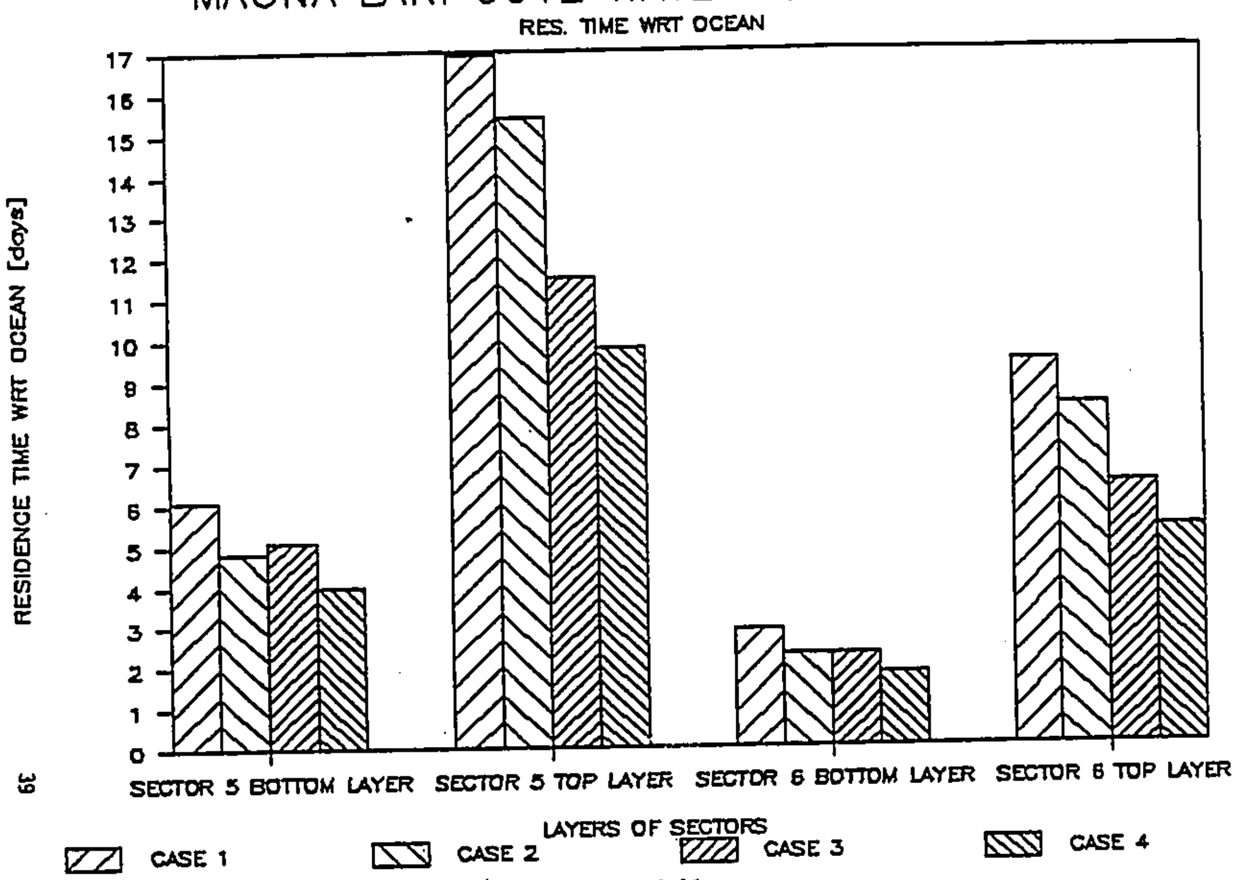


FIGURE A-16

ESTIMATED WATER QUALITY IMPACT
OF THE PROPOSED
MAUNA LANI COVE

PREPARED FOR:

Peratrovich, Nottingham and Drage, Inc.
100 Eastlake Avenue East, Suite 310
Seattle, Washington 98109

PREPARED BY:

OCEES International, Inc.
3786 Pukalani Place
Honolulu, Hawaii 96816

October 1990

PREFACE

This is a preliminary evaluation of the quality of the water that would exit the proposed Mauna Lani Cove. The applicable Hawaii Department of Health Water Quality Standards are used as the basis of comparison. The results of the study "Water Quality And Exchange Characteristics Of Mauna Lani Cove" by OCEES International, Inc. are used as a starting point in this preliminary evaluation. A more complete evaluation will be available shortly.

BACKGROUND

The most important factors influencing the quality of the water that would enter the ocean from the proposed Mauna Lani Cove are the following:

(1) The ambient coastal water quality.

(2) The quality and quantity of the water entering from the land side.

(3) The residence time characteristics of the cove sectors.

(4) The amount and type of discharges from boats.

The ambient coastal water is characterized by low turbidity which is primarily due to very little surface runoff. This means that only very small amounts of land erosion products reach coastal waters and that very little of the primary nutrient, phosphorus, enters from the land. There is, however, a significant discharge of groundwater. This amounts to more than the 3 MGD per mile of coastline dividing line between "wet" and "dry" water quality standards classifications. The groundwater does contain enough of the nutrient, nitrogen, to sometimes cause the standard for Total Nitrogen to be exceeded in the ambient coastal waters. This condition, however, does not cause a deterioration in the water quality because phosphorus, which does not readily move with the groundwater, is the limiting nutrient along this coastline. All of this means that control of the aesthetically pleasing water quality here is primarily dependent on limiting surface runoff and phosphorus input.

The amount of groundwater expected to enter the proposed cove will temporarily be greater than that presently entering the ocean from this coastal area because the flow net will adjust to the effective relocation of the shoreline. After this adjustment period of a few days or a few weeks, however, the amount of fresh water entering the general coastal area will be the same as without the proposed Mauna Lani Cove. The quality of the water entering the ocean from the cove will be influenced by the amount of planktonic growth within the cove. If the influx of phosphorus can be minimized by diverting surface runoff and avoiding the pumping alternative involving taking water from the pond then the growth rate of phytoplankton within the cove can be kept to a minimum.

The residence time of water within the various sectors of the cove defines the amount of time available for plankton growth and subsequent turbidity increase. The previous study results showed that the groundwater flow is large enough to result in the development of a two layer system. The top layer of this system would be flowing outward during both flood and ebb tide and would constitute the net discharge component of the system. The bottom layer would reverse flow with tidal changes but would have a net landward flow because of the upward mixing of salt water to the top layer. The residence time conditions that are considered here are those associated with no additional pumping of either pond water or ocean water. These pumping alternatives did not alter the residence times of the upper layer significantly and the pumping alternative from the pond would very likely cause a decrease in the water quality entering the ocean from the cove.

Potential water quality effects from boats include those associated with drydock discharges, leaching of bottom paint, hydrocarbon spills, and wastewater and debris discharges. Limiting these influences to the point where they do not constitute a water quality problem can be accomplished by enforcement of a no discharge policy and maintaining a spill response capability.

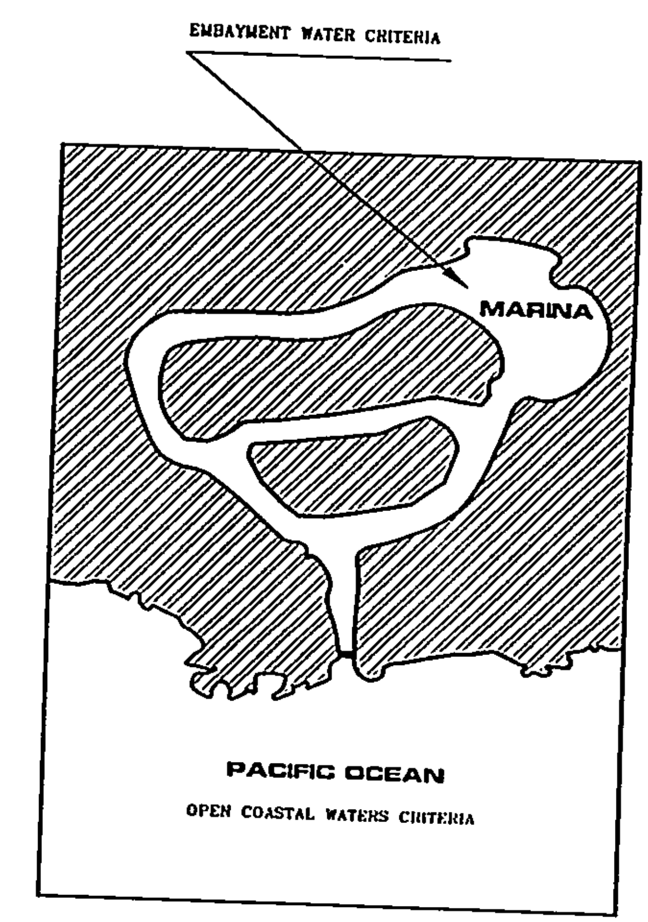
WATER QUALITY EVALUATION

The residence time with respect to the ocean of the water entering the transition zone from the top layer of the Mauna Lani Cove entrance channel is estimated to be an average of about 9.4 days. With an initial concentration of 0.15 ug/l chlorophyll-a and a net growth rate of 0.06 per day the expected geometric mean concentration of chlorophyll-a entering the coastal waters from the cove is 0.26 ug/l with no additional dilution. This means that the water leaving the cove already meets the water quality standard of 0.30 ug/l chlorophyll-a specified for open coastal waters receiving more than 3 MGD of fresh water per shoreline mile. For the two or three days per year when significant amounts of storm runoff might enter the cove the net growth rate is expected to increase to 0.25 per day due to the addition of phosphorus the water entering the coastal waters from the cove is expected to contain about 1.57 ug/l chlorophyll-a which is less than the 1.75 ug/l level allowed 2 percent of the time.

A general map of the Mauna Lani Cove area and associated water quality standard zones is shown in Figure 1. The calculations supporting the applicability of the "wet" criteria for both the embayment standards within the cove and the open coastal area adjacent to the cove are shown in Table 1. Tables 2 and 3 are a listing of the water quality criteria for open coastal and embayment waters respectively.

Since the turbidity of the water along this coast line is primarily a function of the plankton concentration and since that is expected to meet the state standards the turbidity levels are also going to meet or exceed the standards. The ambient turbidity along this coast is about 0.14 NTU which is significantly better than the 0.50 NTU geometric mean allowed in the standards.

The other water quality standards are also all expected to be met with the possible exception of the geometric mean for total



MAUNA LANI COVE WQ COMPARISION STUDY
HAWAII WQ STANDARDS CRITERIA
AUGUST 10, 1990 MZ
FILE: 19D0010

OCEES International, Inc.
OCEAN ENGINEERING & ENERGY SYSTEMS
3786 PUKALANI PL., HONOLULU, HAWAII 96816
TEL. (808) 734-7414

MAUNA LANI COVE WATERQUALITY COMPARISON STUDY DATE 10-Aug-90

CRITERTIA FOR "WET" OR "DRY" CONDITION FOR EMBAYMENT

FILE: FLOWEST

STRATIFICATION 5.00 [ft]

VOLUME OF STRATIFIED MODEL SECTORS:

BOTTOMLAYER	[CBFT]	TOPLAYER	[CBFT]
V1B =	2.87E+06	V1T =	1.79E+06
V2B =	3.36E+0?	V2T =	6.72E+05
V3B =	9.90E+05	V3T =	6.24E+05
V4B =	2.65E+05	V4T =	4.42E+05
V5B =	1.15E+06	V5T =	7.17E+05
V6B =	1.13E+06	V6T =	5.12E+05
VT =	1.24E+09		

SUM OF BOTTOM LAYER 6.74E+06 [CBFT]
SUM OF TOP LAYER 4.76E+06 [CBFT]

TOTAL SECTOR VOLUMS 1.15E+07 [CBFT]

FRESHWATER INFLOW 4.00E+06 [MGD/mile]

FW. INTRUSION IN SECTOR 1 = 1.09E+05 [cbft/day]
FW. INTRUSION IN SECTOR 2 = 7.70E+04 [cbft/day]

SUM INFLOW 1.86E+05 [cbft/day]

FW INFLOW / EMBAYMENT VOLUME 1.62 [%]

THEREFORE "WET" CRITERIA APPLIES

Mauna Lani WQ Comparison Study DATE 10-Aug-90

State of Hawaii Water Quality Criteria

Criteria for Open Coastal Waters

Parameter	Geometric mean not to exceed the given value		Not to exceed the given value more than ten percent of the time		Not to exceed the given value more than two percent of the time	
Total Nitrogen	150.00	*	250.00	*	350.00	*
[ug N/L]	110.00	**	180.00	**	250.00	**
Ammonia Nitrogen	3.50	*	8.50	*	15.00	*
[ug NH3-N/L]	2.00	**	5.00	**	9.00	**
Nitrate & Nitrite Nitrogen	5.00	*	14.00	*	25.00	*
	3.50	**	10.00	**	20.00	**
[ug (NO3+NO2)-N/L]						
Total Phosphorus	20.00	*	40.00	*	60.00	*
[ug P/L]	16.00	**	30.00	**	45.00	**
Light Extinction	0.20	*	0.50	*	0.85	*
Coefficient (k units)	0.10	**	0.30	**	0.55	**
Chlorophyll a	0.30	*	0.90	*	1.75	*
[ug /L]	0.15	**	0.50	**	1.00	**
Turbidity	0.50	*	1.25	*	2.00	*
[N.T.U.]	0.20	**	0.50	**	1.00	**

* "Wet" criteria apply when the open coastal waters receive more than three million gallon per day of fresh water discharge per shoreline mile

* * "Dry" criteria apply when the open coastal waters receive less than three million gallon per day of fresh water discharge per shoreline mile

Mauna Lani WQ Comparison Study DATE 10-Aug-90

State of Hawaii Water Quality Criteria

Criteria for Embayments

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (ug N/L)	200.00 *	350.00 *	500.00 *
	150.00 **	250.00 **	350.00 **
Ammonia Nitrogen (ug NH3-N/L)	6.00 *	13.00 *	20.00 *
	3.50 **	8.50 **	15.00 **
Nitrate & Nitrite Nitrogen (ug (NO3+NO2)-N/L)	8.00 *	20.00 *	35.00 *
	5.00 **	14.00 **	25.00 **
Total Phosphorus (ug P/L)	25.00 *	50.00 *	75.00 *
	20.00 **	40.00 **	60.00 **
Light Extinction Coefficient (k units)	0.40 *	0.80 *	1.20 *
	0.15 **	0.35 **	0.60 **
Chlorophyll a (ug /L)	1.50 *	4.50 *	8.50 *
	0.50 **	1.50 **	3.00 **
Turbidity (N.T.U.)	1.50 *	3.00 *	5.00 *
	0.40 **	1.00 **	1.50 **

* "Wet" criteria apply when the average fresh water inflow from the land equals or exceeds one percent of the embayment volume per day

** "Dry" criteria apply when the average fresh water inflow from the land is less than one percent of the embayment volume per day

nitrogen in open coastal water under the "wet" criteria. This, however, is a general condition along this coastline and is not dependent on the existence of the proposed Mauna Lani Cove.

The worst water quality within the cove is projected to occur in the channel between the two islands. The residence time here with respect to the ocean is expected to be 23.8 days. Consequently a geometric mean chlorophyll-a concentration of 0.63 ug/l is expected. This easily meets the 1.50 ug/l level allowed in "wet" embayments in the state standards as a geometric mean. If, however, significant amounts of phosphorus are allowed to enter the marina via surface runoff or from other sources and the net growth rate increases to 0.25 per day or greater than the waters in the channel between the two islands as well as in the marina will exceed the 8.5 ug/l level allowed two percent of the time.

In summary, the water entering the ocean from the proposed Mauna Lani Cove is expected to meet the state water quality standards without considering any additional dilution. Similarly, the water within the cove is expected to meet the standards without the need to pump additional water. The key item responsible for these fortunate conditions is the low concentration of total phosphorus in the waters along this coast. Control of phosphorus input is necessary in maintaining the high water quality.

APPENDIX T

MAUNA LANI COVE DEVELOPMENT, MODELING OF EFFLUENT PLUMES

MAUNA LANI COVE DEVELOPMENT

MODELING OF EFFLUENT PLUMES IN OCEAN RECEIVING WATERS DUE TO DREDGING OPERATIONS AND NORMAL WATER DISCHARGES FROM THE OPERATING MARINA AND INLAND WATERWAYS

Prepared for:

Peratrovich, Nottingham and Drage, Inc.
100 Eastlake Avenue East, Suite 310
Seattle, Washington 98109

Prepared by:

Edward K. Noda and Associates, Inc.
615 Piikoi Street, Suite 1000
Honolulu, Hawaii 96814

Report No. EKN-1213-R-1-1

October 1990

TABLE OF CONTENTS

MAUNA LANI COVE DEVELOPMENT

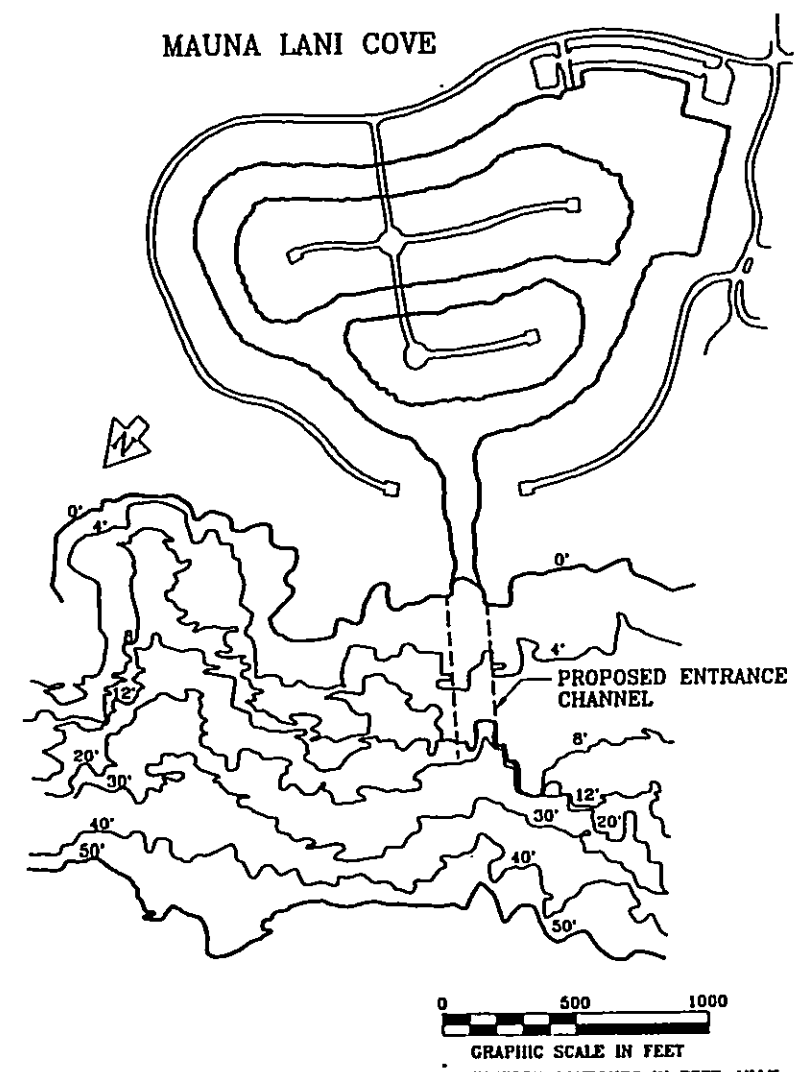
MODELING OF EFFLUENT PLUMES IN OCEAN RECEIVING WATERS DUE TO DREDGING OPERATIONS AND NORMAL WATER DISCHARGES FROM THE OPERATING MARINA AND INLAND WATERWAYS

1.0 INTRODUCTION

The Mauna Lani Resort, located on the west coast of Hawaii, is currently planning the development of an inland marina and waterways with an entrance channel to the open ocean, called the Mauna Lani Cove. The proposed location of the Mauna Lani Cove is situated between the existing Mauna Lani Bay Hotel and the Ritz-Carlton Hotel, with the entrance channel to the ocean located about 0.25 km southwest of Pauoa Bay. The proposed entrance channel will be created by excavating an area which extends seaward about 660 ft from the shoreline, with a channel width of about 150 ft and a depth of about 18 ft MLLW (Mean Lower Low Water). Figure 1 describes the proposed Mauna Lani Cove project, the entrance channel location, and site-specific bathymetry data.

As part of the evaluation of environmental impacts due to the project, the assessment of the impacts to the ocean receiving waters due to excess turbidity generated during the entrance channel excavation operations and the normal flushing discharges from the newly created inland waterways are herein provided.

Figure 1: Proposed Mauna Lani Cove Development



2.0 TURBIDITY IMPACTS DUE TO DREDGING

2.1 Introduction

The proposed construction method for the entrance channel will probably involve blasting operation due to the expected basaltic character of the materials, and the subsequent removal of the fragmented debris using such techniques as clam-shell dredging operations. It is envisioned that the blasting operations will first involve the drilling of an array of vertical holes in the ocean bottom, which would then be packed with explosives, the drill equipment would be moved off-site and the explosives detonated. Dredging equipment would then be mobilized over the blast area where the blast-debris would be lifted from the bottom, placed in a barge and removed from the site area.

In a separate construction operation, the inland waterways will be excavated in the "dry" with a barrier maintained at the shoreline. Only after the entire inland waterways and marina complex has been excavated, and sufficient time has elapsed in order to allow the settling of the suspended solids, will the shoreline barrier (plug) be removed to allow a connection to the ocean.

The probable turbidity caused by the blasting and dredging for the entrance channel is difficult to estimate without measured data on suspended solids concentrations or turbidity levels during similar construction operations in basaltic material. Similar construction activities have been undertaken at Honokohau Harbor and more recently at Keahole Point related to the installation of ocean water pipelines. However, no direct water sampling or turbidity measurements were made during offshore blasting and dredging activities related to these projects. Investigations conducted subsequent to completion of Honokohau Harbor and other turbidity-generating construction activities on the West Hawaii coast indicate no negative impact to the offshore environment due to the rapid dispersion of the turbidity plumes (Marine Research Consultants, 1989).

While no negative impacts are anticipated from the turbidity generated by the entrance channel construction for the Mauna Lani Cove, nevertheless, an analysis was carried out to quantify the probable turbidity generated by the dredging and blasting and the area impacted by the turbidity plume as it disperses and is advected from the area by the nearshore currents. The estimates of construction-generated turbidity plume impacts in the coastal region near the marina site are described in the following sections.

The Natural Energy Laboratory of Hawaii (NELH), with

facilities located at Keahole Point, routinely samples nearshore water quality parameters from their "warm water" intake pipeline. The pipeline intake is located approximately 300 feet offshore Keahole Point in a water depth of 65 ft, with the intake situated about 20 feet above the bottom. The intake is in close proximity to the nearshore trench for the HOST Park cold water pipeline. During the blasting and excavations operations for this nearshore trench, no sampling data was obtained since the seawater intake was shut down in order to avoid ingesting the highly turbid waters. However, data available prior to the blasting/excavation and near completion of the excavation indicate that the suspended solids levels were back to ambient very shortly after completion of major excavation activity. Table 1 summarizes the measurements of total suspended solids from the NELH nearshore seawater intake. The data indicates that the average ambient suspended solids concentration is about 0.7 milligrams per liter (mg/l) in the nearshore waters offshore Keahole Point.

Data obtained during the Barbers Point Deep Draft Harbor construction on the west coast of Oahu may provide some indication of the limit of turbidity that could be generated by entrance channel dredging activities for the Mauna Lani Cove development. The Barbers Point data is probably more extreme than would be expected at the Mauna Lani Cove since the dredged material consisted of limestone and sandy/silty sediments, as compared to the hard basalt material along the west coast of Hawaii. Mean ambient suspended solids concentration in nearshore waters off Barbers Point was reported at 4.2 ± 2.7 mg/l and in offshore waters 1.4 ± 0.4 mg/l (compared to about 0.7 mg/l at Keahole Point).

Turbidity measurements during the Barbers Point Harbor construction were taken 500 feet downstream from the source at the surface, 3 meters below the surface, and near the bottom. The turbidity measurements indicated mean suspended solids concentrations of about 10 ± 9 mg/l at 3 meters below the surface and 15 ± 17 mg/l near the bottom, based on 61 days of measured data. Note that while only routine measurements of turbidity (NTU) were obtained, a limited number of both turbidity and suspended solids measurements resulted in the following conversion:

$$\text{Suspended Solids (mg/l)} = 0.54 + 1.93 \text{ Turbidity (NTU)}$$

Thus, when reference is made to the turbidity measurements during the Barbers Point Deep Draft Harbor entrance channel construction, the suspended solids concentrations are based on the above conversion equation.

Table 1. Measured Total Suspended Solids (TSS) from the NELH Nearshore Seawater Intake Pipeline

Date	TSS (mg/l)	Comments
2-06-87	0.80	
2-12-87	0.55	
2-19-87	0.90	
2-26-87	0.80	
3-03-87	0.75	
3-10-87	0.75	
3-17-87	0.75	
3-24-87	0.60	
4-03-87	0.90	
4-09-87	0.35	
4-16-87	0.85	
4-21-87	0.70	
4-28-87	0.85	
5-05-87	0.85	
5-12-87	0.60	
5-21-87	0.80	
5-26-87	0.60	
6-02-87	0.70	
6-09-87	0.75	
6-17-87	0.60	
6-22-87	-	Initiate offshore excavation (seawater intake shut down)
6-23-87	-	Blasting-3 shots @ 1000,1400,1630 hr
6-30-87	0.45	
7-02-87	0.60	
7-06-87	-	Excavation complete
7-11-87	0.50	
7-17-87	0.80	
7-18-87	0.85	
7-28-87a	0.45	
7-28-87b	0.40	
8-08-87	0.40	

Only on three separate occasions of monitoring did the suspended solids levels exceed 40 mg/l near the bottom. The maximum measured level was about 84 mg/l near the bottom and 42 mg/l near the surface. The higher turbidity levels were generally associated with clamshell dredging activities, with measurements during rising tides, and with increased wave activity. Other dredging activities included augering and blasting. Blasting was accomplished on two separate occasions and turbidity measurements indicated maximum suspended solids levels of 11.2 mg/l (taken 1 hour after blasting) on the first occasion and 3.1 mg/l (taken 3 hours after blasting) on the

second.

While the Barbers Point data can be used to bracket the probable turbidity generated by the dredging and blasting for the Mauna Lani Cove entrance channel, there is the unanswered question of what happens to the turbidity plume as it is dispersed and advected from the area by the nearshore currents. Therefore, the following sections describe the numerical modeling techniques which were used to estimate the probable behavior of the turbidity plume and the areas of impact along the coast.

In order to quantitatively evaluate the turbidity generated during the Mauna Lani Cove entrance channel excavation operations, the following analysis has been divided into two separate operations and processes. First, it is envisioned that underwater blasting technology will be required to fragment the expected basaltic bottom materials. The "instantaneous" blast will create a turbid plume, which will then disperse relative to the center of the concentration and the entire plume will also be transported by the local currents (advection). Second, following the underwater blast it is expected that dredging equipment will be mobilized and a "continuous" (days or weeks) dredging operation will take place to remove the fragmented bottom materials. In the following sections, each of these excavation operations which generate turbidity will be considered separately.

2.2 Estimate of Turbidity Impacts Due To Blasting

In order to construct the Mauna Lani Cove entrance channel underwater blasting operations may be required. The following section evaluates the potential turbidity impacts of nearshore blasting operations and its subsequent fate in the ocean water. The turbidity plume generated by an underwater explosion is a complicated problem which is dependent on many factors including the type of explosive, the method of explosive application (drill and shoot, shaped charges, etc.), the volume of explosive material, the ground pattern of application, the type of material that is being blasted related to the expected fine size fractions that will be generated, the type, size fractions and volume of the surface sediment layer and the oceanographic conditions which will affect the turbidity plume once it is generated.

Since many of the above factors are presently unknown, the following analysis assumes an idealized representation for the underwater blast-generated turbidity plume and its subsequent motions and dilutions in the ocean environment.

Envision that an underwater explosion has just occurred and that a turbid area has been generated off the Mauna Lani Cove. An instantaneous plume has been generated and it is desired to calculate the turbidity and motion of this plume in the nearshore ocean waters. The time-dependent, advective diffusion equation for a conservative substance (Fischer, et al., 1979) could then be applied if the ocean current field and the diffusion coefficients were known everywhere.

When representing the diffusion process as described above, it is tacitly assumed that the ocean current structure can be divided into two parts: a) advection represented by the current vector field, and b) dispersion represented by the tensor K, where K is the dispersion coefficient. Conceptually, the ocean current spectrum might be thought of as split into a low frequency part representing advection and a high frequency part constituting dispersion. For the present problem, we have extended this concept further by considering that the advection and dispersion processes are independent such that they can be analyzed separately.

The advection process is associated with the movement of the turbidity plume due to the ocean current structure and will provide the probability of an instantaneous plume being at a given offshore location after some specified time interval after generation. This process will be discussed in detail in a later section.

A. Dispersion Modeling

The dispersion process is associated with the dispersion of an instantaneous turbidity plume in a water body with no mean current flow, which satisfies the diffusion equation. The fluid field is assumed to extend from minus (-) infinity to plus (+) infinity in the horizontal plane (x and y coordinates) and from 0 to minus (-) infinity in the vertical z coordinate (water depth). Just after the blast, at time $t = 0$, the initial distribution of the turbidity concentration is assumed to be Gaussian or normally distributed in each of the three coordinate directions, with the peak concentration C_o located at the center of the plume at $x = y = z = 0$. The size of the initial turbidity distribution is provided by standard deviations of the coordinate concentrations and are defined by S_o for the horizontal x and y coordinates and S_{zo} for the vertical depth coordinate. For practical purposes, S_{zo} = the water depth at the underwater explosion location.

It is now postulated that the mixing processes in the ocean is Fickian in the vertical and similar to surface ocean diffusion in the horizontal. Applying the 4/3rd law for the horizontal diffusion coefficient yields

$$S_z = (2K_z t + S_{zo}^2)^{1/2} \quad \text{-- Fickian Diffusion}$$

$$S_x = S_y = (2At/3 + S_o^{2/3})^{3/2} \quad \text{-- 4/3rd Law Horizontal Diffusion}$$

The coefficient A in the horizontal diffusion coefficient is obtained from the ocean field measurements of Okubo (1974) in which data tends to be bounded by

$$0.33 \leq A \leq 1.67 \ m^{2/3}/hr.$$

Thus, for the present case, it seems reasonable to select

$$A = 1 \ m^{2/3}/hr = 2.2 \ ft^{2/3}/hr$$

as a nominal representative value.

In the deep ocean the vertical diffusion coefficient K_z is usually related to the ambient density gradient. For the Mauna Lani Cove case, since the surface plume will be in the mixed layer where the vertical density gradient is about zero, the vertical mixing will be driven primarily by surface waves. The work of Golubeva (1963) and Isayeva and Isayev (1963) based on ocean field measurements indicates that within the mixed layer, the vertical diffusion coefficient K_z is given by

$$K_z = 0.02\, H_w^2/T_w$$

where

K_z = the vertical diffusivity at the surface,
H_w = the wave height (ft),
and T_w = the wave period (seconds).

The wave activity offshore of the Mauna Lani Cove is typically very mild, and during the summer months when blasting operations are envisioned, the wave activity is usually associated with swell waves generated in the Southern Hemisphere. Based on wave measurements (Sea Engineering, Inc., 1989), it has been assumed that

$$H_w = 1.0 \text{ ft}$$

and

$$T_w = 14 \text{ seconds}$$

which yields

$$K_z = 0.00143 \text{ ft}^2/\text{sec} = 5.14 \text{ ft}^2/\text{hr}.$$

It should be noted that the above estimate of K_z is conservative in that if larger wave conditions are utilized, the vertical mixing is more vigorous which dilutes and dissipates the turbidity plume more rapidly.

On the basis of the above simplifications, the concentration distribution which satisfies the diffusion equation (Fischer et al., 1979) is

$$C(x,y,z,t) = \frac{M}{2^{1/2}\,\pi^{3/2}\,(S_x S_y S_z)} \exp\left(- \frac{x^2}{2S_x^2} - \frac{y^2}{2S_y^2} - \frac{z^2}{2S_z^2} \right) \quad (1)$$

$$-\infty < x < +\infty$$
$$-\infty < y < +\infty$$
$$-\infty < x <= 0$$

where M = the total mass of suspended sediments in the initial turbidity plume.

From Equation (1) the peak initial turbidity concentration at the center of the plume is given by

$$C_o = C(0,0,0,0) = M/(2^{1/2}\,\pi^{3/2}\,S_o^2\,S_{zo})$$

and similarly, the turbidity concentration at the center of the plume at any time t is

$$C(0,0,0,t) = M/(2^{1/2}\,\pi^{3/2}\,S_x\,S_y\,S_z)$$

Thus, the peak concentration ratio at the center of the plume is given by

$$\frac{C(0,0,0,t)}{C(0,0,0,0)} = \frac{C}{C_o} = \frac{S_o^2\,S_{zo}}{S_x\,S_y\,S_z} \quad (2)$$

The selection of the horizontal standard deviation of the initial turbidity plume concentration, S_o, is clearly dependent on the blasting operations. It should be noted that since the initial turbidity distribution is modeled as a normal distribution, within ± 1 standard deviation includes 68% of the total mass and within ± 2 standard deviations encompasses 95% of the total mass. For the present situation, two times the initial horizontal standard deviation of the turbidity concentration, $2S_o$, can be assumed to represent the radius of the initial turbidity plume. Table 2 provides a listing of the peak turbidity concentration ratio at the center of the plume and at the surface as a function of time given the following constants:

$$A = 2.2 \text{ ft}^2/\text{hr}$$
$$K_z = 5 \text{ ft}^2/\text{hr}$$

and

$$S_{zo} = 18.9 \text{ ft}.$$

Also shown in Table 2 are the equivalent dilutions of the peak concentration which is represented by the reciprocal of the concentration ratio given by Eqn. 2.

The results shown in Table 2 clearly indicate the dependence of the subsequent concentration on the radius of the initial turbidity plume. The values of S_o shown in Table 2 are considered reasonable, where an S_o = 25 ft represents an initial diameter of the plume of about 100 ft and similarly, S_o = 50 ft represents an initial diameter of about 200 ft. Notice that for S_o = 25 ft, after 24 hours the peak concentration has been reduced by a dilution factor of about 173.

The above analysis has assumed that following the instantaneous generation of the turbidity cloud, no suspended sediments settle out of the plume and deposit on the ocean bottom. Thus, the above analysis provides a very conservative estimate for the turbidity concentration as a function of time.

For completeness, the effects of settling can be estimated as follows. At any instant, the material is envisioned to be uniformly distributed over the vertical by turbulence. The mass flux downward is simply the product of the material concentration

T-7

and the particle fall velocity. Consequently, the concentration in an isolated element is found to be given by

$$C = C_o \exp(-wt/h) \quad (3)$$

where

w = the fall velocity
C_o = the initial turbidity concentration
h = the depth of the plume
and t = time.

Table 2: Peak Turbidity Concentration Ratio And Dilution For An Instantaneous Plume Generated By An Underwater Explosion As A Function Of Time And Plume Initial Size (Without Sediment Fallout).

Time (Hours)	Concentration Ratio C/C_o S_o = 25 ft	Concentration Ratio C/C_o S_o = 50 ft	Dilution, C_o/C S_o = 25 ft	Dilution, C_o/C S_o = 50 ft
0	1.000	1.000	1.00	1.00
1	0.613	0.725	1.63	1.38
2	0.402	0.541	2.49	1.85
3	0.276	0.414	3.62	2.42
4	0.198	0.323	5.06	3.10
5	0.146	0.256	6.85	3.90
6	0.111	0.207	9.03	4.84
7	0.086	0,169	11.66	5.93
8	0.068	0.139	14.77	7.17
9	0.054	0.116	18.42	8.59
10	0.044	0.098	22.65	10.19
11	0.036	0.083	27.52	11.99
12	0.030	0.071	33.07	14.00
18	0.012	0.032	83.77	31.33
24	0.006	0.017	173.24	60.00

Besides the concentration within the turbidity plume as a function of time due to settling, of additional interest is the rate of deposition of previously suspended sediments onto the ocean bottom. This can be determined by taking the derivative of Eqn. 3 with respect to time, t, and multiplying this concentration rate by the depth of the plume, h, to yield the following:

$$\text{Sediment Deposition Rate} = -C_o\, w \exp(-wt/h) \quad (4)$$

If a complete description of the composition of the suspended sediment size distribution in the turbid plume was known, then Eqn. 3 could be applied to each individual representative size fraction, and the cumulative concentration determined.

In the envisioned blasting operations, fragmented material will be distributed through the water column and the relatively coarse sand-sized particles will fall rapidly and even if advected by the ambient current will settle near the blast site. For the finer silt-size fraction, settling is retarded and the currents may carry a substantial quantity of material a considerable distance from the source location. For the present analysis the focus will be on such fine materials and, in fact, for numerical calculation purposes it will be assumed that the entire fine fraction entering the water column can be represented by a single fall velocity. The selected representative sediment has a particle diameter of 0.02 millimeters with a fall velocity in quiescent water of approximately 0.05 cm/sec. This assumption of the representative suspended sediment material is believed to be conservative since it is expected that much of the actual materials will be volcanic in origin and of much large size fractions, and consequently will fall faster that 0.05 cm/sec and will remain nearer the source area.

Table 3 shows the resulting relative suspended sediment concentrations, C/C_o, from Eqn. 3 and the sediment deposition rate from Eqn. 4. Also shown is the equivalent dilution factor which is the reciprocal of the relative concentration. In developing the results shown in Table 3 it has been assumed that the plume depth is 18.9 ft which is the depth of the entrance channel relative to mean sea level (MSL), w = 180 cm/hr and the initial turbidity concentration of the blast-generated plume is C_o = 40 mg/liter. This value of the initial turbidity concentration is based on the Barbers Point Deep Draft Harbor entrance channel excavation data, and is considered to be a very conservative estimate for the expected situation for the Mauna Lani Cove entrance channel excavation. Nevertheless, this value provides an upper limit as to the expected impacts along the coastal regions of the project site.

The concentration described by Eqn. 3 represents only the effects of suspended sediment fallout from the turbid water. This is analogous to placing some fine sediment in a glass of water, shaking the mixture to obtain a uniform distribution, then allowing the fine sediments to slowly settle to the bottom. Eqn. 3 then describes the average concentration of the water-sediment mixture as a function of time, and similarly Eqn. 4 describes the sediment deposition rate at the bottom of the glass. Thus, it is clear that the process of mixing and dispersion described by Eqn. 2 and Table 2, which will also reduce the turbidity concentration have not been included in Eqns. 3 and 4 and in Table 3. If it is envisioned that the processes of suspended sediment fallout and dispersion are independent, and that no re-suspension of sediment takes place, then the actual sediment concentration, dilution and sediment deposition rates must be obtained by multiplying the values in Table 3 by the respective values in Table 2 for the

Table 1. Measured Total Suspended Solids (TSS) from the NELH Nearshore Seawater Intake Pipeline

Date	TSS (mg/l)	Comments
2-06-87	0.80	
2-12-87	0.55	
2-19-87	0.90	
2-26-87	0.80	
3-03-87	0.75	
3-10-87	0.75	
3-17-87	0.75	
3-24-87	0.60	
4-03-87	0.90	
4-09-87	0.35	
4-16-87	0.85	
4-21-87	0.70	
4-28-87	0.85	
5-05-87	0.85	
5-12-87	0.60	
5-21-87	0.80	
5-26-87	0.60	
6-02-87	0.70	
6-09-87	0.75	
6-17-87	0.60	
6-22-87	-	Initiate offshore excavation (seawater intake shut down)
6-23-87	-	Blasting-3 shots @ 1000,1400,1630 hr
6-30-87	0.45	
7-02-87	0.60	
7-06-87	-	Excavation complete
7-11-87	0.50	
7-17-87	0.80	
7-18-87	0.85	
7-28-87a	0.45	
7-28-87b	0.40	
8-08-87	0.40	

T-4

Only on three separate occasions of monitoring did the suspended solids levels exceed 40 mg/l near the bottom. The maximum measured level was about 84 mg/l near the bottom and 42 mg/l near the surface. The higher turbidity levels were generally associated with clamshell dredging activities, with measurements during rising tides, and with increased wave activity. Other dredging activities included augering and blasting. Blasting was accomplished on two separate occasions and turbidity measurements indicated maximum suspended solids levels of 11.2 mg/l (taken 1 hour after blasting) on the first occasion and 3.1 mg/l (taken 3 hours after blasting) on the

second.

While the Barbers Point data can be used to bracket the probable turbidity generated by the dredging and blasting for the Mauna Lani Cove entrance channel, there is the unanswered question of what happens to the turbidity plume as it is dispersed and advected from the area by the nearshore currents. Therefore, the following sections describe the numerical modeling techniques which were used to estimate the probable behavior of the turbidity plume and the areas of impact along the coast.

In order to quantitatively evaluate the turbidity generated during the Mauna Lani Cove entrance channel excavation operations, the following analysis has been divided into two separate operations and processes. First, it is envisioned that underwater blasting technology will be required to fragment the expected basaltic bottom materials. The "instantaneous" blast will create a turbid plume, which will then disperse relative to the center of the concentration and the entire plume will also be transported by the local currents (advection). Second, following the underwater blast it is expected that dredging equipment will be mobilized and a "continuous" (days or weeks) dredging operation will take place to remove the fragmented bottom materials. In the following sections, each of these excavation operations which generate turbidity will be considered separately.

probability of visitation. The current meter was located directly offshore of the proposed entrance channel alignment at a location where the bottom depth was 40 ft with the sensor located 6 ft off the bottom, 34 ft below the water surface. Current data was recorded for 6 months, during two separate deployments extending from January 12 to April 13, 1989 and April 13 to July 25, 1989. Since blasting operations will probably take place during the summer months, the most relevant data for the present analysis is the current data set for the April - July 1989 period. For the present analysis, 1-hour vector-averaged current data was provided by Sea Engineering on a floppy disk.

The area offshore of the Mauna Lani Cove Development was divided into 1 kilometer by 1 kilometer square grids with the orientation of the grid axes selected to generally represent the orientation of the coastline. The endpoints from each progressive vector when started at the marina entrance area were cumulated for each grid square and divided by the total number of vectors for a given time period (hours). Since the progressive vector could cross the shoreline boundary, in this situation the vector was reflected about this shoreline to an equivalent offshore location.

Figures 2, 3, 4 and 5 provide the probabilities of advective transport or visitation probabilities for time durations of 6, 12, 18 and 24 hours respectively after the instantaneous plume generation. The results shown in Figures 2-5 can be interpreted as follows. Consider Figure 2 which represents a time horizon of 6 hours after the plume generation, at the 1 km square grid located off Waawaa Point to the southwest of the entrance channel which is between 1 to 2 kilometers from the blast site, the visitation probability is 6%. In other words, if 100 plumes were to be generated, about 6 of these events would reach and impact this grid square area off Waawaa Point. Correspondingly, for any individual blast-generated turbidity event, there is a 6% chance that this plume will impact the nearshore Waawaa Point grid.

To complete the evaluation, Figures 2 to 5 can be used in association with Table 4 to estimate the turbidity at a particular offshore grid square. For example, for a time duration of 6 hours and assuming an initial plume diameter of 200 ft (S_o = 50 ft), and assuming a source turbidity concentration of c_o = 40 mg/l, Table 4 shows that the peak concentration ratio would become C/C_o = 0.032 and C_o = 1.3 mg/l. Thus, for the Waawaa Point nearshore grid square, while there is only a 6% chance that the area would be impacted by a blast-generated turbidity plume, if impacted, the turbidity concentration would be about 1.3 mg/l assuming that sediment fallout is considered. These values of the turbidity concentration are assumed to be excess values above ambient conditions. Notice that Table 4 indicates that for the 9 hr duration period, the suspended sediment concentration becomes about 0.28 mg/l, which is lower

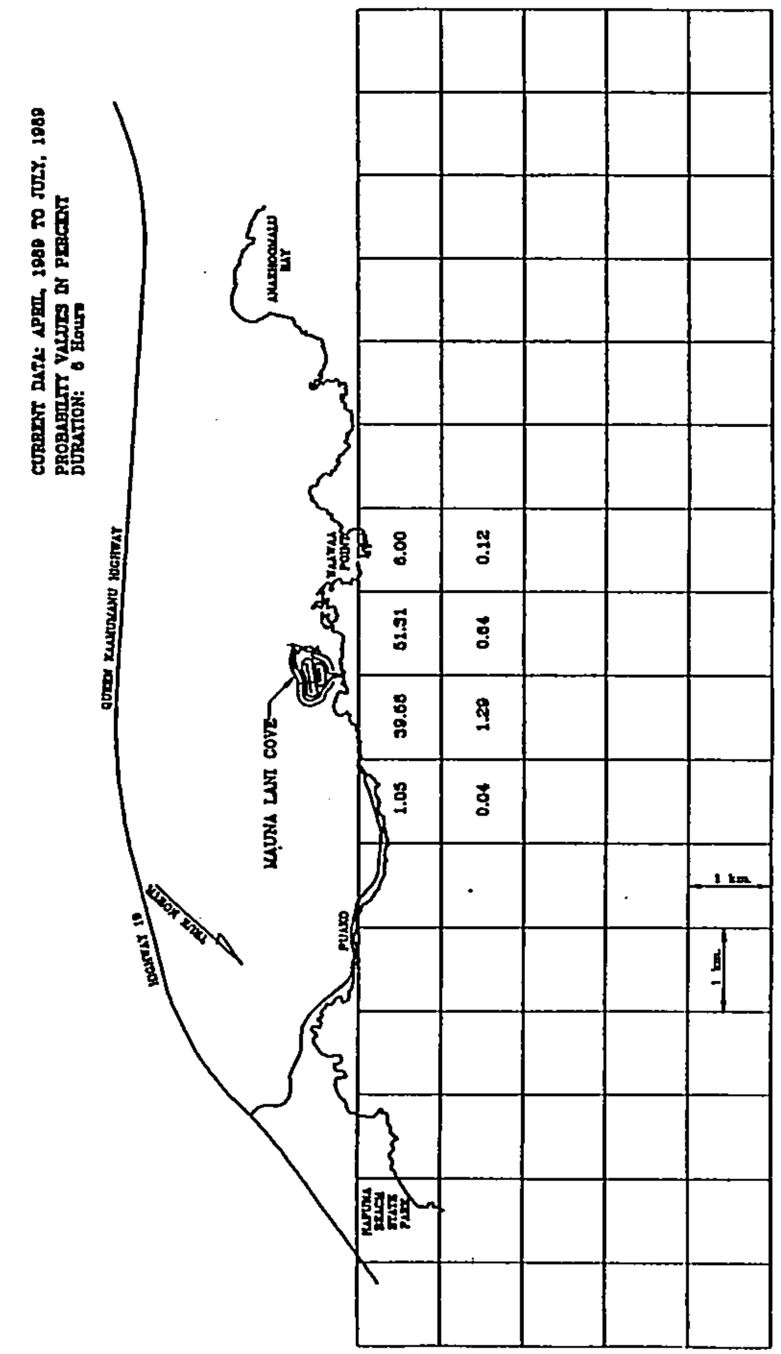


Figure 2: Probability Of Turbidity Plume Impact Due To Channel Blasting Within A 6-hour Period After The Explosive Event.

$$K_z = 0.02\, H_w^2/T_w$$

where

K_z = the vertical diffusivity at the surface,
H_w = the wave height (ft),
and T_w = the wave period (seconds).

The wave activity offshore of the Mauna Lani Cove is typically very mild, and during the summer months when blasting operations are envisioned, the wave activity is usually associated with swell waves generated in the Southern Hemisphere. Based on wave measurements (Sea Engineering, Inc., 1989), it has been assumed that

$$H_w = 1.0 \text{ ft}$$
and
$$T_w = 14 \text{ seconds}$$

which yields

$$K_z = 0.00143 \text{ ft}^2/\text{sec} = 5.14 \text{ ft}^2/\text{hr}.$$

It should be noted that the above estimate of K_z is conservative in that if larger wave conditions are utilized, the vertical mixing is more vigorous which dilutes and dissipates the turbidity plume more rapidly.

On the basis of the above simplifications, the concentration distribution which satisfies the diffusion equation (Fischer et al., 1979) is

$$C(x,y,z,t) = \frac{M}{2^{1/2}\,\pi^{3/2}\,(S_x S_y S_z)} \exp\left(-\frac{x^2}{2S_x^2} - \frac{y^2}{2S_y^2} - \frac{z^2}{2S_z^2}\right) \quad (1)$$

$$-\infty < x < +\infty$$
$$-\infty < y < +\infty$$
$$-\infty < x <= 0$$

where M = the total mass of suspended sediments in the initial turbidity plume.

From Equation (1) the peak initial turbidity concentration at the center of the plume is given by

$$C_o = C(0,0,0,0) = H/(2^{1/2}\,\pi^{3/2}\,S_o^2\,S_{zo})$$

and similarly, the turbidity concentration at the center of the plume at any time t is

$$C(0,0,0,t) = H/(2^{1/2}\,\pi^{3/2}\,S_x\,S_y\,S_z)$$

Thus, the peak concentration ratio at the center of the plume is given by

$$\frac{C(0,0,0,t)}{C(0,0,0,0)} = \frac{C}{C_o} = \frac{S_o^2\,S_{zo}}{S_x\,S_y\,S_z} \quad (2)$$

The selection of the horizontal standard deviation of the initial turbidity plume concentration, S_o, is clearly dependent on the blasting operations. It should be noted that since the initial turbidity distribution is modeled as a normal distribution, within ± 1 standard deviation includes 68% of the total mass and within ± 2 standard deviations encompasses 95% of the total mass. For the present situation, two times the initial horizontal standard deviation of the turbidity concentration, $2S_o$, can be assumed to represent the radius of the initial turbidity plume. Table 2 provides a listing of the peak turbidity concentration ratio at the center of the plume and at the surface as a function of time given the following constants:

$$A = 2.2 \text{ ft}^2/\text{hr}$$
$$K_z = 5 \text{ ft}^2/\text{hr}$$
and
$$S_{zo} = 18.9 \text{ ft.}$$

Also shown in Table 2 are the equivalent dilutions of the peak concentration which is represented by the reciprocal of the concentration ratio given by Eqn. 2.

The results shown in Table 2 clearly indicate the dependence of the subsequent concentration on the radius of the initial turbidity plume. The values of S_o shown in Table 2 are considered reasonable, where an S_o = 25 ft represents an initial diameter of the plume of about 100 ft and similarly, S_o = 50 ft represents an initial diameter of about 200 ft. Notice that for S_o = 25 ft, after 24 hours the peak concentration has been reduced by a dilution factor of about 173.

The above analysis has assumed that following the instantaneous generation of the turbidity cloud, no suspended sediments settle out of the plume and deposit on the ocean bottom. Thus, the above analysis provides a very conservative estimate for the turbidity concentration as a function of time.

For completeness, the effects of settling can be estimated as follows. At any instant, the material is envisioned to be uniformly distributed over the vertical by turbulence. The mass flux downward is simply the product of the material concentration

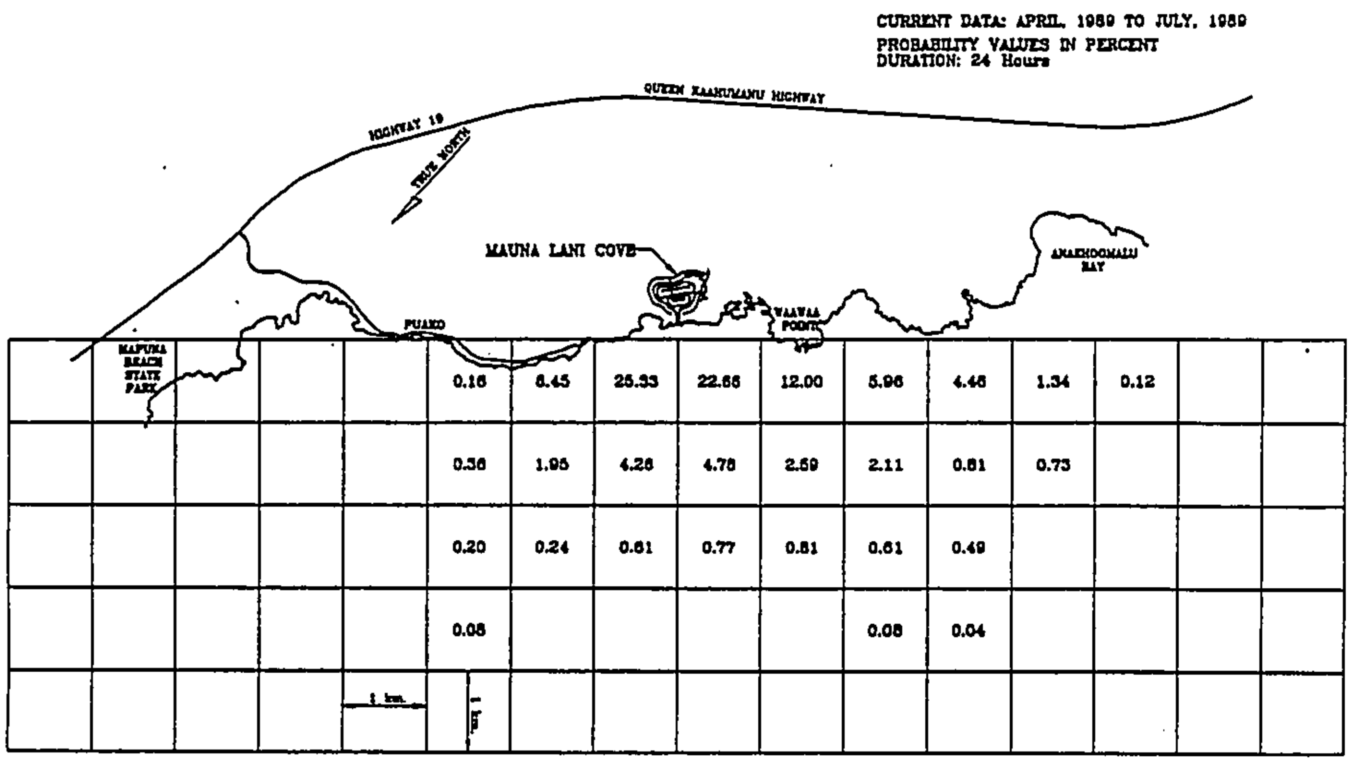


Figure 5: Probability Of Turbidity Plume Impact Due To Channel Blasting Within A 24-hour Period After The Explosive Event.

than the "open" ocean value of 0.7 mg/l.

C. Discussion And Summary

The probability of visitation results shown in Figures 2-5 indicate that the probable impact areas of a blast-generated turbidity cloud is localized to an area of about 2 kilometers distance from the Mauna Lani Cove entrance channel within 12 hours after the blast. Moreover, the highest probability of impact is generally confined to an area within 1 km of the entrance channel.

The dilution results shown in Table 4, which includes both the effects of mixing and dispersion and sediment fallout, indicates that within about 9 hours after the blast, the peak turbidity concentration will be reduced to values which are significantly less then the background "open" ocean turbidity.

Finally, it should again be noted that the assumption of a peak initial source concentration of the blast-generated turbidity cloud of C_o = 40 mg/l is considered to be a very conservative value. Thus, the results provided in the above section are considered very conservative estimates and provide an over-estimate of the impact turbidity for environment assessment purposes.

same time, t after the blast. Table 4 describes the resulting values.

Table 3: Relative Concentration (C/C_o), Dilution And Sediment Deposition Rate On The Ocean Bottom Due Only To The Fallout Of Suspended Sediments For A Plume Generated By An Instantaneous Underwater Explosion As Function Of Time.

Time (Hours)	C/C_o	Dilution	C_o = 40 mg/l Sediment Deposition Rate (g/m^2-hr)
1	0.732	1.37	52.68
2	0.535	1.87	38.54
3	0.392	2.55	28.20
4	0.287	2.55	20.63
5	0.210	4.77	15.09
6	0.153	6.52	11.04
7	0.112	8.91	8.08
8	0.082	12.18	5.91
9	0.060	16.65	4.32
10	0.044	22.76	3.16
11	0.032	31.11	2.32
12	0.024	42.51	1.69
18	0.004	277.15	0.26

Table 4: Peak Turbidity Concentration (C/C_o), Dilution And Sediment Deposition Rate On The Ocean Bottom For C_o = 40 mg/l, Due To Both Dispersion And Settling From A Turbid Plume Generated By An Instantaneous Underwater Explosion.

Time	S_o = 25 ft			S_o = 50 ft		
(Hrs)	C/C_o	Dilution	Sed. Deposition Rate (g/m^2-hr)	C/C_o	Dilution	Sed. Deposition Rate (g/m^2-hr)
1	0.449	2.23	32.29	0.531	1.88	38.19
2	0.215	4.65	15.49	0.289	3.46	20.85
3	0.108	9.24	7.78	0.162	6.16	11.68
4	0.057	17.60	4.09	0.093	10.79	6.66
5	0.031	32.62	2.20	0.054	18.60	3.86
6	0.017	58.88	1.23	0.032	31.58	2.29
7	0.010	103.82	0.70	0.019	52.83	1.37
8	0.006	179.34	0.40	0.011	87.74	0.82
9	0.003	308.64	0.23	0.007	143.68	0.50

B. Advective Transport Analysis

In the previous analysis, the singular focus has been the time-dependent evaluation of the decay of the explosion-generated turbidity plume due to both mixing and dispersion, and sediment fallout through the water column. Simultaneous with the time-dependent decay of the turbid plume is the transport of the plume with the prevailing local currents. This transport process which is also called advection will now be considered. The advection of the plume does not affect the turbidity concentrations previously calculated, but it will determine the areas of impact in the ocean environment. In the following section the probability of advective transport due to the currents which exist at the Mauna Lani Cove site will be defined and determined. The methodology used herein has been developed by Koh (1988).

Given a current meter record u(t), it is possible to calculate by time integration

$$x(t) = \int_0^t u(\tau)\, d\tau$$

which is the location of a particle if advected by the current $\vec{u}(t)$. A diagram displaying $\vec{x}(t)$ is commonly referred to as a progressive vector diagram. For a given continuous and long time-series of current data $\vec{u}(t)$, it is possible to construct many short progressive vector diagrams of duration t_d by starting the integration at different times along the time series. For a current record of duration T and sample interval dt, it is possible to construct $(T-t_d)/dt$ number of individual vectors. The endpoints of these vectors when considered statistically can be utilized to estimate the advective transport probabilities at the site of interest. There is the important difference between the Eulerian current statistics, as utilized herein versus the Lagrangian current statistics associated with the following of a water particle, but theoretically the methodology can be improved by providing more current meters and pooling the data appropriately.

It should be emphasized that the concept of the advective transport probability implies that we are not considering the plume motions as a deterministic process. In others words, since it is presently unknown as to exactly when a turbidity plume will be generated relative to the time-dependent currents, the above methodology presents a probabilistic representation of where the plume might be if we were to release many plumes at different times.

For the Mauna Lani Cove evaluation, the current data measured by Sea Engineering (1989) was used to develop the advective transport probability or what could also be called the width at the source is estimated to be 30 ft (9.14 meters). Based on the Barbers Point Deep Draft Harbor turbidity measurements, a very conservative estimate of the initial concentration has been assumed to be 40 mg/liter. Thus, the calculated turbidity from the nearfield model should represent a conservative or over-estimate of the actual turbidity expected to be encountered during the Mauna Lani Cove entrance channel excavation.

The results of calculations with the above input parameters are shown in Table 5 and Figure 6. For example, with sediment fallout (settling), at about 1.3 kilometers (km) downstream the centerline sediment concentration is about 0.7 mg/liter which is similar to background "open" ocean turbidity and 2 km from the dredging site, the turbidity has been reduced to about 0.14 mg/l which is significantly less than ambient open ocean turbidity.

In a strict sense, the Brook-type nearfield model should only be applied for short durations of time which should be about 2-3 hours and less than 6 hours which is the time of flow either up or down coast driven by the semi-diurnal tides. A time of 3 hours based on a flow velocity of 0.18 km/hr represents a distance of 0.54 km. Moreover, since vertical mixing has been neglected from the Brook model, the calculated results from this model should be viewed as conservative.

B. Farfield Modeling

For the farfield, continuous-dredging plume modeling methodology, the approach that is used herein is to perform a Monte Carlo simulation of the transport processes directly. It is known that the solution to the simple diffusion equation is equivalent to that resulting from a random-walk process. With the ready availability of inexpensive computing power, it has become quite feasible to simulate ocean transport processes directly. The effectiveness of this method depends on the quality and quantity of the available ocean transport data. For the present study, the current measurements obtained for the project will provide the necessary and sufficient data. This methodology for the evaluation of the continuously turbidity plume is considered to be a more realistic assessment than the nearfield analysis described previously.

The simulation model used herein is concerned with the transport of a conservative substance. Let it be assumed that the velocity field in the ocean can be completely described. Let a parcel of marked fluid be released at the source point which will be called the origin. Since the velocity field is known completely, it is now possible to trace the motion of the marked parcel as a function of time (x(t),y(t),z(t)) where t is time since release. This process can now be repeated at other times

TRANSVERSE DIFFUSION COEFFICIENT (K=Ab**n)

A - CONSTANT (XAO)	=	1.00 (M**2/3)/HR
bo - INITIAL WIDTH OF PLUME (SIGO)	=	9.14 M
n - Nth LAW OF K (XN)	=	1.333
KO - INITIAL VALUE OF K (XKO)	=	19.11 M**2/HR
Y(1) - INITIAL SEDIMENT CONCENTRATION	=	40.000 mg/liter
Us - PARTICLE FALL VELOCITY	=	.05 CM/SEC
Ht - DEPTH OF WATER COLUMN	=	5.76 M
V - DRIFT VELOCITY	=	.180 KM/HR

Note: X = Distance from source

X	PLUME	CONCENTRATIONS (mg/liter)		DEPOSITION
(KM)	WIDTH (M)	NONSETTLING	WITH SETTLING	RATE (G/(M**2*HR)
.00	25.97	.39818E+02	.39693E+02	.71448E+02
.18	38.54	.26832E+02	.19631E+02	.35335E+02
.36	52.81	.19581E+02	.10481E+02	.18866E+02
.54	68.50	.15095E+02	.59112E+01	.10640E+02
.72	85.51	.12094E+02	.34649E+01	.62368E+01
.90	103.72	.99701E+01	.20898E+01	.37617E+01
1.08	123.07	.84027E+01	.12886E+01	.23195E+01
1.26	143.49	.72068E+01	.80858E+00	.14554E+01
1.44	164.92	.62700E+01	.51467E+00	.92641E+00
1.62	187.34	.55199E+01	.33149E+00	.59669E+00
1.80	210.68	.49082E+01	.21565E+00	.38818E+00
1.98	234.92	.44018E+01	.14149E+00	.25469E+00
2.16	260.03	.39768E+01	.93525E-01	.16835E+00
2.34	285.97	.36161E+01	.62218E-01	.11199E+00
2.52	312.72	.33067E+01	.41626E-01	.74926E-01
2.70	340.25	.30391E+01	.27990E-01	.50381E-01
2.88	368.55	.28058E+01	.18905E-01	.34029E-01
3.06	397.59	.26008E+01	.12821E-01	.23078E-01
3.24	427.36	.24197E+01	.87267E-02	.15708E-01
3.42	457.84	.22586E+01	.59596E-02	.10727E-01
3.60	489.00	.21147E+01	.40822E-02	.73480E-02
3.78	520.85	.19854E+01	.28040E-02	.50473E-02
3.96	553.35	.18687E+01	.19310E-02	.34757E-02
4.14	586.51	.17631E+01	.13329E-02	.23991E-02
4.32	620.30	.16670E+01	.92202E-03	.16596E-02

Table 5: Nearfield Turbidity Plume Concentration And Deposition Rate For A Continuous Dredging Operation.

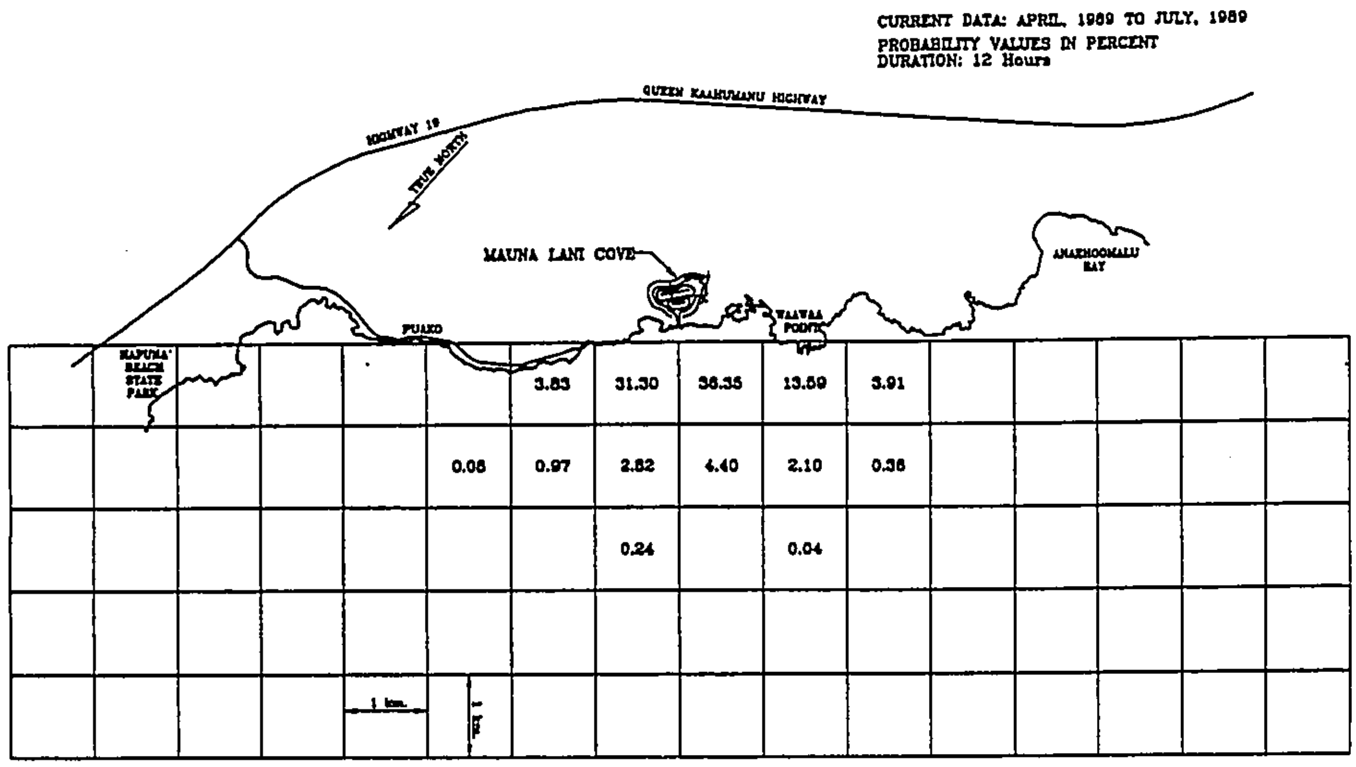


Figure 3: Probability Of Turbidity Plume Impact Due To Channel Blasting Within A 12-hour Period After The Explosive Event.

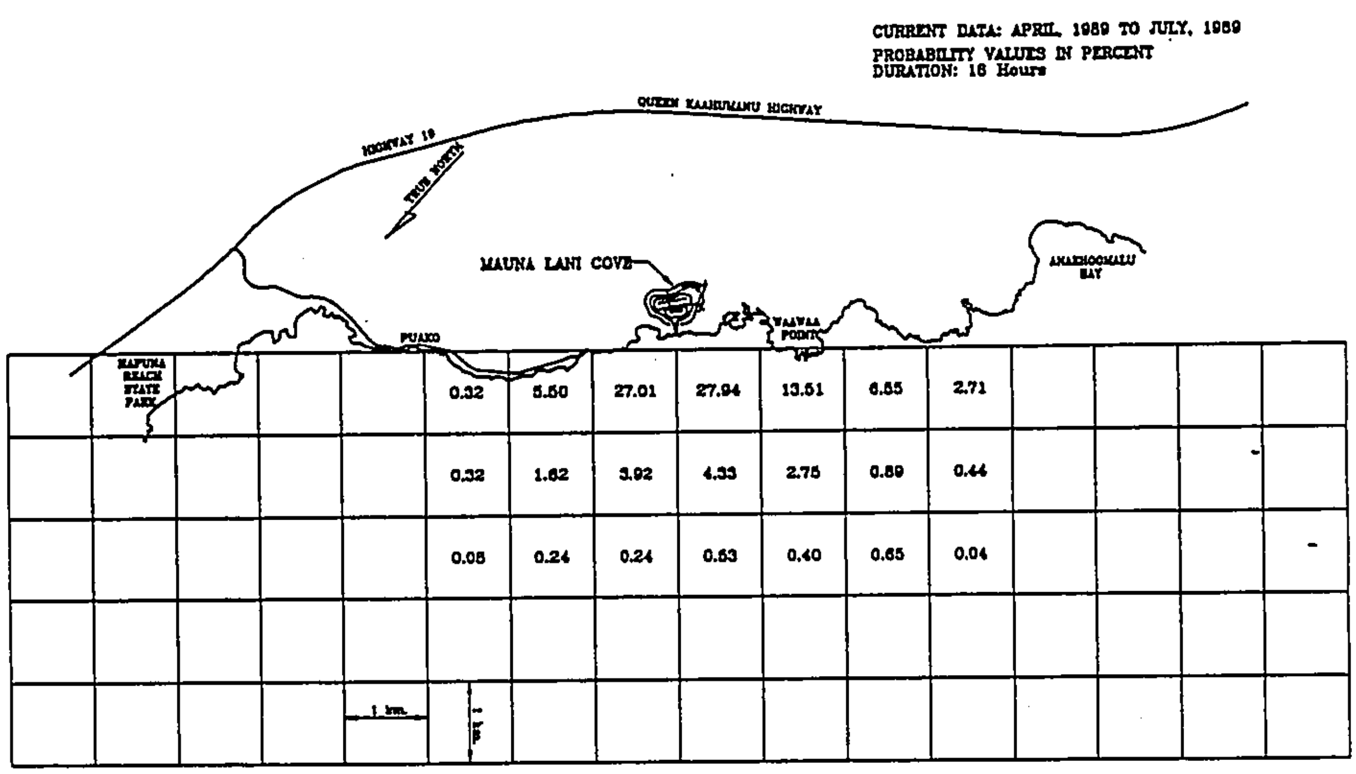


Figure 4: Probability Of Turbidity Plume Impact Due To Channel Blasting Within A 18-hour Period After The Explosive Event.

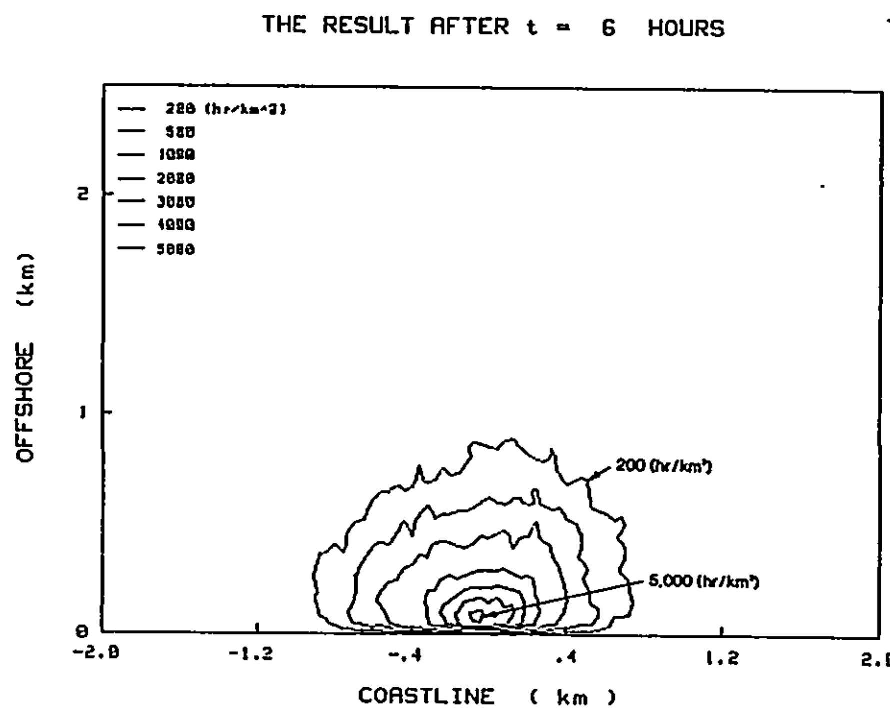


Figure 7: Impact Probabilities For A Continuous Dredging Operation At The Mauna Lani Cove Entrance Channel For A Time t = 6 hrs. After The Start Of The Operation.

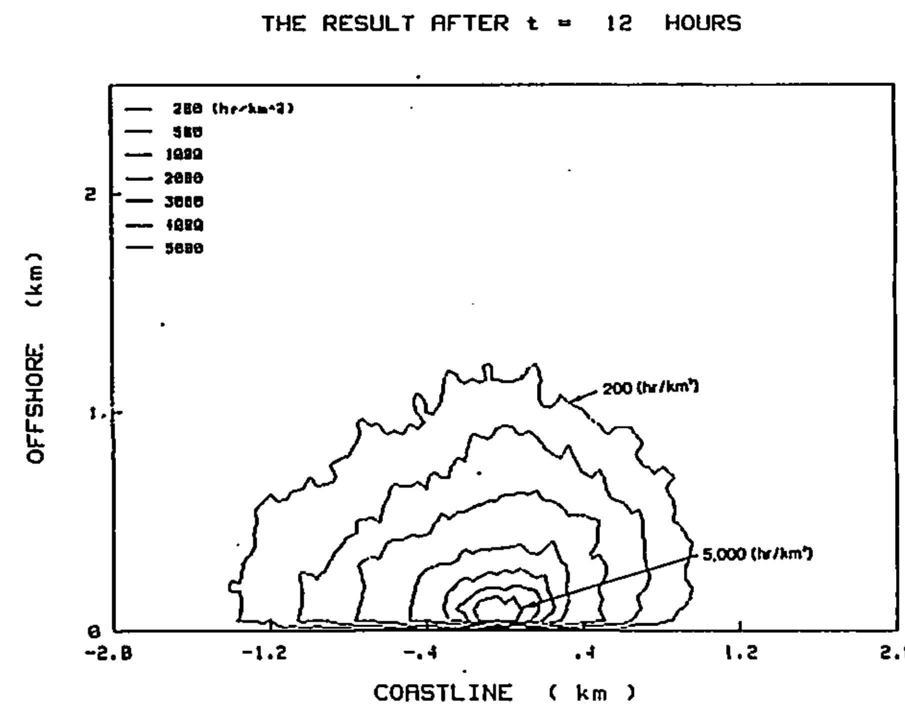


Figure 8: Impact Probabilities For A Continuous Dredging Operation At The Mauna Lani Cove Entrance Channel For A Time t = 12 hrs. After The Start Of The Operation.

2.3 Turbidity Impacts Due To Continuous Dredging Operations

If underwater blasting operations are utilized, following the blasting or similar ocean bottom breakup operations, the fragmented material must be removed. It is envisioned that some type of continuous (8 hrs/day) dredging operations will occur such as using a clam-shell dredge, which will suspend fine solid materials in the water column and generate a relatively continuous, quasi-steady source for a turbidity plume. The following section evaluates this phenomenon as a completely separate process from the instantaneous plume analysis in the previous section.

In the envisioned dredging operations a clam-shell type of dredge would be used to transfer the fragmented debris from the bottom to a floating barge. During each lifting cycle of the clam-shell, sediments will be suspended through the water column in a very confined source volume. As described in Section 2.2, the relatively large size particles (sand size and larger) will fall rapidly and settle near the dredging site. For the finer silt-size materials, the settling velocities are very small and thus, the local currents may carry the suspended sediments a substantial distance from the source point. As described in Section 2.2, for the present analysis a single size fraction that is considered representative of the suspended sediments is selected, consisting of a particle diameter of 0.02 millimeters with a fall velocity in quiescent water of about 0.05 cm/sec (0.0016 ft/sec).

In order to evaluate the turbidity plume from a continuous source, two different methodologies have been used herein. One methodology involves a deterministic estimate using a phenomenological model of transport and settling. Its applicability is in the relative nearfield surrounding the dredging operations and consequently it has been designated as the "nearfield" model for the following discussions. The second methodology involves a probabilistic analysis similar in concept to the development of the advective transport probability developed in Section 2.2, and has been termed the "farfield" model for the present discussions.

A. Nearfield Modeling

For the deterministic nearfield model, the ambient current is envisioned to sweep past the dredge site forming a plume of suspended material downstream of the site. This plume grows in width by turbulent dispersion causing a decrease in sediment concentration. An additional decrease is associated with the fact that particles settle out of suspension. Sediment re-suspension processes have been neglected.

The flow is assumed to alternate direction up and down coast. Consequently, the maximum distance a particle might be carried during one tidal cycle in the absence of any mean drift is equal to the amplitude of the water particle orbit for the tide. During flow in one direction, only a portion of the suspended material falls out. The remaining fraction is swept back over the source and adds to the source concentration for the plume on the opposite side. This process repeats, leading to a quasi-steady condition. The constant current velocity in the model is assumed to be the average value of the tidal current over one direction of the flow.

The Brooks-type model (Brooks, 1960) which provides an estimate of the plume growth and concentration reduction by mixing in a uniform current flow has been adopted. For the horizontal mixing coefficient, the 4/3rd law is assumed and based on the data from Okubo (1974) as described in Section 2.2

$$A = 1.0\ m^{2/3}/hr = 2.2\ ft^{2/3}/hr$$

which is the midpoint of the range of field measured data. Note that the Brooks model does not consider vertical mixing processes.

The effects of sediment fallout from the plume was evaluated in Section 2.2 and is given by Eqn. 3. This exponential decay is superimposed on the quasi-steady Brooks-type plume model since a point downstream in the plume corresponds to time after injection by virtue of the additional assumption that the ambient flow velocity is a constant.

The measured current data from Sea Engineering (1989) indicates that the currents are relatively slow, typically 4 to 7 cm/sec (about 0.1 knots), with a very slight overall net transport towards the southwest at about 1 cm/sec. There was no strong correlation with tidal changes and the maximum velocity recorded during the 6 months was 33 cm/sec (0.6 knots). From the 1 hour vector averaged current data provided by Sea Engineering, in-house processing was performed and the standard current data output format is shown in Appendix A and B for the January-April and April-July 1989 data sets respectively. Since the blasting and entrance channel dredging operations are expected to occur during the summer months, the current data shown in Appendix B would be most representative of summer current conditions, and this shows a mean current velocity of about 5.0 cm/sec. Thus, this value of the current flow was selected as the most appropriate value for the nearfield turbidity plume model.

The final factors requiring estimates are the source concentration and size of the turbidity plume. Based on the concept of the use of a clam-shell dredge, the initial plume

$$\dot{M} = 3.345\ WdvC_o\ \text{(grams/hr)} = 3.79 \times 10^5\ \text{g/hr}$$

where W = 30 ft, the diameter of the clam-shell-generated turbidity source,

d = 18.9 ft, the water depth at the turbidity source, relative to MSL,

v = 5 cm/sec, the average current velocity during summer months,

and C_o = 40 mg/liter, the suspended sediment concentration at the source area.

In the application of the above methodology for the calculation of the mass flow rate, it has been assumed that the clam-shell dredging operations would be performed continuously, 24 hours a day. This is a very conservative assumption since typical operations would only involve clam-shell dredging operations performed 8-12 hours per day.

Based on the above value of the turbidity mass flow rate, the contour values shown in Figures 7 to 10 were translated to turbidity concentrations values and these are shown in Figures 11 to 14. From the results shown in Figures 11 to 14, which can be considered to represent the excess or increase in turbidity over ambient levels, the gradual growth of the area of influence can readily be seen. The results shown in Figures 11 to 14 generally show a greater dilution or smaller suspended sediment concentration than predicted by the Brooks-type model. This is due to the fact that these results should be considered as a cumulative average concentration based on the actual measured current time-series statistics, while the Brooks-type model shows a worse case, deterministic assessment. The results shown in Figures 11 - 14 are considered most representative of typical turbidity conditions to be encountered for the Hauna Lani Cove entrance channel dredging operations.

C. Discussion And Summary

While the contour maps shown in Figures 11 to 14 can be interpreted as representative of the concentrations due to a continuous release of turbidity due to dredging, it would be unlikely that these calculated results would occur on a given day. Instead, the contour results should be interpreted as a form of dosage from cumulative impact at the particular location, since it is a time summation (integral) of all possible impacts. In other words, the results shown in Figures 11 to 14 represent an average impact turbidity concentration based on the assumption that the continuous dredging operations have persisted for some reasonable time in the past, such as a few days to weeks.

The results shown in Figures 11 to 14 indicate the slow expansion of the area of impact, and even at 24 hours after the start of operations, the 0.5 mg/l suspended solids concentration

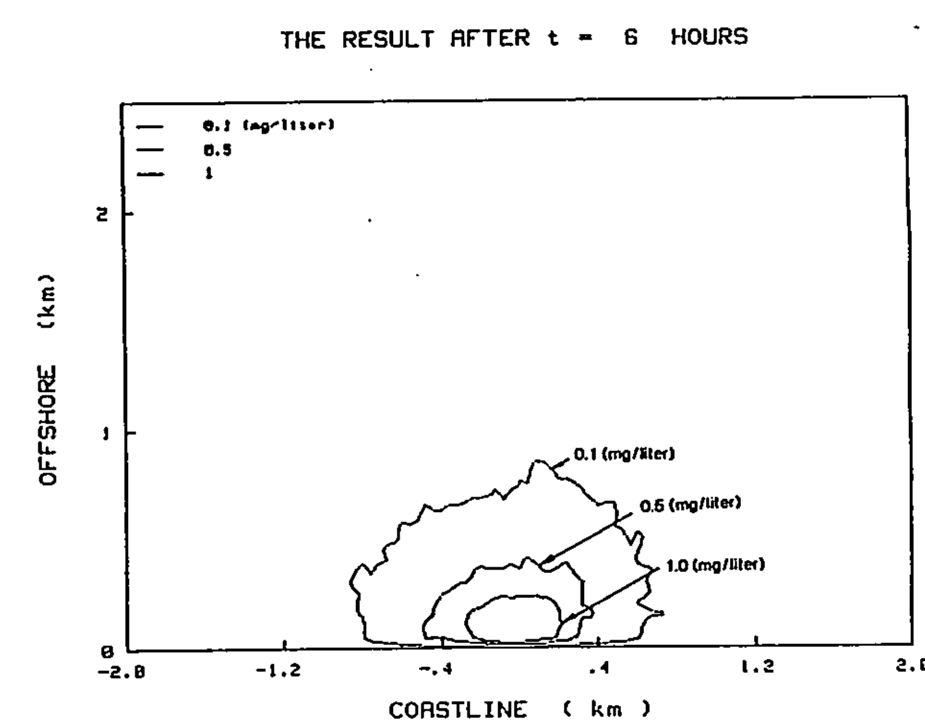
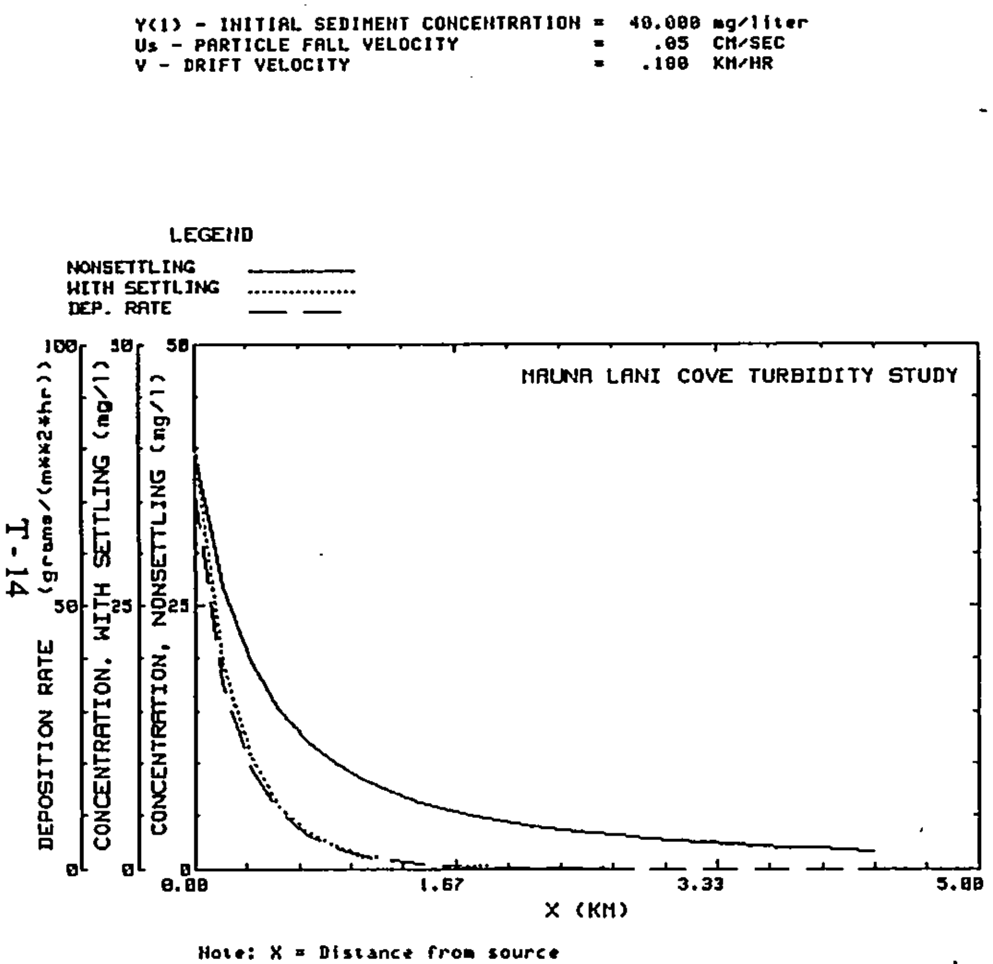


Figure 11: Probable Suspend Sediment Concentrations For A Continuous Dredging Operation At The Mauna Lani Cove Entrance Channel For A Time t = 6 hrs. After The Start Of Operation.



T-14

Figure 6: Nearfield Turbidity Plume Concentration And Deposition Rate For A Continuous Dredging Operation.

since for the i-th such realization, the motion of the i-th parcel is $(x_i(t), y_i(t), z_i(t))$.

A function of practical interest is the probability density $f(x,y,z,t)$ that parcels released at the origin will be in the cell $\vec{x}$ to $\vec{x}+d\vec{x}$ at t. This can be estimated by counting the number of such parcels and dividing by the total number of releases and by the volume of the elemental cell. If the velocity field were a pure random walk, this particular simulation would lead to an estimate of $f(x,y,z,t)$ which would satisfy the classical Fickian diffusion equation. For other stochastic velocity fields, it is still possible to perform the simulation and the interpretation of the resulting $f(x,y,z,t)$ remains the same. However, the differential equation to which it is the solution would not be a Fickian diffusion equation. Inasmuch as the goal of the present modeling effort is to obtain estimates of environmental impact, the probability density of visitation at various locations around the discharge site and the estimated travel times would be of interest. Furthermore, by taking the integral of the probability densities of visitation, the resulting solutions would represent the impacts due to a continuous discharge of effluent.

The methodology described above has been utilized in the present farfield model development. The stochastic velocity field is represented by the actual times-series of measured currents at the project site. The model implemented herein assumes that there is spatial homogeneity in the currents or that the Lagrangian velocity field can be adequately represented by the Eulerian measurements. The numerous time-series of measured currents then gives rise to individual estimates of the advective transport probabilities.

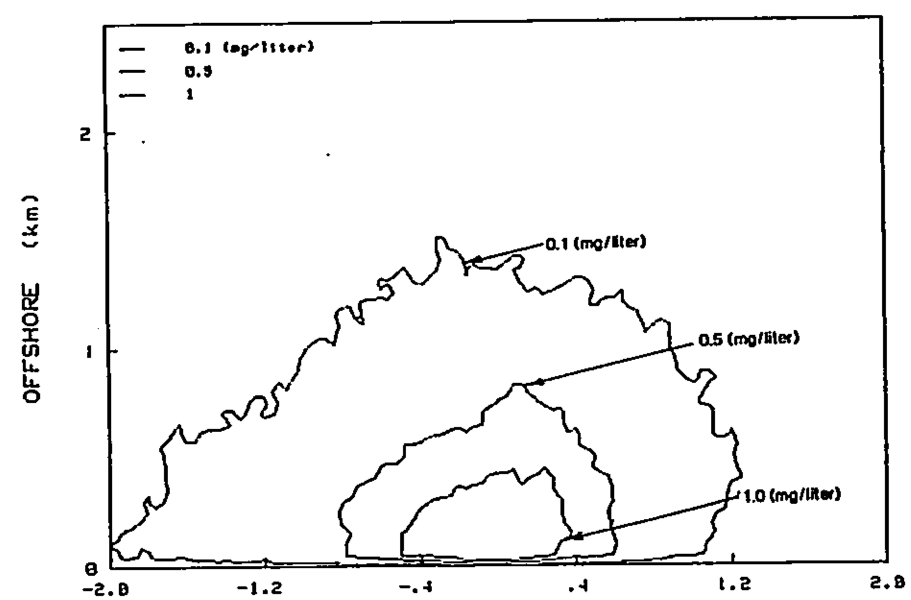
As described previously, the current data from the 2nd current meter deployment, April - July 1989 (Appendix B), which is most representative of the summer months, was used for the present farfield model.

Figures 7 to 10 provide the results of the above described farfield analysis. Physically, these figures can be interpreted as representative of the concentrations of the discharged materials at time t after release (6, 12, 18 and 24 hours), due to the continuous discharge of material at a uniform rate (of value unity) starting at t=0. The contour values, in units of hr/km^3, should be multiplied by the source mass emission rate (mass/hr) to arrive at the concentration ($mass/km^3$).

In order to calculate the mass flow rate from the clam-shell dredging operations, a vertical plane is envisioned perpendicular to the axis along which the current flow is directed. The plane is located just outside of the W = 30 ft diameter turbidity source generation region. The mass flow rate is then given by only extends about 0.8 km up and down coast and offshore from the entrance channel site.

In general, Figures 11 to 14 show that the turbidity plume from continuous dredging operations at the Mauna Lani Cove entrance channel will be confined to very limited areas, typically within about 1 km from the source point.

THE RESULT AFTER t = 24 HOURS



COASTLINE (km)

Figure 14: Probable Suspend Sediment Concentrations For A Continuous Dredging Operation At the Mauna Lani Cove Entrance Channel For A Time t = 24 hrs. After The Start Of Operation.

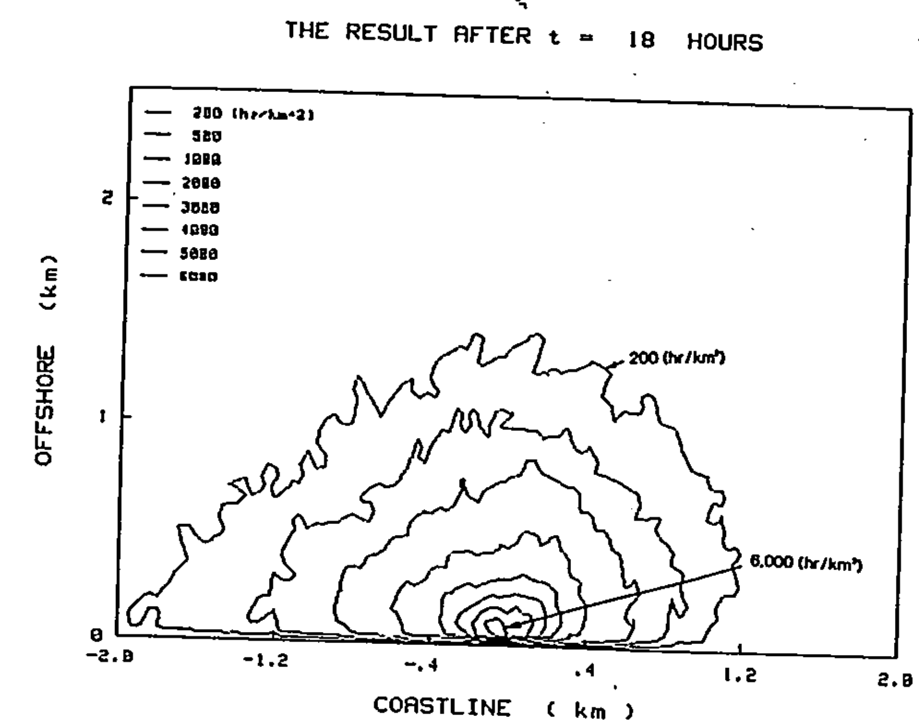


Figure 9: Impact Porbabilities For A Continuous Dredging Operation At The Mauna Lani Cove Entrance Channel For A Time t = 18 hrs. After The Start Of The Operation.

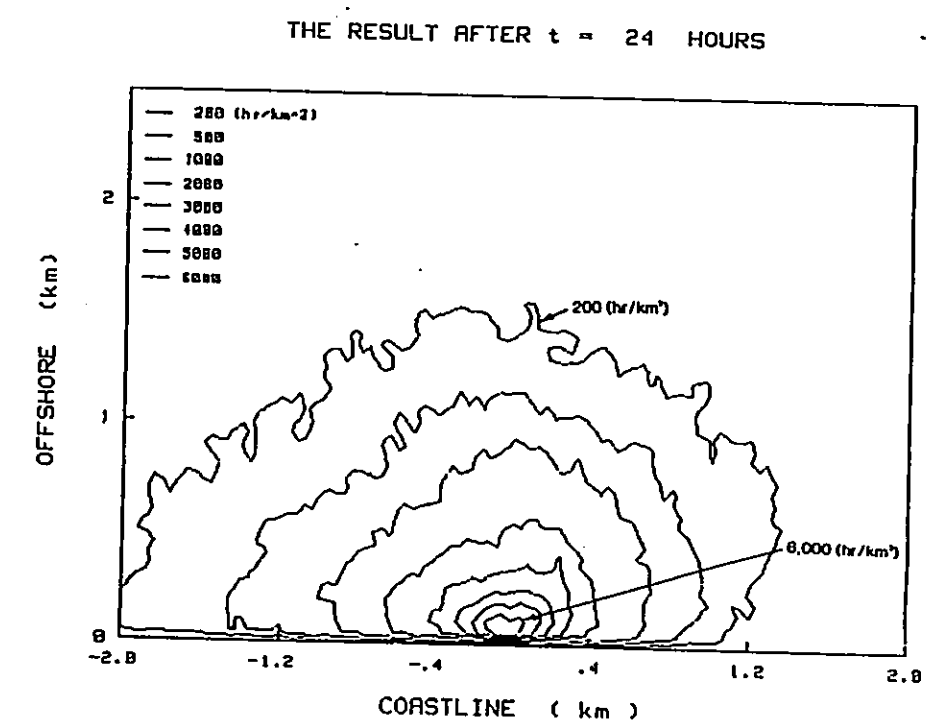


Figure 10: Impact Probabilities For A Continuous Dredging Operation At The Mauna Lani Cove Entrance Channel For A Time t = 24 hrs. After The Start Of The Operation.

waterways is well documented. The estimated ground water flow rate into the Mauna Lani Cove is between 2.5 and 5.9 million gallons per day (MGD), with a reasonable value for the present analysis of 5.0 MGD or 7.7 ft^3/sec [Tom Nance, 1990, personal communication]. Thus, in comparison to the average tide driven flow rate through the entrance channel, the addition of ground water would only represent an increase in flow rate of about 3.4%. Consequently, flow velocity changes in the entrance channel due to groundwater inflow are not significant.

3.2 Nearfield Plume Evaluation

The quantitative determination of whether the nearfield plume will behave as a jet flow is provided by the densimetric Froude Number, F_d, which essentially represents the ratio of the inertia to gravitational or buoyancy forces and is defined analytically as

$$F_d = \frac{U}{(gd\Delta\rho/\rho_o)^{1/2}}$$

where U = the velocity of the flow out of the entrance channel,
g = the acceleration of gravity,
d = the water depth in the entrance channel,
$\Delta\rho = \rho_a - \rho_o$ = the density difference,
ρ_a = the density of the ambient water,
and ρ_o = the density of discharged Cove waters.

For $F_d>2$ the flow is considered to be a jet and the nearfield modeling equations would be applicable. For $F_d<2$, the plume flow is dynamically passive and of insufficient strength to provide significant mixing and dispersion of the discharged marina waters. Consequently, the nearfield modeling equations would not be applicable, and the "farfield" modeling methodology can be immediately implemented.

In order to calculate the densimetric Froude number, the density of both the ocean waters and exiting Cove waters are required. Baseline "open" ocean water salinity and temperature data was obtained by Daxboeck (1988) offshore of the proposed Mauna Lani Cove. This data shows an average annual salinity of 34.53 parts per thousand (ppt) and an average annual water temperature of 26.5°C. The salinity and water temperature of the exiting Cove waters were calculated by assuming an inflow of 5 MGD of groundwater at a temperature of 26.1°C [Tom Nance, 1990 personal communication], which fully mixes with the average tidal prism volume during flood inflow. The resulting Cove water salinity is calculated to be 32.00 ppt and with a water temperature of 26.47°C. Assuming a maximum flow velocity of U_{max} = 0.1 ft/sec, the densimetric Froude number is calculated to be F_d = 0.09. Even with sensitivity variations in the various flow parameters, the densimetric Froude Number remains much less than 1.

Based on such small densimetric Froude numbers which are substantially <2, the Cove water discharge is not sufficiently dynamic to be modeled by the "nearfield" equations. Consequently, the "farfield" modeling technique will be immediately implemented upon the discharge of the Cove waters into the ocean receiving waters, as shown in the next section.

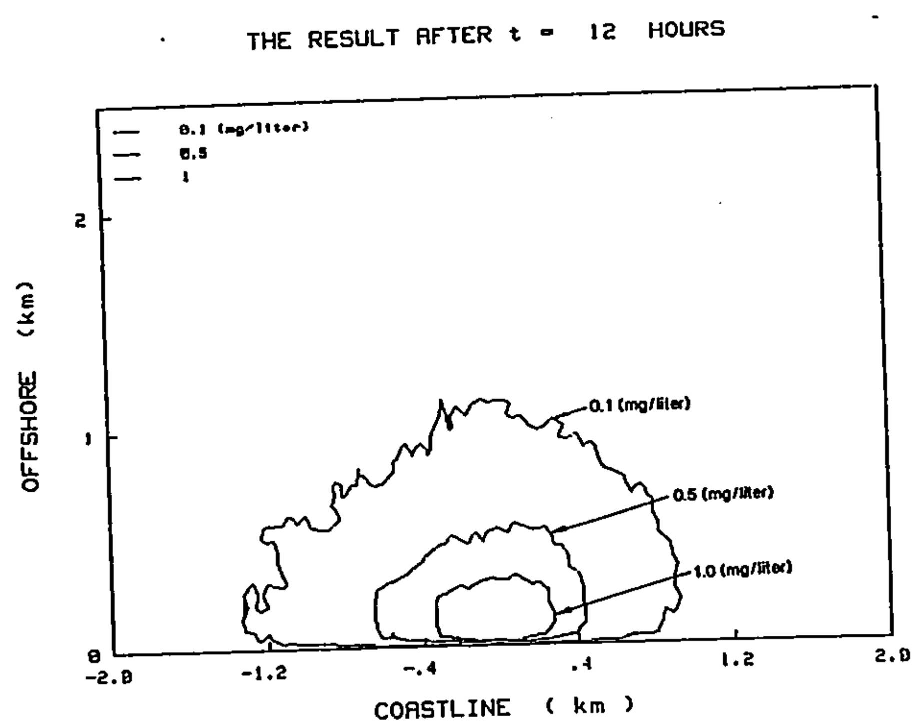


Figure 12: Probable Suspend Sediment Concentrations For A Conti..uous Dredging Operation At The Mauna Lani Cove Entrance Channel For A Time t = 12 hrs. After The Start Of Operation.

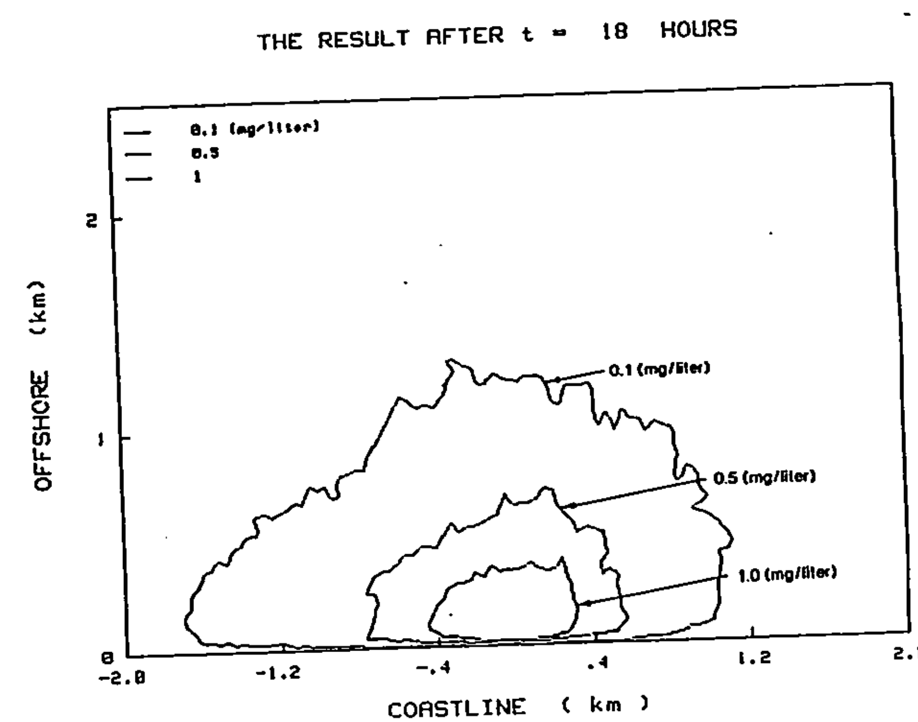


Figure 13: Probable Suspend Sediment Concentrations For A Continuous Dredging Operation At The Mauna Lani Cove Entrance Channel For A Time t = 18 hrs. After The Start Of Operation.

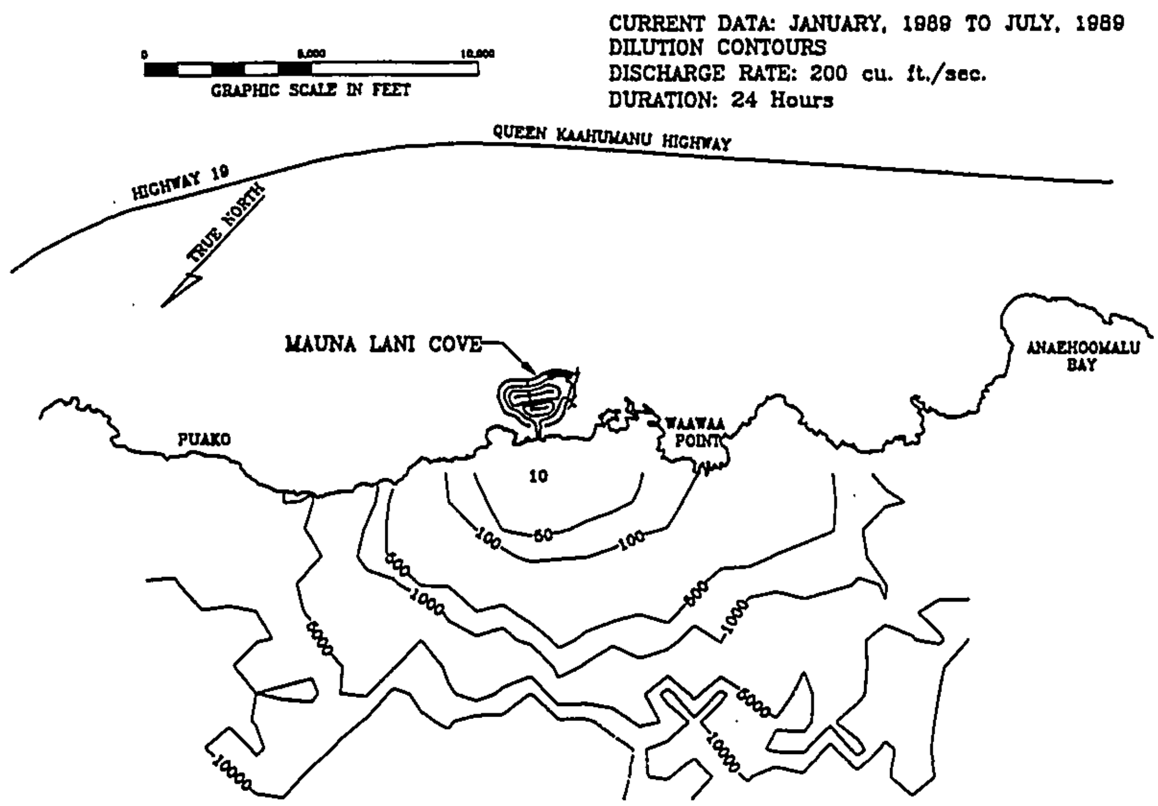


Figure 17: Probable Dilutions For Discharged Flow (Q=200 cfs) From The Mauna Lani Cove At Time t = 24 hrs. After Discharge.

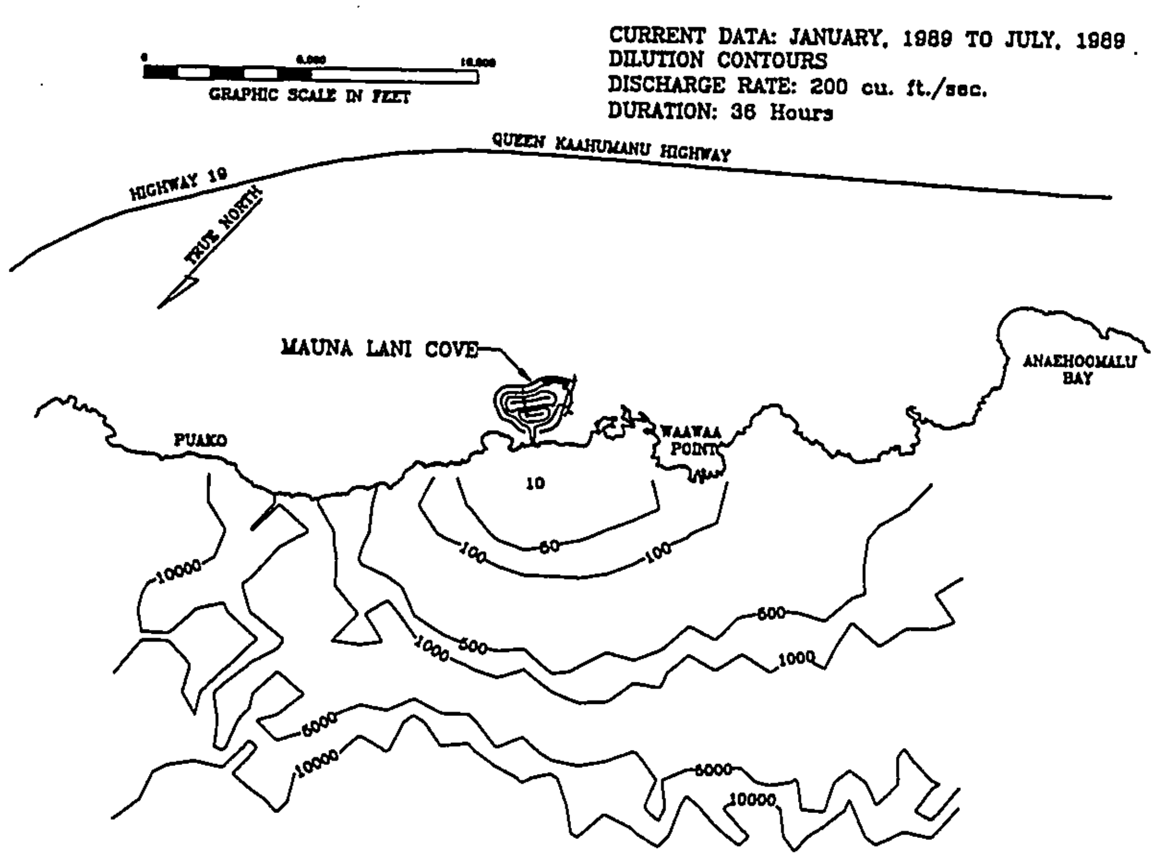


Figure 18: Probable Dilutions For Discharged Flow (Q=200 cfs) From The Mauna Lani Cove At Time t = 36 hrs. After Discharge.

3.3 Farfield Modeling Evaluation

The methodology used in the evaluation of the farfield modeling of the quasi-continuous discharge from the Mauna Lani Cove is similar to the Monte Carlo simulation model developed for the farfield evaluation described in Section 2.3. For the Cove ebb flow, the entire set of 6 months of current data was used for the evaluation.

Since the concentration of a particular constituent of interest is presently unknown, the resulting contour values (hrs/km^3) which were developed in Section 2.3 can be transformed into dilutions based on a volume flow rate from the Mauna Lani Cove. Since the flow out of the Cove is periodic, occurring for 6 hours out of every 12 hours, some judgement is necessary in the selection of the continuous flow rate parameter. The average flow rate during ebb flow was calculated in Section 3.1 as Q = 200 ft^3/sec. If this value were to be used as the continuous flow rate, it would provide a very conservative number since the flow rate is zero during the 6 hours of flood flow. On the other hand, the ebb flow rate could be averaged over the entire 12 hr period, yielding an average flow rate of Q = 100 ft^3/sec. For environmental assessment purposes, both of these flow rates have been used in order to bracket the farfield dilutions from the continuous discharge of Mauna Lani Cove waters during ebb flow.

Figures 16 to 19 provide the dilution results for Q = 200 ft^3/sec and Figures 20 to 23 provide the results for Q = 100 ft^3/sec for time horizons of 12, 24, 36 and 48 hours respectively after the initiation of discharge. Notice that changing the flow rate has a direct (reciprocal) change in the dilutions.

The above described far-field model represents a probabilistic and time-dependent solution for the advection, mixing and dilution of the Mauna Lani Cove waters released into the ocean environment on a continuous basis. While the marina waters are released continuously, the solution for the concentration of a conservative substance in the ocean receiving waters does not provide a steady-state solution. The reason for this is that since there is a source but no sink for the tracer substance, as time extends to infinity, the plume will continue to grow in the finite ocean waters. For the Mauna Lani Cove discharge, the rate of growth of the plume with time quickly (within about 36 - 48 hours) slows and becomes asymptotic, such that the plume dilutions at about 48 hours is reasonably representative of the plume spread for longer time periods and can be considered a quasi-steadystate description of the plume.

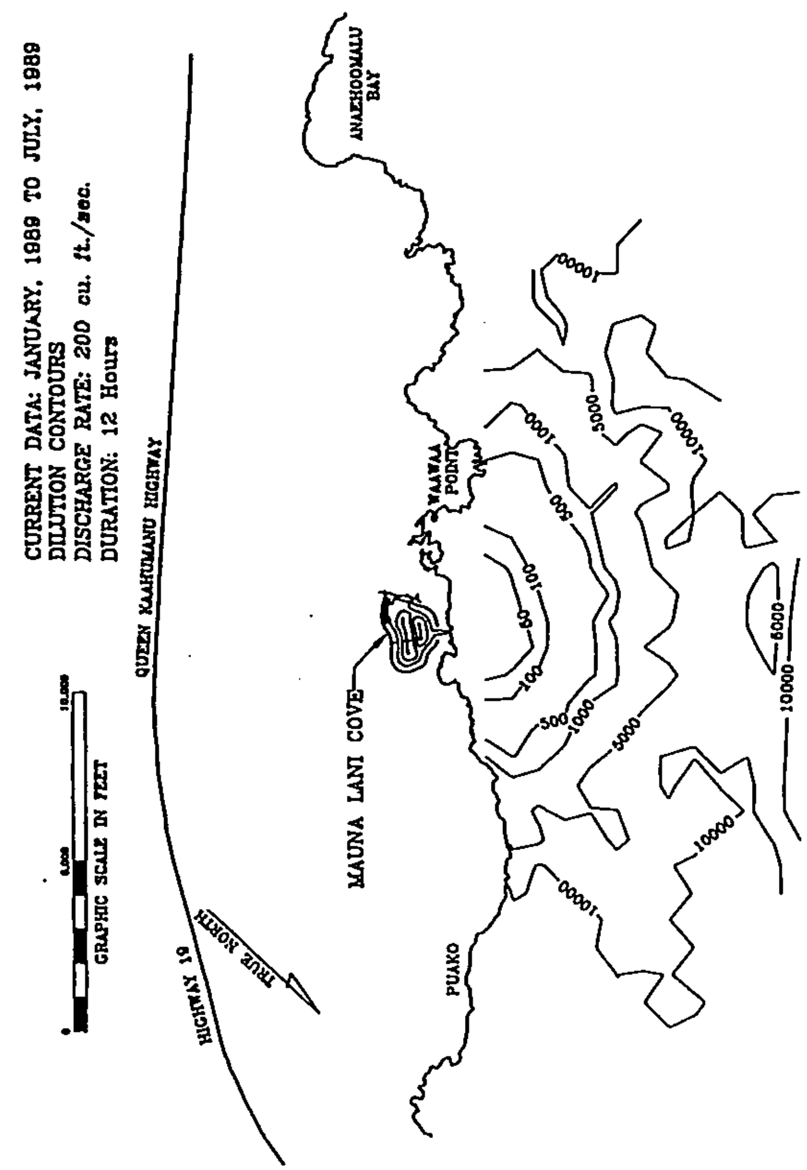


Figure 16: Probable Dilutions For Discharged Flow (Q=200 cfs) From The Mauna Lani Cove At Time t = 12 hrs. After Discharge.

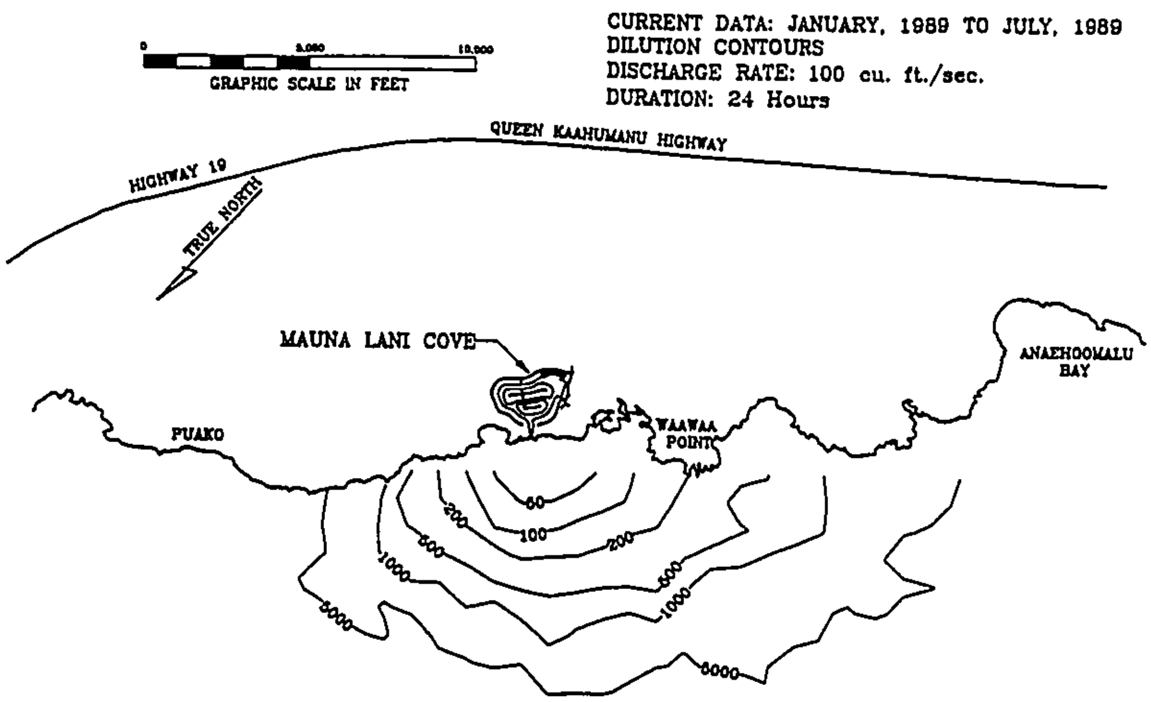


Figure 21: Probable Dilutions For Discharged Flow (100 cfs) From The Mauna Lani Cove At Time t = 24 hrs. After Discharge.

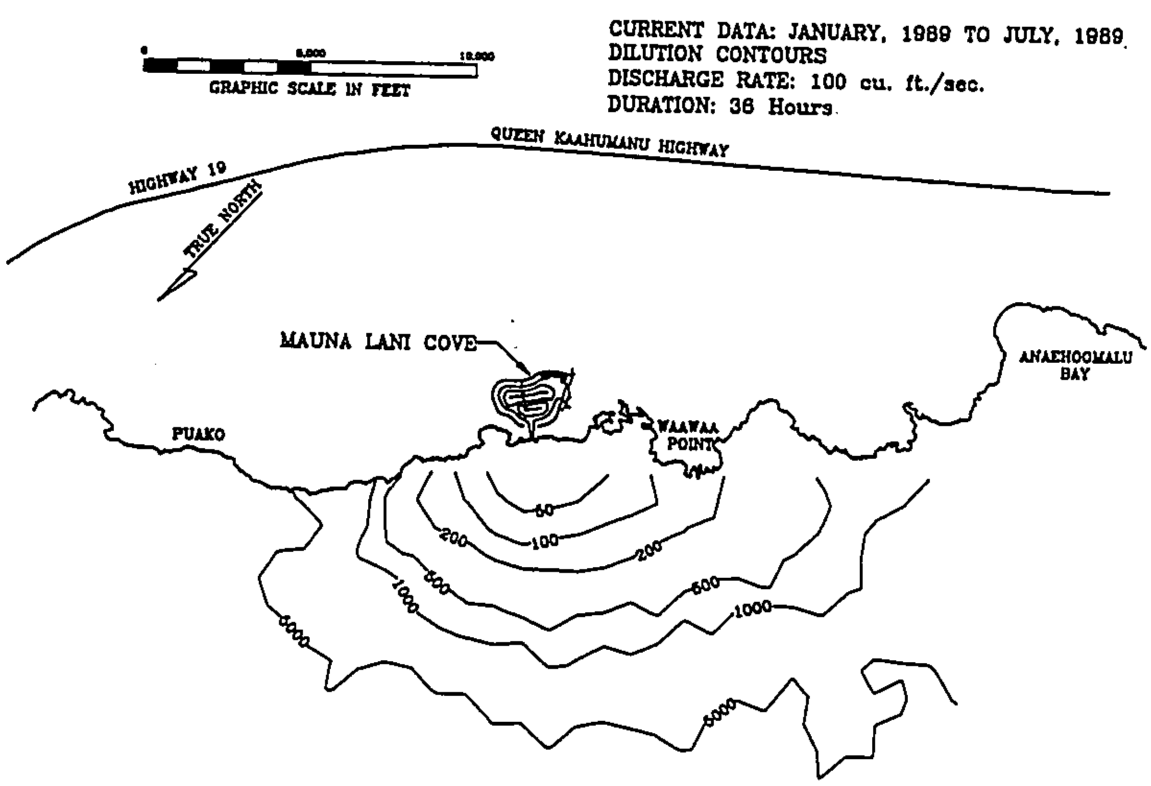


Figure 22: Probable Dilutions For Discharged Flow (100 cfs) From The Mauna Lani Cove At Time t = 36 hrs. After Discharge.

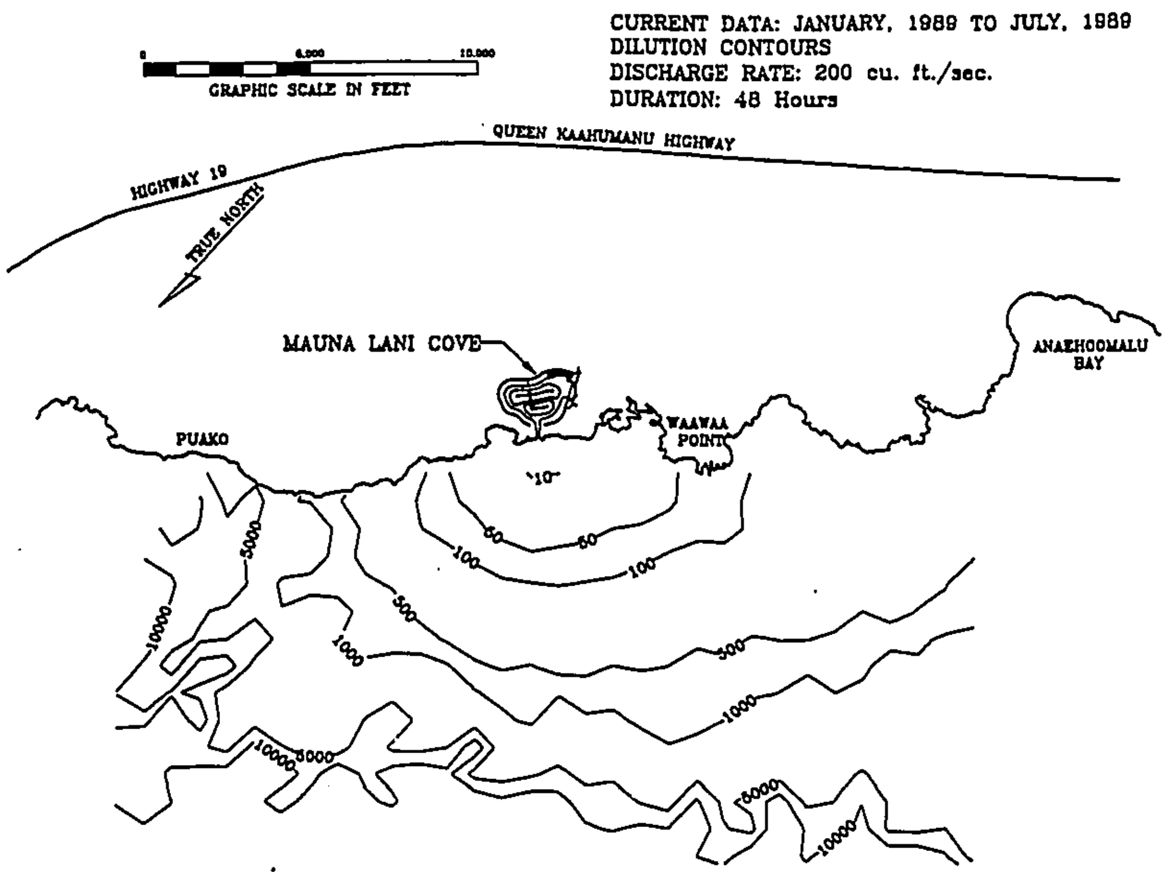


Figure 19: Probable Dilutions For Discharged Flow (Q=200 cfs) From The Mauna Lani Cove At Time t = 48 hrs. After Discharge.

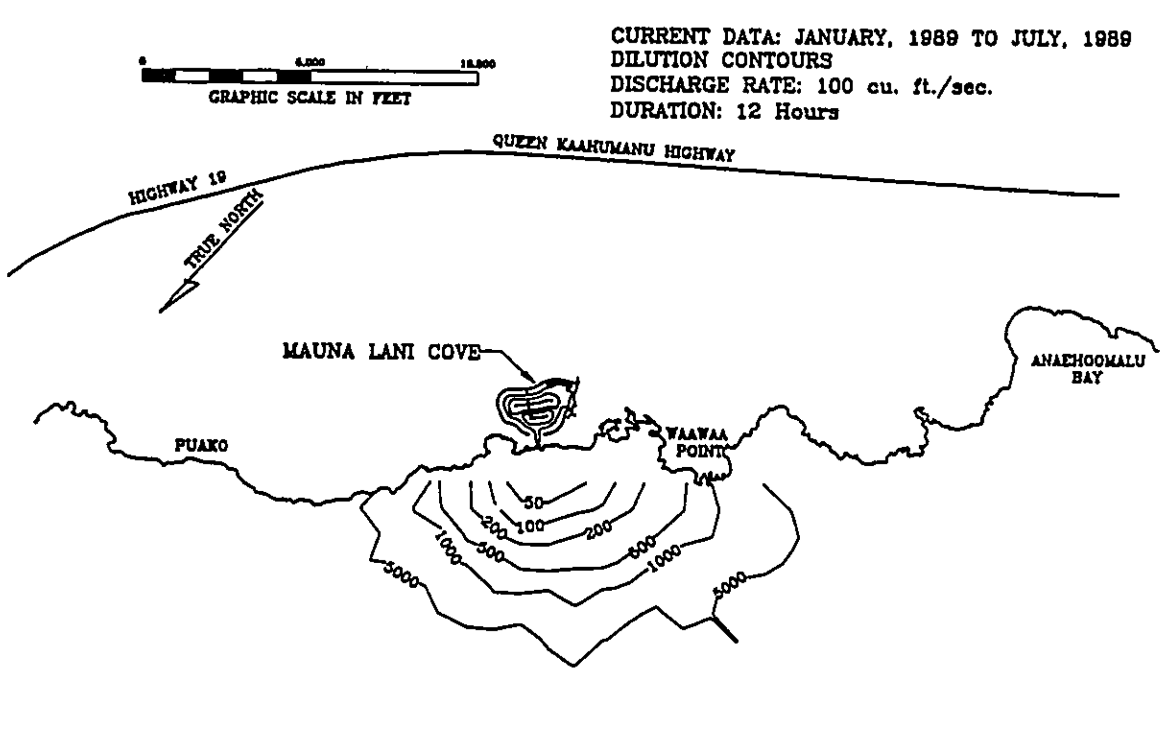


Figure 20: Probable Dilutions For Discharged Flow (100 cfs) From The Mauna Lani Cove At Time t = 12 hrs. After Discharge.

The above calculations can be performed for any conservative constituent such as temperature, salinity, etc. and could also be applied to non-conservative parameters such as nutrients which will then yield a conservative estimate of their ocean concentrations.

In general, Figures 16 to 23 show that there are significant dilution factors which exist in the nearshore waters surrounding the Mauna Lani Cove entrance channel due to the existing offshore current structure. This relatively high dilution capability will mix and dilute any discharged effluent within a very short distance from the entrance channel, thereby significantly limiting the extent of areal impact to the adjacent coastal environments.

4. REFERENCES

1. Brooks, N.H. (1960), "Diffusion Of Sewage Effluent In An Ocean Current," Proc. Int. Conf. Waste Disposal Mar. Environment, 1st, 246-267, Pergamon, Oxford.

2. Daxboeck, C. (1988), "Effects On Water Quality, And Reef Fish Community Structure From Beach Reconstruction At Makaiwa Bay, Mauna Lani Resort, Inc., South Kohala, Hawaii, Phase IV-1988," Report By Mauna Lani Resort, Inc.

3. Fischer, H.B, E.J. List, R.C.Y. Koh, J. Imberger and N.H. Brooks (1979), Mixing In Inland And Coastal Waters, Academic Press.

4. Golubeva, V.N. (1964), "The Formation of the Temperature Field in a Stratified Sea," Bull. of Acad. of Sci. of the USSR, Geophy. Ser. (Transl. by F. Goodspeed), No. 5, pp. 4670-4671.

5. Isayeva, L.S. and Isayev, I.L. (1963), "Determination of Vertical Eddy Diffusion in the Upper Layer of the Black Sea by a Direct Method," Issue No. 2, 1963 series, Soviet Oceanography Trans. of the Marine Hydrophysical Institute, Acad. of Sci. of the USSR, (Transl. by Scripta Technica, Inc.), pp. 22-24.

6. Koh, R.C.Y. (1988), "Shoreline Impact From Ocean Waste Discharges," Journal of Hydraulic Engineering, Vol. 109, No. 9, September.

7. Marine Research Consultants (1989), "Preliminary Assessment Of The Marine And Pond Environment In The Vicinity Of The Proposed Mauna Lani Cove, South Kohala, Hawaii," Report Prepared For Belt, Collins and Associates, Inc., 3 October.

8. Ocees International, Inc. (1989), "Water Quality and Exchange Characteristics of Mauna Lani Cove," Report Prepared For Peratrovich, Nottingham and Drage, Inc., December.

9. Ocees International, Inc. (1990), "Water Quality and Exchange Characteristics of Mauna Lani Cove, Addendum," Report Prepared For Peratrovich, Nottingham and Drage, Inc., January.

10. Okubo, A. (1974), "Some Speculation On Oceanic Diffusion Diagrams," Rapp. P.-v. Reun. Cons. Int. Explor. Mer. 167, pp. 77-85.

11. Rudavsky, A.B. and A.W.K. Law (1989), "Hydraulic Model Study Of The Mauna Lani Cove," Report Prepared For Peratrovich, Nottingham and Drage, Inc. By Hydro Research Science, Inc., September.

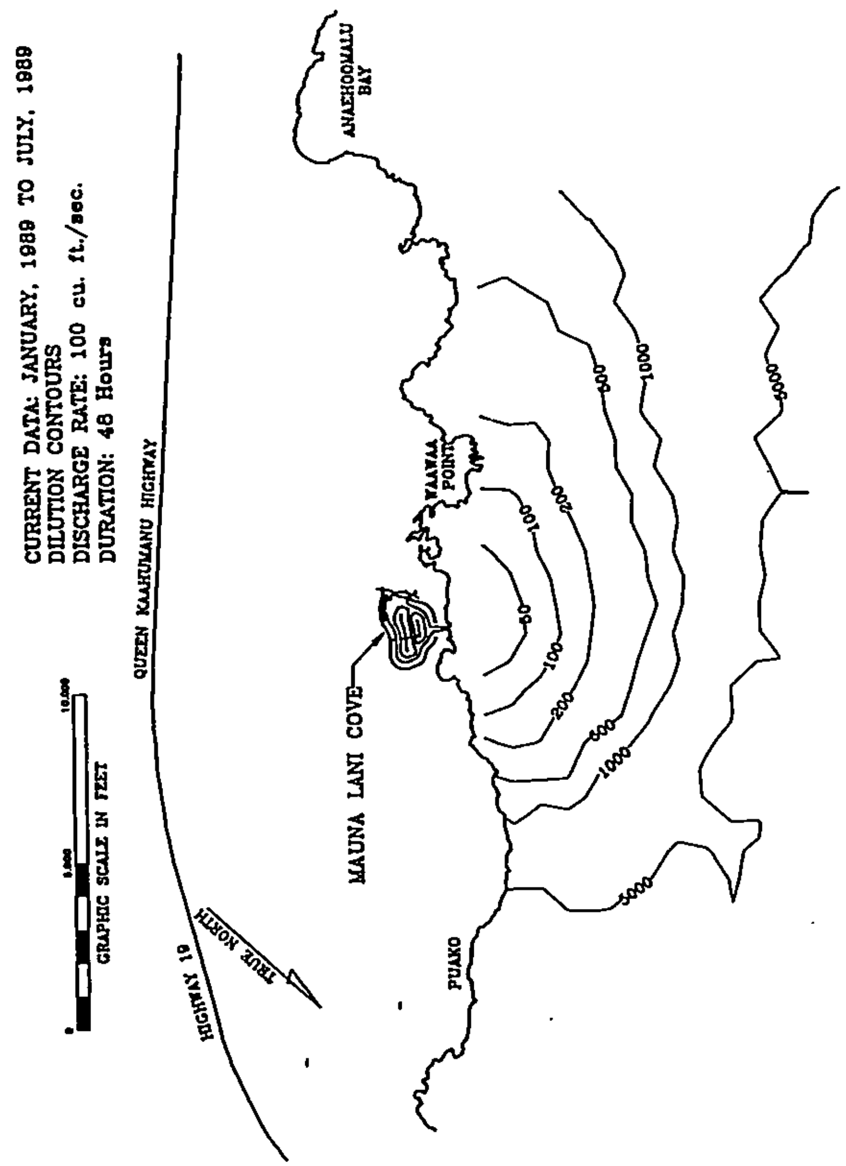


Figure 23: Probable Dilutions From Discharged Flow (100 cfs) From The Mauna Lani Cove At T me t = 48 hrs. After Discharge.

3.4 Discussion And Summary

Figures 16 - 23 can be used to calculate the concentration of any conservative parameter which is released into the ocean from the out flow of the Mauna Lani Cove inland waterways through the proposed entrance channel. The calculated contours are provided in dilution values where the dilution, D, is defined as

$$D = \frac{Q}{Q_o}$$

where
Q_o = initial volume of fluid discharged from the waterways,
$Q = Q_o + Q_a$
Q_a = ambient waters which have mixed with the initial volume of fluid discharged from the waterways.

Based on the above definition of dilution, the concentration of any specified constituent, S, in the ocean receiving waters can be directly calculated by the following relationship

$$S = S_a + (S_o - S_a)/D \qquad (5)$$

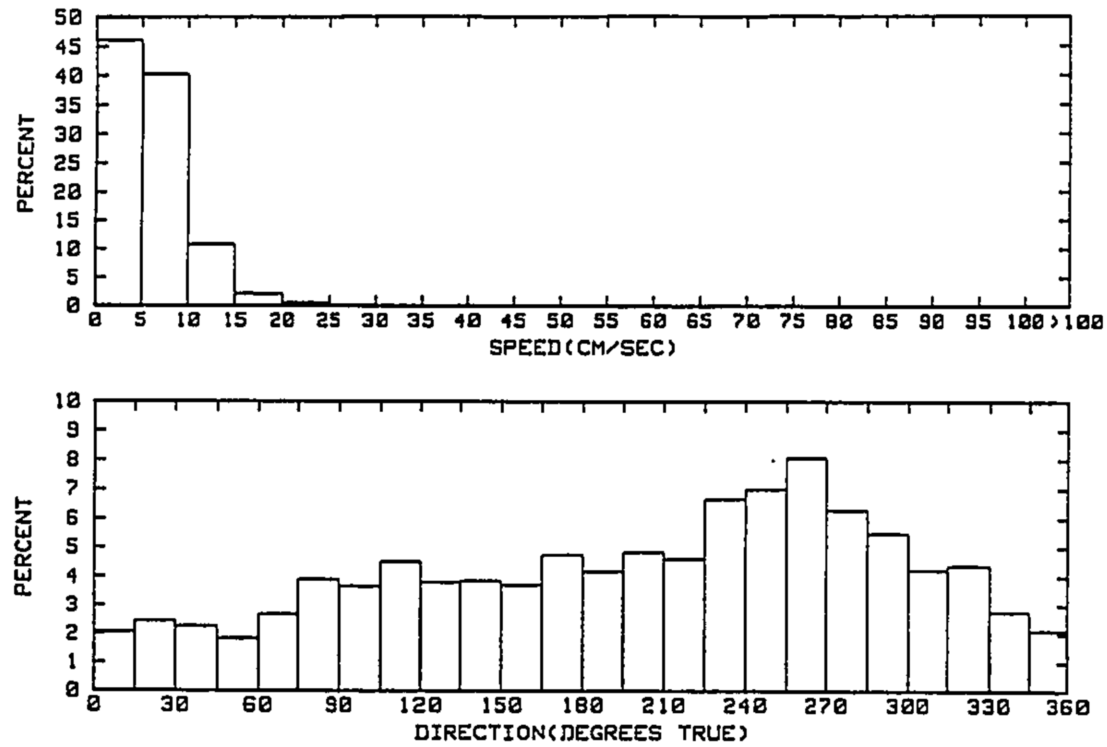
where
S = the concentration of a constituent in the ocean environment,
D = the dilution values obtained from Figures 16-23,
S_a = concentration of the constituent in the ambient ocean waters,
S_o = concentration of the constituent in the initially discharged Cove flow.

The following example is provided to show the use of Eqn. 5. Consider turbidity in the form of total suspended solids (TSS) with a concentration of say S_o = 30 mg/l in the waters of the Mauna Lani Cove, and which are discharged during ebb flow. The turbidity concentration in the ambient ocean waters is assumed to be S_a = 0.7 mg/l. For a time duration of 36 hours after the initiation of the discharge, Figure 18 (for a flow rate of 200 ft^3/sec) shows that a dilution of D = 100 will occur within about 1.5 kilometers from the entrance channel. Based on Eqn. 5 the turbidity concentration at this contour is 1.0 mg/l which represents an excess above ambient of 0.3 mg/l. For a flow rate of 100 ft^3/sec, Figure 22 indicates that at this contour location, the dilution is about D = 200. Thus, Eqn. 5 shows that the estimated turbidity concentration would be 0.85 mg/liter or 1/2 the excess value of the previous calculations. Thus, the expected turbidity concentration at t = 36 hrs and within about 1.5 km from the entrance channel would be bracketed between 0.85 - 1.0 mg/l.

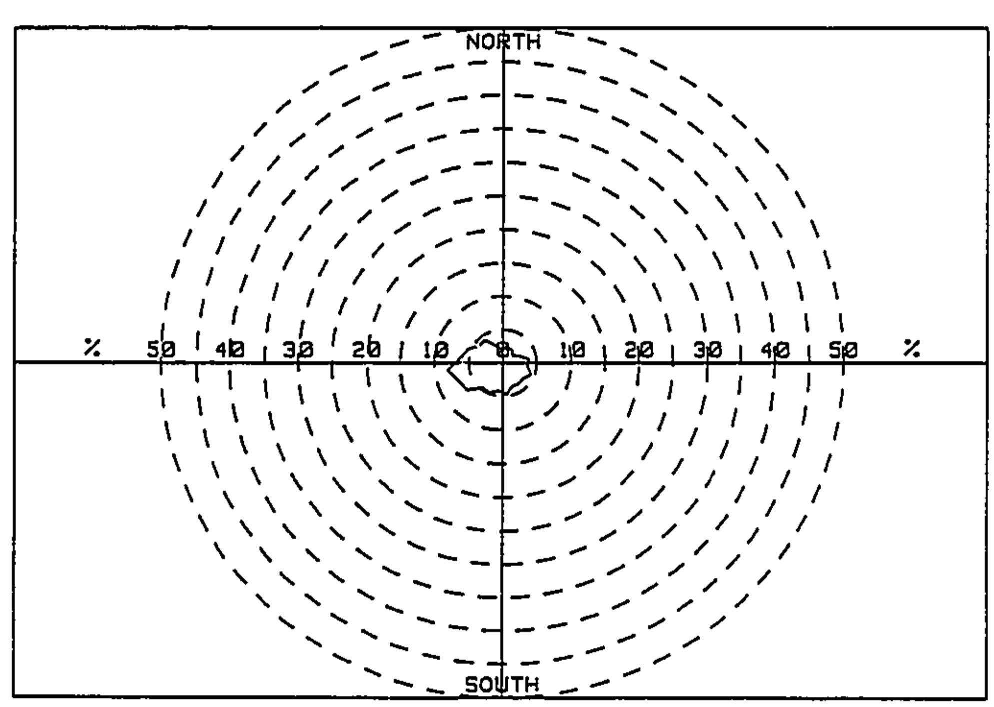
APPENDIX A: JANUARY 12 - APRIL 13, 1990
PROCESSED CURRENT DATA

```
MAUNA LANI, HAWAII METER DEPLOYMENT -- 1

CURRENT METER S/N --    0

METER POSITION ----- 1

DATA ACQUISITION
   DEPLOYMENT DATE(HST) - JAN. 13,1989
   DEPLOYMENT.TIME(HST) - 1400

   RETRIEVAL DATE(HST) --- APR. 12,1989
   RETRIEVAL TIME(HST) --- 0800

MOORING LOCATION
   LATITUDE --------
   LONGITUDE -------

SENSOR DEPTH(M) ---- 10

BOTTOM DEPTH(M) ---- 12

REV/COUNT SETTING --   1

DATA ANALYSIS
   START DATE(HST) - JAN. 13,1989
   START TIME(HST) - 1400

   ENDING DATE(HST) - APR. 12,1989
   ENDING TIME(HST) - 0800

TIME INTERVAL(MIN) -  60.00

NO. OF DATA FILES --   8
```

12.Sea Engineering, Inc. (1989), "Final Data Report - Nearshore Wave and Current Measurements For The Mauna Lani Resort, North Kona, Hawaii," Report Prepared For Peratrovich, Nottingham and Drage, Inc., October.



HISTOGRAMS OF CURRENT SPEEDS
(HST) 1400 JAN 13 1989 TO 0800 APR 12 1989
LATITUDE: LONGITUDE: NOMINAL DEPTH(M): 10



PERCENT OCCURRENCE VS DIRECTION(DEG TRUE)
(HST) 1400 JAN 13 1989 TO 0800 APR 12 1989
LATITUDE: LONGITUDE: NOMINAL DEPTH(M): 10

DISTRIBUTION FREQUENCY

1.00 HOUR AVERAGES
DEPLOYMENT 1 METER POSITION 1
FROM 1400 13 JAN 1989 TO 800 12 APR 1989

DIRECTION DEGREES TRUE — 10 METERS DEPTH

0- 15	21	18	5	0	0	0	0	0	0	0
15- 30	32	13	7	0	0	0	0	0	0	0
30- 45	26	20	2	0	0	0	0	0	0	0
45- 60	22	12	0	3	2	0	0	0	0	0
60- 75	25	25	2	4	0	1	0	0	0	0
75- 90	30	36	11	3	2	1	0	0	0	0
90-105	36	23	18	1	0	0	0	0	0	0
105-120	39	42	13	2	0	0	0	0	0	0
120-135	37	31	10	1	1	1	0	0	0	0
135-150	31	37	10	4	0	0	0	0	0	0
150-165	35	32	11	0	1	0	0	0	0	0
165-180	59	30	12	0	0	0	0	0	0	0
180-195	54	26	9	0	0	0	0	0	0	0
195-210	58	41	4	0	0	0	0	0	0	0
210-225	65	28	4	1	0	0	0	0	0	0
225-240	64	66	9	3	0	0	0	0	0	0
240-255	56	69	22	2	0	0	0	0	0	0
255-270	67	74	22	7	1	1	0	0	0	0
270-285	55	57	21	1	0	0	0	0	0	0
285-300	42	56	13	5	1	0	0	0	0	0
300-315	35	38	9	5	2	0	1	0	0	0
315-330	41	40	9	2	1	0	0	0	0	0
330-345	28	26	4	1	0	0	0	0	0	0
345-360	24	18	3	0	0	0	0	0	0	0
SPEED CM/SEC	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50

0- 15	0	0	0	0	0	0	0	0	0	0	0
15- 30	0	0	0	0	0	0	0	0	0	0	0
30- 45	0	0	0	0	0	0	0	0	0	0	0
45- 60	0	0	0	0	0	0	0	0	0	0	0
60- 75	0	0	0	0	0	0	0	0	0	0	0
75- 90	0	0	0	0	0	0	0	0	0	0	0
90-105	0	0	0	0	0	0	0	0	0	0	0
105-120	0	0	0	0	0	0	0	0	0	0	0
120-135	0	0	0	0	0	0	0	0	0	0	0
135-150	0	0	0	0	0	0	0	0	0	0	0
150-165	0	0	0	0	0	0	0	0	0	0	0
165-180	0	0	0	0	0	0	0	0	0	0	0
180-195	0	0	0	0	0	0	0	0	0	0	0
195-210	0	0	0	0	0	0	0	0	0	0	0
210-225	0	0	0	0	0	0	0	0	0	0	0
225-240	0	0	0	0	0	0	0	0	0	0	0
240-255	0	0	0	0	0	0	0	0	0	0	0
255-270	0	0	0	0	0	0	0	0	0	0	0
270-285	0	0	0	0	0	0	0	0	0	0	0
285-300	0	0	0	0	0	0	0	0	0	0	0
300-315	0	0	0	0	0	0	0	0	0	0	0
315-330	0	0	0	0	0	0	0	0	0	0	0
330-345	0	0	0	0	0	0	0	0	0	0	0
345-360	0	0	0	0	0	0	0	0	0	0	0
SPEED CM/SEC	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	>100

SUMMARY STATISTICS

DEPLOYMENT 1 METER POSITION 1
FROM 1400 13 JAN 1989 TO 800 12 APR 1989

DIRECTION(DEGREES TRUE)	TOTAL OBSERVATIONS	PERCENT
0 TO 15	44	2.06
15 TO 30	52	2.44
30 TO 45	48	2.25
45 TO 60	39	1.83
60 TO 75	57	2.67
75 TO 90	83	3.89
90 TO 105	78	3.66
105 TO 120	96	4.50
120 TO 135	81	3.80
135 TO 150	82	3.85
150 TO 165	79	3.71
165 TO 180	101	4.74
180 TO 195	89	4.18
195 TO 210	103	4.83
210 TO 225	98	4.60
225 TO 240	142	6.66
240 TO 255	149	6.99
255 TO 270	172	8.07
270 TO 285	134	6.29
285 TO 300	117	5.49
300 TO 315	90	4.22
315 TO 330	93	4.36
330 TO 345	59	2.77
345 TO 360	45	2.11

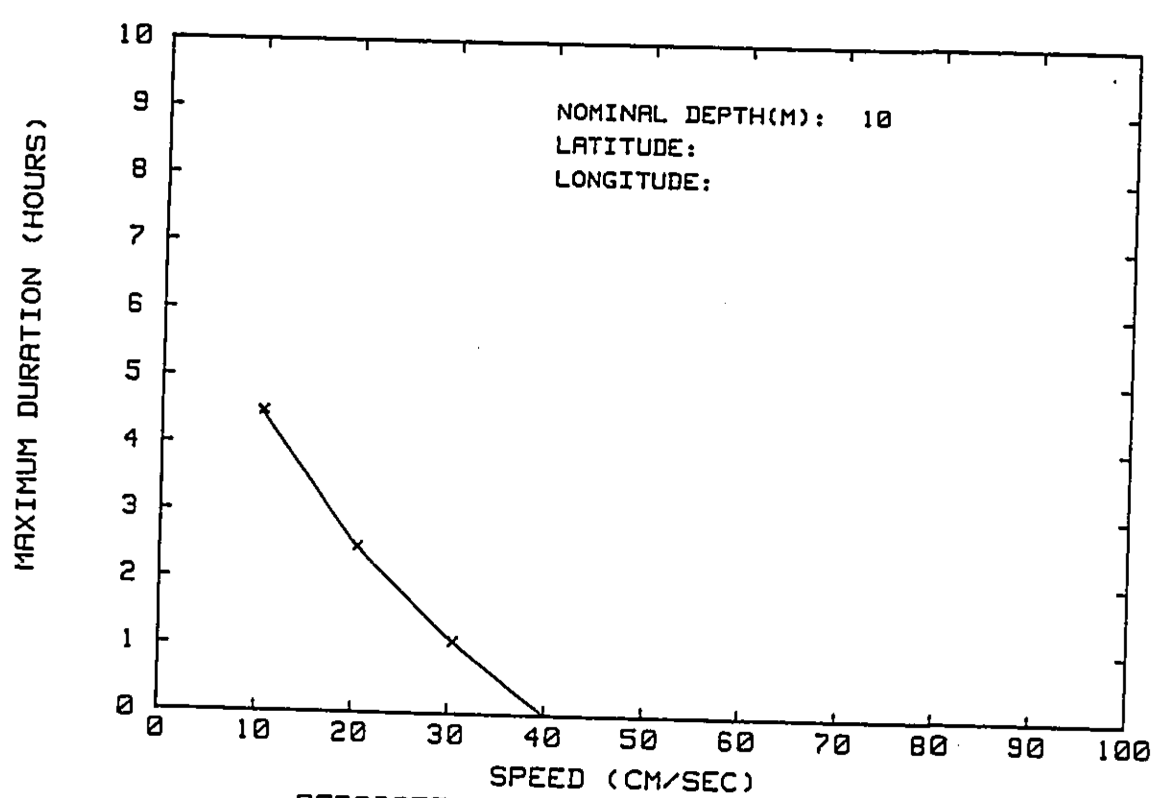
SPEED(CM/SEC)	TOTAL OBSERVATIONS	PERCENT
0.0 TO 5.0	982	46.08
5.0 TO 10.0	858	40.26
10.0 TO 15.0	230	10.79
15.0 TO 20.0	45	2.11
20.0 TO 25.0	11	.52
25.0 TO 30.0	4	.19
30.0 TO 35.0	1	.05
35.0 TO 40.0	0	0.00
40.0 TO 45.0	0	0.00
45.0 TO 50.0	0	0.00
50.0 TO 55.0	0	0.00
55.0 TO 60.0	0	0.00
60.0 TO 65.0	0	0.00
65.0 TO 70.0	0	0.00
70.0 TO 75.0	0	0.00
75.0 TO 80.0	0	0.00
80.0 TO 85.0	0	0.00
85.0 TO 90.0	0	0.00
90.0 TO 95.0	0	0.00
95.0 TO 100.0	0	0.00
ABOVE 100	0	0.00

TOTAL NUMBER OF POINTS READ = 2131
TOTAL NUMBER OF OBSERVATIONS USED IN THE DISTRIBUTIONS = 2131
MEAN SPEED = 6.10 CM/SEC
STANDARD DEVIATION = 3.85 CM/SEC
MAXIMUM SPEED = 32.99 CM/SEC
MINIMUM SPEED = .08 CM/SEC
RANGE = 32.91 CM/SEC

LATITUDE:
LONGITUDE:
NOMINAL DEPTH(METERS): 10
TIME SPAN(HST): 1400 JAN 13 1989 TO 0800 APR 12 1989

PERSISTENCE OF CURRENT SPEEDS

SPEED (CM/SEC)	MAXIMUM DURATION (HOURS)
10	4.52
20	2.52
30	1.12
40	0.00

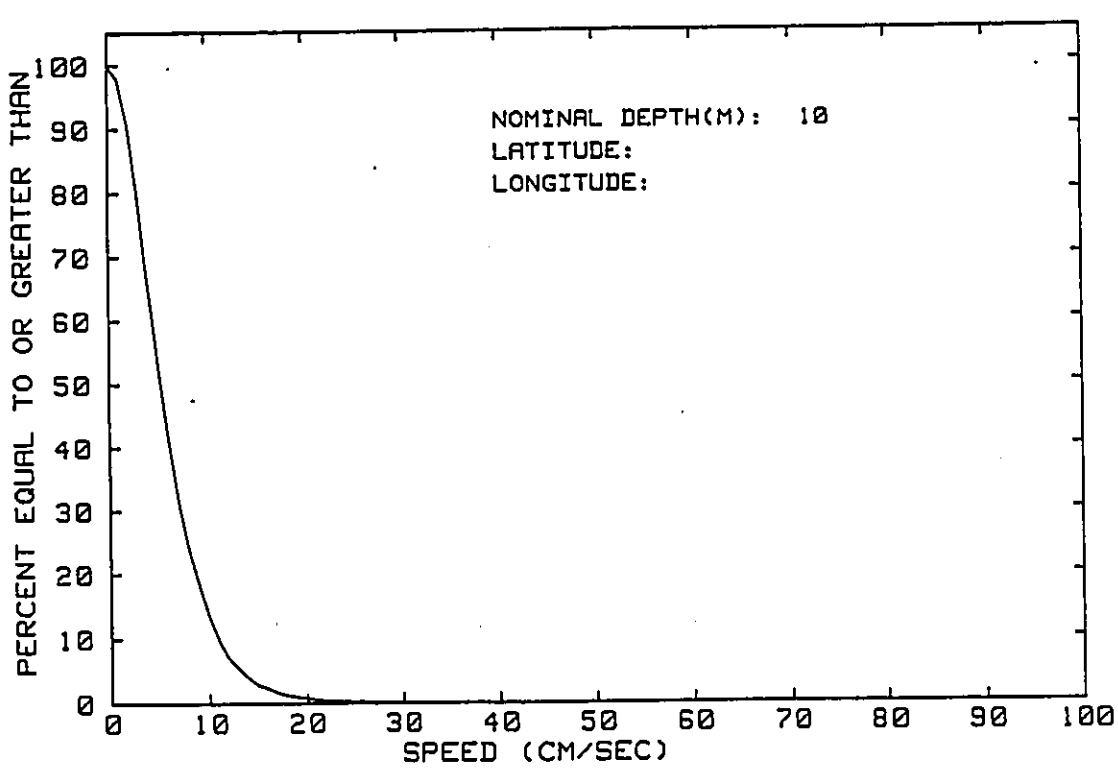


PERSISTENCE OF CURRENT SPEED FROM:
(HST) 1400 JAN 13 1989 TO 0800 APR 12 1989

LATITUDE:
LONGITUDE:
NOMINAL DEPTH(METERS): 10
TIME SPAN(HST): 1400 JAN 13 1989 TO 0800 APR 12 1989

CUMULATIVE OCCURENCE OF CURRENT SPEEDS

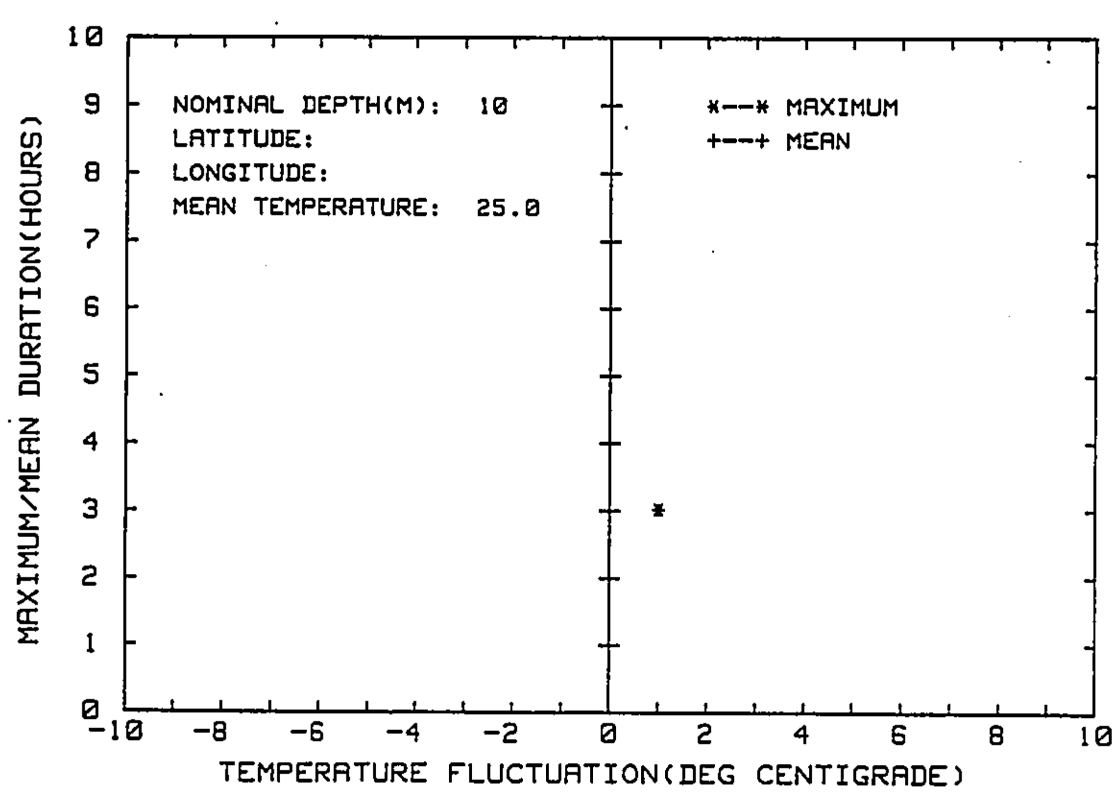
SPEED (CM/SEC)	PERCENT EQUAL TO OR GREATER THAN
0	100.000
3	79.822
6	42.234
9	18.958
12	7.100
15	2.863
18	1.267
21	.563
24	.328
27	.188
30	.047
33	0.000



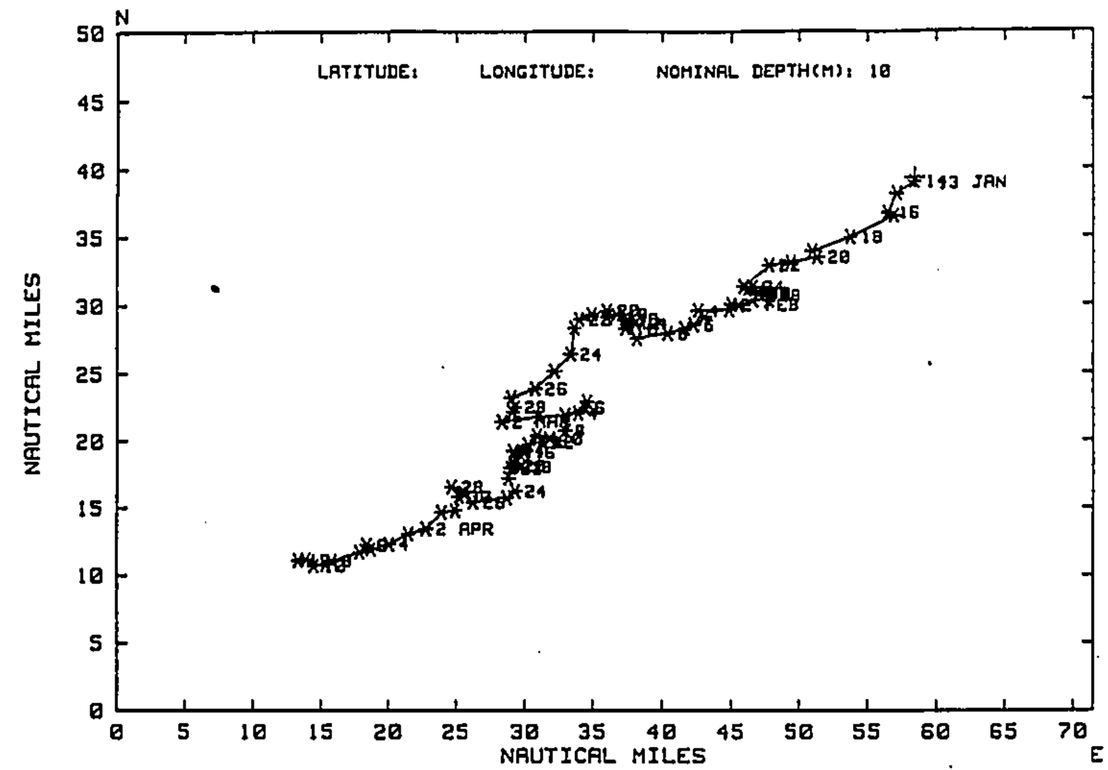
CUMULATIVE OCCURENCE OF CURRENT SPEEDS
(HST) 1400 JAN 13 1989 TO 0800 APR 12 1989

PERSISTENCE OF TEMPERATURE ABOUT MEAN

FLUCTUATION ABOUT MEAN	MAX DURATION(HRS)	MEAN DURATION(HRS)
+10	0.0	0.0
+ 9	0.0	0.0
+ 8	0.0	0.0
+ 7	0.0	0.0
+ 6	0.0	0.0
+ 5	0.0	0.0
+ 4	0.0	0.0
+ 3	0.0	0.0
+ 2	0.0	0.0
+ 1	3.0	3.0
MEAN TEMPERATURE = 25.0382		
-1	0.0	0.0
-2	0.0	0.0
-3	0.0	0.0
-4	0.0	0.0
-5	0.0	0.0
-6	0.0	0.0
-7	0.0	0.0
-8	0.0	0.0
-9	0.0	0.0
-10	0.0	0.0



PERSISTENCE OF TEMPERATURE ABOUT MEAN FROM:
(HST) 1400 JAN 13 1989 TO 0800 APR 12 1989

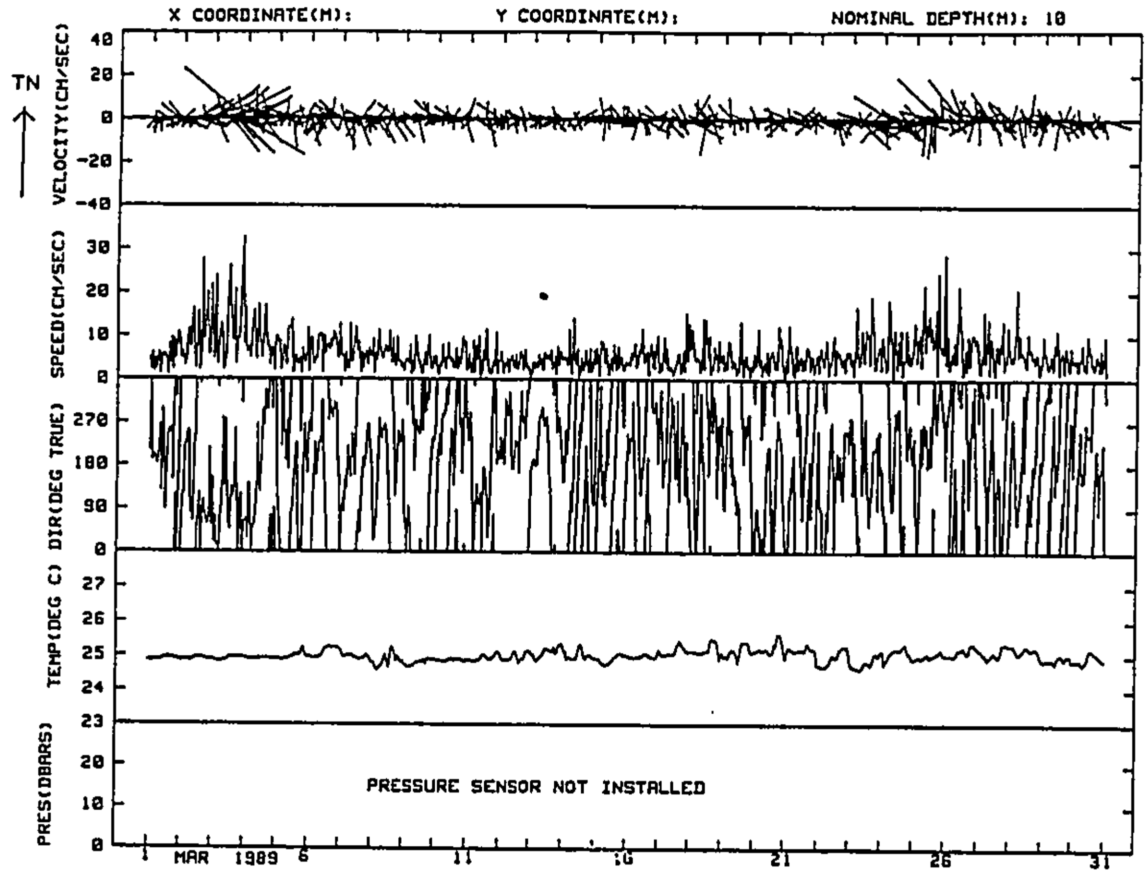


PROGRESSIVE VECTOR DIAGRAM OF CURRENTS
(HST) 1400 JAN 13 1989 TO 0800 APR 12 1989

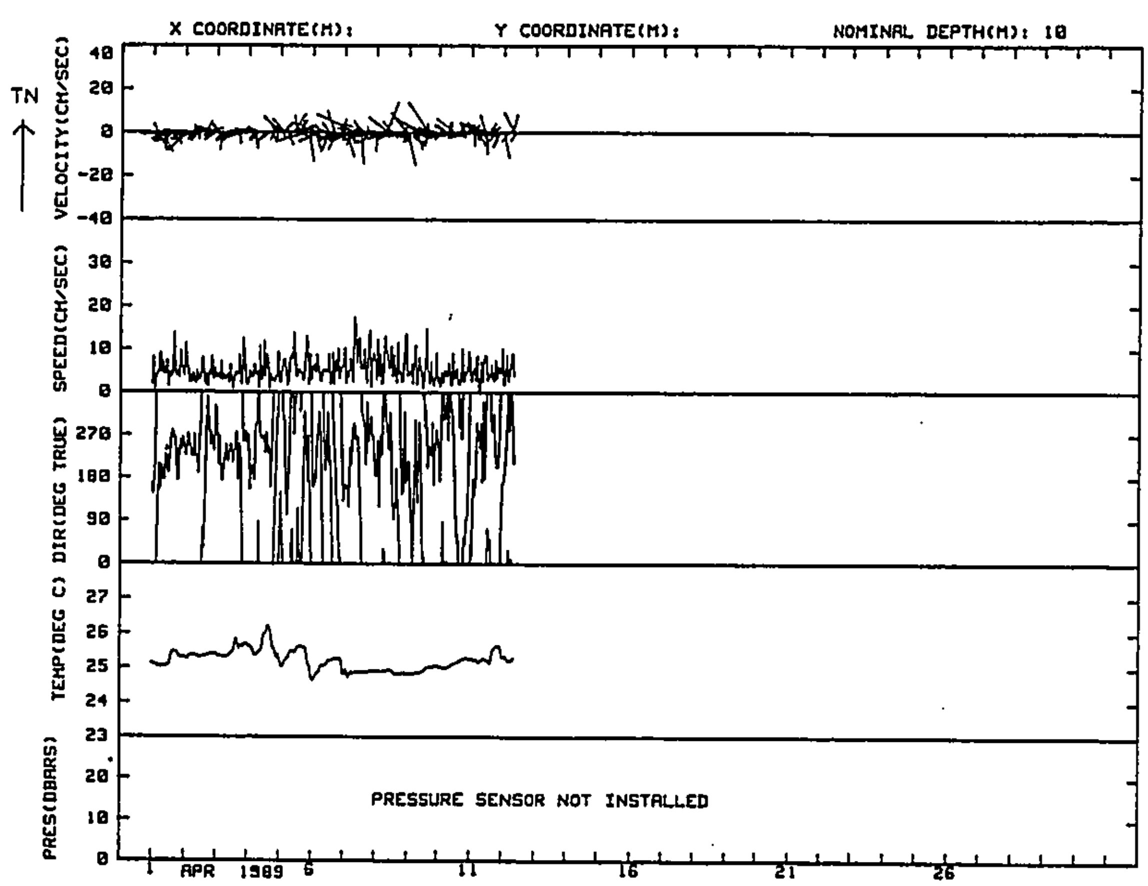
TEMPERATURE STATISTICS
DEPLOYMENT 1   METER POSITION 1
FROM 1400 13 JAN 1989 TO 800 12 APR 1989

TEMPERATURE(CENTIGRADE)	TOTAL OBSERVATIONS	PERCENT
0 TO 1	0	0.00
1 TO 2	0	0.00
2 TO 3	0	0.00
3 TO 4	0	0.00
4 TO 5	0	0.00
5 TO 6	0	0.00
6 TO 7	0	0.00
7 TO 8	0	0.00
8 TO 9	0	0.00
9 TO 10	0	0.00
10 TO 11	0	0.00
11 TO 12	0	0.00
12 TO 13	0	0.00
13 TO 14	0	0.00
14 TO 15	0	0.00
15 TO 16	0	0.00
16 TO 17	0	0.00
17 TO 18	0	0.00
18 TO 19	0	0.00
19 TO 20	0	0.00
20 TO 21	0	0.00
21 TO 22	0	0.00
22 TO 23	0	0.00
23 TO 24	0	0.00
24 TO 25	967	45.38
25 TO 26	1160	54.43
26 TO 27	4	.19
27 TO 28	0	0.00
28 TO 29	0	0.00
29 TO 30	0	0.00

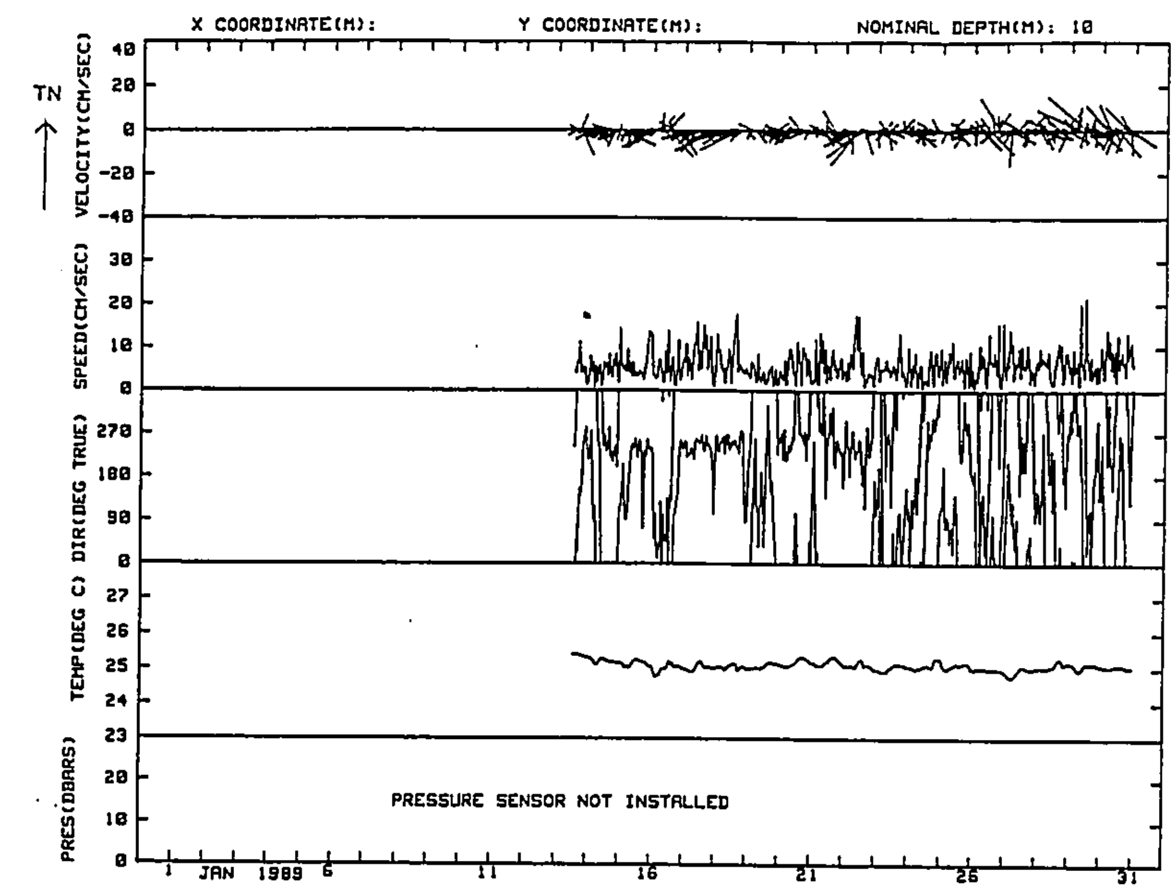
TOTAL NUMBER OF POINTS READ = 2131
TOTAL NUMBER OF OBSERVATION USED IN THE DISTRIBUTION = 2131
MEAN TEMPERATURE = 25.0 DEGREES CENTIGRADE
STANDARD DEVIATION = .2 DEGREES CENTIGRADE
MAXIMUM TEMPERATURE = 26.2 DEGREES CENTIGRADE
MINIMUM TEMPERATURE = 24.5 DEGREES CENTIGRADE
RANGE = 1.7 DEGREES CENTIGRADE



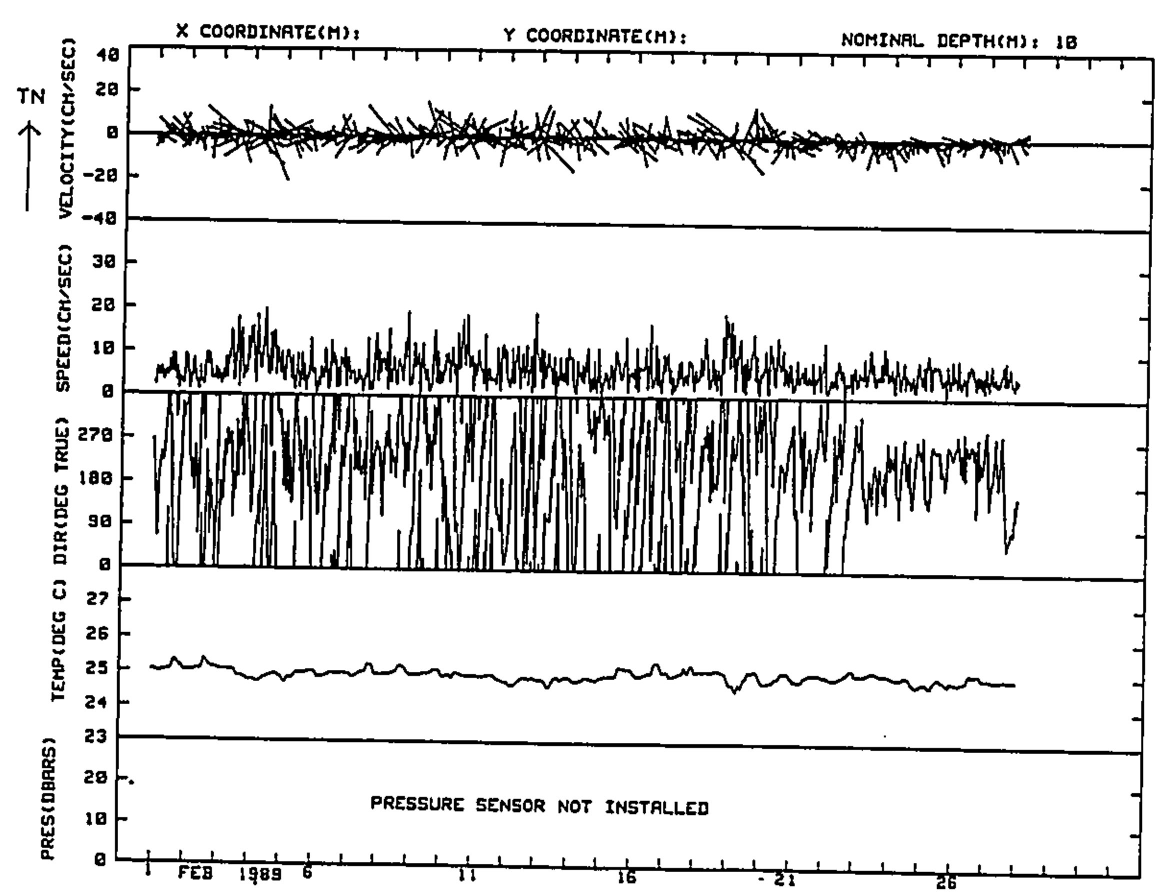
X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
SPEED(CM/SEC)
DIR(DEG TRUE)
TEMP(DEG C)
PRES(DBARS)
PRESSURE SENSOR NOT INSTALLED
MAR 1989



X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
SPEED(CM/SEC)
DIR(DEG TRUE)
TEMP(DEG C)
PRES(DBARS)
PRESSURE SENSOR NOT INSTALLED
APR 1989



X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
SPEED(CM/SEC)
DIR(DEG TRUE)
TEMP(DEG C)
PRES(DBARS)
PRESSURE SENSOR NOT INSTALLED
JAN 1989



X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
SPEED(CM/SEC)
DIR(DEG TRUE)
TEMP(DEG C)
PRES(DBARS)
PRESSURE SENSOR NOT INSTALLED
FEB 1989

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

Latitude: Longitude:
Meter Depth(m): 10.0 Bottom Depth(m): 12.0

Period: MARCH 1989

Mean Speed(cm/sec): 6.18
Maximum Speed(cm/sec): 32.99
Standard Deviation: 4.31
Average North Vector Component(cm/sec): -.52
Average East Vector Component(cm/sec): -.36
Resultant Magnitude(cm/sec): .63
Resultant Direction(°T): 215

Minimum Temperature(°C): 24.6
Maximum Temperature(°C): 25.6
Mean Temperature(°C): 25.0
Standard Deviation: .2

Day	Maximum Speed	Minimum Temperature	Maximum Temperature
1	10.76	24.9	25.0
2	28.10	24.8	25.0
3	32.99	24.8	25.0
4	17.50	24.9	24.9
5	13.98	24.9	25.2
6	12.86	24.9	25.3
7	13.03	24.9	25.2
8	11.49	24.6	25.3
9	10.12	24.7	24.9
10	9.07	24.8	24.9
11	11.65	24.8	25.1
12	6.91	24.8	25.1
13	7.65	24.8	25.3
14	14.45	24.9	25.4
15	8.93	24.7	25.1
16	11.81	24.9	25.1
17	15.64	25.0	25.4
18	14.44	24.9	25.5
19	13.60	24.8	25.4
20	12.45	25.1	25.6
21	12.73	24.9	25.4
22	10.17	24.7	25.3
23	19.43	24.6	25.3
24	10.60	24.7	25.4
25	29.12	24.9	25.2
26	29.12	25.0	25.4
27	16.04	24.9	25.4
28	21.25	25.0	25.3
29	11.41	24.8	25.0
30	10.27	24.7	25.2
31	10.32	24.8	25.2

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

Latitude: Longitude:
Meter Depth(m): 10.0 Bottom Depth(m): 12.0

Period: APRIL 1989

Mean Speed(cm/sec): 5.45
Maximum Speed(cm/sec): 17.72
Standard Deviation: 3.20
Average North Vector Component(cm/sec): -.68
Average East Vector Component(cm/sec): -2.05
Resultant Magnitude(cm/sec): 2.16
Resultant Direction(°T): 252

Minimum Temperature(°C): 24.6
Maximum Temperature(°C): 26.2
Mean Temperature(°C): 25.2
Standard Deviation: .3

Day	Maximum Speed	Minimum Temperature	Maximum Temperature
1	14.00	25.0	25.5
2	11.59	25.3	25.4
3	12.74	25.3	25.9
4	12.05	25.3	26.2
5	13.92	25.0	25.6
6	10.33	24.6	25.3
7	17.72	24.7	25.2
8	13.60	24.8	24.9
9	14.95	24.8	25.1
10	10.20	25.0	25.3
11	9.51	25.1	25.7
12	10.32	25.2	25.6

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

Latitude: Longitude:
Meter Depth(m): 10.0 Bottom Depth(m): 12.0

Period: JANUARY 1989

Mean Speed(cm/sec): 6.08
Maximum Speed(cm/sec): 21.62
Standard Deviation: 3.58
Average North Vector Component(cm/sec): -1.09
Average East Vector Component(cm/sec): -1.50
Resultant Magnitude(cm/sec): 1.85
Resultant Direction(°T): 234

Minimum Temperature(°C): 24.7
Maximum Temperature(°C): 25.4
Mean Temperature(°C): 25.1
Standard Deviation: .1

Day	Maximum Speed	Minimum Temperature	Maximum Temperature
13	11.25	25.3	25.4
14	8.65	25.1	25.3
15	14.73	25.0	25.3
16	14.05	24.7	25.2
17	15.84	24.9	25.2
18	17.94	24.9	25.1
19	8.67	25.0	25.2
20	11.55	25.0	25.3
21	13.68	25.1	25.3
22	17.64	25.0	25.3
23	13.57	24.9	25.1
24	10.11	25.0	25.3
25	11.31	25.0	25.3
26	16.07	25.0	25.1
27	16.07	24.7	25.1
28	11.19	25.0	25.3
29	21.62	24.9	25.2
30	14.06	25.0	25.1
31	16.99	24.9	25.3

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

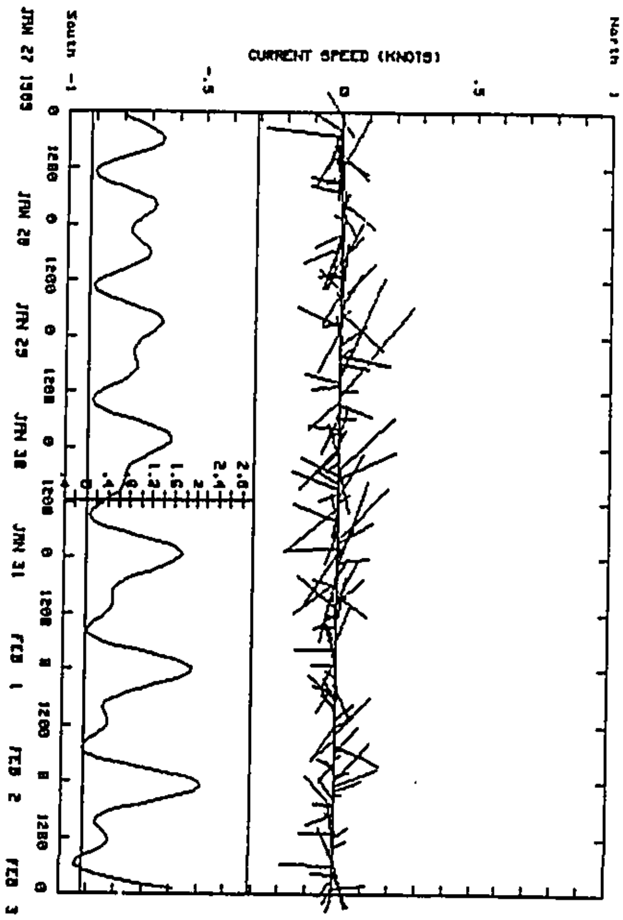
Latitude: Longitude:
Meter Depth(m): 10.0 Bottom Depth(m): 12.0

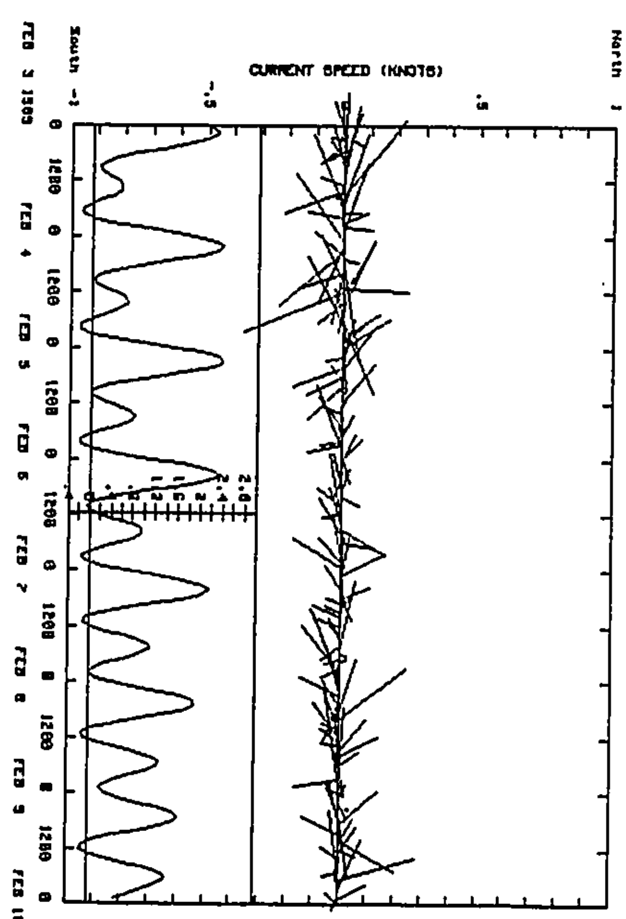
Period: FEBRUARY 1989

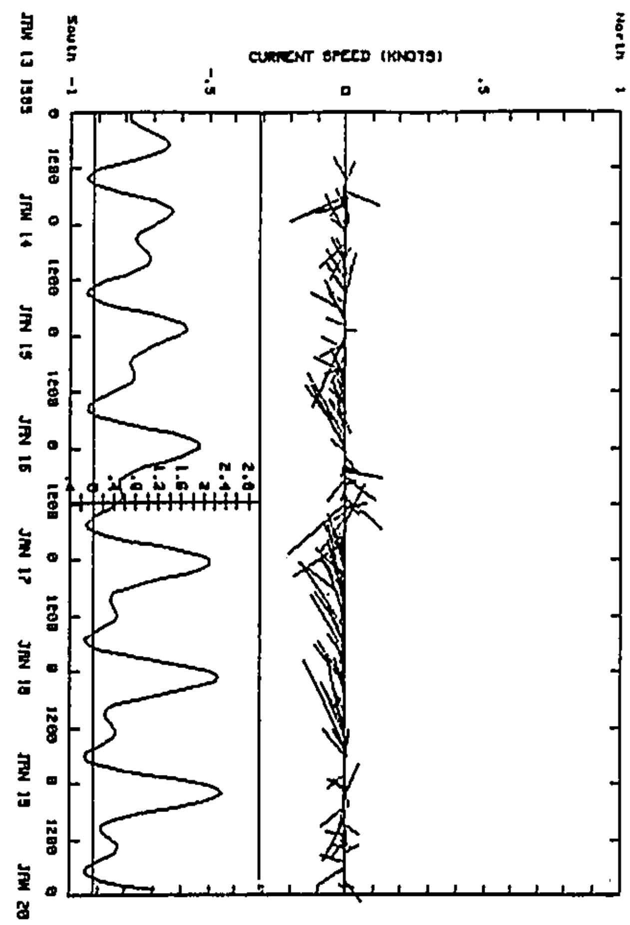
Mean Speed(cm/sec): 6.28
Maximum Speed(cm/sec): 20.03
Standard Deviation: 3.71
Average North Vector Component(cm/sec): -.60
Average East Vector Component(cm/sec): -1.26
Resultant Magnitude(cm/sec): 1.40
Resultant Direction(°T): 244

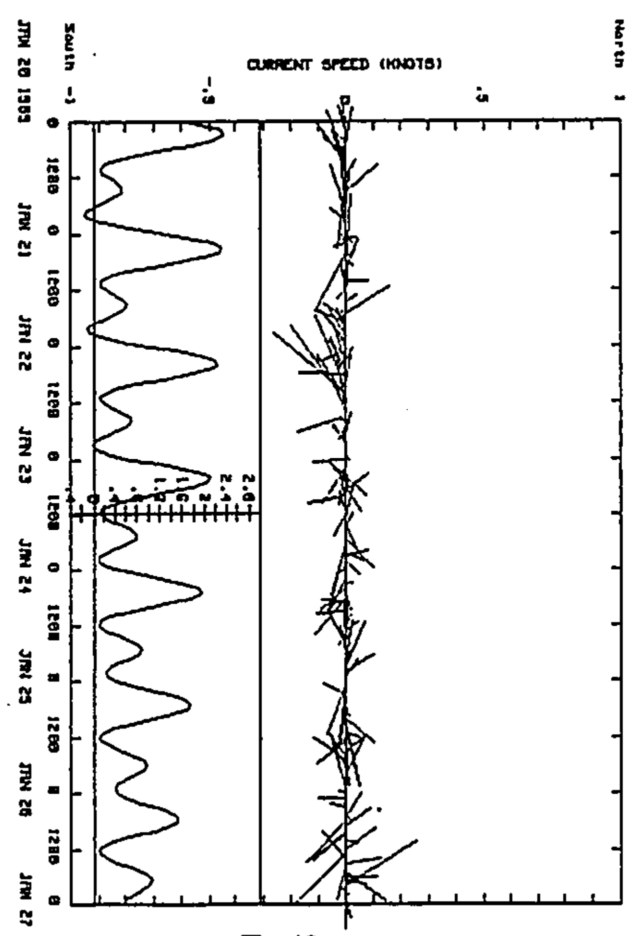
Minimum Temperature(°C): 24.5
Maximum Temperature(°C): 25.4
Mean Temperature(°C): 25.0
Standard Deviation: .1

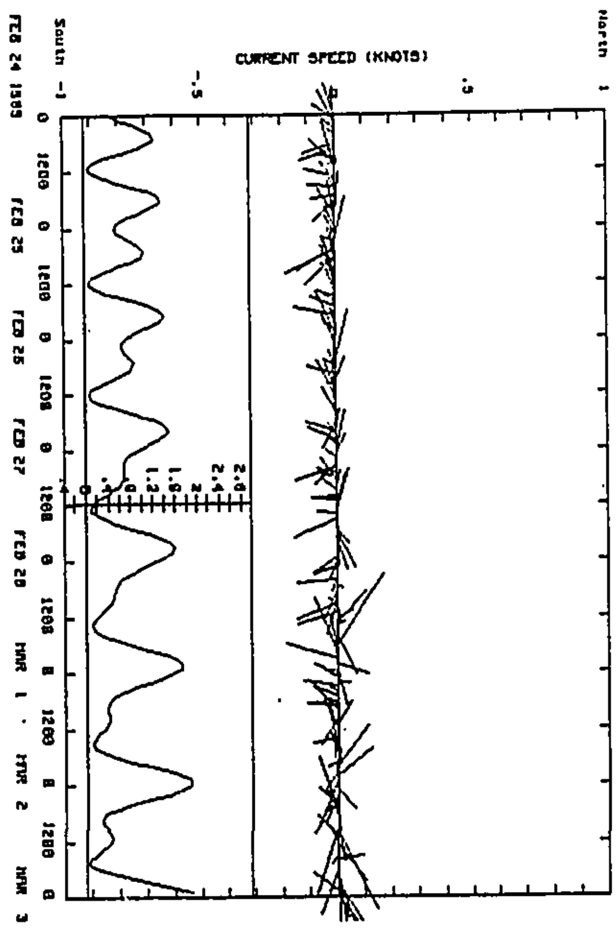
Day	Maximum Speed	Minimum Temperature	Maximum Temperature
1	9.61	25.0	25.3
2	9.07	25.0	25.4
3	10.14	24.8	25.1
4	20.03	24.7	25.0
5	13.19	24.7	25.0
6	12.62	24.9	25.1
7	14.28	24.9	25.3
8	19.51	25.0	25.2
9	15.10	25.0	25.1
10	19.00	24.9	25.1
11	14.75	24.8	25.0
12	19.58	24.6	24.9
13	11.34	24.6	24.9
14	11.52	24.8	24.9
15	13.86	24.9	25.2
16	17.07	24.9	25.4
17	10.29	24.9	25.3
18	19.79	25.0	25.2
19	10.05	24.5	25.2
20	14.13	24.8	25.1
21	12.96	24.8	25.1
22	12.96	24.9	25.2
23	11.87	25.0	25.2
24	9.40	24.7	25.0
25	10.21	24.7	25.0
26	9.22	24.8	25.1
27	8.81	24.9	25.0
28	16.03	24.9	24.9

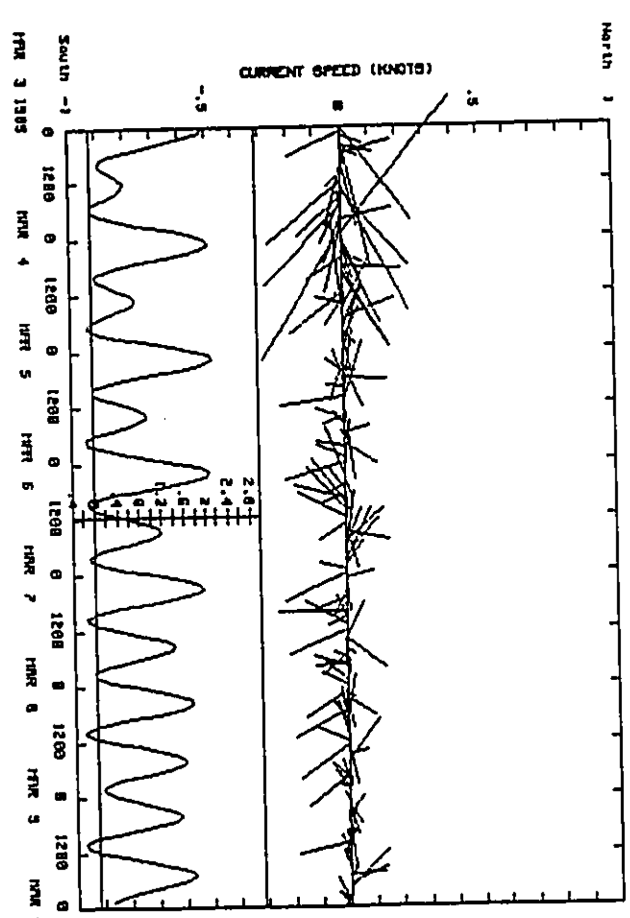

CURRENT SPEED (KNOTS)
North
South

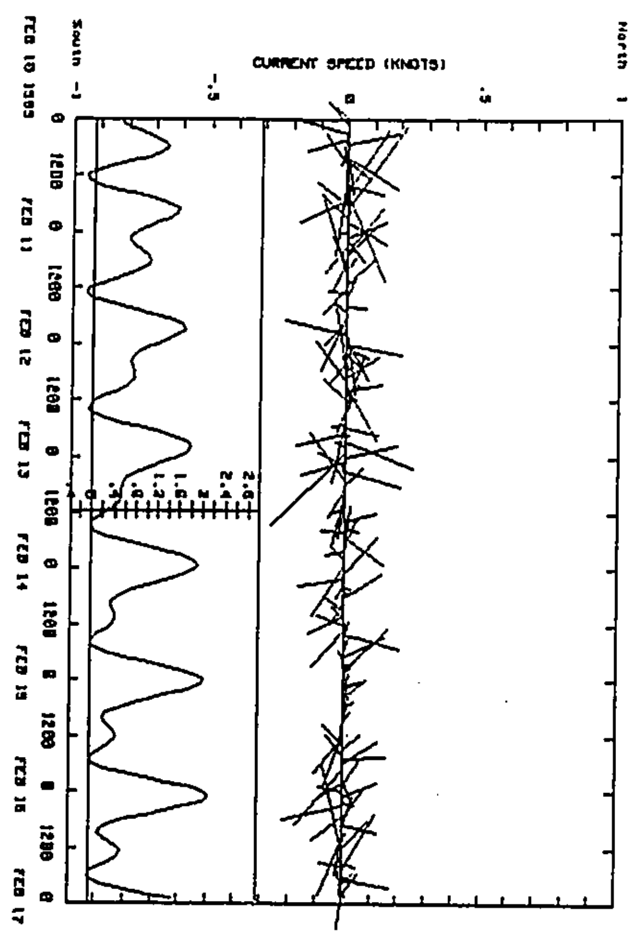

CURRENT SPEED (KNOTS)
North
South

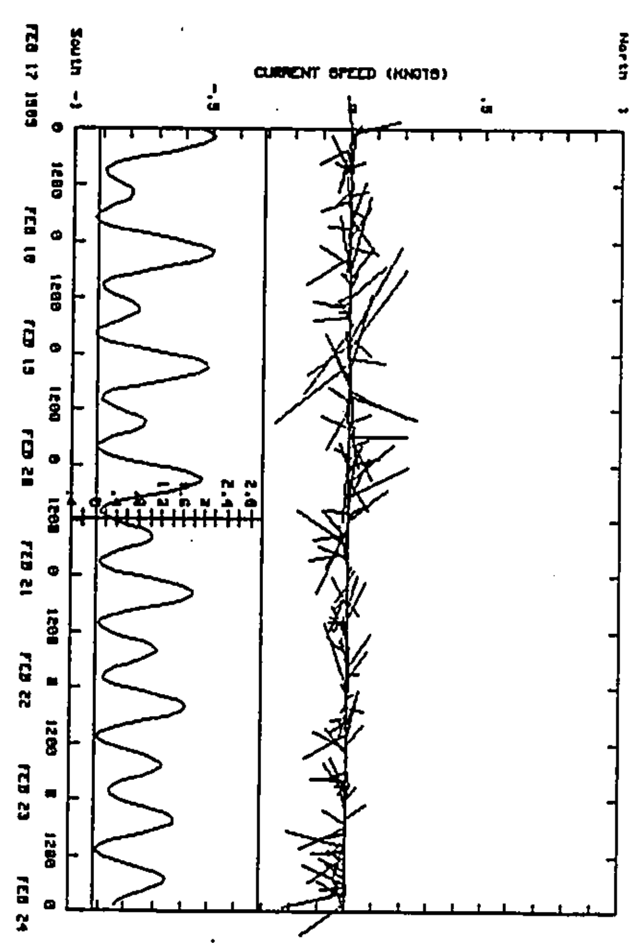

CURRENT SPEED (KNOTS)
South
North
JAN 14
JAN 15
JAN 16
JAN 17
JAN 18
JAN 19
JAN 20

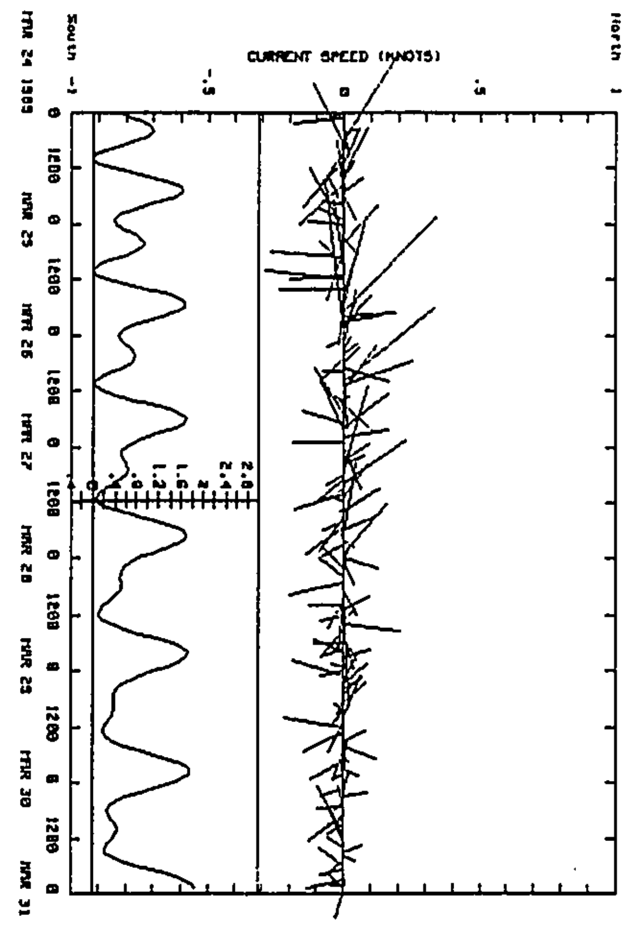

CURRENT SPEED (KNOTS)
South
North
JAN 21
JAN 22
JAN 23
JAN 24
JAN 25
JAN 26
JAN 27

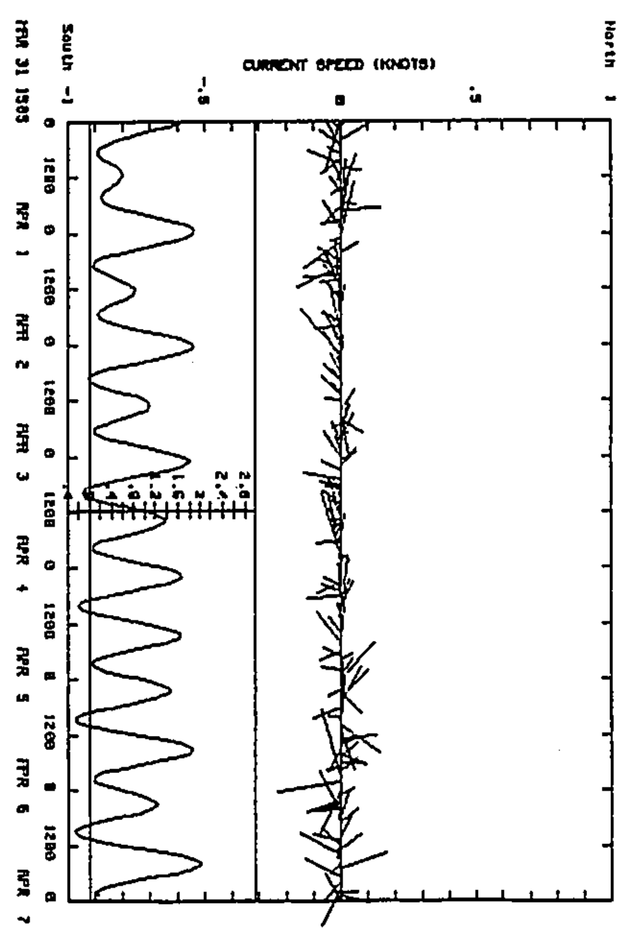

North
CURRENT SPEED (KNOTS)
South

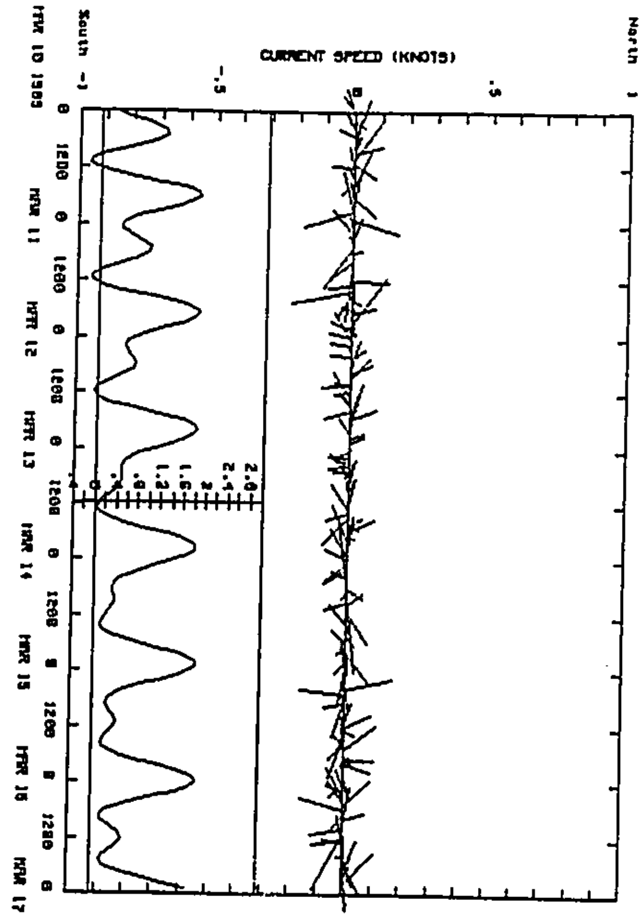

North
CURRENT SPEED (KNOTS)
South

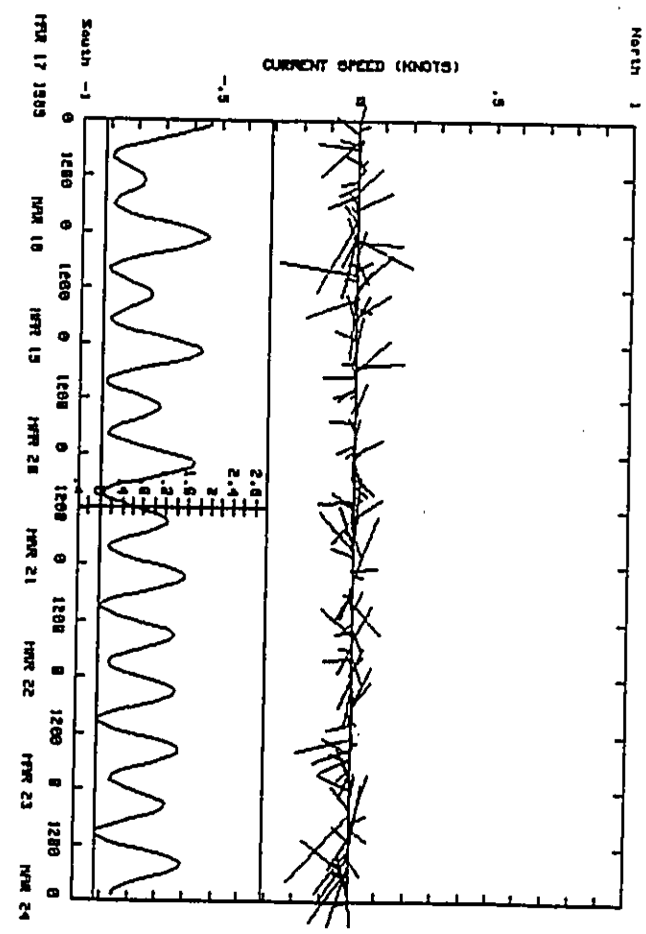

CURRENT SPEED (KNOTS)
South
North
FEB 10 1989
FEB 11
FEB 12
FEB 13
FEB 14
FEB 15
FEB 16
FEB 17

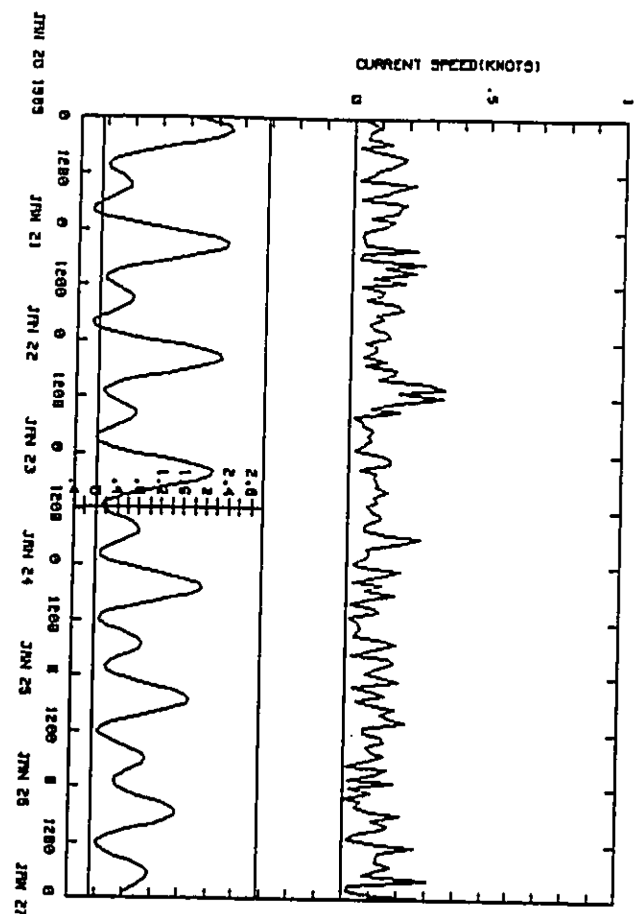

CURRENT SPEED (KNOTS)
South
North
FEB 17 1989
FEB 18
FEB 19
FEB 20
FEB 21
FEB 22
FEB 23
FEB 24

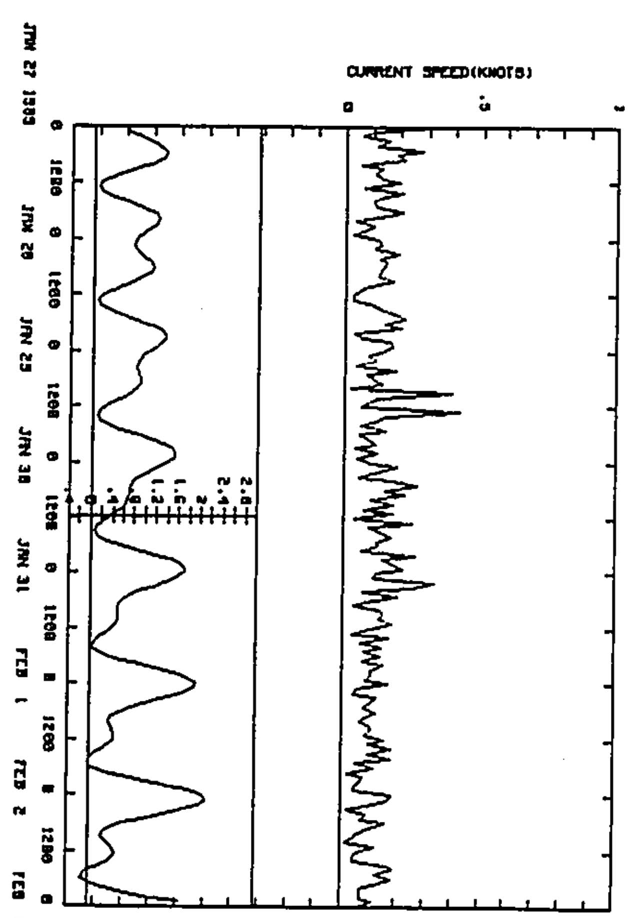

CURRENT SPEED (KNOTS)
North
South
MAR 24 1985
MAR 31

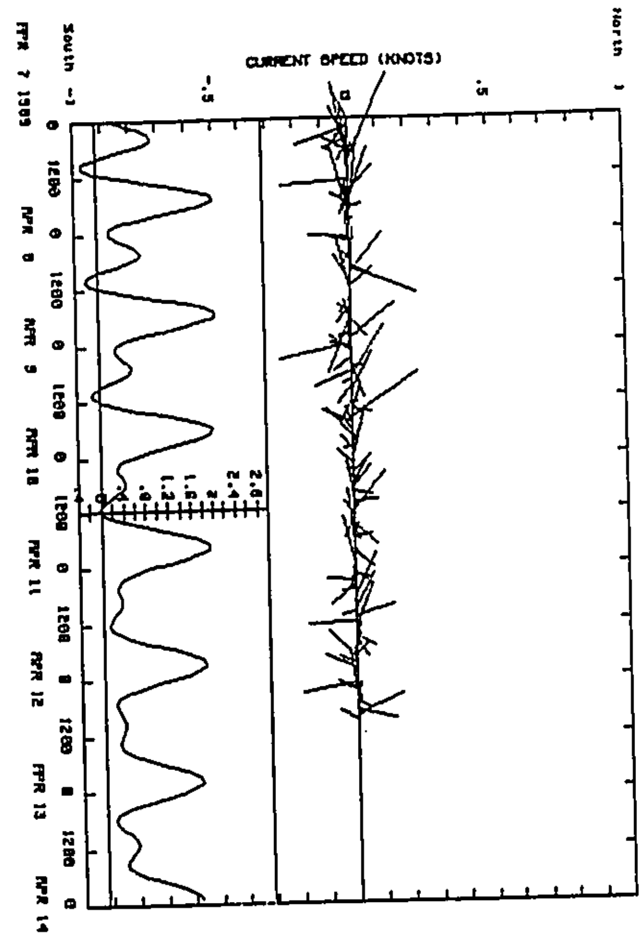

CURRENT SPEED (KNOTS)
North
South
MAR 31 1985
APR 7

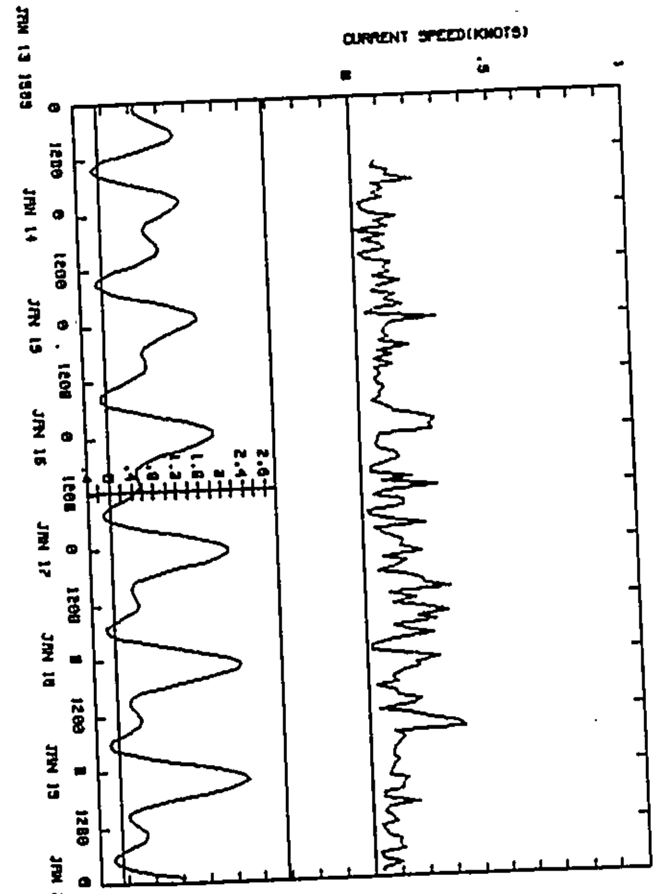

CURRENT SPEED (KNOTS)
North
South
MAR 10 1989

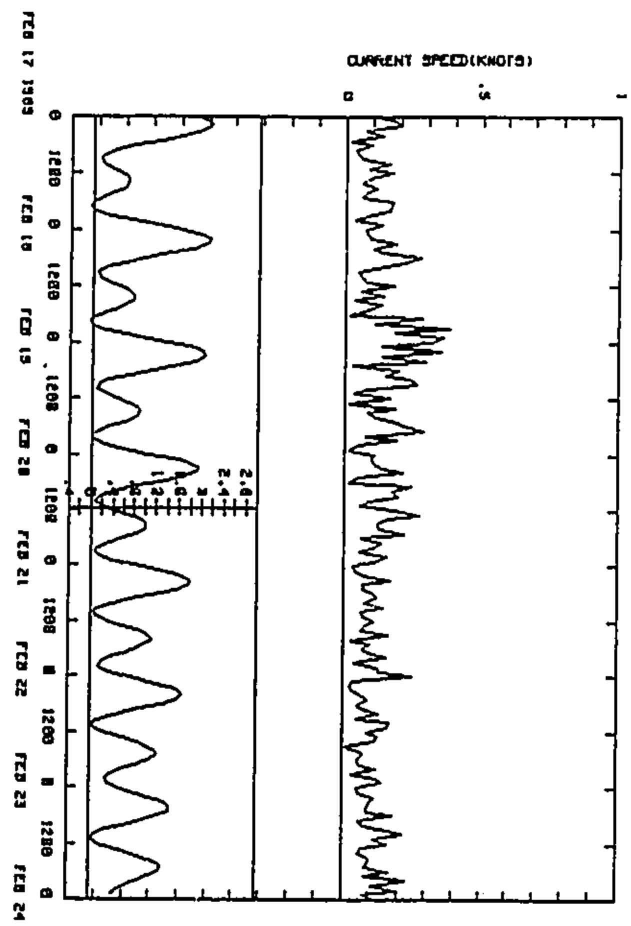

CURRENT SPEED (KNOTS)
North
South
MAR 17 1989

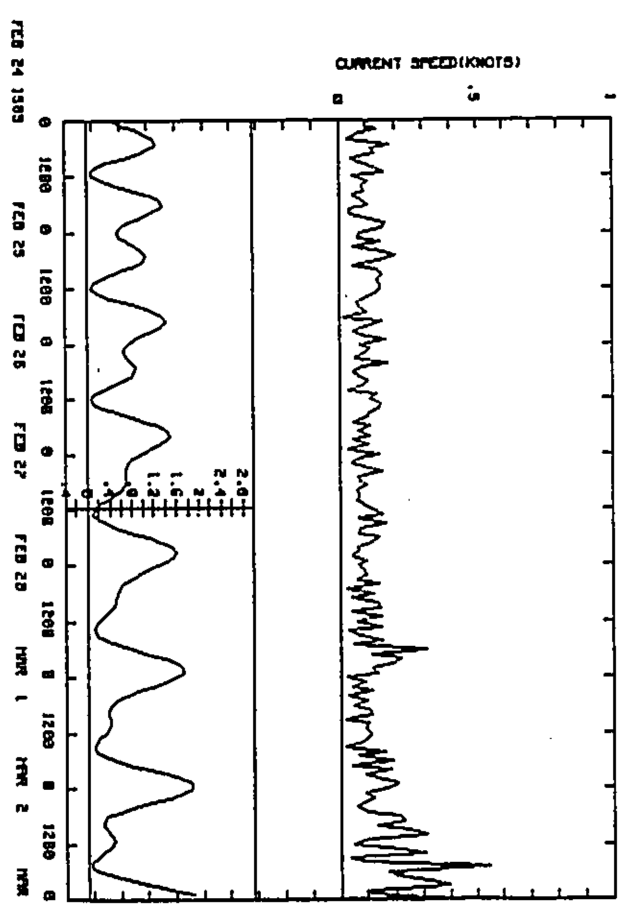

CURRENT SPEED(KNOTS)

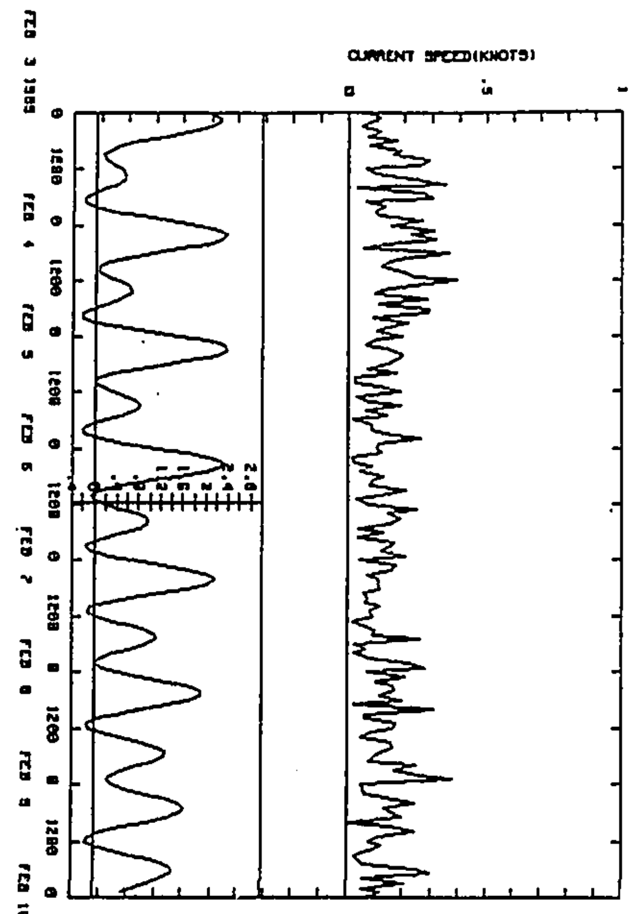

CURRENT SPEED(KNOTS)

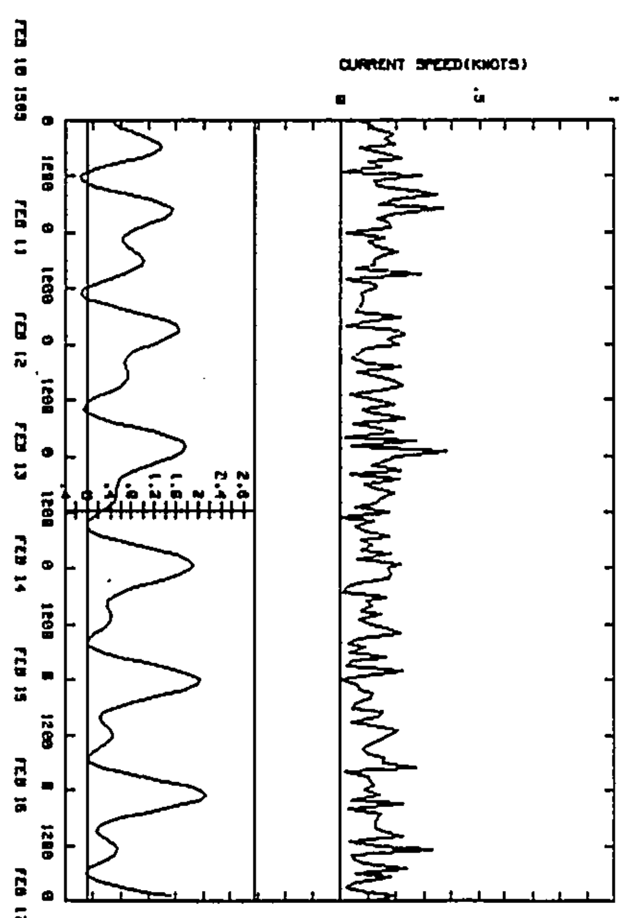

CURRENT SPEED (KNOTS)
North
South
APR 7 1989
APR 8
APR 9
APR 10
APR 11
APR 12
APR 13
APR 14

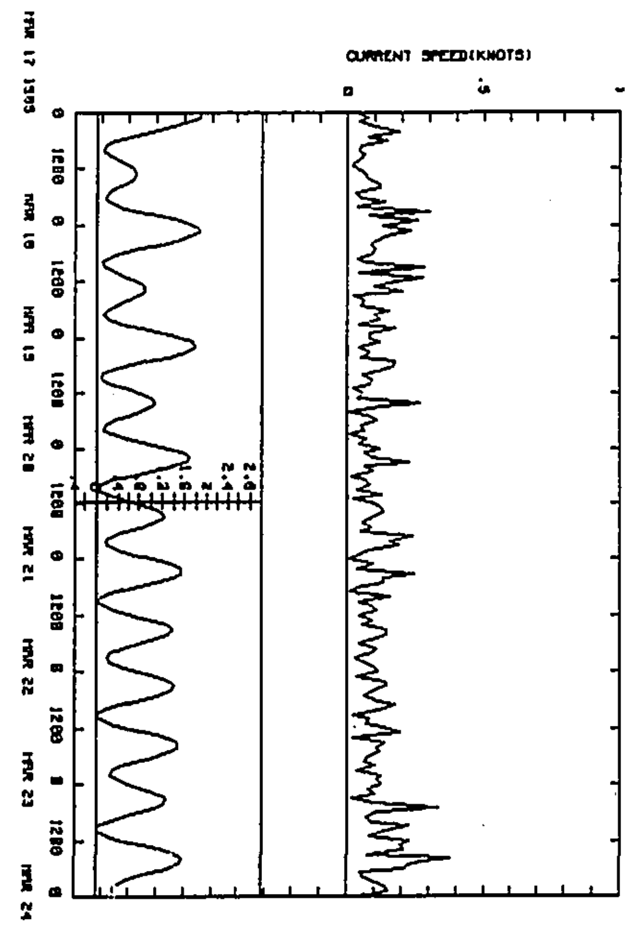

CURRENT SPEED(KNOTS)
JAN 13 1989
JAN 14
JAN 15
JAN 16
JAN 17
JAN 18
JAN 19
JAN 20

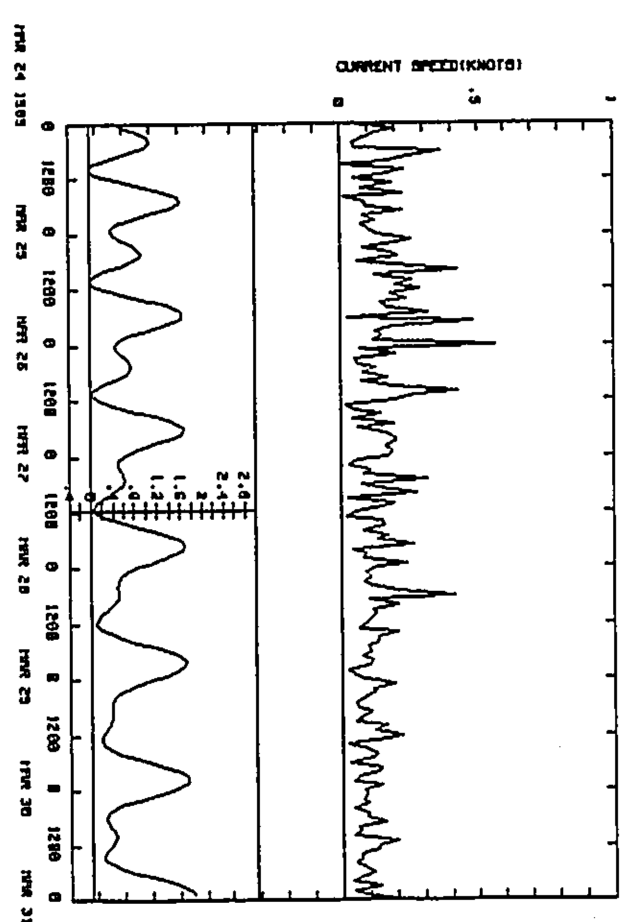

CURRENT SPEED(KNOTS)

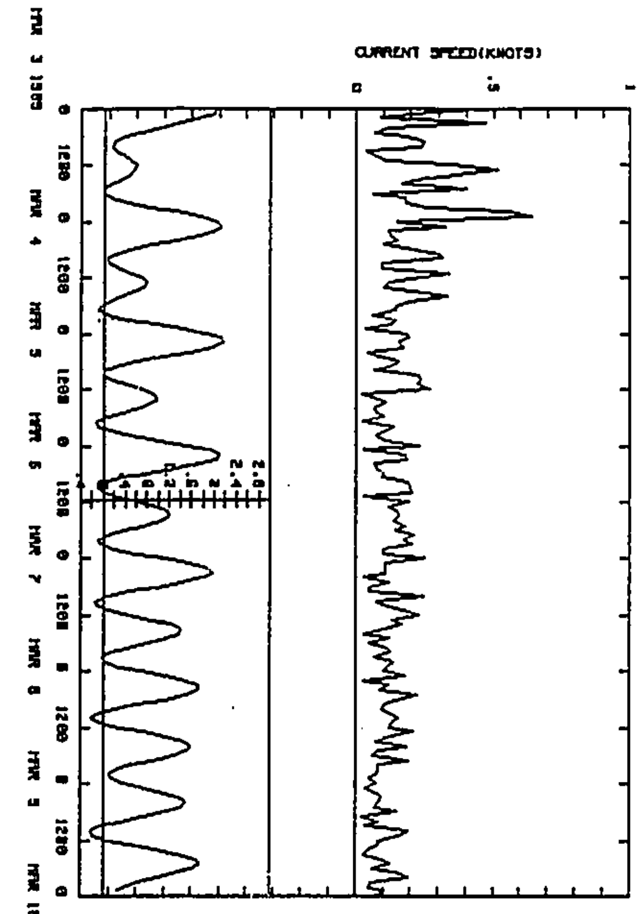

CURRENT SPEED(KNOTS)

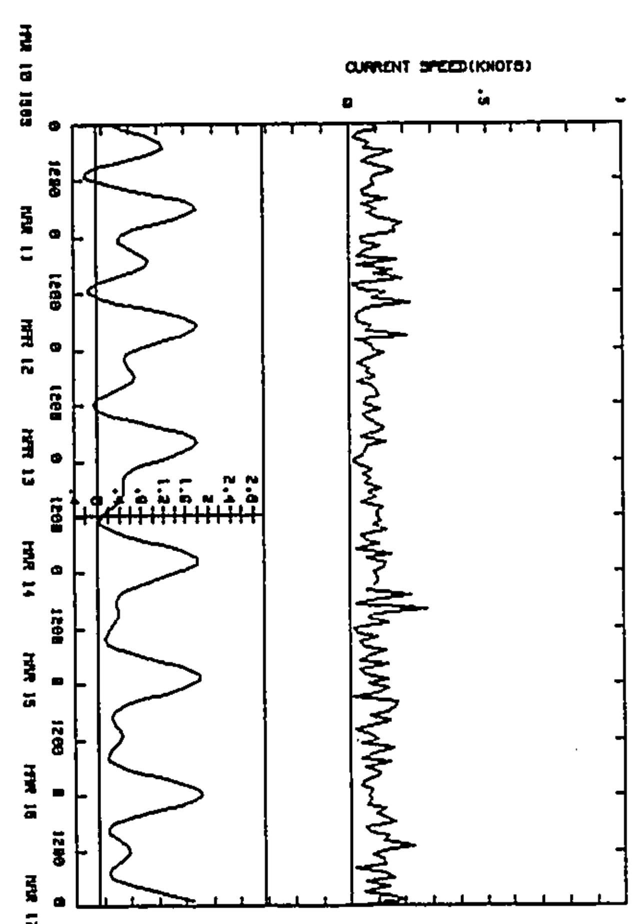

CURRENT SPEED(KNOTS)


CURRENT SPEED(KNOTS)


CURRENT SPEED(KNOTS)

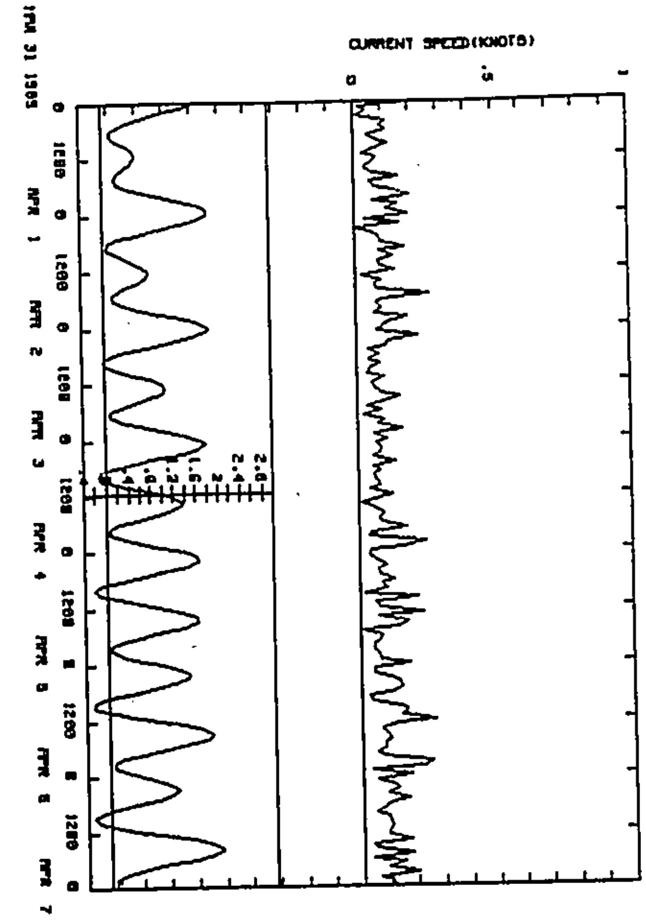

CURRENT SPEED(KNOTS)

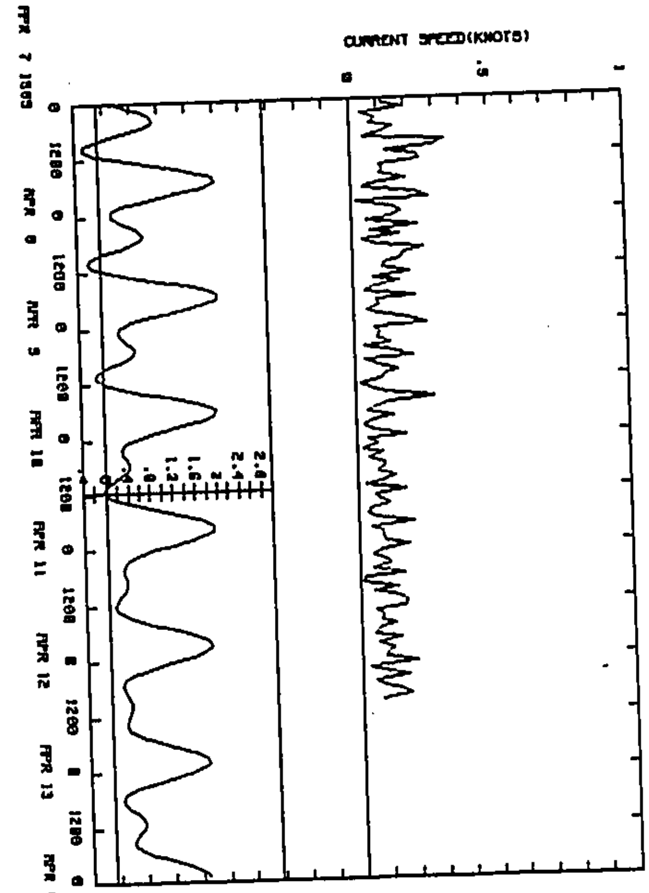

CURRENT SPEED(KNOTS)
0
.5
1

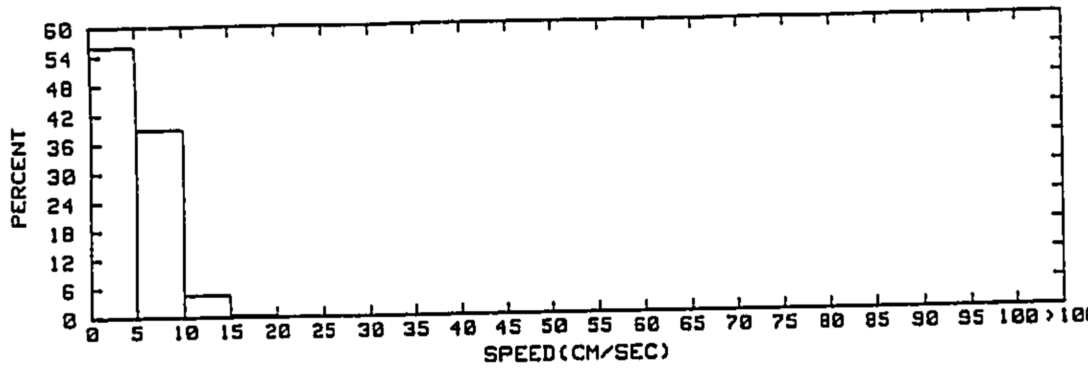

CURRENT SPEED(KNOTS)
0
.5
1

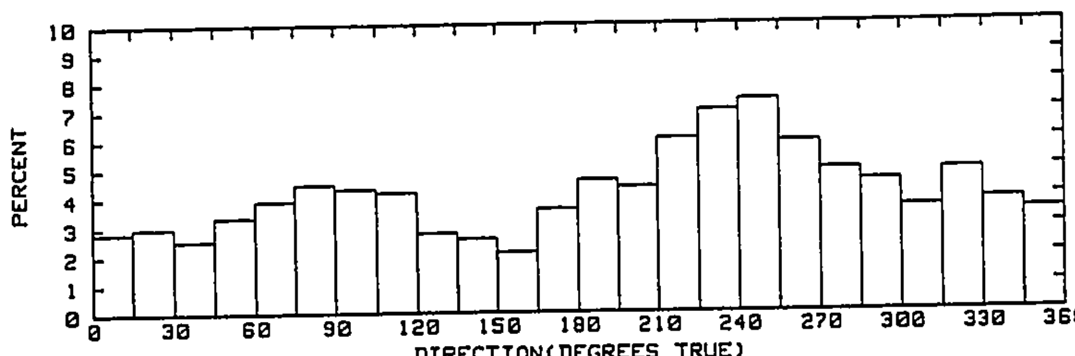
APPENDIX B: APRIL 13 - JULY 25, 1990
PROCESSED CURRENT DATA

```
MAUNA LANI, HAWAII METER DEPLOYMENT -- 2

CURRENT METER S/N -- 5003

METER POSITION ----- 1

DATA ACQUISITION
   DEPLOYMENT DATE(HST) - APR. 12,1989
   DEPLOYMENT TIME(HST) - 1600

   RETRIEVAL DATE(HST) --- JUL. 25,1989
   RETRIEVAL TIME(HST) --- 0900

MOORING LOCATION
   LATITUDE --------
   LONGITUDE -------

SENSOR DEPTH(M) ---- 10

BOTTOM DEPTH(M) ---- 12

REV/COUNT SETTING --   1

DATA ANALYSIS
   START DATE(HST) - APR. 12,1989
   START TIME(HST) - 1600

   ENDING DATE(HST) - JUL. 25,1989
   ENDING TIME(HST) - 0900

TIME INTERVAL(MIN) -  60.00

NO. OF DATA FILES --   9
```

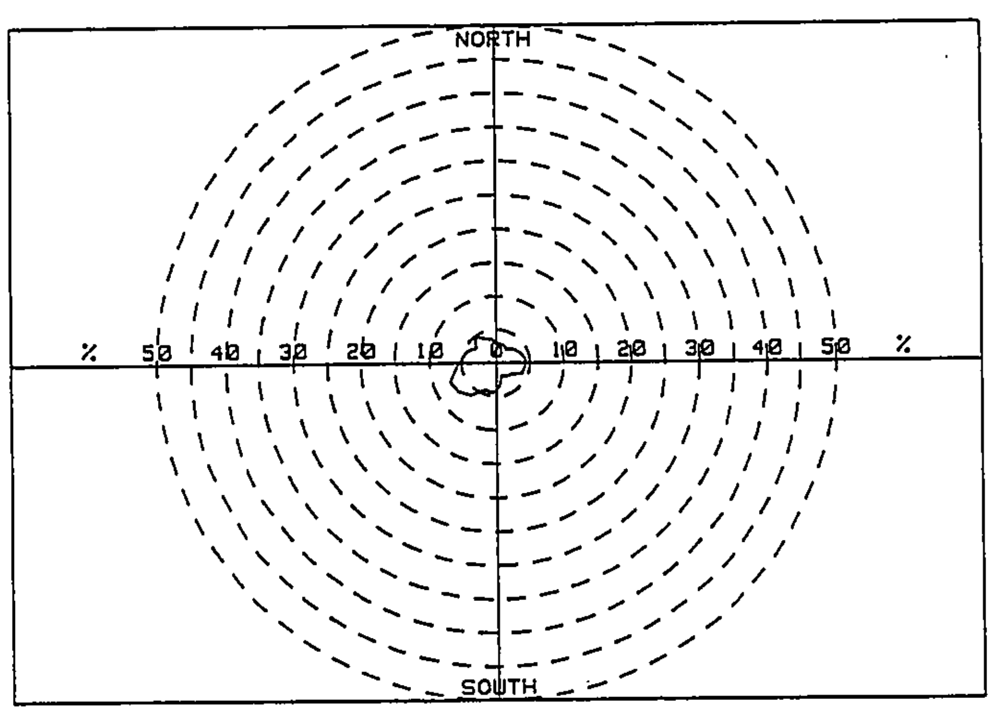

CURRENT SPEED(KNOTS)


CURRENT SPEED(KNOTS)





HISTOGRAMS OF CURRENT SPEEDS
(HST) 1600 APR 12 1989 TO 0900 JUL 25 1989
LATITUDE: LONGITUDE: NOMINAL DEPTH(M): 10



PERCENT OCCURRENCE VS DIRECTION(DEG TRUE)
(HST) 1600 APR 12 1989 TO 0900 JUL 25 1989
LATITUDE: LONGITUDE: NOMINAL DEPTH(M): 10

DISTRIBUTION FREQUENCY

1.00 HOUR AVERAGES
DEPLOYMENT 2 METER POSITION 1
FROM 1600 12 APR 1989 TO 900 25 JUL 1989

DIRECTION DEGREES TRUE — 10 METERS DEPTH

DIRECTION DEGREES TRUE	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
0- 15	41	29	0	0	0	0	0	0	0	0
15- 30	46	28	0	0	0	0	0	0	0	0
30- 45	43	20	0	0	0	0	0	0	0	0
45- 60	51	30	2	0	0	0	0	0	0	0
60- 75	53	42	2	0	0	0	0	0	0	0
75- 90	53	48	9	1	0	0	0	0	0	0
90-105	51	44	12	0	0	0	0	0	0	0
105-120	42	52	8	2	0	0	0	0	0	0
120-135	36	23	8	1	1	0	0	0	0	0
135-150	36	25	3	0	0	0	0	0	0	0
150-165	35	16	1	0	0	0	0	0	0	0
165-180	50	36	3	0	0	0	0	0	0	0
180-195	70	42	2	0	0	0	0	0	0	0
195-210	64	42	2	0	0	0	0	0	0	0
210-225	90	54	6	0	0	0	0	0	0	0
225-240	103	64	6	1	0	0	0	0	0	0
240-255	100	68	15	0	0	0	0	0	0	0
255-270	93	49	5	0	0	0	0	0	0	0
270-285	71	42	8	2	0	0	0	0	0	0
285-300	57	51	4	1	0	0	0	0	0	0
300-315	45	42	3	0	0	0	0	0	0	0
315-330	62	53	7	0	0	0	0	0	0	0
330-345	49	39	5	3	0	0	0	0	0	0
345-360	51	32	4	0	0	0	0	0	0	0
SPEED CM/SEC	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50

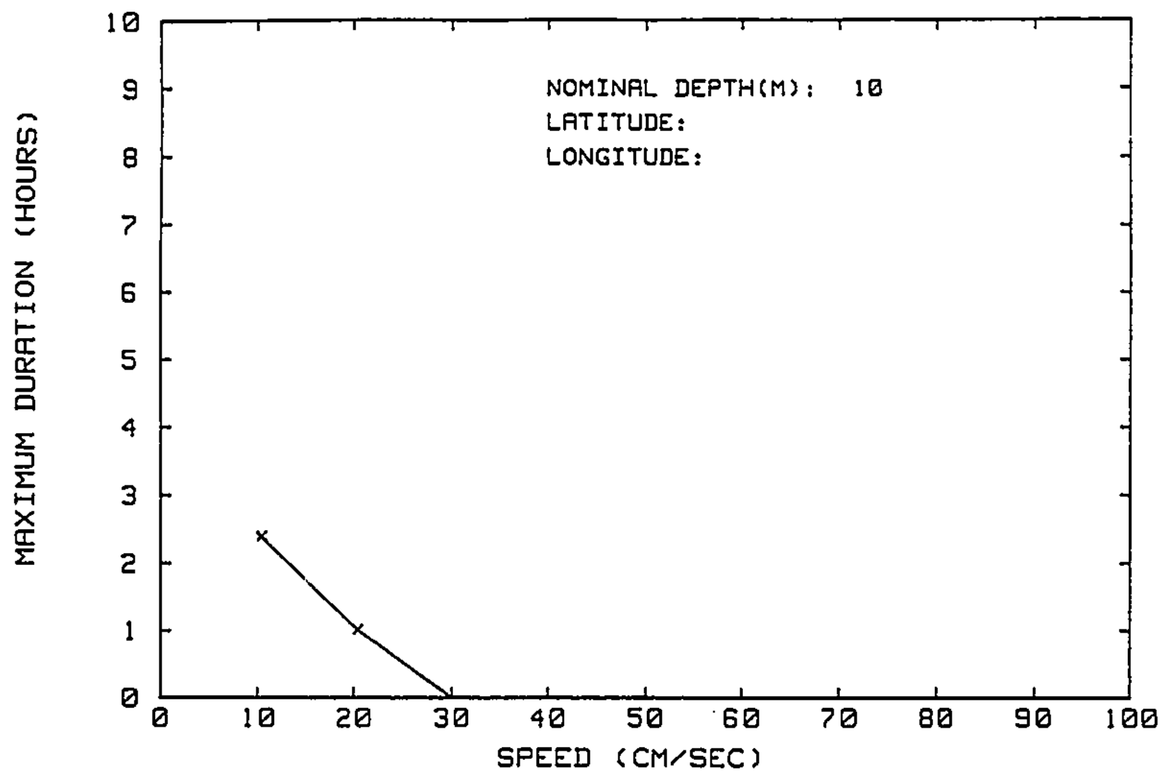
DIRECTION DEGREES TRUE	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	>100
0- 15	0	0	0	0	0	0	0	0	0	0	0
15- 30	0	0	0	0	0	0	0	0	0	0	0
30- 45	0	0	0	0	0	0	0	0	0	0	0
45- 60	0	0	0	0	0	0	0	0	0	0	0
60- 75	0	0	0	0	0	0	0	0	0	0	0
75- 90	0	0	0	0	0	0	0	0	0	0	0
90-105	0	0	0	0	0	0	0	0	0	0	0
105-120	0	0	0	0	0	0	0	0	0	0	0
120-135	0	0	0	0	0	0	0	0	0	0	0
135-150	0	0	0	0	0	0	0	0	0	0	0
150-165	0	0	0	0	0	0	0	0	0	0	0
165-180	0	0	0	0	0	0	0	0	0	0	0
180-195	0	0	0	0	0	0	0	0	0	0	0
195-210	0	0	0	0	0	0	0	0	0	0	0
210-225	0	0	0	0	0	0	0	0	0	0	0
225-240	0	0	0	0	0	0	0	0	0	0	0
240-255	0	0	0	0	0	0	0	0	0	0	0
255-270	0	0	0	0	0	0	0	0	0	0	0
270-285	0	0	0	0	0	0	0	0	0	0	0
285-300	0	0	0	0	0	0	0	0	0	0	0
300-315	0	0	0	0	0	0	0	0	0	0	0
315-330	0	0	0	0	0	0	0	0	0	0	0
330-345	0	0	0	0	0	0	0	0	0	0	0
345-360	0	0	0	0	0	0	0	0	0	0	0
SPEED CM/SEC	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100	>100

SUMMARY STATISTICS
DEPLOYMENT 2 METER POSITION 1
FROM 1600 12 APR 1989 TO 900 25 JUL 1989

DIRECTION(DEGREES TRUE)	TOTAL OBSERVATIONS	PERCENT
0 TO 15	70	2.81
15 TO 30	74	2.97
30 TO 45	63	2.53
45 TO 60	83	3.33
60 TO 75	97	3.90
75 TO 90	111	4.46
90 TO 105	107	4.30
105 TO 120	104	4.18
120 TO 135	69	2.77
135 TO 150	64	2.57
150 TO 165	52	2.09
165 TO 180	89	3.57
180 TO 195	114	4.58
195 TO 210	108	4.34
210 TO 225	150	6.02
225 TO 240	174	6.99
240 TO 255	183	7.35
255 TO 270	147	5.90
270 TO 285	123	4.94
285 TO 300	113	4.54
300 TO 315	90	3.61
315 TO 330	122	4.90
330 TO 345	96	3.86
345 TO 360	87	3.49

SPEED(CM/SEC)	TOTAL OBSERVATIONS	PERCENT
0.0 TO 5.0	1392	55.90
5.0 TO 10.0	971	39.00
10.0 TO 15.0	115	4.62
15.0 TO 20.0	11	.44
20.0 TO 25.0	1	.04
25.0 TO 30.0	0	0.00
30.0 TO 35.0	0	0.00
35.0 TO 40.0	0	0.00
40.0 TO 45.0	0	0.00
45.0 TO 50.0	0	0.00
50.0 TO 55.0	0	0.00
55.0 TO 60.0	0	0.00
60.0 TO 65.0	0	0.00
65.0 TO 70.0	0	0.00
70.0 TO 75.0	0	0.00
75.0 TO 80.0	0	0.00
80.0 TO 85.0	0	0.00
85.0 TO 90.0	0	0.00
90.0 TO 95.0	0	0.00
95.0 TO 100.0	0	0.00
ABOVE 100	0	0.00

TOTAL NUMBER OF POINTS READ = 2490
TOTAL NUMBER OF OBSERVATIONS USED IN THE DISTRIBUTIONS = 2490
MEAN SPEED = 5.81 CM/SEC
STANDARD DEVIATION = 2.73 CM/SEC
MAXIMUM SPEED = 20.92 CM/SEC
MINIMUM SPEED = .14 CM/SEC
RANGE = 20.78 CM/SEC



PERSISTENCE OF CURRENT SPEED FROM:
(HST) 1600 APR 12 1989 TO 0900 JUL 25 1989

TEMPERATURE STATISTICS
DEPLOYMENT 2 METER POSITION 1
FROM 1600 12 APR 1989 TO 900 25 JUL 1989

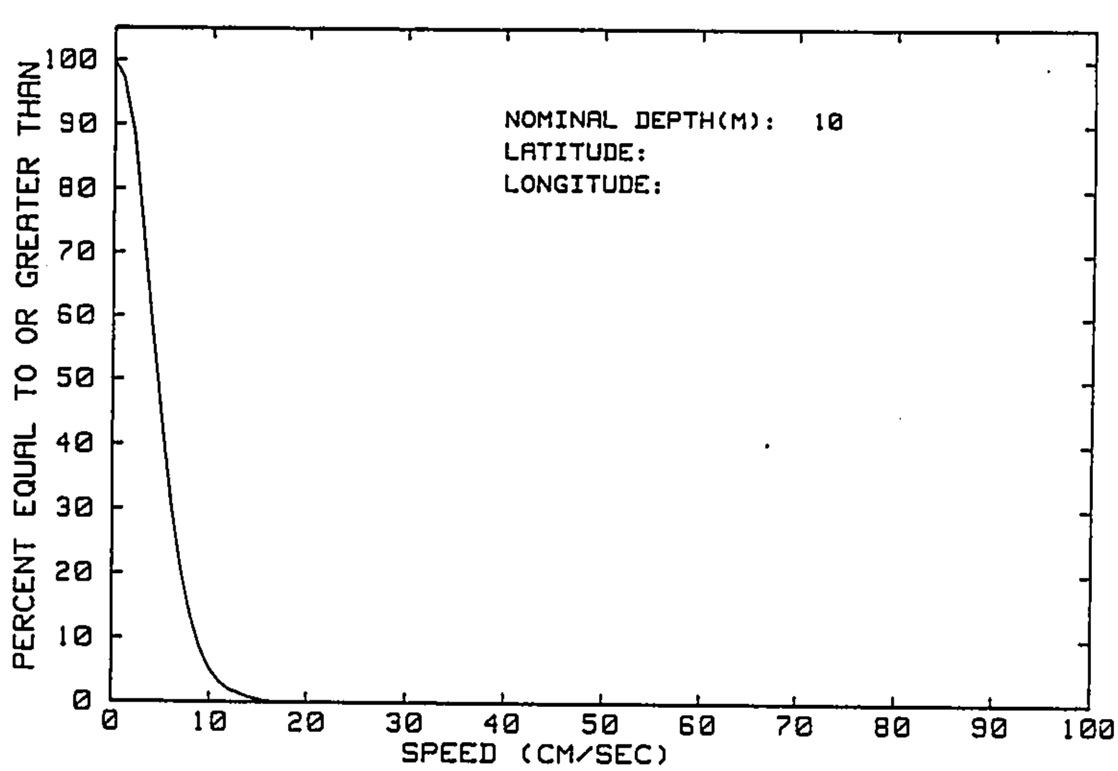
TEMPERATURE(CENTIGRADE)	TOTAL OBSERVATIONS	PERCENT
0 TO 1	0	0.00
1 TO 2	0	0.00
2 TO 3	0	0.00
3 TO 4	0	0.00
4 TO 5	0	0.00
5 TO 6	0	0.00
6 TO 7	0	0.00
7 TO 8	0	0.00
8 TO 9	0	0.00
9 TO 10	0	0.00
10 TO 11	0	0.00
11 TO 12	0	0.00
12 TO 13	0	0.00
13 TO 14	0	0.00
14 TO 15	0	0.00
15 TO 16	0	0.00
16 TO 17	0	0.00
17 TO 18	0	0.00
18 TO 19	0	0.00
19 TO 20	0	0.00
20 TO 21	0	0.00
21 TO 22	0	0.00
22 TO 23	0	0.00
23 TO 24	0	0.00
24 TO 25	101	4.06
25 TO 26	1159	46.55
26 TO 27	1200	48.19
27 TO 28	30	1.20
28 TO 29	0	0.00
29 TO 30	0	0.00

TOTAL NUMBER OF POINTS READ = 2490
TOTAL NUMBER OF OBSERVATION USED IN THE DISTRIBUTION = 2490
MEAN TEMPERATURE = 26.0 DEGREES CENTIGRADE
STANDARD DEVIATION = .6 DEGREES CENTIGRADE
MAXIMUM TEMPERATURE = 27.2 DEGREES CENTIGRADE
MINIMUM TEMPERATURE = 24.6 DEGREES CENTIGRADE
RANGE = 2.6 DEGREES CENTIGRADE

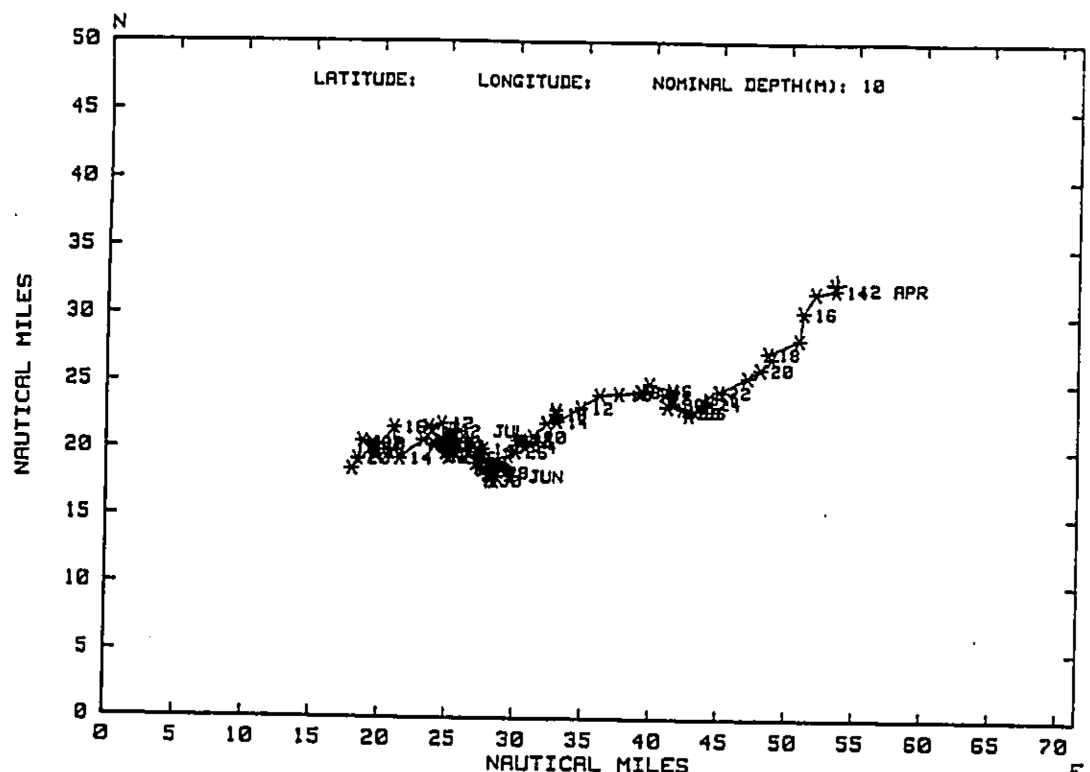
LATITUDE:
LONGITUDE:
NOMINAL DEPTH(METERS): 10
TIME SPAN(HST): 1600 APR 12 1989 TO 0900 JUL 25 1989

CUMULATIVE OCCURENCE OF CURRENT SPEEDS

SPEED (CM/SEC)	PERCENT EQUAL TO OR GREATER THAN
0	100.000
3	74.980
6	30.361
9	8.434
12	1.968
15	.482
18	.040
21	0.000



CUMULATIVE OCCURENCE OF CURRENT SPEEDS
(HST) 1600 APR 12 1989 TO 0900 JUL 25 1989



PROGRESSIVE VECTOR DIAGRAM OF CURRENTS
(HST) 1600 APR 12 1989 TO 0900 JUL 25 1989

PERSISTENCE OF TEMPERATURE ABOUT MEAN

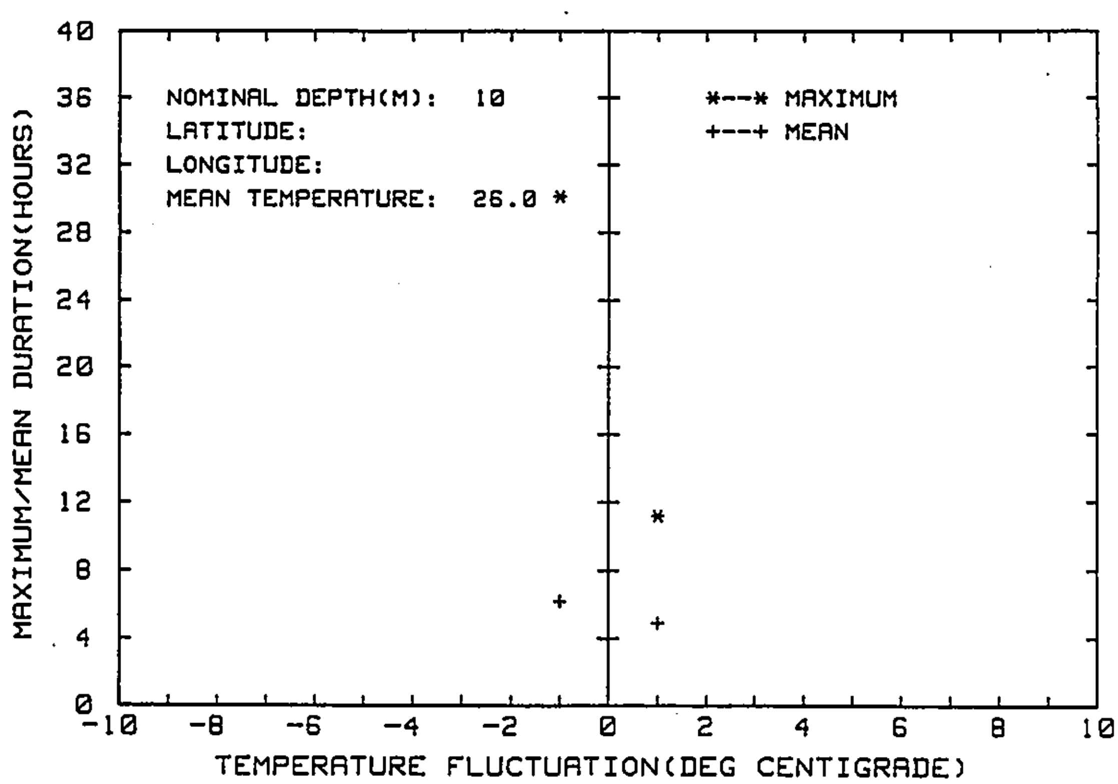
FLUCTUATION ABOUT MEAN	MAX DURATION(HRS)	MEAN DURATION(HRS)
+10	0.0	0.0
+ 9		
+ 8	0.0	0.0
+ 7		
+ 6	0.0	0.0
+ 5		
+ 4	0.0	0.0
+ 3		
+ 2	0.0	0.0
+ 1	0.0	0.0
	11.2	4.9
-1	30.1	6.2
-2	0.0	0.0
-3	0.0	0.0
-4		
-5	0.0	0.0
-6	0.0	0.0
-7		
-8	0.0	0.0
-9	0.0	0.0
-10	0.0	0.0

MEAN TEMPERATURE = 25.9521

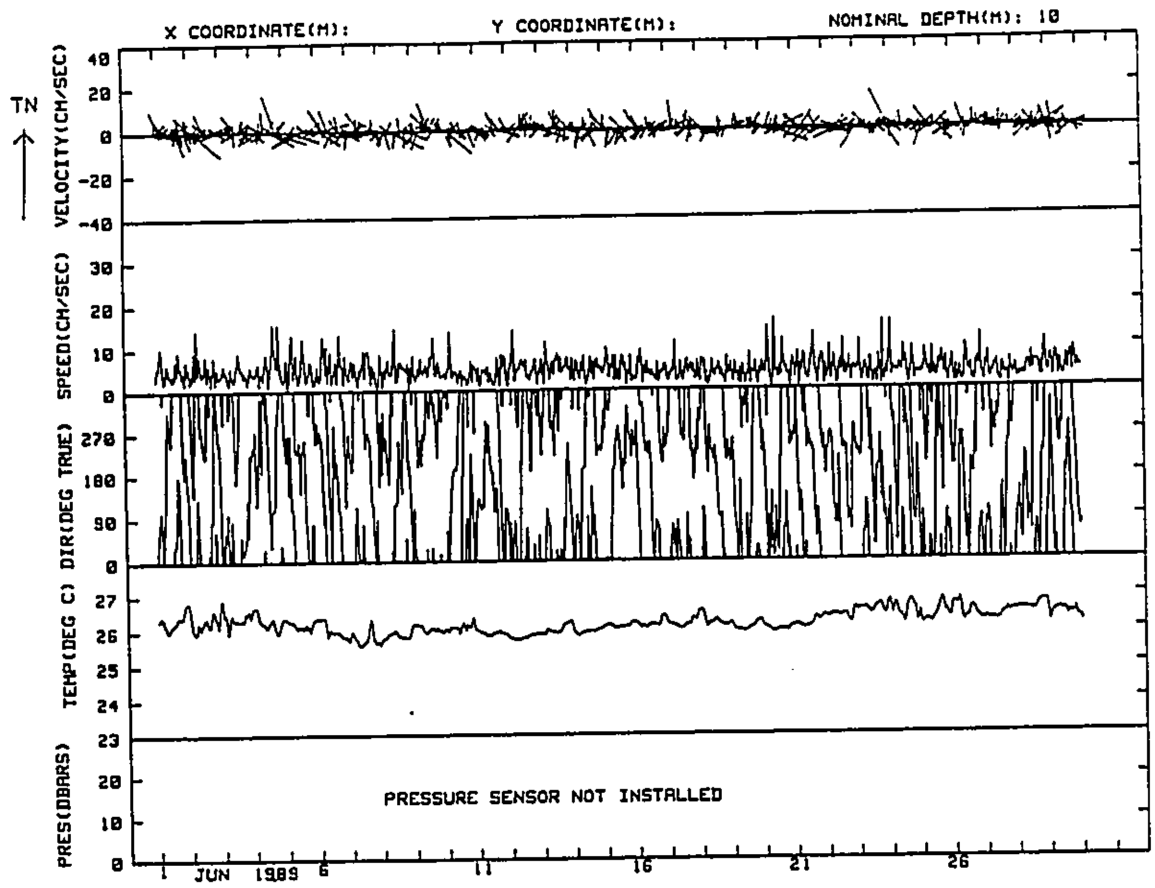
LATITUDE:
LONGITUDE:
NOMINAL DEPTH(METERS): 10
TIME SPAN(HST): 1600 APR 12 1989 TO 0900 JUL 25 1989

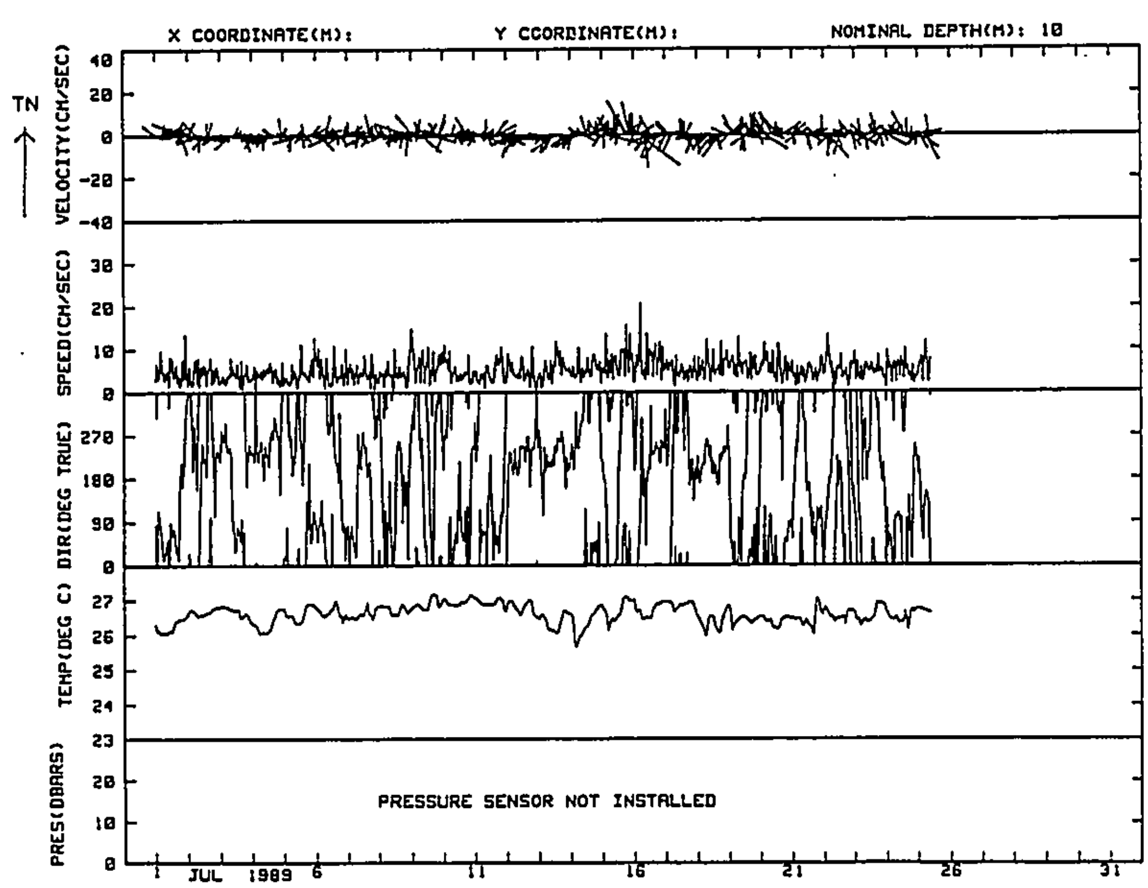
PERSISTENCE OF CURRENT SPEEDS

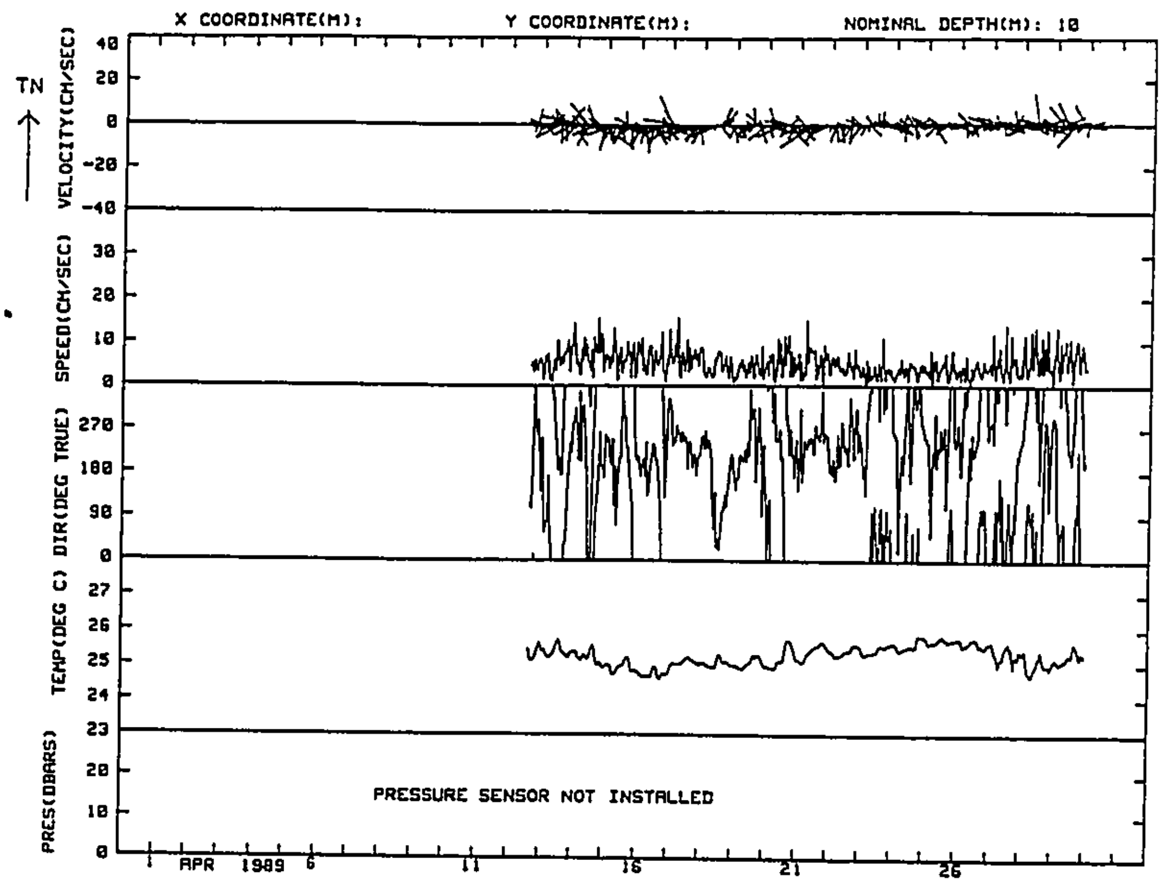
SPEED (CM/SEC)	MAXIMUM DURATION (HOURS)
10	2.45
20	1.06
30	0.00

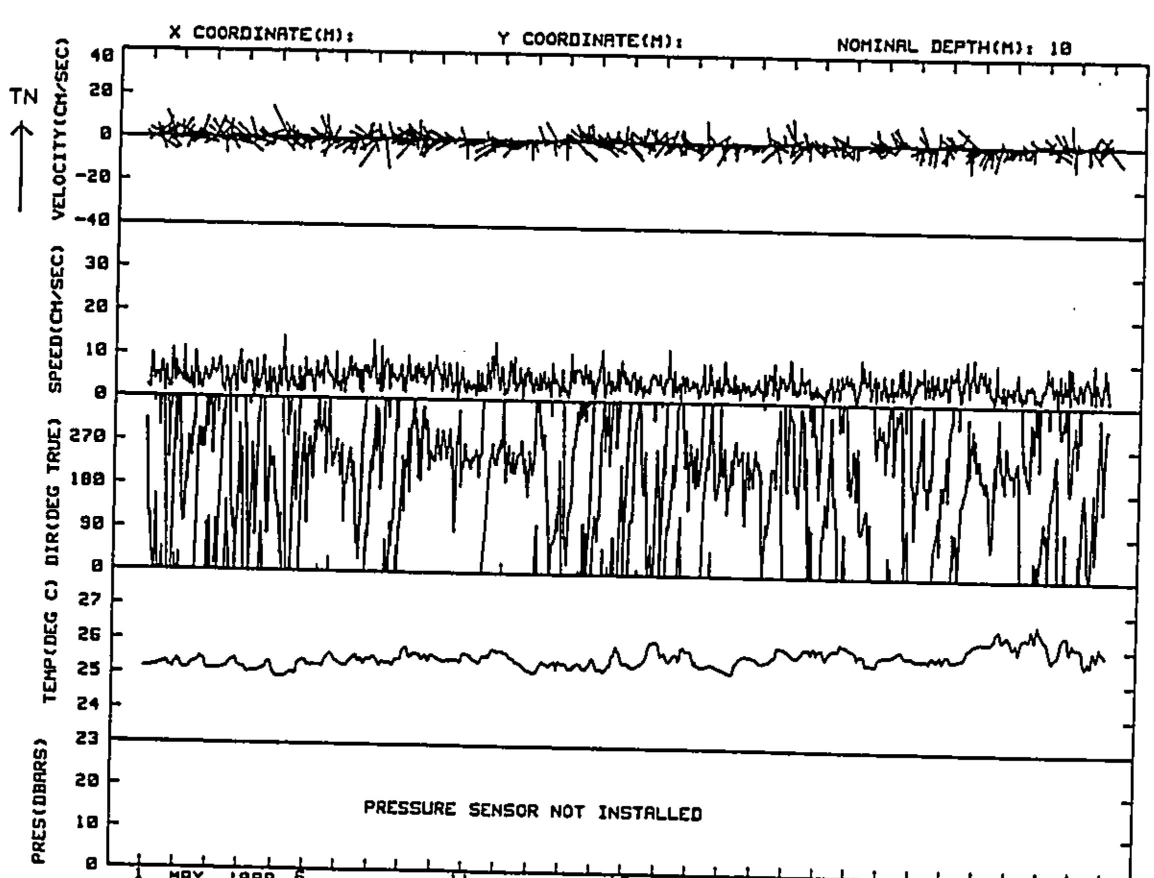


PERSISTENCE OF TEMPERATURE ABOUT MEAN FROM:
(HST) 1600 APR 12 1989 TO 0900 JUL 25 1989


X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
SPEED(CM/SEC)
DIR(DEG TRUE)
TEMP(DEG C)
PRES(DBARS)
PRESSURE SENSOR NOT INSTALLED
JUN 1989


X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
SPEED(CM/SEC)
DIR(DEG TRUE)
TEMP(DEG C)
PRES(DBARS)
PRESSURE SENSOR NOT INSTALLED
JUL 1989


X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
40
20
0
-20
-40
SPEED(CM/SEC)
30
20
10
0
DIR(DEG TRUE)
270
180
90
0
TEMP(DEG C)
27
26
25
24
23
PRES(DBARS)
20
10
0
PRESSURE SENSOR NOT INSTALLED
1
APR 1989
6
11
16
21
26


X COORDINATE(M):
Y COORDINATE(M):
NOMINAL DEPTH(M): 10
TN
VELOCITY(CM/SEC)
40
20
0
-20
-40
SPEED(CM/SEC)
30
20
10
0
DIR(DEG TRUE)
270
180
90
0
TEMP(DEG C)
27
26
25
24
23
PRES(DBARS)
20
10
0
PRESSURE SENSOR NOT INSTALLED
1
MAY 1989
6
11
16
21
26
31

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

Latitude: Longitude:
Meter Depth(m): 10.0 Bottom Depth(m): 12.0

Period: JUNE 1989

Mean Speed(cm/sec): 4.83
Maximum Speed(cm/sec): 16.60
Standard Deviation: 2.70
Average North Vector Component(cm/sec): .20
Average East Vector Component(cm/sec): -.22
Resultant Magnitude(cm/sec): .29
Resultant Direction(°T): 313

Minimum Temperature(°C): 25.6
Maximum Temperature(°C): 26.9
Mean Temperature(°C): 26.2
Standard Deviation: .3

Day	Maximum Speed	Minimum Temperature	Maximum Temperature
1	11.41	26.0	26.8
2	14.57	25.9	26.9
3	9.08	25.9	26.9
4	15.70	25.9	26.7
5	13.21	26.0	26.4
6	13.24	25.7	26.4
7	9.49	25.6	26.3
8	14.73	25.7	26.2
9	12.51	25.9	26.2
10	13.90	25.9	26.3
11	8.40	25.8	26.0
12	14.01	25.7	25.9
13	11.46	25.9	26.3
14	7.93	25.8	26.1
15	9.91	26.0	26.2
16	9.05	26.1	26.4
17	11.24	26.0	26.5
18	7.59	26.1	26.5
19	8.42	25.9	26.3
20	16.60	25.9	26.1
21	12.97	26.0	26.4
22	11.56	26.2	26.6
23	15.91	26.4	26.8
24	15.77	26.2	26.8
25	9.37	26.1	26.8
26	12.77	26.2	26.8
27	8.20	26.2	26.5
28	11.22	26.5	26.8
29	9.20	26.2	26.6
30	15.38	26.1	26.4

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

Latitude: Longitude:
Meter Depth(m): 10.0 Bottom Depth(m): 12.0

Period: JULY 1989

Mean Speed(cm/sec): 5.26
Maximum Speed(cm/sec): 20.92
Standard Deviation: 2.76
Average North Vector Component(cm/sec): -.10
Average East Vector Component(cm/sec): -.38
Resultant Magnitude(cm/sec): .39
Resultant Direction(°T): 255

Minimum Temperature(°C): 25.7
Maximum Temperature(°C): 27.2
Mean Temperature(°C): 26.6
Standard Deviation: .3

Day	Maximum Speed	Minimum Temperature	Maximum Temperature
1	13.70	26.1	26.6
2	8.32	26.6	26.8
3	8.05	26.4	26.8
4	7.24	26.8	26.8
5	12.79	26.3	26.9
6	12.79	26.4	27.0
7	10.10	26.5	26.9
8	10.27	26.6	26.9
9	15.00	26.7	27.2
10	11.10	26.8	27.2
11	10.61	26.7	27.1
12	10.80	26.5	27.0
13	11.93	26.0	26.7
14	10.45	25.7	26.9
15	15.86	26.1	27.1
16	20.92	26.4	27.0
17	8.54	26.6	27.0
18	12.25	26.0	26.8
19	12.97	26.1	26.8
20	11.53	26.2	26.5
21	8.27	26.0	27.1
22	13.30	26.3	26.8
23	9.39	26.3	26.9
24	10.15	26.2	26.8
25	11.97	26.6	26.8

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

Latitude:
Meter Depth(m): 10.0
Longitude:
Bottom Depth(m): 12.0

Period: APRIL 1989

Mean Speed(cm/sec): 5.37
Maximum Speed(cm/sec): 15.84
Standard Deviation: 3.01
Average North Vector Component(cm/sec): -1.08
Average East Vector Component(cm/sec): -1.45
Resultant Magnitude(cm/sec): 1.81
Resultant Direction(°T): 233

Minimum Temperature(°C): 24.6
Maximum Temperature(°C): 25.9
Mean Temperature(°C): 25.3
Standard Deviation: .3

Day	Maximum Speed	Minimum Temperature	Maximum Temperature
12	6.36	25.1	25.5
13	10.61	25.2	25.7
14	15.82	25.0	25.6
15	13.51	24.7	25.2
16	12.45	24.6	25.0
17	15.84	24.7	25.2
18	9.04	24.9	25.3
19	9.20	24.9	25.3
20	11.60	24.9	25.7
21	15.26	25.1	25.7
22	8.51	25.3	25.6
23	11.27	25.3	25.6
24	6.33	25.4	25.9
25	8.35	25.6	25.9
26	6.94	25.5	25.8
27	14.20	24.9	25.7
28	13.44	24.7	25.4
29	13.69	25.0	25.7
30	9.61	24.9	25.4

Mauna Lani Monthly Current-Temperature Statistics

DEPLOYMENT LOCATION: 1

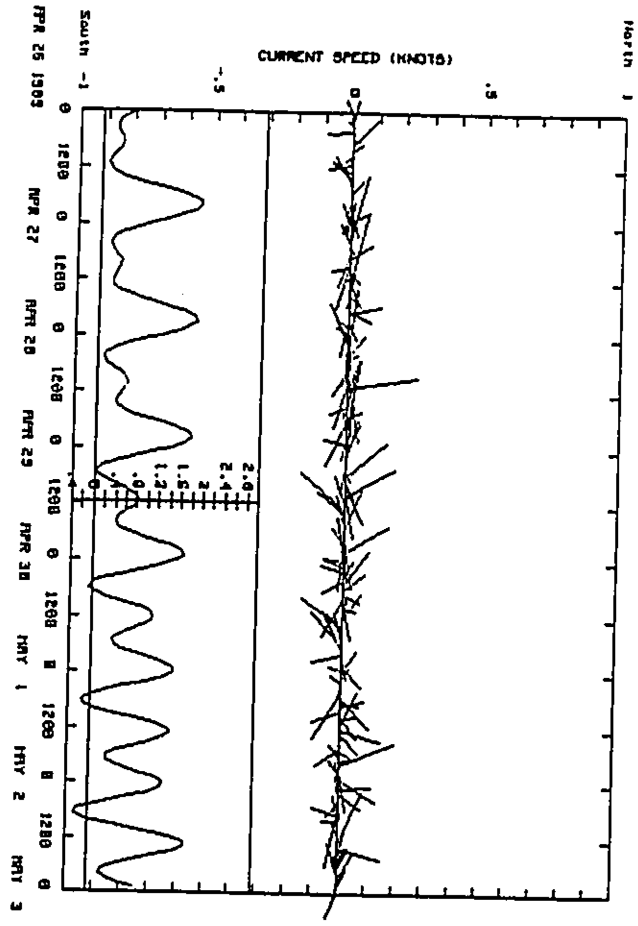
Latitude:
Meter Depth(m): 10.0
Longitude:
Bottom Depth(m): 12.0

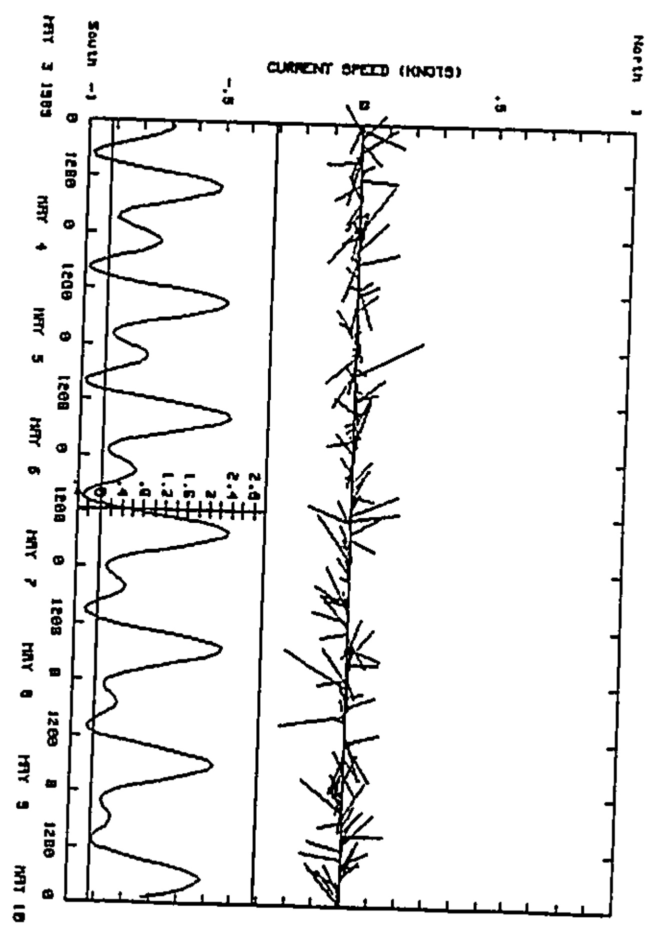
Period: MAY 1989

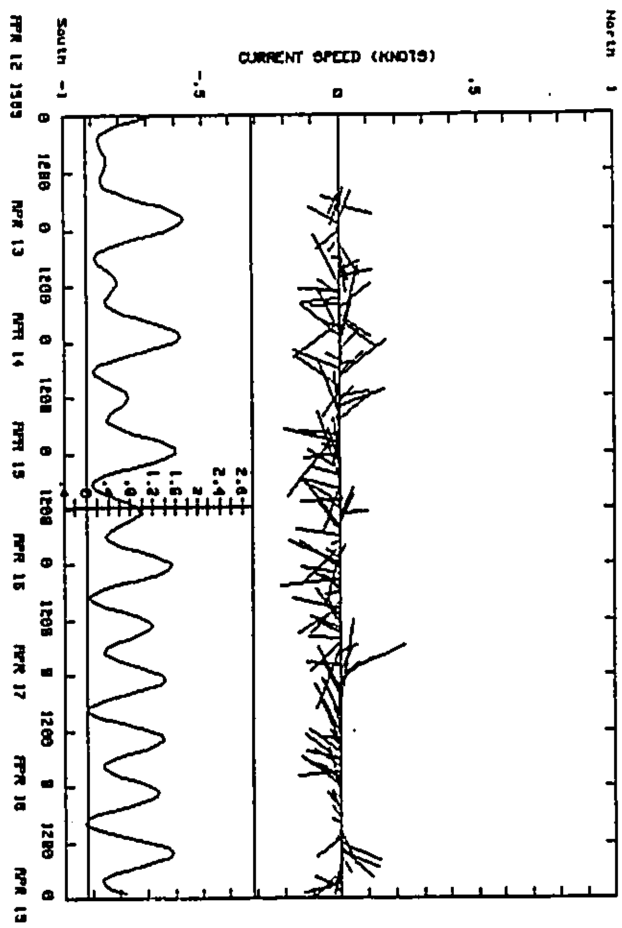
Mean Speed(cm/sec): 4.77
Maximum Speed(cm/sec): 14.31
Standard Deviation: 2.54
Average North Vector Component(cm/sec): -.37
Average East Vector Component(cm/sec): -.89
Resultant Magnitude(cm/sec): .97
Resultant Direction(°T): 247

Minimum Temperature(°C): 24.9
Maximum Temperature(°C): 26.7
Mean Temperature(°C): 25.6
Standard Deviation: .3

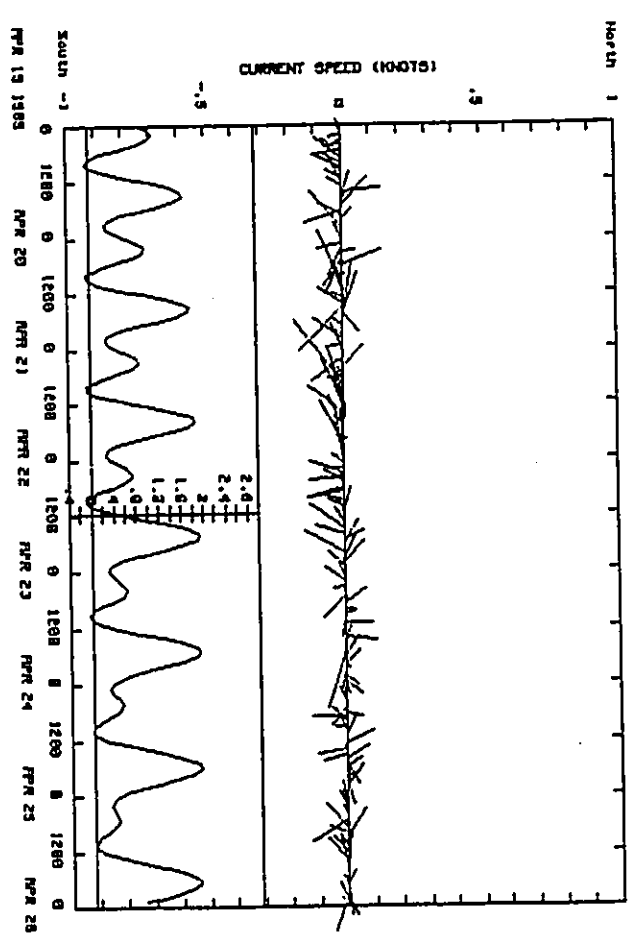
Day	Maximum Speed	Minimum Temperature	Maximum Temperature
1	11.27	25.2	25.3
2	11.67	25.1	25.5
3	10.77	25.1	25.5
4	9.65	25.1	25.4
5	14.31	24.9	25.4
6	10.71	25.2	25.6
7	9.56	25.3	25.6
8	13.59	25.3	25.6
9	10.20	25.4	25.8
10	10.28	25.4	25.7
11	13.43	25.4	25.8
12	10.10	25.2	25.8
13	8.81	25.1	25.5
14	10.98	25.2	25.6
15	11.98	25.2	25.9
16	6.96	25.3	26.1
17	12.27	25.5	26.1
18	9.25	25.3	25.8
19	9.84	25.2	25.7
20	9.59	25.5	26.0
21	10.41	25.7	26.0
22	7.13	25.6	26.1
23	10.57	25.5	26.0
24	8.89	25.7	25.9
25	8.94	25.6	25.8
26	11.20	25.6	26.1
27	9.77	26.2	26.6
28	7.82	25.9	26.7
29	9.45	25.7	26.5
30	10.21	25.5	26.2
31	13.91	25.7	26.4


CURRENT SPEED (KNOTS)
North 1
South -1
APR 25 1989

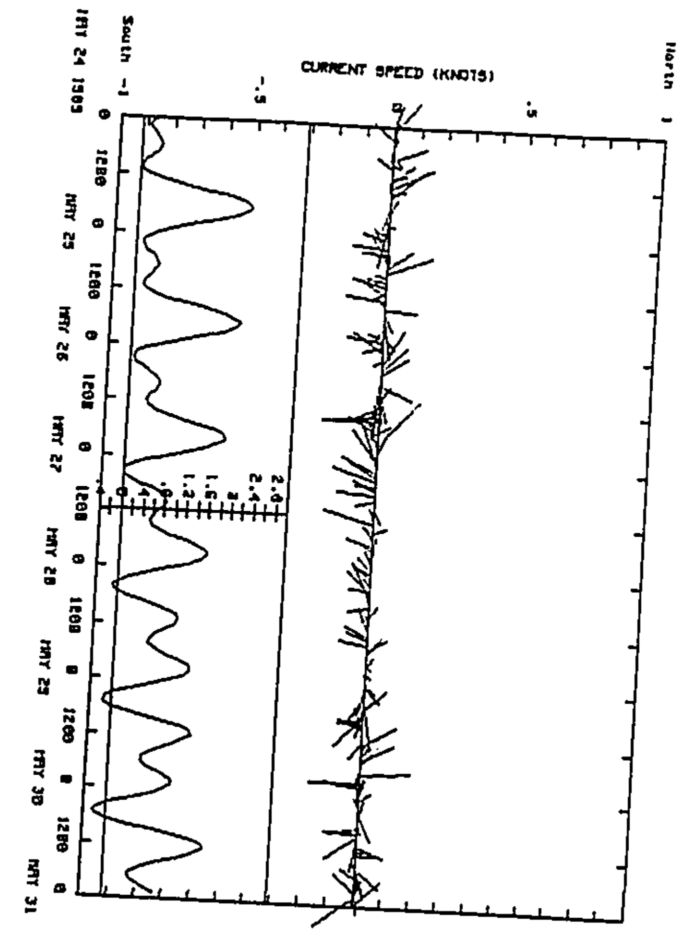

CURRENT SPEED (KNOTS)
North 1
South -1
MAY 3 1989

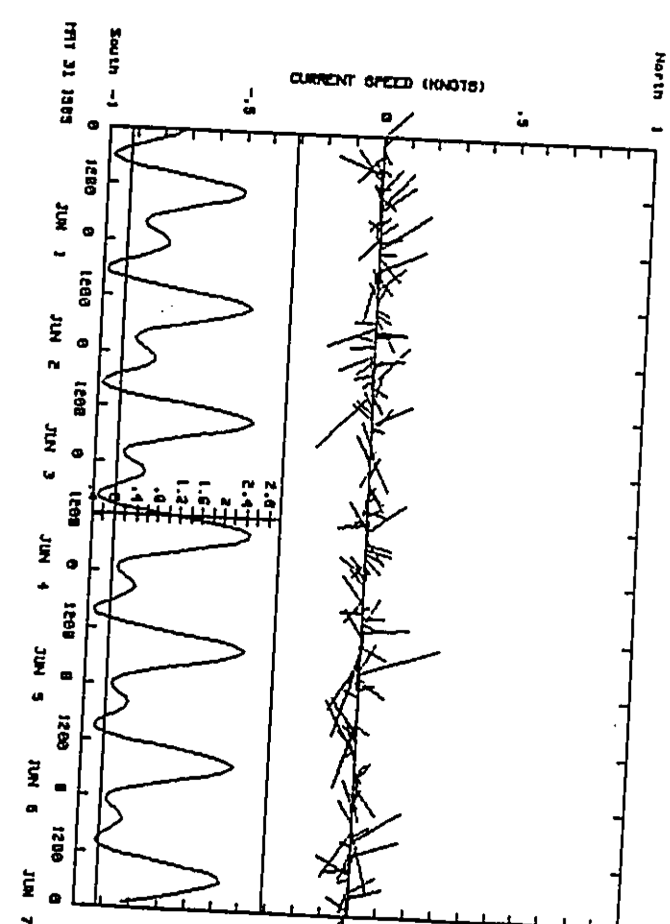


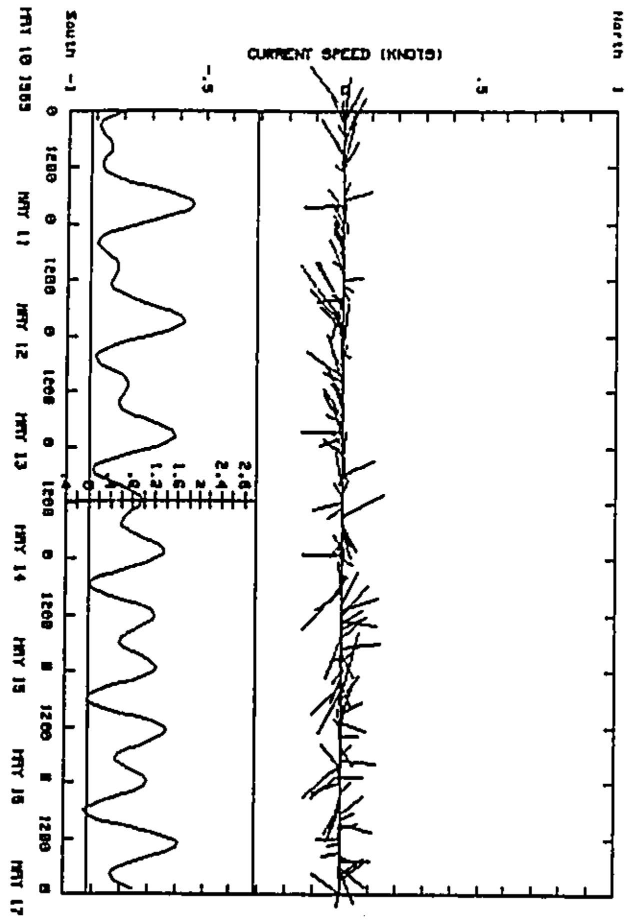
CURRENT SPEED (KNOTS)
North 1
.5
0
-.5
South -1
APR 12 1985
APR 13
APR 14
APR 15
APR 16
APR 17
APR 18
APR 19

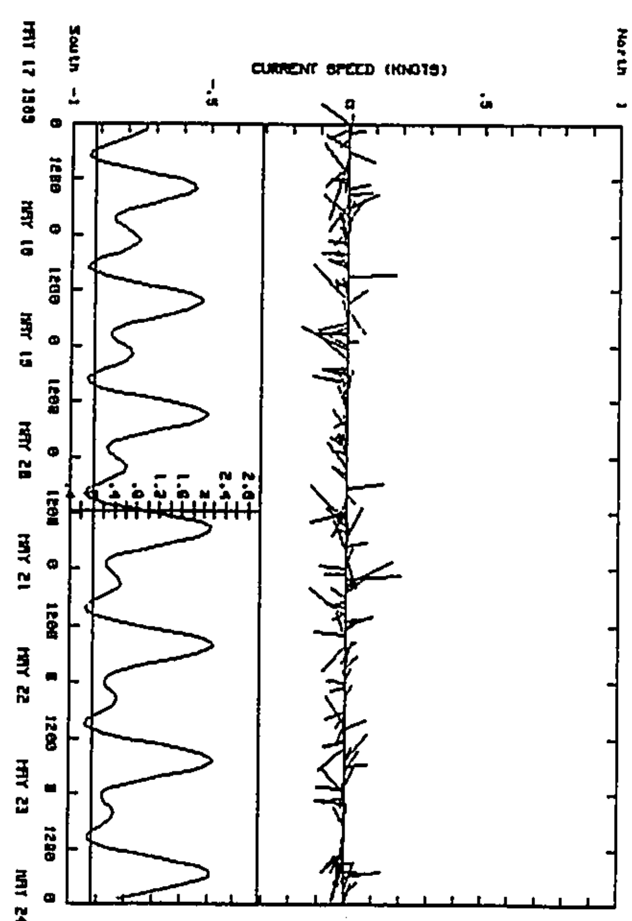


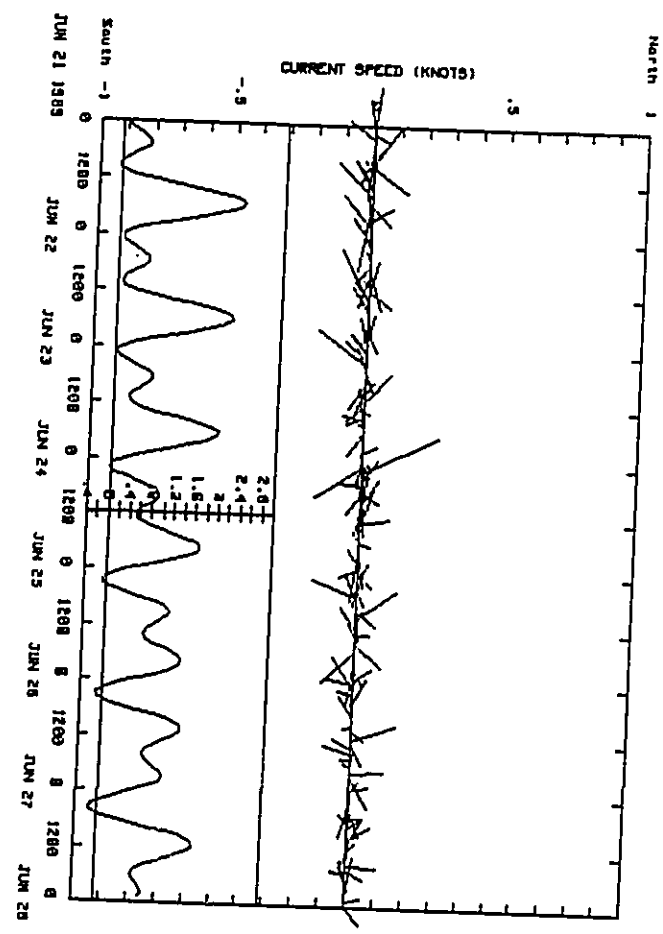
CURRENT SPEED (KNOTS)
North 1
.5
0
-.5
South -1
APR 19 1985
APR 20
APR 21
APR 22
APR 23
APR 24
APR 25
APR 26

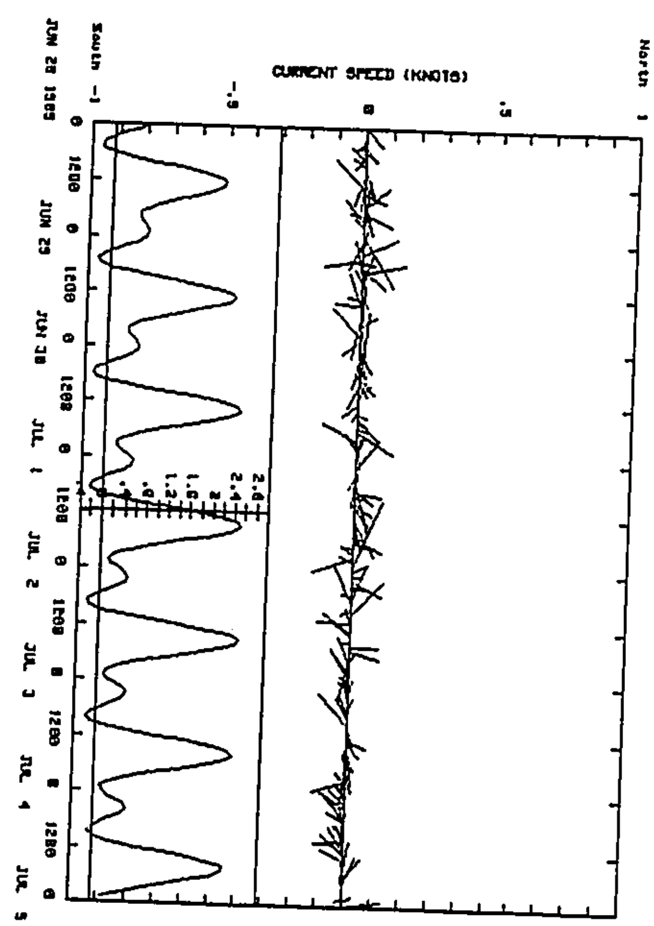

CURRENT SPEED (KNOTS)
North
South
MAY 24 1985
MAY 25
MAY 26
MAY 27
MAY 28
MAY 29
MAY 30
MAY 31

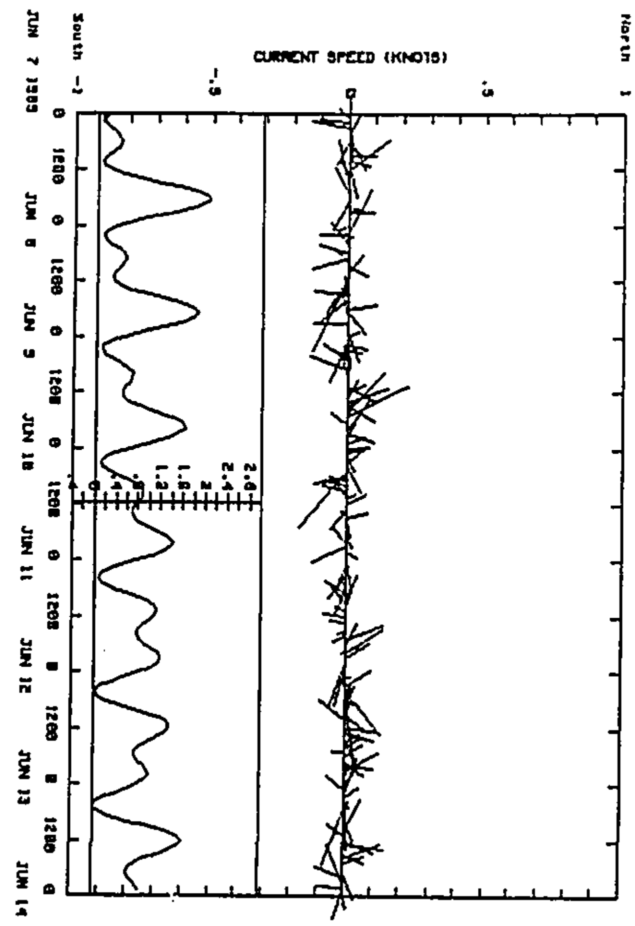

CURRENT SPEED (KNOTS)
North
South
MAY 31 1985
JUN 1
JUN 2
JUN 3
JUN 4
JUN 5
JUN 6
JUN 7

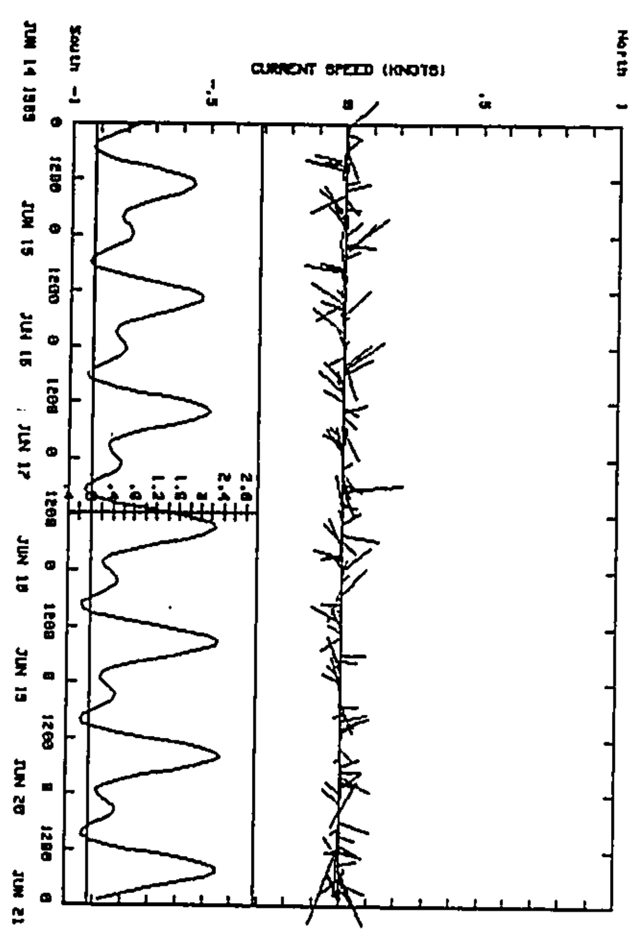

CURRENT SPEED (KNOTS)
North
South
MAY 10 1989
MAY 11
MAY 12
MAY 13
MAY 14
MAY 15
MAY 16
MAY 17

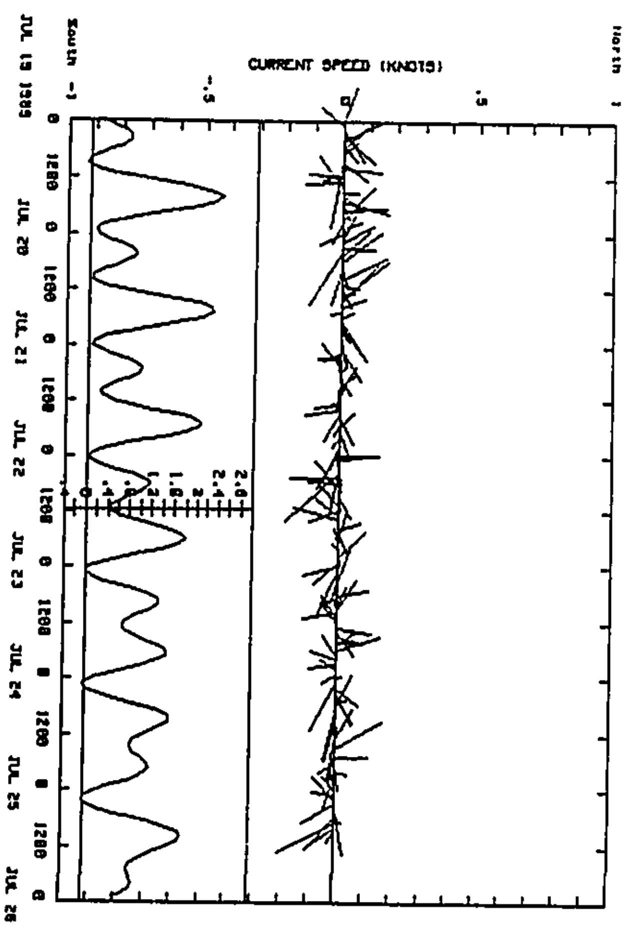

CURRENT SPEED (KNOTS)
North
South
MAY 17 1989
MAY 18
MAY 19
MAY 20
MAY 21
MAY 22
MAY 23
MAY 24

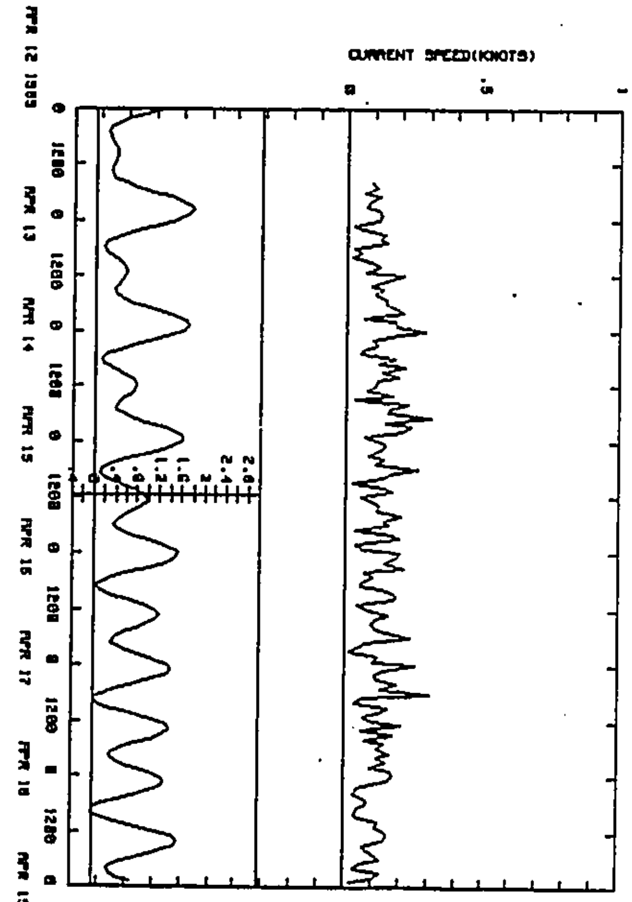

North
CURRENT SPEED (KNOTS)
South

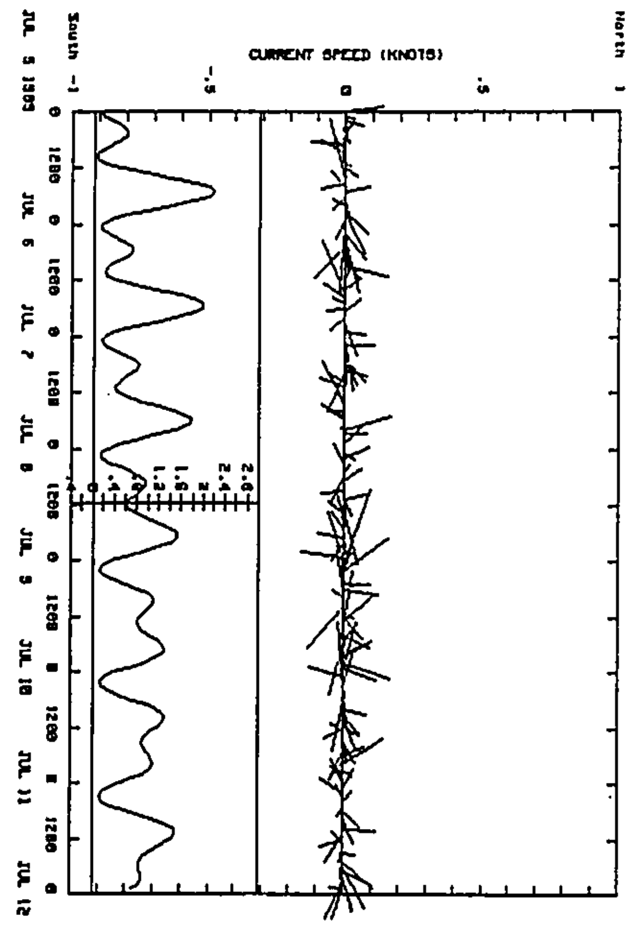

North
CURRENT SPEED (KNOTS)
South

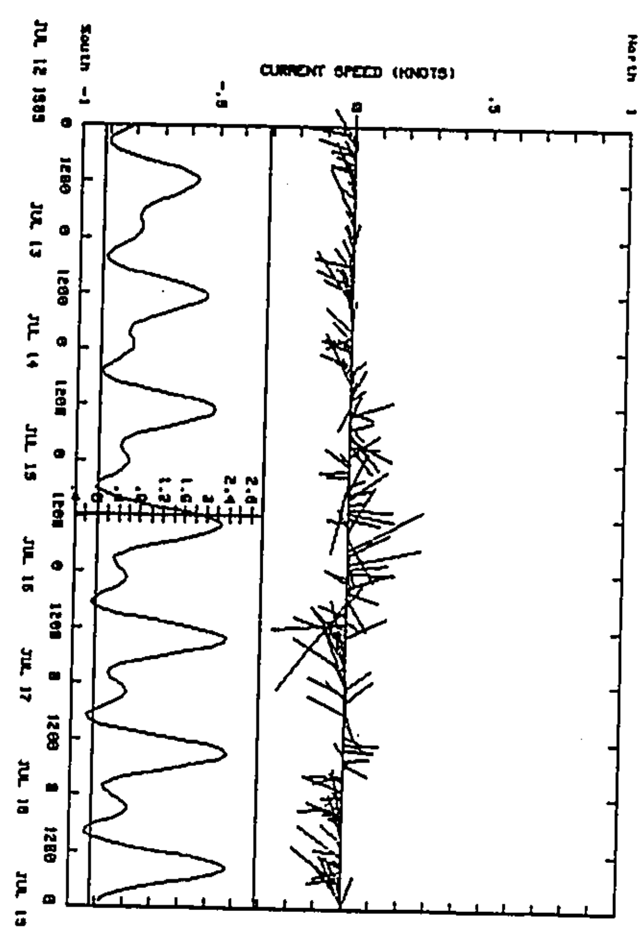

CURRENT SPEED (KNOTS)
South -1
North 1
JUN 7 1985

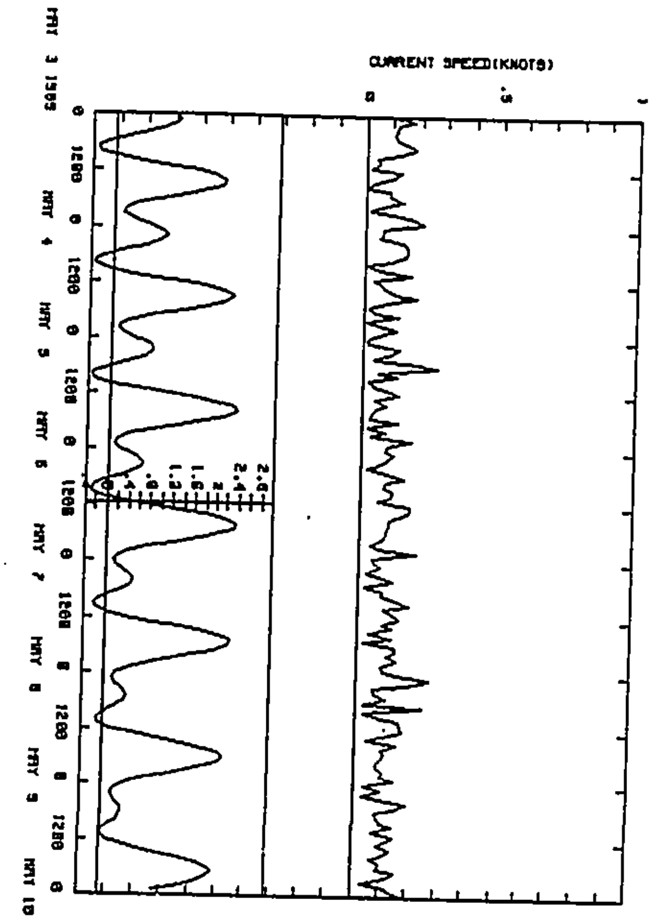

CURRENT SPEED (KNOTS)
South -1
North 1
JUN 14 1985

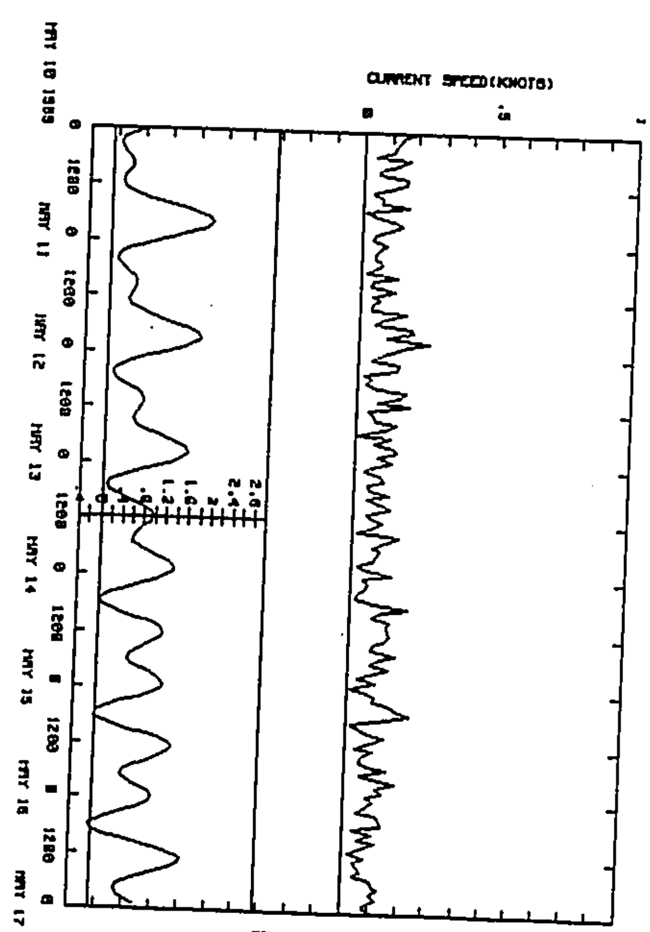

CURRENT SPEED (KNOTS)
North
South
JUL 19 1989
JUL 20
JUL 21
JUL 22
JUL 23
JUL 24
JUL 25
JUL 26

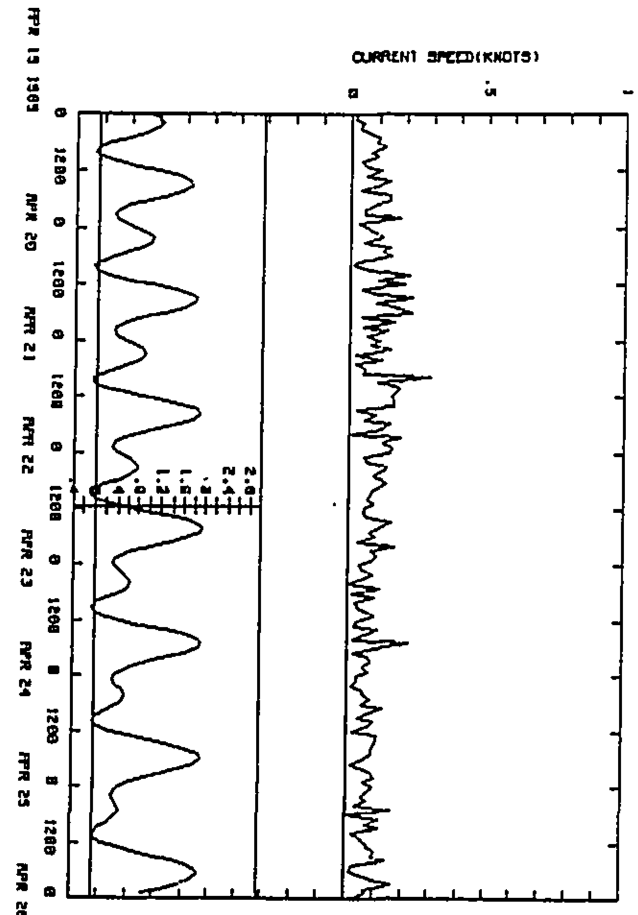

CURRENT SPEED(KNOTS)
APR 12 1989
APR 13
APR 14
APR 15
APR 16
APR 17
APR 18
APR 19

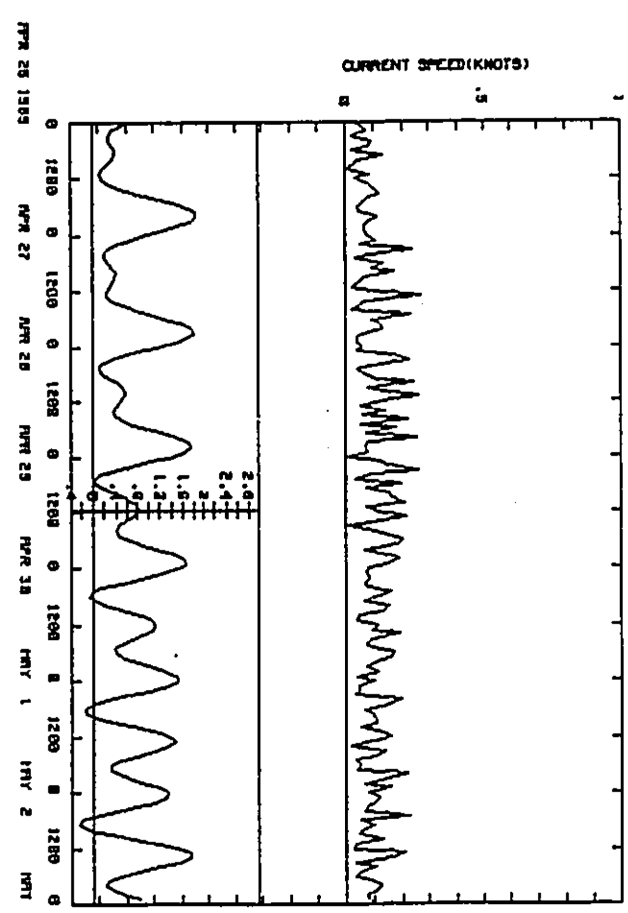

CURRENT SPEED (KNOTS)
North
South

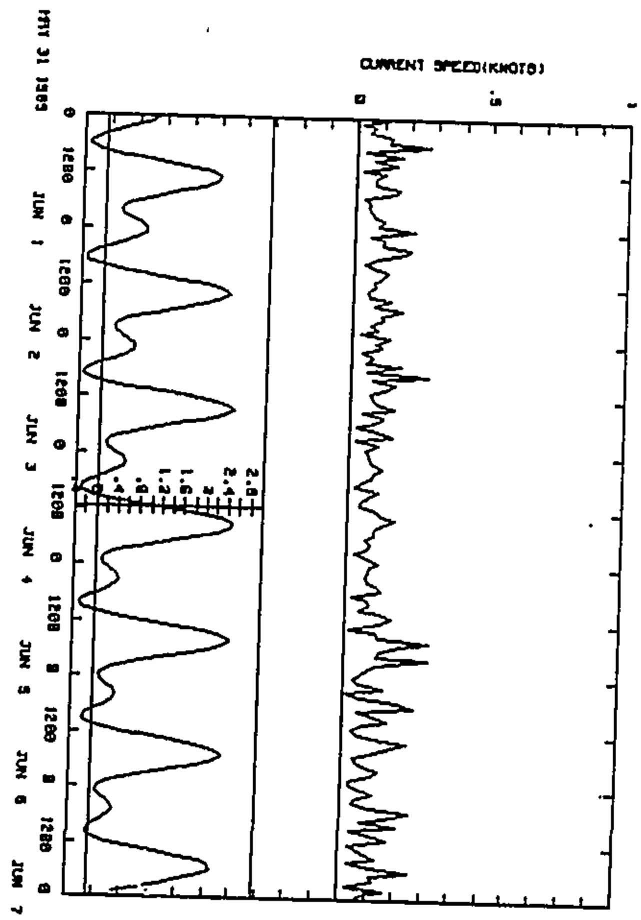

CURRENT SPEED (KNOTS)
North
South

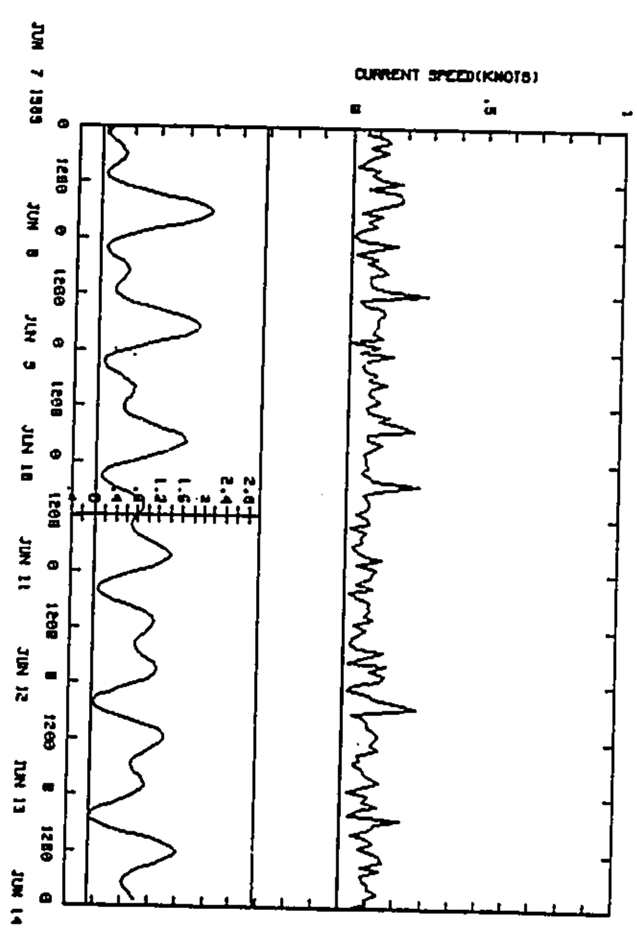

CURRENT SPEED(KNOTS)

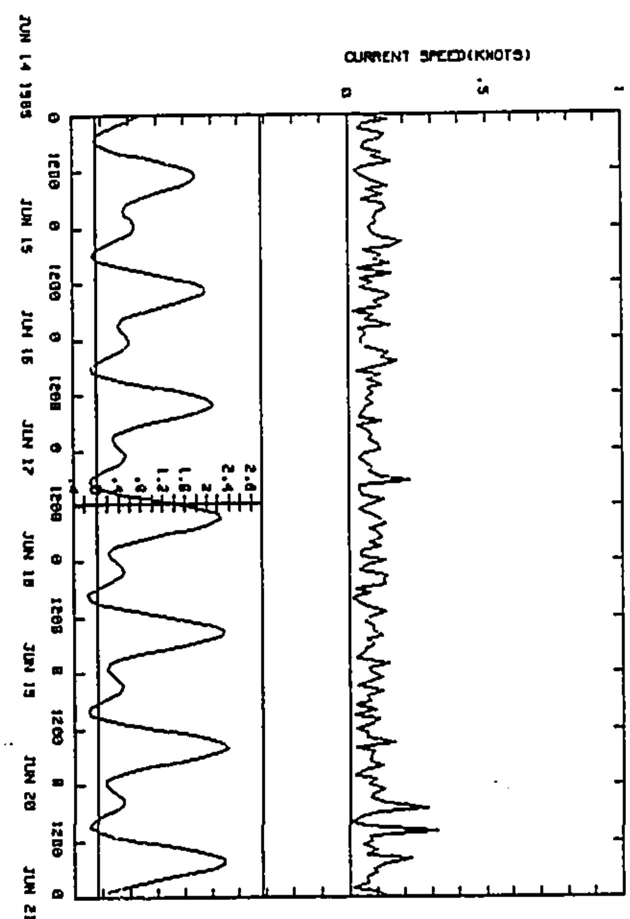

CURRENT SPEED(KNOTS)

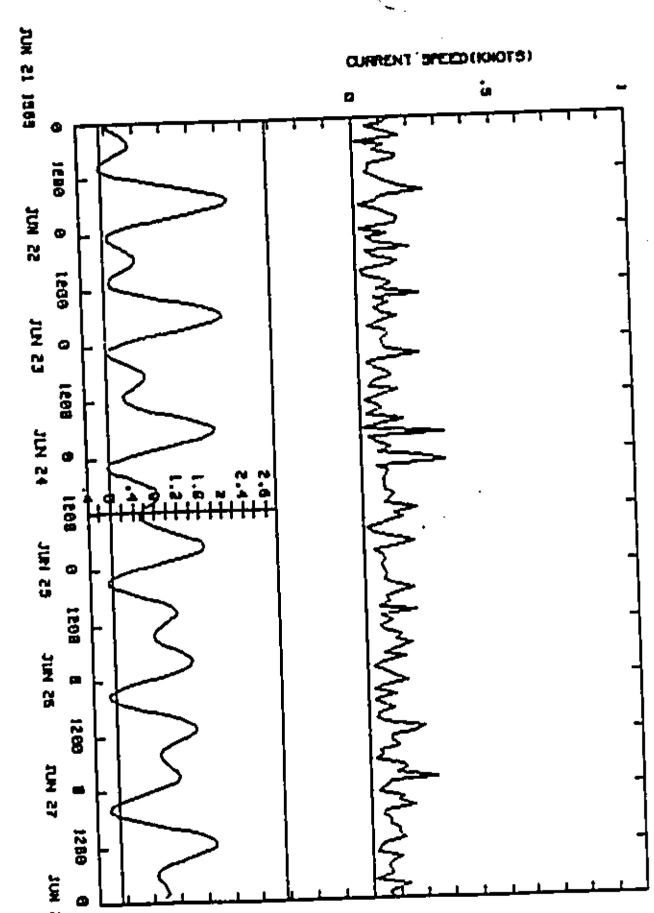

CURRENT SPEED(KNOTS)
APR 19 1985
APR 20
APR 21
APR 22
APR 23
APR 24
APR 25
APR 26

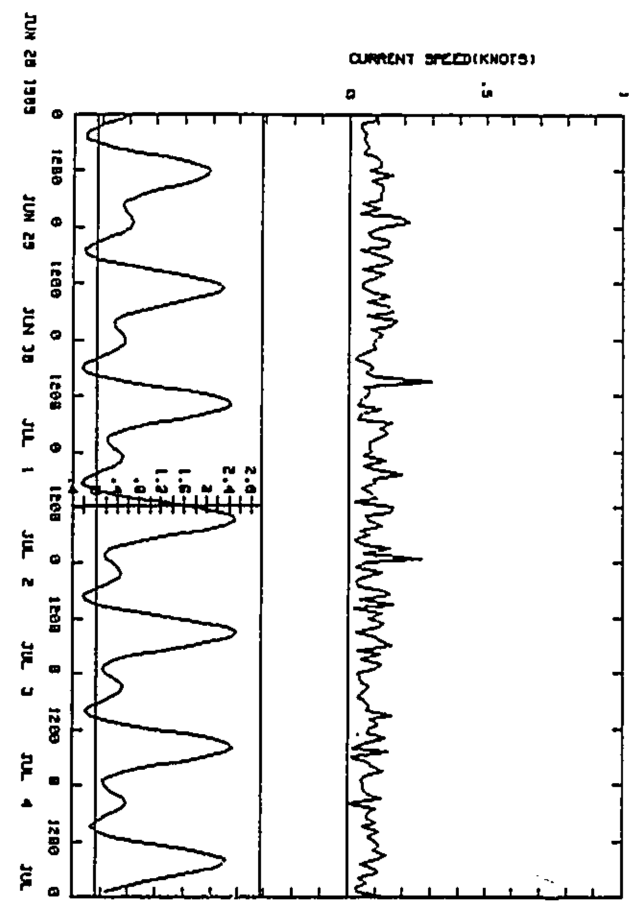

CURRENT SPEED(KNOTS)
APR 26 1985
APR 27
APR 28
APR 29
APR 30
MAY 1
MAY 2
MAY 3

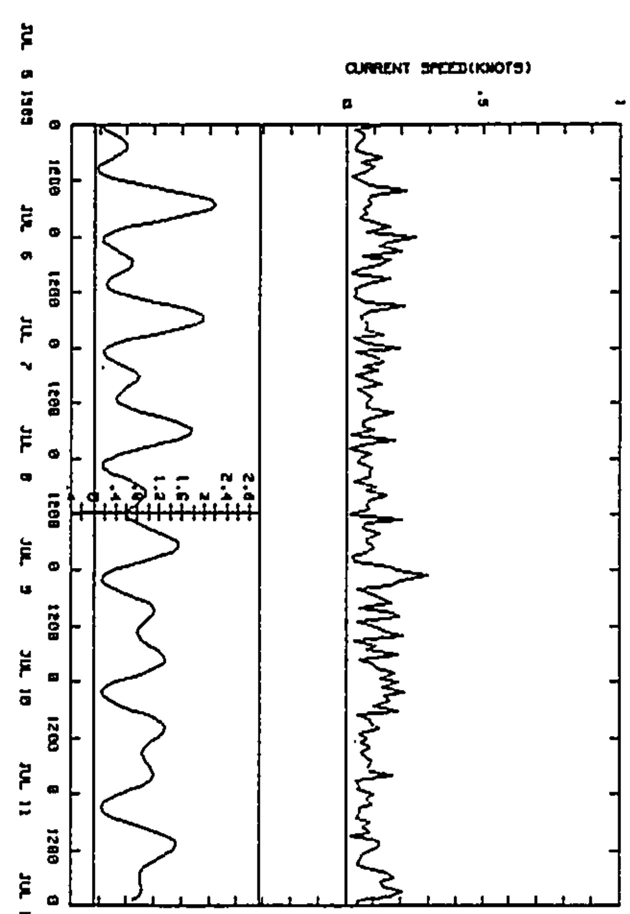

CURRENT SPEED(KNOTS)

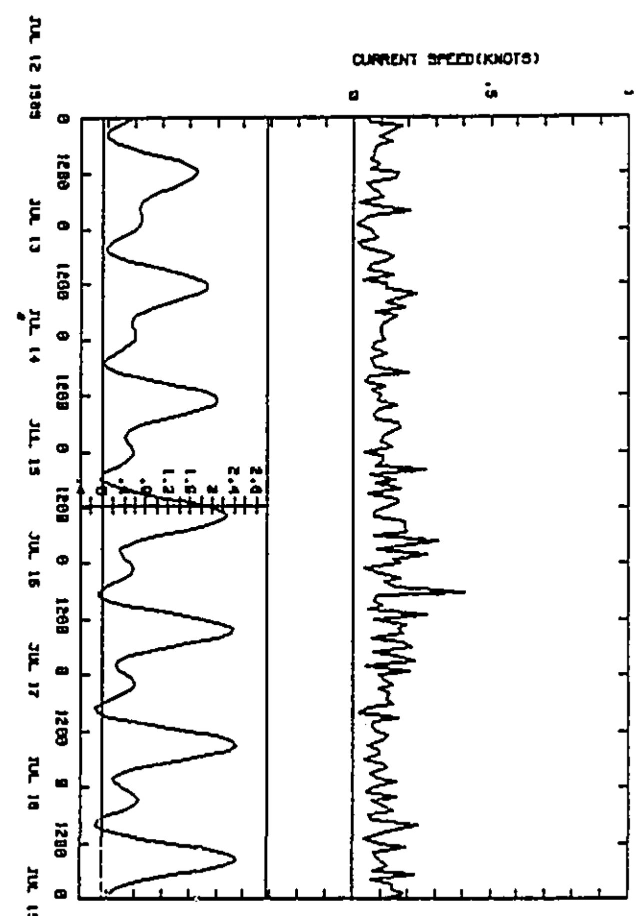

CURRENT SPEED(KNOTS)

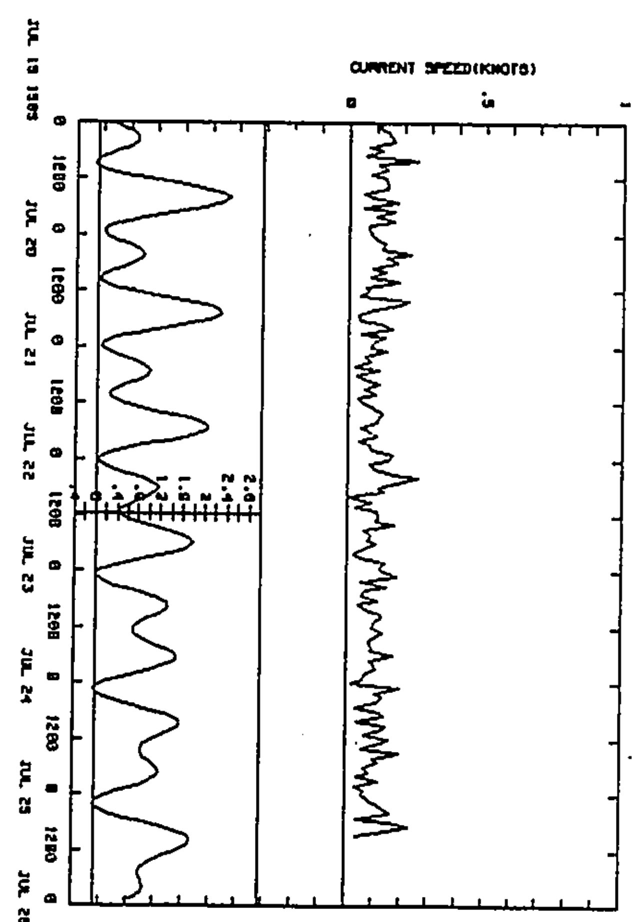

CURRENT SPEED(KNOTS)


CURRENT SPEED(KNOTS)


CURRENT SPEED(KNOTS)
JUN 28 1989
JUN 29
JUN 30
JUL 1
JUL 2
JUL 3
JUL 4
JUL 5


CURRENT SPEED(KNOTS)
JUL 5 1989
JUL 6
JUL 7
JUL 8
JUL 9
JUL 10
JUL 11
JUL 12


CURRENT SPEED(KNOTS)


CURRENT SPEED(KNOTS)

APPENDIX U

CIGUETERA MONITORING RESULTS

University of Hawaii at Manoa

John A. Burns School of Medicine
Department of Pathology
1960 East-West Road • Honolulu, Hawaii 96822

September 14, 1990

Ms. Francine Duncan
Vice-president of Mauna Lani Resort
P.O. Box 4959, HCR 2
Kohala Coast, Hawaii 96743-4959

Dear Francine,

Enclosed are the results of our Mauna Lani sampling trip. The S-EIA is our laboratory test and the SPIA is the simplified test that is still in development. Therefore, the SPIA is generally more sensitive than the S-EIA. These fishes are still being extracted and will be further tested with the mouse bioassay and the guinea pig atria study.

An analysis of the gut contents was also performed. The enclosed sheet is mainly on algae found in the guts of the fishes collected. The gut contents of selected kole were also examined. Little or no G. toxicus and red algae were found.

Dinoflagellates were also cultured from red algae collected between the two resorts. The amount of G. toxicus found per gram of algae was approximately 8-10. According to Yasumoto's 1984 paper, this level of G. toxicus is not very significant in terms of a potential of CTX. However, this dinoflagellate population shoud be carefully monitored before, during, and after the development project to determine the full effects of the project on the reefs. Also, some G. toxicus do not produce toxins, even in nature. This too, must be evaluated.

We look forward to developing a good program, one which will be a model for all future environmental impact on dredging, etc. in the ocean areas as it pertains to natural marine toxins.

Sincerely,

Y. Hokama

Yoshitsugi Hokama, Ph.D.
Professor

cc: Gordon Chapman

Seaweeds in fish guts, Mauna Lani Bay Hotel

June 28-29, 1990

Fish processed by Jenny, Ellen, Audrey

Seaweeds identified by I. A. Abbott
(g=green; b=brown; r=red algae)

JH 36-1. uhu.
lots of sand in gut
only small parts of macroscopic algae more than 1 mm diam:
Pterocladia (r), Laurencia(r), Cladophoropsis(g)
JH 36-2 po'ou
no food
JH 36-3 black trigger
mostly Pterocladia (r), Jania(r), Sphacelaria(b)
JH 36-4 huna
copepod parts
crustose coralline piece(r); Amphiroa (r),
Cladophoropsis(g)
JH 36-5 manini
mixture of small algae: Jania, Gelidiopsis, Chondria (all r); Cladophora socialis and Cladophoropsis (both g)
JH 36-6 yellow tang
abundant Pterocladia capillacea, Gelidiopsis intricata, Martensia fragilis (all r)
JH 36-7 4-spot butterfly
Cladophoropsis (g), Cladophora(hg), Sphacelaria (b),
Enteromorpha (g)
JH 36-8 long nose
no food
JH 36-9 ornate butter
no food
JH 36-10 moorish idol
no algae
JH 36-11 blue spot tang
no algae
JH 36-12 kumu
no algae
a crab claw
JH 36-13 sailfin tang
mostly Pterocladia capillacea (r); Sphacelaria (b)
JH 36-14 enenue
whole pieces of algae, many 0.5 cm long
(most to least abundant0: Pterocladia capillacea (r),
Dictyota friabilis (b), Hypnea (r), Laurencia(r), Chondria (r)
about 10 other species, less abundant
JH 36-15 Achilles tang
Cladophora (g), Caulerpa (g), Gymnothamnion elegans (r)
JH 36-16 oi tang
2 pieces of Laurencia (r)
JH 36-17 hawkfish
no algae: fishbones

1

I. Abbott--fish gut list (page 2)

JH 36-18 mamo
algae and crustacea
Cladophora (g), Gelidiella (r), Amansia (r)
JH 36-19 manini--Mauna Lani pools
Enteromorpha, Cladophora (both g)
* JH 36-20 mullet
only diatoms (Coscinodiscus-type)
JH 36-21 aholehole
only green algae!
Enteromorpha: Cladophora vagabunda, Chaetomorpha
JH 36-22 milkfish
whole pieces of algae: Gelidiella intricata (r),
Enteromorpha clathrata (g), E. lingulata (g), Sphacelaria (b)

one sample unlabelled: sand in gut: no algae.

Later samples: (came by themselves)--not in fish guts.
1. two from pool near Hole 11. Cladophora (g)
2. turtle pond: Ulva, two species nteromorpha (both g)
3. Audrey's by 2 resorts: Gelidium (r), Amphiroa (r) - Associated with G. torreu
4. Ahnfeltia concinna (don't know where from, but common on rocks) various small rocks and pebbles containing young Ahnfeltia and Peyssonellia sp. (r).

U-2 Manini guts (food was digested - no algae)

MAUNA LANI FISH SAMPLING RESULTS - JUNE 27-28, 1990

UH LOG	FISH SPECIES	S-EIA RESULTS	SCORE	SPIA
6845	UHU	2.3	+	+/-
6846	UHU	2.2	+	+/-
6847	UHU	1.83	+/-	+/-
6848	UHU	2.3	+	+/-
6849	UHU	2.2	+	+/-
6850	UHU	2.0	+	+
6851	UHU	2.3	+	+/-
6852	UHU	1.8	+/-	+/-
6853	UHU	2.3	+	+/-
6854	UHU	1.8	+/-	+/-
6855	UHU	2.0	+	+/-
6856	PO'OU	2.5	+	+/-
6857	BLACK TRIGGER	2.0	+	+/-
6858	BLACK TRIGGER	1.83	+/-	+/-
6859	BLACK TRIGGER	2.2	+	+/-
6860	BLACK TRIGGER	2.0	+	+/-
6861	BLACK TRIGGER	1.5	+/-	+/-
6862	HUMU	2.3	+	+/-
6863	KOLE	1.2	-	+/-
6864	KOLE	1.83	+/-	+/-
6865	KOLE	2.0	+	+/-
6866	KOLE	1.83	+/-	+/-
6867	KOLE	1.3	+/-	+/-
6868	KOLE	1.5	+/-	+/-
6869	KOLE	2.2	+	+/-
6870	KOLE	1.67	+/-	+/-
6871	KOLE	2.0	+	+/-
6872	KOLE	2.0	+	-
6873	KOLE	1.5	+/-	+/-
6874	KOLE	1.67	+/-	-
6875	KOLE	1.67	+/-	+/-
6876	KOLE	2.0	+	-
6877	KOLE	1.83	+/-	+/-
6878	KOLE	2.0	+	+/-
6879	KOLE	2.0	+	+/-
6880	KOLE	1.67	+/-	+/-
6881	KOLE	2.33	+	+/-
6882	KOLE	1.5	+/-	+/-
6883	KOLE	1.0	-	+/-
6884	KOLE	1.5	+/-	+/-
6885	KOLE	2.0	+	+/-
6886	KOLE	2.2	+	-
6887	KOLE	1.67	+/-	+/-
6888	KOLE	1.83	+/-	+/-
6889	KOLE	2.0	+	+/-
6890	MANINI	1.5	+/-	+/-
6891	MANINI	1.67	+/-	+/-
6892	MANINI	1.3	+/-	+/-
6893	MANINI	-		+/-
6894	MANINI	1.33	+/-	+/-
6895	MANINI	1.5	+/-	+/-

I Abbott
7/27/90

6896	MANINI	1.83	+/-	+/-
6897	MANINI	1.83	+	+/-
6898	YELLOW TANG	1.5	+/-	+/-
6899	YELLOW TANG	1.0	-	+/-
6900	YELLOW TANG	1.5	+/-	+/-
6901	YELLOW TANG	1.83	+/-	+/-
6902	4 SPOT BUTTERFLY	1.83	+/-	+/-
6903	LONG NOSE BUTTERFLY	1.5	+/-	+/-
6904	ORNATE BUTTERFLY	.83	-	+/-
6905	ORNATE BUTTERFLY	1.17	-	+/-
6906	MOORISH IDOL	.5	-	-
6907	KOLE	.83	-	-
6908	KOLE	1.17	-	+/-
6909	KOLE	.33	-	+/-
6910	KOLE	2.0	+	+/-
6911	KOLE	1.8	+/-	+/-
6912	KOLE	2.0	+	+/-
6913	KOLE	1.5	+/-	-
6914	BLUE SPOTTED GROUPER	2.0	+	+/-
6915	BLUE SPOTTED GROUPER	1.5	+/-	+/-
6916	BLUE SPOTTED GROUPER	2.0	+	-
6917	BLUE SPOTTED GROUPER	1.5	+/-	+/-
6918	KUMU	1.8	+/-	+/-
6919	KUMU	2.0	+	+/-
6920	KUMU	2.0	+	[illegible]
6921	SAILFIN TANG	2.0	+	+/-
6922	ENENUE	1.5	+/-	+/-
6923	ENENUE	1.67	+/-	+
6924	ENENUE	1.5	+/-	+
6925	ACHILLES TANG	1.25	-	+/-
6926	ACHILLES TANG	1.3	+/-	+/-
6927	ORANGE SHOULDER TANG	1.8	+	+
6928	ACHILLES TANG	1.5	+/-	+/-
6929	ACHILLES TANG	1.5	+/-	+/-
6930	HAWK FISH	1.67	+/-	+/-
6931	HAWK FISH	2.0	+	+/-
6932	UOUOA	1.5	+/-	+/-
6933	UOUOA	1.17	-	+/-
6934	UOUOA	.5	-	+/-
6935	UOUOA	.83	-	+/-
6936	UOUOA	1.0	-	+/-
6937	UOUOA	1.0	-	+/-
6938	UOUOA	.83	-	+/-
6939	UOUOA	1.67	+/-	+/-
6940	UOUOA	1.5	+/-	+/-
6941	UOUOA	2.0	+	
6942	UOUOA	.5	-	
6943	UOUOA	2.0	+	
6944	UOUOA	1.17	-	
6945	UOUOA	2.33	+	
6946	UOUOA	1.5	+/-	
6947	UOUOA	1.67	+/-	
6948	UOUOA	1.83	+/-	
6949	UOUOA	2.17	+	
6950	UOUOA	2.17	+	
6951	UOUOA	2.33	+	

6952	UOUOA	2.0	+
6953	UOUOA	2.33	+
6954	UOUOA	1.83	+/-
6955	UOUOA	1.5	+/-
6956	UOUOA	2.17	+
6957	MANINI	.75	-
6958	MANINI	1.0	-
6959	MANINI	1.83	+/-
6960	MANINI	2.83	+
6961	MANINI	2.33	+
6962	MANINI	1.83	+/-
6963	MANINI	2.0	+
6964	MANINI	1.5	+/-
6965	MANINI	2.17	+
6966	MANINI	1.83	+/-
6967	MANINI	2.67	+
6968	MANINI	2.0	+
6969	MANINI	2.17	+
6970	MANINI	2.17	+
6971	MANINI	1.5	+/-
6972	MANINI	1.33	+/-
6973	MANINI	2.0	+
6974	MANINI	1.17	-
6975	MANINI	1.6	+/-
6976	MANINI	1.0	-
6977	MANINI	1.5	+/-
6978	MANINI	1.3	+/-
6979	MANINI	.83	-
6980	MANINI	1.17	-
6981	MANINI	1.83	+/-
6982	MANINI	1.33	+/-
6983	MANINI	1.66	+/-
6984	MANINI	1.5	+/-
6985	MANINI	1.66	+/-
6986	MANINI	.83	-
6987	MANINI	1.66	+/-
6988	MAHO	1.17	-
6989	MAHO	.83	-
6990	MAHO	2.0	+
6991	BLUE SPOTTED GROUPER	1.0	-
6992	ACHILLES TANG	.83	-
6993	KOLE	.83	-
6994	MANINI	1.5	+/-
6995	MANINI	1.0	-
6996	MANINI	.83	-
6997	MANINI	.67	-
6998	MANINI	1.0	-
6999	MANINI	1.67	+/-
7000	MANINI	1.67	+/-
7001	MANINI	.83	-
7002	MANINI	1.83	+/-
7003	MANINI	1.33	+/-
7004	MANINI	.83	-
7005	MANINI	.83	-
7006	MANINI	.67	-
7007	?	1.5	+/-

7008	?	1.5	+/-
7009	?	1.67	+/-
7010	?	.83	-
7011	?	1.0	-
7012	?	1.17	-
7013	?	1.17	-

#6845-6992 FROM OUTSIDE MAUNA LANI RESORT

#6993-7006 FROM MAUNA LANI POND.

#7007-7013 FROM OUTSIDE MAUNA LANI - FISH NOT IDENTIFIED.

THE FOLLOWING SAMPLES WERE CAUGHT FROM MAUNA LANI POND AND WERE CONSUMED, THEREFORE, NO S-EIA VALUES ARE REPORTED.

89	MILKFISH	+
90	MILKFISH	+/-
91	MILKFISH	+
92	MILKFISH	+
93	MULLET	+/-
94	MULLET	+/-
95	MULLET	+/-
96	MULLET	+/-
97	MULLET	+/-
98	MULLET	+/-
99	MULLET	+
100	MULLET	+
101	MULLET	+
102	MULLET	+/-
103	MULLET	+/-
104	MULLET	+/-
105	MULLET	+/-
106	MULLET	+/-
107	MULLET	+/-
108	MULLET	+/-
109	MULLET	+/-
110	MULLET	+/-
111	MULLET	+
112	MULLET	+/-
113	MULLET	+/-
114	MULLET	-
115	MULLET	+
116	MULLET	+
117	MULLET	+/-
118	MULLET	+/-
119	MULLET	+/-
120	PUFFER	+/-
121	MANINI	+/-
122	UHU	+/-
123	MAMO	+
124	MAMO	+
125	AHOLEHOLE	+
126	AHOLEHOLE	+
127	AHOLEHOLE	+/-

128	AHOLEHOLE			+/-
129	AHOLEHOLE			+/-
130	AHOLEHOLE			+/-
131	AHOLEHOLE			+/-
132	AHOLEHOLE			+
133	AHOLEHOLE			+/-
134	AHOLEHOLE			+/-
135	AHOLEHOLE			+
136	AHOLEHOLE			+/-
137	AHOLEHOLE			-
138	AHOLEHOLE			+/-
139	AHOLEHOLE			+/-
140	AHOLEHOLE			+/-
141	AHOLEHOLE			+
142	AHOLEHOLE			+/-
143	MANINI	.17	-	+/-
144	MANINI	.17	-	-
145	MANINI	0	-	-
146	MANINI	.33	-	+/-
147	MANINI	.17	-	+/-

#143..147 WERE FROM THE TURTLE POND IN THE RESORT.